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YARRABILBA PRECINCT 6 ROL2 STORMWATER MANAGEMENT PLAN

VERSION 1

DesignFlow

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Table of Contents

1 INTRODUCTION 1
2 SITE CHARACTERISTICS 2
2.1 LOCATION 2
2.2 TOPOGRAPHY, CATCHMENTS AND DRAINAGE 2
2.3 GEOLOGY AND SOILS 4
2.4 VEGETATION 4
2.5 WATERWAYS 5
2.6 PROPOSED DEVELOPMENT 5
3 STORMWATER QUALITY 7
3.1 DESIGN OBJECTIVES 7
3.2 STORMWATER QUALITY MANAGEMENT STRATEGY 7
3.3 STORMWATER QUALITY ASSESSMENT 11
3.4 COMPLIANCE AND CERTIFICATION 16
4 WATERWAY MANAGEMENT 17
4.1 WATERWAY OBJECTIVES 17
4.2 WATERWAY ASSESSMENT 17
4.3 WATERWAY STABILITY MANAGEMENT STRATEGY 25
5 STORMWATER QUANTITY 30
5.1 FLOODING 30
5.2 WATERWAY STABILTY DETENTION 31
6 EROSION AND SEDIMENT CONTROL 35
6.1 DESIGN OBJECTIVES 35
6.2 MANAGEMENT STRATEGY 36
6.3 MONITORING AND AUDITING 37
7 CONCLUSION 39
8 REFERENCES 40
APPENDIX A FUNCTIONAL DESIGN PLANS 41
APPENDIX B P6 ROL2 WATERWAY INSPECTION SUMMARY 43
APPENDIX C ARR DATA HUB 45

List of Tables

Table 1: Stormwater quality objectives 7
Table 2: Stormwater treatment elements 8
Table 3: Western treatment zone concept design levels summary 8
Table 4: North-eastern treatment zone concept design levels summary 9
Table 5: South-eastern treatment zone concept design levels summary 9
Table 6: MUSIC modelling parameters 12
Table 7: MUSIC model catchment split data 14
Table 8: High flow bypass / secondary link data 15
Table 9: MUSIC results 15
Table 10: Derived waterway stability objectives 17
Table 11: 1 year ARI discharge in Precinct 6 ROL1/ROL2 Waterways (downstream ends) 21

Table 12: Catchment data 31
Table 13: Rainfall losses 32
Table 14: Preliminary stage storage data 33
Table 15: Basin preliminary design 33
Table 16: Discharge results 34
Table 17: Basin water levels 34
Table 18: Construction phase stormwater quality 35

List of Figures

Figure 1: Yarrabilba Precinct 6 ROL2 locality 3
Figure 2: Existing topography, catchments and drainage 3
Figure 3: Geology and soils 4
Figure 4: Precinct 6 ROL2 proposed layout 6
Figure 5: Precinct 6 ROL2 stormwater quality management strategy 10
Figure 6: MUSIC model layout 11
Figure 7: Precinct 6 waterway layout 19
Figure 8: 1 year ARI bed shear stress comparison 23
Figure 9: Waterway stabilisation management strategy 27
Figure 10: 1% AEP Flood levels and preliminary earthworks 30
Figure 11: Western catchment layout (extract from Figure 5) 32

1 INTRODUCTION

The Yarrabilba Priority Development (PDA) is located within the Logan City Council area and occupies a former pine plantation situated south of Logan Village. The Yarrabilba PDA was declared by regulation under the Economic Development Act (2012). Yarrabilba is part of a regional growth area identified in the South East Queensland Regional Plan, which identifies a need for a further 70,000 dwellings across a number of localities in the Logan City Council area by 2031. The Yarrabilba development aims to provide approximately 17,000 dwellings for a population of 45,000.

Precinct 6 (P6) ROL2 (subject site) covers an area of approximately 36.1 hectares (ha) which includes just over 19.8 ha of development lots, 10.5 ha of roads and around 5.8 ha of open space, waterway corridor and stormwater treatment areas.

This document presents the stormwater management strategy for the subject site to meet the requirements set out in the *Context Planning Area Strategy – Precinct 6* (Lendlease. 2022). These are generally consistent with the S*tate Planning Policy*, *Yarrabilba Total Water Cycle Management Strategy* (DesignFlow, 2021) and *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2021). This report provides details of the proposed stormwater quality treatment measures including location, conceptual sizing and functional earthworks.

This report focusses on the construction phase erosion/sediment control and operational phase stormwater quality and waterway elements specific to Precinct 6 ROL2. Flood management has been addressed separately in *the Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017) as the flood management strategy spans numerous current and future precincts requiring site wide planning. No flood infrastructure is required within the subject precinct.

2 SITE CHARACTERISTICS

2.1 LOCATION

Development Precinct 6 ROL2 (P6 ROL2) lies in the central portion of the Lendlease Yarrabilba site bordering the western edge of existing Precinct 4 as shown in Figure 1. The precinct covers a total area of approximately 36.1ha. It forms the southern portion of the broader Precinct 6 Context Planning Area Strategy (CPAS) approved by EDQ (DEV2011/187/27, 13 July 2023)

2.2 TOPOGRAPHY, CATCHMENTS AND DRAINAGE

The existing topography across much of the precinct exhibits fairly consistent grades in the order of 4-5% falling generally east and west from a central ridgeline. The waterway corridor defines the eastern edge of development while future precincts adjoin the south and west within similar grade terrain. The existing P6 ROL1 development precinct forms the northern limit of the ROL2 area which is bounded by waterway corridors on the east and west. The confluence of these waterways defines the northern apex of the broader Precinct 6 area, with the northern access road extending north from this point. Elevations vary from 64mAHD to 36mAHD within the P6 ROL2 site. The site topography is shown in Figure 2.

Precinct 6 ROL2 sits generally within flood Catchment 4 of the broader Yarrabilba development site as defined in the *Yarrabilba (Quinzeh Creek) Flood Study - Version 1* (DesignFlow, 2017).

2.2.1 Lawful Point of Discharge

The lawful point of discharge for stormwater from Precinct 6 ROL2 is to the existing waterways on the northwestern and eastern boundaries, which flow to the southern tributary of Quinzeh Creek as illustrated in Figure 1. These watercourses are mapped as drainage feature under the Water Act (2000). Quinzeh Creek flows through Yarrabilba before discharging north (between Precinct 3A and 3C) near Steele Road approximately 3 km downstream of Precinct 6 ROL2.

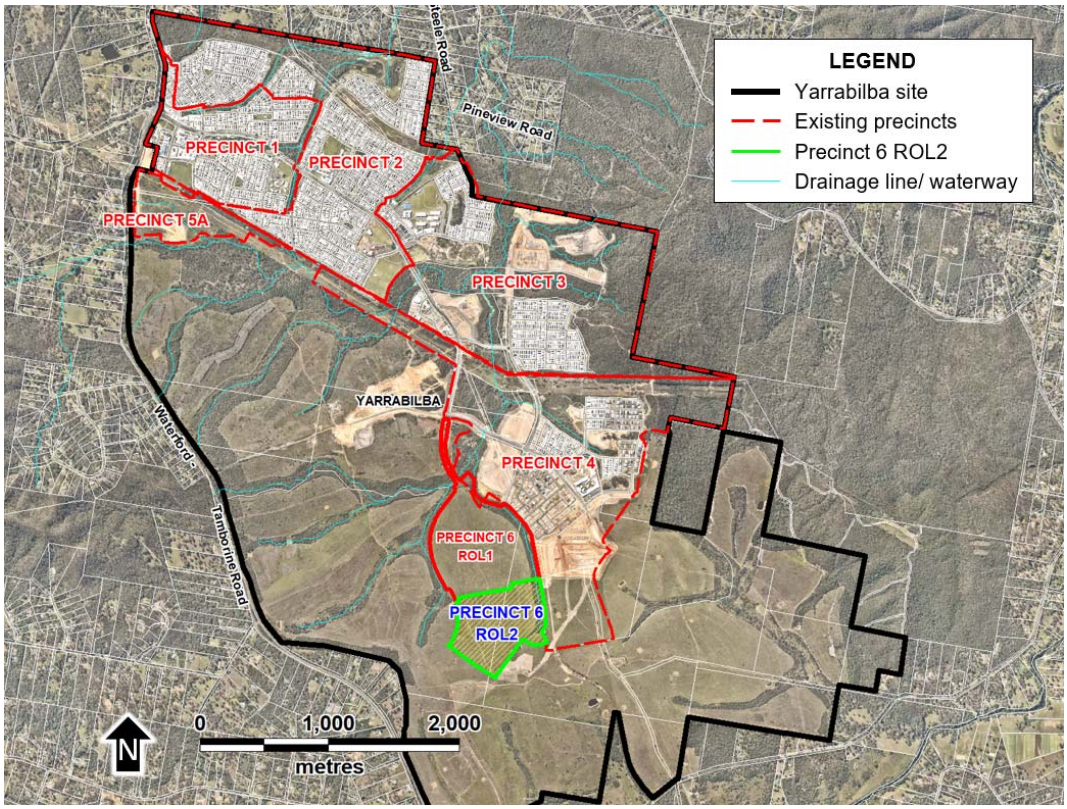


Figure 1: Yarrabilba Precinct 6 ROL2 locality

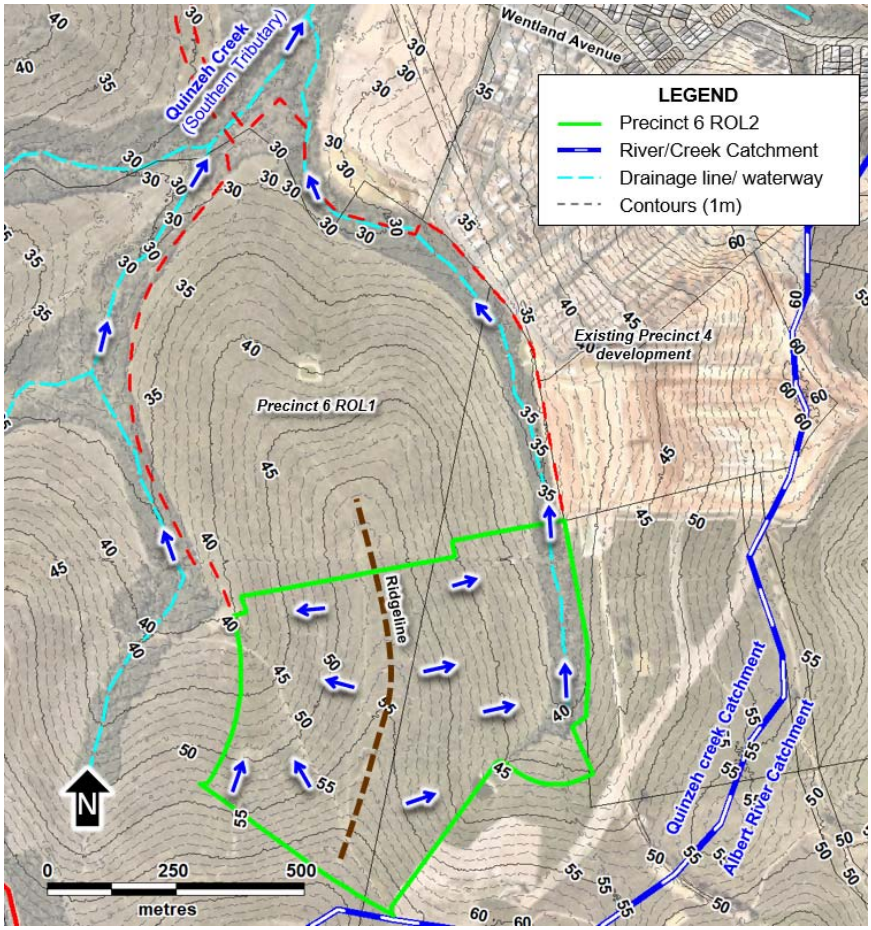


Figure 2: Existing topography, catchments and drainage

2.3 GEOLOGY AND SOILS

Geological mapping indicates Precinct 6 ROL2 is located across two geological units:

- Woogaroo sub-group (RJbw)
- Alluvium (Qa)

Broad scale geotechnical investigations completed across the site (Bowler, 2004) indicate subsurface soils are typically sands overlying silty clays and weathered sandstones. The soil conditions for much of Precinct 6 ROL2 are not expected to vary significantly from those encountered in the balance of Precinct 3 and 4 previously (i.e. those within the lower slope development zones). The alluvium zones (perimeter of P6 ROL2) have often displayed deep sand zones in localised areas where historic channel/creek incisions have been filled with sediment eroded from upslope catchments. Further site specific geotechnical investigations will occur within Precinct 6 ROL2 to confirm soil conditions for civil engineering design.

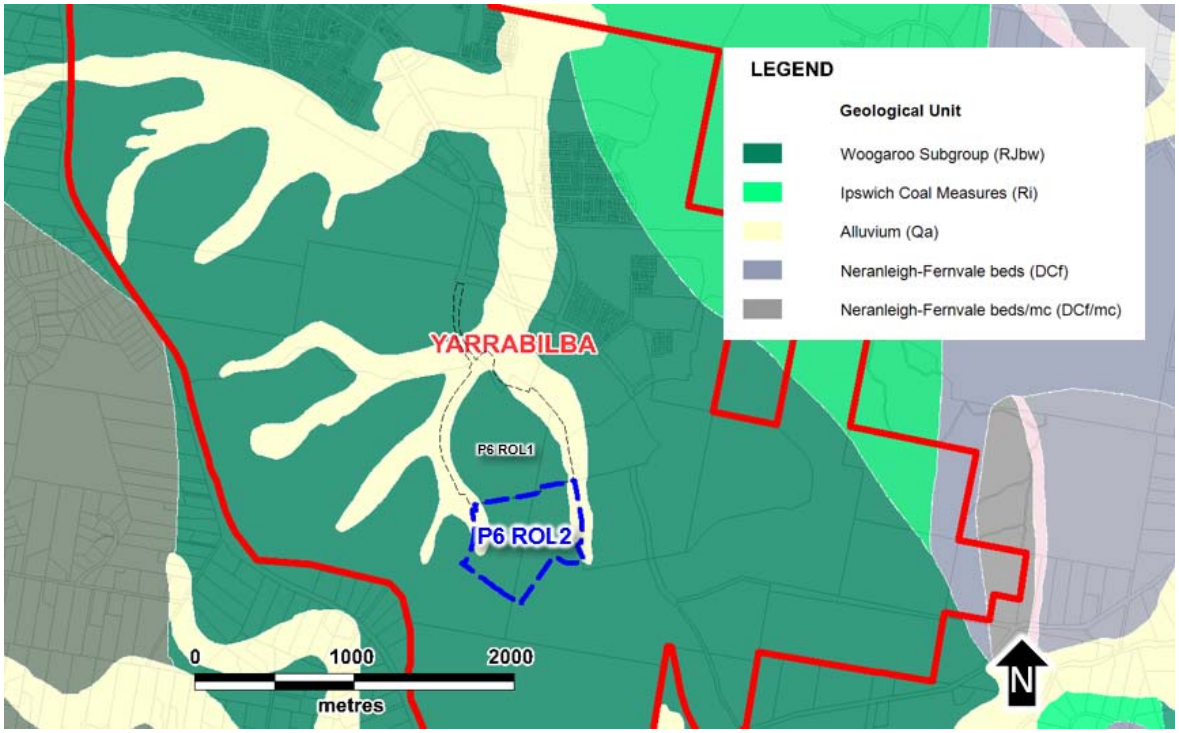


Figure 3: Geology and soils

2.4 VEGETATION

The majority of the Yarrabilba site was previously pine plantation, with most vegetation associated with grassland or pine and eucalypt/acacia regrowth of limited ecological value. Historical aerial imagery illustrates grassland and pine areas represent around 80% of the existing land use across the Yarrabilba site, which have subsequently been cleared and are currently grazed or covered with regrowth (refer Figure 2). Moderate to dense vegetation generally occurs along drainage lines in the development area.

Vegetation management will generally be undertaken in accordance with *Yarrabilba Development: Natural Environment Site Strategy* (Natura Consulting, 2012) which highlights vegetation management procedures with regards to clearing approvals, revegetation, monitoring/compliance and design requirements. Strategy 14 in the CPAS provides the individual mapping for waterway, flora and fauna constraints as well as bushfire setbacks for the Precinct 6 ROL2 development.

2.5 WATERWAYS

Retained waterways exist on the northwestern and eastern extents of P6 ROL2 (and existing P6 ROL1) and are ephemeral in nature. The overall condition of the eastern waterway is generally rated as a mix of poor (upper reaches) to average (lower reaches) with some areas of good condition (middle reaches) in the *Yarrabilba General Waterway Condition Assessment* (DesignFlow, 2021). Future management/ rehabilitation will be important to the improvement of this waterway for long term ecological and geomorphological benefits.

The eastern waterway lies within the P6 ROL2 boundary and receives treated discharge from proposed bioretention basins in the eastern side of P6 ROL2 (and P6 ROL1). This waterway has been assessed in detail as part of previous Precinct 4 development assessment. The details provided in this report in relation to the eastern waterway are derived directly from the previously approved strategy.

The western waterway lies outside and downstream of the P6 ROL2 boundary but is considered here as it receives discharge from the development area. This waterway is broadly defined as being in good overall condition based on the above condition assessment, with the uppermost extent showing average conditions mainly due to reduced riparian habitat. This waterway interfaces with multiple future precincts so management of stability and vegetation values will be an important aspect of the planning for these development areas.

Both waterways have been included in the site planning for the purpose of assigning the minimum waterway buffers set out in the *Stormwater Infrastructure Master Plan* (DesignFlow, 2021). In conjunction with existing vegetation and bushfire considerations, the development extent has been defined outside this waterway corridor.

2.6 PROPOSED DEVELOPMENT

The proposed development covers an area of approximately 36.1 ha which includes just over 19.8 ha of development lots, 10.5 ha of roads and around 5.8 ha of open space, waterway corridor and stormwater treatment areas. The precinct layout is shown in Figure 4.

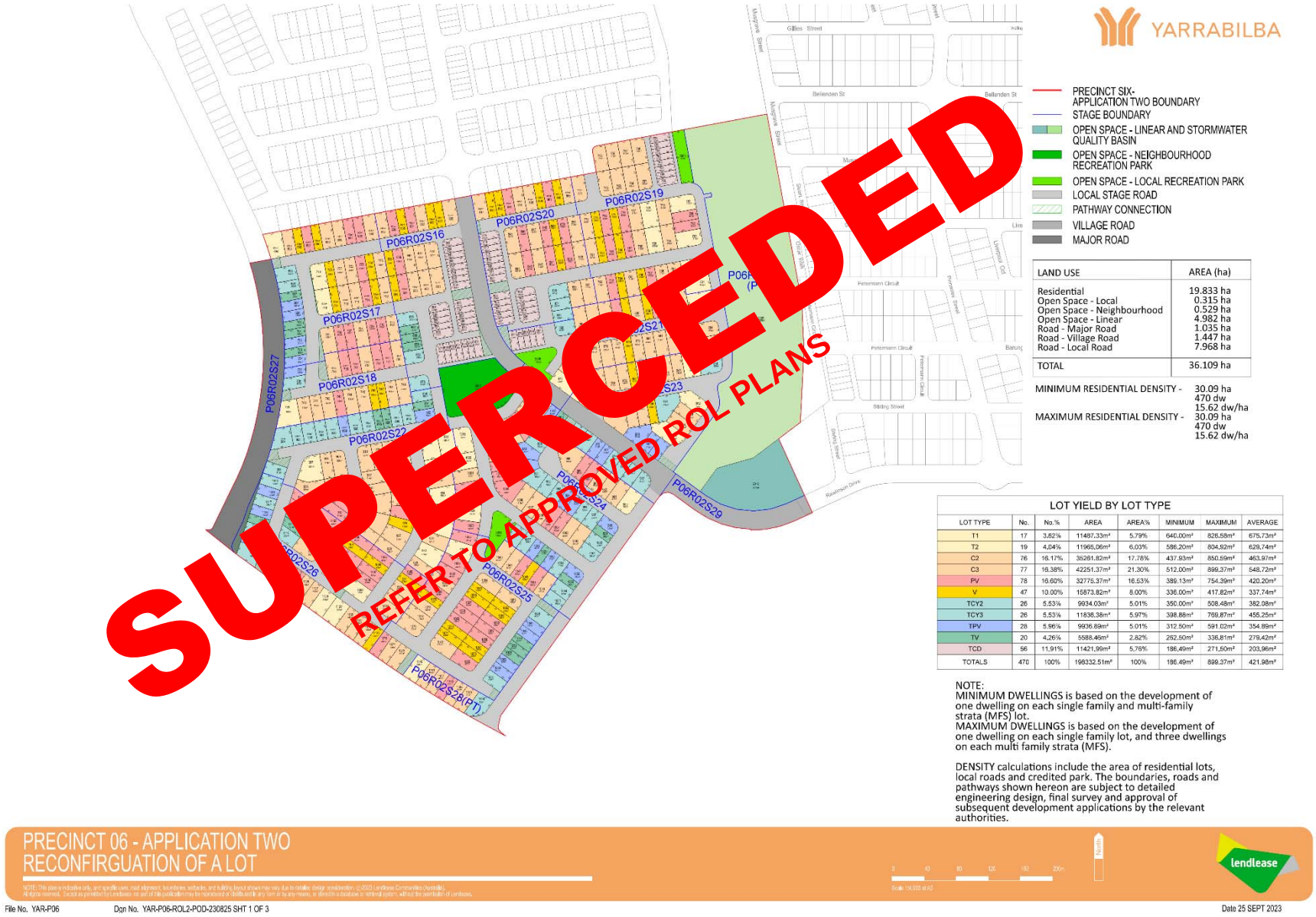


Figure 4: Precinct 6 ROL2 proposed layout

3 STORMWATER QUALITY

3.1 DESIGN OBJECTIVES

The stormwater quality management objectives that apply to the operational phase of Yarrabilba Precinct 6 ROL2 are listed in Table 1 as defined by *the Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021), which are consistent with the State Planning Policy (DSDIP, 2017).

These objectives require the reduction of pollutant loads discharged from the development site once all construction works are complete. These load reductions are aimed at protecting the environmental values of downstream receiving waterways from the impacts of urban stormwater runoff.

Table 1: Stormwater quality objectives

Pollutant	Discharge criteria (% reduction in mean annual load)
Total suspended solids (TSS)	80%
Total phosphorous (TP)	60%
Total nitrogen (TN)	45%
Gross pollutants (GP)	90%

3.2 STORMWATER QUALITY MANAGEMENT STRATEGY

A stormwater management strategy has been developed for Precinct 6 ROL2 based on a review of the site characteristics, constraints, masterplan for the proposed development zones and discussions with Lendlease. The proposed strategy has been developed in collaboration with the design team to ensure it is well integrated with both engineering and landscape aspects of the design.

When developing the treatment strategy, a number of key principles were considered:

- Adopt multiple use open space principles where possible
- Locate treatments in waterway buffer zones, where applicable, as per *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021)
- Adopt similar treatment philosophy as per Precinct 1, 2, 3 and 4 developments to maintain consistency across the development
- Integrate with landscape outcomes
- Minimise the impact on existing vegetation and ecosystems
- Ensure future development/catchments are allowed for in precinct scale treatment systems.

Figure 5 shows the overall proposed treatment strategy for Precinct 6 ROL2 with details of treatment systems provided in Table 2. Design levels and the relevant flood immunity details are provided in Table 3 and Table 4. Further details of performance assessments of the proposed treatment strategy are presented in Section 3.3.

Table 2: Stormwater treatment elements

Treatment Type and ID	Size	Catchments	Comment
Sediment Pond 6B1 [2] *Bioretention 6B3* [2]	*300 m²* *700 m²*	*6B1* [1] *(ROL1)*	Multi basin treatment system (with ROL1 strategy)
Sediment Pond 6B2 Bioretention 6B4	300 m² 700 m²	6B2 [1]	
Sediment Pond 6C1 [3] Bioretention 6C2-6C3 [3]	350 m² 2 x 850 m²	6C1, FUT1, FUT2	Multi basin treatment system
Bioretention 6D1	800 m²	6D1, 6D2	Single basin

Note:

1. Sediment ponds 6B1 and/or 6B2 may be omitted and replaced with sediment forebays (depending on ultimate catchment, landscape and basin configuration). If this occurs further MUSIC modelling will occur to ensure overall treatment objectives are achieved.
2. Sed 6B1/Bio 6B3(catchment 6B1) from P6 ROL1 is shown for reference only as part of the overall multi-basin treatment area linked to Sed 6B2/Bio 6B4 (catchment 6B2). Refer to ROL1 for previous details.
3. Sed 6C1/Bio 6C2-6C3 receives inflow from future development areas outside P6 ROL2.

The concept layout for the proposed sediment ponds and bioretention basins has been documented in the functional design plans by KN Group (Appendix A). Key design parameters are summarised in Table 3 and Table 4. These are subject to detailed design as part of operational works and some flexibility in configuration exists in these basins to enable design response to ultimate catchment and landscape outcomes in these zones (e.g. sediment ponds may be replaced with sediment forebays).

Table 3: Western treatment zone concept design levels summary

Parameter	Sed 6C1	Bio 6C2-6C3
Area	350 m²	2 x 800 m²
Surface level	RL41.6	RL41.5
Bunds	RL43.0 (min.) *	
1% AEP flood (in adjacent waterway)	RL38.0 [2]	RL38.0 [2]

Notes:

1. Sed 6C1/Bio 6C2-C3 incorporates Q1 minor flood storage zone above the treatment area to manage waterway stability in the downstream western waterway. Refer to Section 5.2 for the hydraulic assessment of this basin.
2. Regional flood mapping does not interface directly with this treatment system. Local overland flow is well below basin design levels stated above.

Table 4: North-eastern treatment zone concept design levels summary

Parameter	Sed 6B2 [1, 2]	Bio 6B4 [1]
Area	300 m²	700 m²
Surface level	RL37.6	RL37.5
Bunds	RL38.5 (min.)	
1% AEP flood	36.55	36.25

Note:

1. An existing sed pond and bio basin are proposed as part of existing P6 ROL1 adjoining these basins to the north as part of a multi basin treatment system.
2. Sed pond 6B2 may be replaced with sediment forebay where catchment or landscape design dictates layout changes in this zone.

Table 5: South-eastern treatment zone concept design levels summary

Parameter	Bio 6D1
Area	800 m²
Surface level	RL44.5
Bunds	RL45.5
1% AEP flood	n/a [1]

Note:

3. No flood mapping exists for this area. Design levels are generally >1m above the adjoining natural waterway overland flow path.

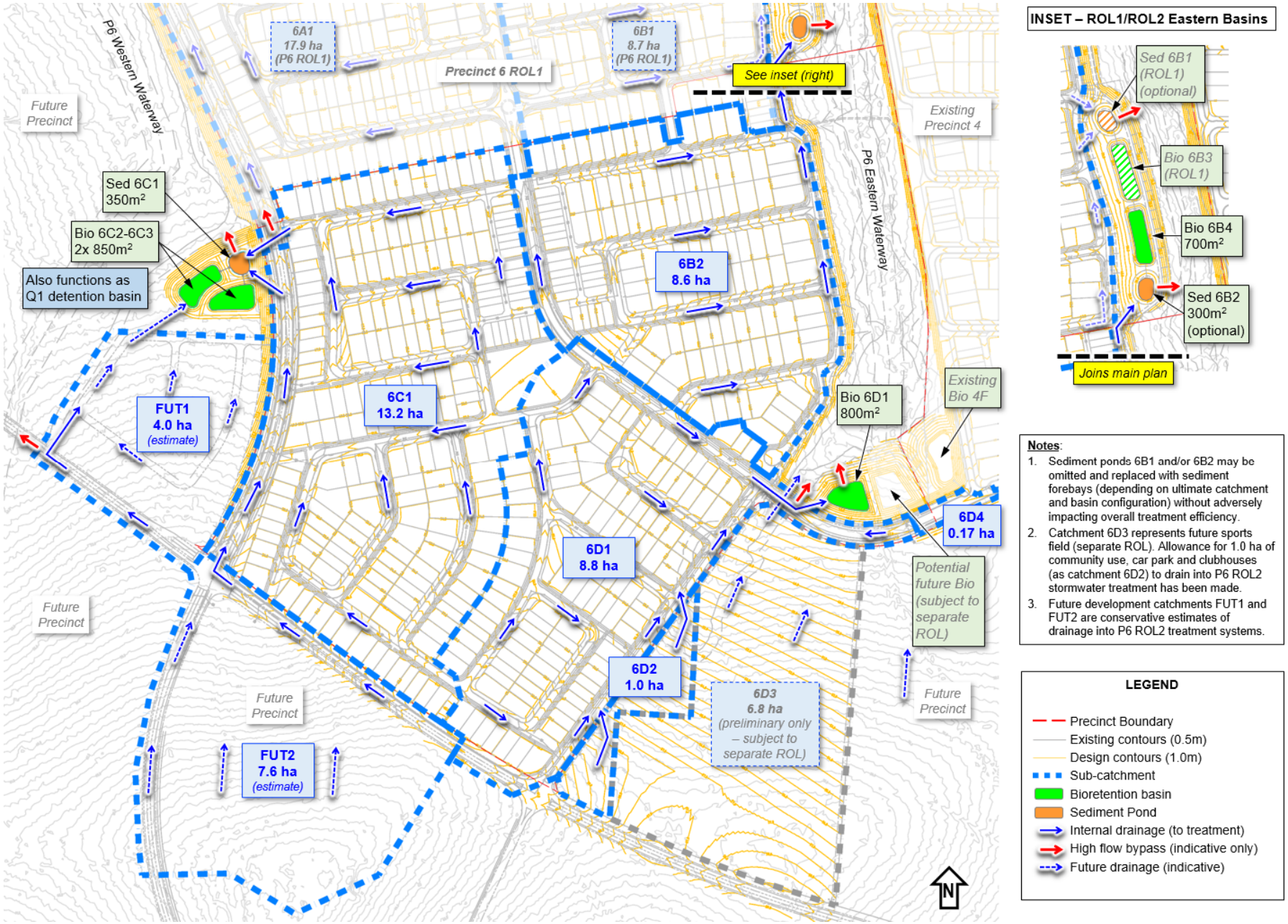


Figure 5: Precinct 6 ROL2 stormwater quality management strategy

3.3 STORMWATER QUALITY ASSESSMENT

MUSIC modelling was undertaken to assess the stormwater treatment performance of the proposed treatment strategy. MUSIC Version 6.3 was used for the assessment.

3.3.1 Model Structure

The structure of the MUSIC model is shown in Figure 6 with the general data provided in Table 6. MUSIC model parameters were adopted generally in accordance with the *MUSIC Modelling Guidelines* (Water by Design, 2010/2018) using 10 years (1990-2000) of modified Shailer Park meteorological data. Six minute rainfall data and monthly average evapotranspiration data was used. The Shailer Park station was selected for adoption as it is the closest rainfall station to the site with 6 minute data. The rainfall data set was modified to generate a data set closer representing Logan Village rainfall. The Shailer Park 6 minute rainfall was reduced by a factor of 0.849 to produce a rainfall data set with a similar annual total to Logan Village (950mm) for the period considered. Discussion of this was provided in Section 5.1 of the *Precinct 1 Stormwater Management Plan* (DesignFlow, 2011) and has been consistently used in all subsequent applications since that time.

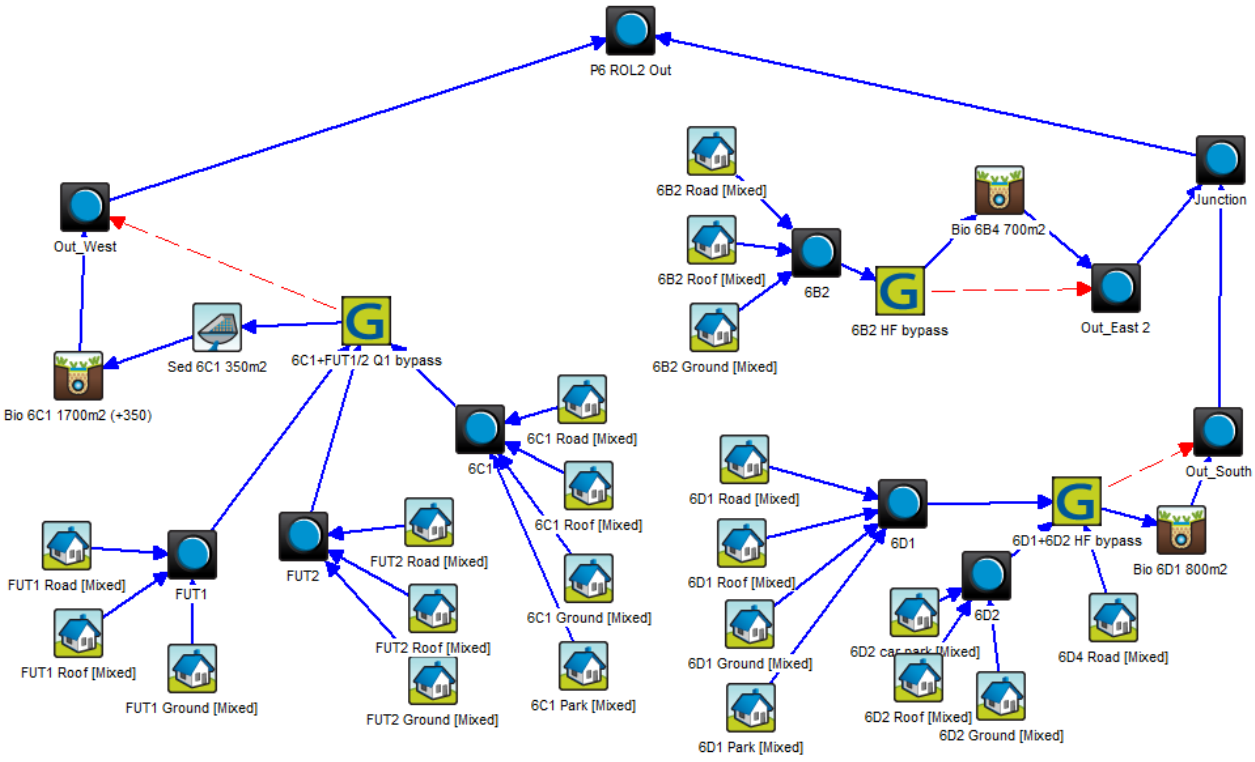


Figure 6: MUSIC model layout

Table 6: MUSIC modelling parameters

Parameter	Value
Source Data	
Rainfall data set	1990-99– Modified Shailer Park Station 040715
Modelled time step	6 minute
Mean annual rainfall 1990-2000	950 mm
Potential evapotranspiration	1,446 mm
Soil properties (runoff generation parameters)	Table 3.7 Music Modelling Guidelines (as appropriate depending on land use)
Pollutant concentrations (base flow and storm flow concentration)	Table 3.8 Music Modelling Guidelines (as appropriate depending on land use)
Percent impervious	Table 3.5 and 3.6 Music Modelling Guidelines (as appropriate depending on land use)
Treatment Devices	
Bioretention	Filter media depth = 0.6 m Extended detention depth = 0.3 m Extended detention area = Bio area (when stand-alone) or Bio + wetland + sed pond (when in combined system) Seepage = 0 mm/hr TN content 400 mg/kg Orthophosphate content 30 mg/kg Overflow weir width = bio area/10
Sediment Basin	Extended detention depth (EDD) = 0.01 m (extended detention depth over 0.01m is included in bio basin where linked) Evaporative loss 75% of PET Notional detention time = <0.1hr (upstream of wetland or bioretention basin) Overflow weir width = sediment pond area/10

3.3.2 Assumptions

1. A split catchment approach was adopted for modelling. Split land use percent imperviousness is generally in accordance with Table 3.5 in MUSIC Modelling Guidelines (Water by Design, 2010/2019).

2. Bioretention default values for TN and OP content have been adopted as 400mg/kg and 30mg/kg respectively as per Water by Design advice (and in line with MUSIC Guideline 2019)

3. High flow bypass thresholds (based on future development estimates of 63.2% AEP) are set at Generic nodes upstream of all treatment nodes for easy identification. Refer to Section 3.3.4 for details.

4. Sediment ponds connect via culverts to bioretention basins with minimal flow restriction (i.e. minimum allowable 0.01m extended detention adopted in MUSIC with large pipe connection to freely convey inflows)

5. Bioretention basin cells 6C2-6C3 are modelled as combined total surface area (where actual design will split these into multiple cells to ensure flow distribution across filter).

6. Bioretention basins have 0.3m extended detention depth before overflowing to discharge. Extended detention area is taken as sum of 'shared' area over bioretention and sediment pond (see notes regarding extended detention depths assumed in item 4 above) as bioretention controls rapid water level drawdown for all these systems.

7. All overflow weirs from all treatment systems have adopted the treatment area/10 for the weir width as per the *MUSIC Modelling Guideline* which ensures conservatively large weirs and avoids any additional treatment resulting from extended detention above weirs. Detailed design will resolve actual weir sizes (as well as pit sizing where applicable) with accompanying MUSIC model verification.

The above assumptions ensure the current functional design of all treatment systems is conservative and allows for more than adequate earthworks, treatment and maintenance space allowances within the current development layout. All systems will be subject to detailed catchment, hydraulic and MUSIC model verification at detailed design stage to optimise the system sizing for the contributing catchments and surrounding open space integration.

3.3.3 Catchment Data

The catchment areas draining to each treatment system have been derived from the urban design and drainage layouts for sub-stages where available. Table 2 previously identified catchments contributing to each treatment element. Table 7 below lists the catchment area, land use and percent impervious for each sub-catchment modelled with a detailed breakdown of surface types.

Table 7: MUSIC model catchment split data

Catchment ID	Total Area (ha)	% Impervious	Surface Type	Sub-Area (ha)	Impervious %
6B2	8.6	60%	Road	2.15	60%
			Roof	3.23	100%
			Ground	3.23	20%
6C1	13.2	59%	Road	3.22	60%
			Roof	4.83	100%
			Ground	4.83	20%
			Park	0.32	10%
6D1	8.8	62%	Road	2.15	60%
			Roof	3.22	100%
			Ground	3.22	30%
			Park	0.21	10%
6D2	1.0	84%	Car park	0.60	100%
			Roof	0.20	100%
			Ground	0.20	20%
6D4	0.17	60%	Road	0.17	60%
FUT1	4.0	67%	Road	1.20	70%
			Roof	1.40	100%
			Ground	1.40	30%
FUT2	7.6	60%	Road	1.90	60%
			Roof	2.85	100%
			Ground	2.85	20%
Total	**43.37**	**61%**		**43.37**	**61%**

Notes:

1. Catchment 6D2 represents the car park, club house and community use areas of the future sports field. While the sports field will be subject to a separate ROL, the runoff from the main impervious areas will be managed through the P6 ROL2 treatment strategy.
2. Future development catchments FUT1 and FUT2 are conservative estimates of drainage into P6 ROL2 treatment systems from future precincts.

3.3.4 Secondary Link Data

Table 8 summarises the secondary links used in the MUSIC modelling and the relevant high flow bypass (HFB) threshold (where relevant) or flow component (from upstream treatment node). Where HFB applies, a dedicated Generic node has been used in the model to readily identify the bypass location and downstream connection node. All flows above HFB thresholds are diverted around treatment via secondary links.

Table 8: High flow bypass / secondary link data

From Node	To Node	Outflow Components	HFB Threshold	Comment
6B2HF Bypass	Out_East 2	High flow bypass	0.9 m^3/s	HFB estimated at Q1 flow from 8.6 ha
6C1+FUT1/2 HF Bypass	Out_West	High flow bypass	2.6 m^3/s	HFB estimated at Q1 flow from 24.8 ha
6B1 HF Bypass	Out_East 3	High flow bypass	1.0 m^3/s	HFB estimated at Q1 flow from 9.8 ha

3.3.5 Results

The results of the MUSIC modelling are presented in Table 9. All water quality objectives can be readily achieved with the proposed treatment strategy.

Table 9: MUSIC results

Catchments	Treatment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (%)
6B2	Sed 6B2 (optional), Bio 6B4	TSS	22100	3940	82.1
		TP	46.9	12.9	72.5
		TN	295	150	49.3
		GP	3710	57.7	98.4
6C1, Fut1, FUT2	Sed 6C1, Bio 6C2-6C3	TSS	7510	1420	81.1
		TP	16.1	4.36	72.8
		TN	103	50.8	50.9
		GP	1300	20.8	98.4
6D1, 6D2, 6D4	Bio 6D1	TSS	10300	1970	80.8
		TP	21	5.82	72.3
		TN	122	61.6	49.6
		GP	1520	27.7	98.2
Total Precinct P6 ROL2 (✓ denotes compliance with water quality objectives)		TSS	39900	7330	81.6 ✓
		TP	84	23.1	72.5 ✓
		TN	521	262	49.7 ✓
		GP	6520	106	98.4 ✓

These results indicate conservative outcomes which enables the detailed design of the basins or stormwater drainage network (or earthworks updates) to divert flows to different parts of the catchment without adversely impacting overall treatment performance. It also provides flexibility in design for integration (and downsizing) of treatment systems in open space areas. This will be resolved in conjunction with civil and landscape design with verification MUSIC modelling provided with each basin.

3.4 COMPLIANCE AND CERTIFICATION

Design and construction certification of operational stormwater quality measures is to occur in accordance with the following guidelines:

- Water by Design (2014). *Bioretention Technical Design Guidelines (Version 1.1)* Healthy Waterways Ltd, Brisbane
- Water by Design (2009), *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands*, SEQ Healthy Waterways Partnership. Brisbane, Queensland.
- Water by Design (2012), *Transferring Ownership of Vegetated Stormwater Assets Version 1*. Healthy Waterways Partnership. Brisbane, Queensland.

4 WATERWAY MANAGEMENT

The assessment of receiving waterways for P6 ROL2 draws on existing waterway assessment and management strategies from Precinct 6 ROL1 (for the eastern waterway, which also interfaces with Precinct 4 to the east) as well as a more recent assessment of the P6 western waterway (not included in P6 ROL1).

4.1 WATERWAY OBJECTIVES

4.1.1 Waterway Stability

The waterway stability objectives adopted for the site are based on protecting high value waterways from erosion because of increased flow from urban development and providing improvements to average or degraded waterways under developed hydrology. This applies to waterways and drainage lines within the site as well as downstream receiving waterways beyond the development boundary. Due to the large size of the site and significant variation in waterway types and riparian and in-stream condition, the waterway stability objective has been derived for a range of situations as shown in Table 10. These objectives are consistent with the *Yarrabilba Total Water Cycle Management Strategy* (DesignFlow, 2021), *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2021) and *State Planning Policy* (DSDIP, 2017).

Table 10: Derived waterway stability objectives

Waterway classification	Waterway Stability Criteria
Site waterway reach in good condition (i.e. well vegetated and stable waterway)	Limit post development 1 year ARI flows in waterway to pre-development conditions*
Site waterway reach in average/poor condition (i.e. poorly vegetated or active erosion)	As per above OR Rehabilitate waterway to convey the post development 1 year ARI flows without the risk of erosion*
External waterways	Limit 1 year ARI flows at site boundary for critical duration event (60 minutes or longer) to pre-development conditions

* Localised increases in 1 year ARI flows can be accepted provided the erosion criteria for sandy vegetated soils (50% cover for native grasses) is achieved in accordance with QUDM. The objective supports the rehabilitation of waterways and allows local increases in 1 year ARI provided the rehabilitation design provides an appropriately stable waterway for the increased 1 year ARI flows.

4.2 WATERWAY ASSESSMENT

The stability assessment for the waterways in or adjacent to P6 ROL2 has been based on both site investigations and the detailed hydraulic (Tuflow) modelling undertaken as part of the *Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017) which included modelling of the 1 year ARI discharge as well as velocity and bed shear

stress analysis of minor and major flood flows. The assessment included below is generally confined to those areas of waterway that are within the extent of waterway mapping and/or within the modelled floodways. Details below are supported by the photographic log and waterway reference plan in Appendix B. The overall waterway layout is provided in Figure 7.

4.2.1 Characteristics

The eastern waterway within P6 ROL1 and ROL2 (Figure 7) is characterised by very low gradients with broad shallow profile and minimal low flow channel definition. Waterway grades are typically around 0.7%.

The upper Quinzeh Creek section to the north of Precinct 6 ROL1 (and extending downstream to Precinct 4) has an overall average longitudinal gradient of less than 0.25% with many flat areas of no discernible or measurable gradient, including wetland areas. The uppermost portion of this drainage line increases to just under 0.4% which is still very flat and not of concern for long term stability.

The western waterway grades up at around 0.7% from the upper Quinzeh Creek confluence increasing to just under 2.6% in the uppermost reaches adjacent to P6 ROL2. These grades are greater than the eastern waterway and indicate potential for locally higher velocity flows and potential for greater instability.

The overall waterway condition ratings provided in the *Yarrabilba General Waterway Condition Assessment* (DesignFlow, 2021) indicates the main drainage line (Quinzeh Creek southern tributary) is generally in good condition while the eastern waterway extending up into Precinct 6 ROL2 to the east was more varied with mostly average condition along the waterway and local areas of poor and good condition. The western waterway was reported to be in generally good overall condition in the general assessment reference above.

A more detailed site assessment of the eastern waterway (and Quinzeh Creek reach) was undertaken on 20 April 2017 (as part of previous Precinct 4 assessment) and a more recent review of the western waterway carried out on 29 August 2023. This was done to further assess the characteristics and condition of the waterways in Precinct 6 ROL1 and ROL2 since the original field work undertaken in 2013 for the general waterway condition assessment.

A brief overview of these findings is provided below with additional information provided in Appendix B. Figure 7 provides the Precinct 6 waterway layout and chainage locations referred to in the following sections.

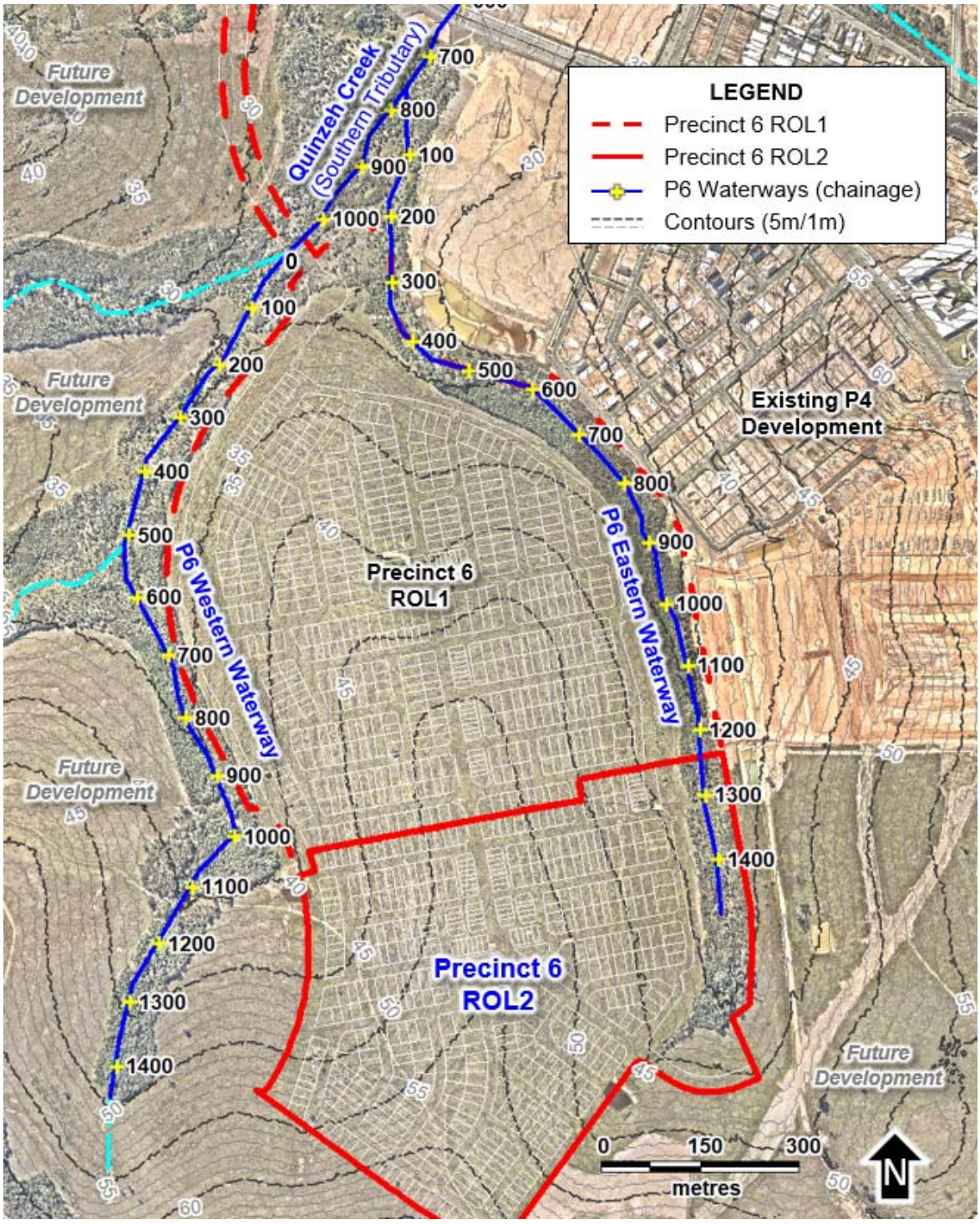


Figure 7: Precinct 6 waterway layout

P6 Eastern Waterway

This inspection occurred around 3 weeks after the significant rainfall event of late March 2017 that caused widespread flooding in the surrounding Logan and Albert River catchments. The observations are therefore based on a comparatively wet catchment (evidenced as base flow) compared to waterway inspections in previous years and therefore reference to any ponds may be only temporary in nature based on the timing.

The eastern waterway of P6 extends generally south-east to south off the main upper Quinzeh Creek floodway. The lower end (chainage 0-500m in Figure 7) is characterised by a broad cross section, very low gradient with no discernible low flow channel. Scattered saturated areas exist where seepage accumulates in depressions. Dense grass cover interspersed with dense shrubs/immature trees dominates the lower drainage line with no instability evident. The eastern waterway contains iron bacteria (visual observations only) which is more extensive than seen in Upper Quinzeh Creek assessment previously. Orange/brown slimy deposits and oily sheens (in stagnant pools) was observed mainly along the low flow channel where it was defined, often masked by groundcover vegetation. As noted previously, the significant rainfall of late March 2017 (3 weeks prior to observations) meant groundwater stores were recharged and low flow seepage was quite prevalent. In areas where groundwater contains iron, this creates ideal conditions for iron bacteria proliferation.

The mid and upper reaches are characterised by localised scour pools between areas of dense undergrowth and scattered trees. Low flow channel(s) are evident periodically along the reach and can often be associated with livestock/wild animal tracks (longitudinal and transverse). Some ponding/scour holes also appear to be livestock watering points (when wet) and show disturbance and vegetation trampling/dieback at the edges. At approximately 1300m chainage, a ponded zone of approximately 30m wide extending 50m upstream has been formed upstream of a vehicle track crossing. Review of previous inspection notes and historical aerial photos indicates that this is very ephemeral in nature, with open water not persisting long term (returns to wet depression via infiltration and low flow seepage to downstream channel).

P6 Western Waterway

This inspection occurred in late winter 2023 following an extended period of low rainfall. No surface or groundwater seepage was observed throughout the waterway at this time.

The western waterway of P6 extends generally south-west to south from the main upper Quinzeh Creek floodway. The lower reach (chainage 0-500m in Figure 7) is very broad with low gradient (~0.7%) and intermittent low flow channel (very narrow and shallow) and localised scour pools. Generally good grass groundcover exists with scattered trees and shrubs and local areas of more dense trees (regrowth). Localised ground disturbance and grazing was evident from native and feral animals (kangaroos and pig observed) and livestock (horses and goats in adjacent areas) but no significant instabilities present. While no standing water was present, evidence of scattered shallow scour holes/former ponds and emergent water plants was observed (now died back and dry).

The mid reach (chainage 500-1000 in Figure 7) shows a gradual increase in slope to around 1.1% with the broad, well vegetated waterway profile continuing. Tree density increased in this area compared to lower reach. Localised and scattered scour pools were evident (now dry) towards the upper end of this reach and typically associated with livestock tracks. Just upstream of CH950, a localised open area with lower tree density exists just south of a vehicle access track (slightly mounded) crossing the

waterway. Evidence of former shallow ponding and water plants (now died back and dry) exists in this location.

The upper reach (CH1000-1450) is characterised by an increase in grade to around 2.5% with greater presence of a localised low flow channel (scour gully) and localised scour/head cut. Between about Ch1150-1200, a pronounced scour has occurred and moved upstream evidenced by an expanded erosion head at CH1200. Weak and/or dispersive soils appear to be partly responsible combined with increased waterway slope and flow concentration. Surrounding areas remain wooded and partially grassed. A separate but more minor instability (and weak/dispersive soil) occurs at CH1320 with apparent reactive soil layer at ~0.8m depth. Upstream of this zone, the flow path returns to broad grassed area with scattered trees which gives way to cleared grazing paddock beyond.

4.2.2 Modelling

The existing flood model for the Yarrabilba site (within Quinzeh Creek) was used to extract waterway stability information to assist with the assessment and development of an appropriate waterway stability management strategy. It should be noted however that the resolution of the flood model (3m grid) is such that very localised scour issues will not necessarily be identifiable from model outputs and therefore should not be relied upon solely for the management of specific areas. The adoption of both targeted engineering approaches as well as an adaptive monitoring and management of stability issues will ensure that the strategy presented in Section 4.3 below responds to changes over time.

Table 11 provides a broad scale analysis of the flow characteristics at the downstream end of the main drainage lines for pre and post-development catchment conditions adjacent to and downstream of P6 ROL1 (receiving P6 ROL2 flows). It should be noted that this data is based on the fully developed site conditions (i.e. Precinct 6 plus existing Precinct 4 and upstream future precincts developed) and therefore Precinct 6 (in the short term) will show lower developed flows and velocities accordingly.

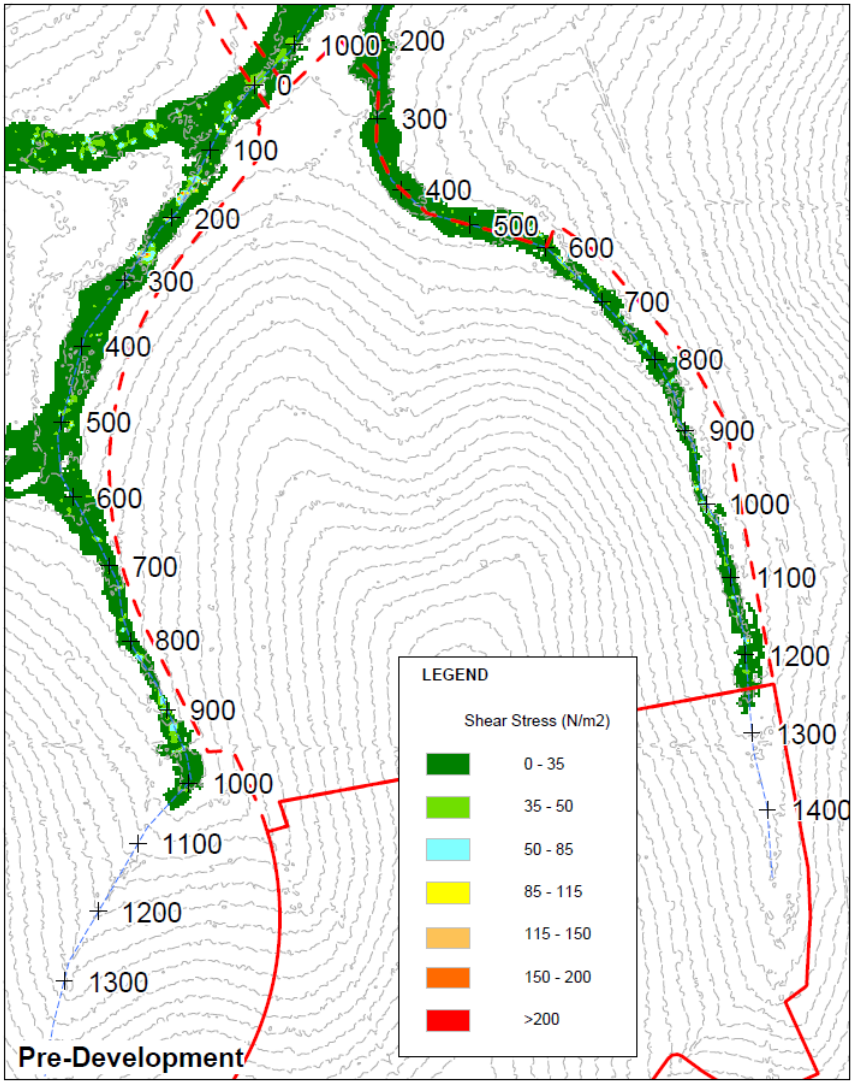
Table 11: 1 year ARI discharge in Precinct 6 ROL1/ROL2 Waterways (downstream ends)

	Flow (m^3/s)		Velocity (m/s)	
	Existing	Developed	Existing	Developed
Upper Quinzeh Creek	20.9	24.8	0.57	0.66
P6 Eastern Waterway	3.9	13.9	0.53	0.80
P6 Western Waterway	6.2	15.5	0.57	0.71

This data indicates that while the peak discharge (at bottom of each drainage line) increases because of urbanisation, the actual velocity increases are comparatively small and very low in overall magnitude under both pre- and post-development scenarios. This is in most parts due to the broad flat profile of the drainage lines that

can experience significant increase in flow rate (and width) with only very minor increase in flow depth and velocity. Further analysis and discussion of the pre and post-development flood modelling is provided Section 4.2.3 below with reference to Figure 8.

Further detailed review of the upper western waterway has also been undertaken due to the increased waterway slope in the mid to upper reaches and the presence of existing scour and potential adverse soil conditions.



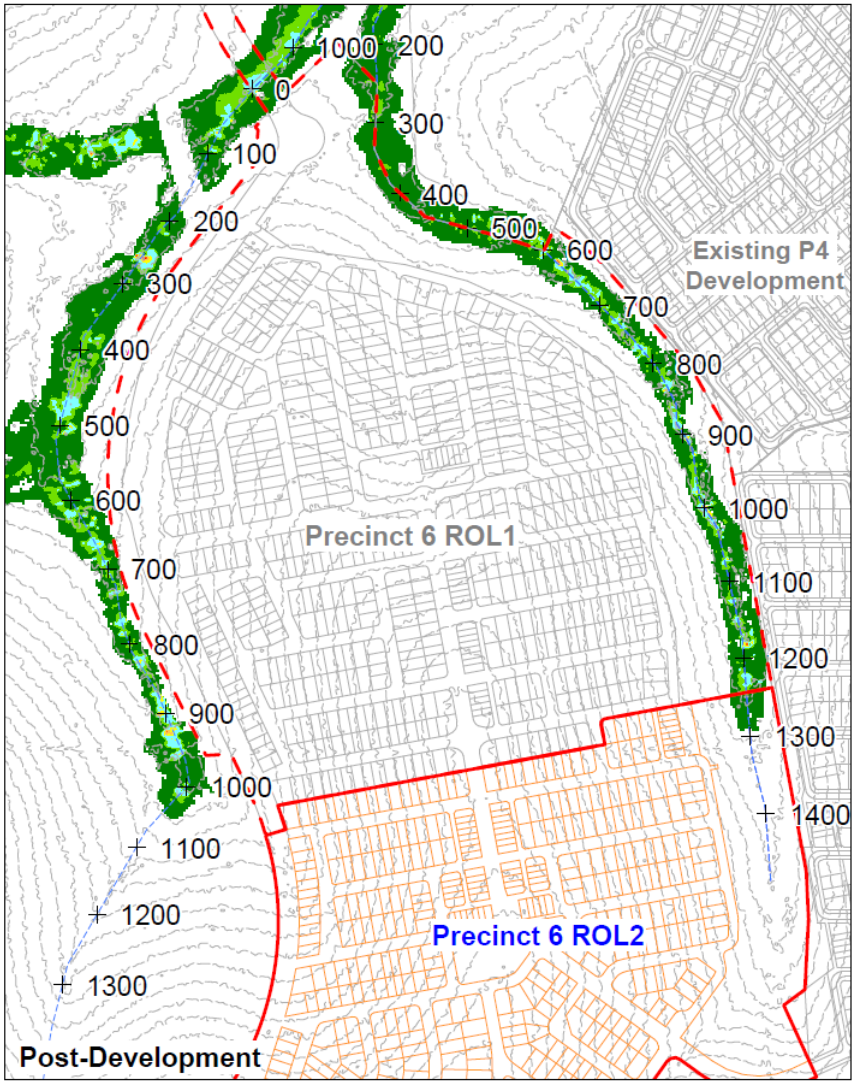


Figure 8: 1 year ARI bed shear stress comparison

4.2.3 Discussion

Shear stress modelling provided in Figure 8 has been derived from the Quinzeh Creek catchment flood model (DesignFlow, 2017) at a 3m grid to broadly identify the relative shear stress changes and does not specifically account for:

- Minor flow attenuation that occurs within stormwater treatment basins (and the fact that pipe drainage network will input flows generally lower down in the local waterway than the regional flood model accounts for).
- Very localised spatial variations in vegetation and tree coverage (i.e. Tuflow roughness/materials layers are more broad scale and representative of a total reach)
- Very minor areas of bare soil and scour and/or woody debris causing flow deflection
- Longer term rehabilitation and regrowth of channel vegetation

Due to these constraints and the limited justification for updating the catchment flood model to this level of detail, the bed shear stress mapping was used as a reference point for the development of the Waterway Stability Management Strategy (Section 4.3 below).

P6 Eastern Waterway

The bed shear stress mapping indicates that under pre-development conditions, the P6 eastern waterway shear stresses (in the order of 35-85 N/m2) represents relatively minor and localised instability (i.e. model outputs were broadly correlated with site based investigations/observations of current conditions in Appendix B). Under post-development hydrology, the shear stress magnitude generally remains in this range but over a broader area through the channel invert (refer Figure 8 above). The targeted waterway management strategy therefore aims to manage existing scour issues while also allowing rehabilitation/stabilisation to target the expected post development flow regime coupled with an adaptive management strategy that responds to the uncertainties in channel geomorphology.

With comparison to the QUDM permissible velocities (QUDM Table 9.5.2) assuming 50% stable vegetation cover on easily erodible soils, the above post development velocities (at downstream end of reach where flows are greatest) are significantly below the maximum suggested of 1.2m/s and therefore represents low risk in terms of increased susceptibility to broad scale erosion. However, localised areas of scour may be likely where surface features such as mounds, pools or fallen trees create concentrated or high energy flow (beyond the resolution of the abovementioned flood modelling).

Review of bed shear stress data from the minor 1 year ARI flow against threshold values derived by Prosser and Slade (1994) and Prosser *et. al.* (1995) for a number of vegetation

types indicate that bed shear stress values derived from the broadscale flood model are below those for tussock and sedges in various states of disturbance (240 N/m^2 undisturbed and 180 N/m^2 disturbed) and bunch grasses long and short (184 to 104 N/m^2 respectively). This evidence suggests that for a range of vegetation types, erosion thresholds are generally higher than modelled for this waterway. However, recognition that higher values are likely due to localised conditions and flow patterns, that are beyond the resolution of modelling and therefore management strategies are adaptive.

Locations where shear stress is at its highest (typically between chainage CH600-CH1300) is also where targeted waterway stability management strategies are focussed. This enables the stabilisation works to ensure post development hydrology is considered. Where the post-development 1 year ARI flow extent is broader than pre-development, bed shear stress is very low (green areas <35N/m^2 in Figure 8) and does not present risk of instability.

P6 Western Waterway

Similar to the eastern waterway, bed shear stress mapping in the lower and mid reaches of the P6 western waterway indicates that under pre-development conditions, the bed shear stress (in the order of 35-85 N/m2) represents relatively minor and localised instability (i.e. model outputs were broadly correlated with site based investigations/observations of current conditions in Appendix B). Under post-development hydrology, the bed shear stress magnitude generally remains in this range for much of the waterway but over a broader area through the channel invert (refer Figure 8 in Section 4.2.2). However, there are a few more areas of significantly higher bed sheer stress that mat be attributed to the slight increase in waterway slope in the western waterway and these are expected to be exacerbated in the areas at and upstream of the limit of flood modelling available (where slopes increase to around 2.5%). In contrast to the eastern waterway where slopes remain fairly consistent, the increase in channel slope in the upper reaches represents a greater risk to increased instability, especially under post-development flows.

The targeted waterway management strategy therefore aims to mitigate the increase in local discharge to the upper waterway through minor flow attenuation over stormwater treatment basin(s) while managing existing scour issues and revegetation/natural regeneration coupled with an adaptive management strategy that responds to the uncertainties in channel geomorphology. Preliminary hydraulic assessment of the local detention requirements for this waterway is provided in Section 5.2.

4.3 WATERWAY STABILITY MANAGEMENT STRATEGY

As described in Section 4.2.1, the waterways adjacent to and downstream of Precinct 6 ROL2 are considered to be in varying condition (ecologically) while being relatively stable owing largely to the very low gradients and vegetation cover of these drainage lines. The exception being the upper reaches of the western waterway that exhibit steeper gradients and increased risk of instability. The localised areas of instability combined with impacts of historical livestock interaction and future increases in flows

from development dictates the need to provide protection and improvements to these areas to ensure long term sustainability of these waterways.

The following provides the recommended waterway stability management strategy which can be broadly defined by a number of main actions:

- Removal of livestock and feral animal access to waterways.
- Areas of very minor instability should be monitored to assess the success of natural regeneration of groundcover vegetation following the removal of livestock from waterways.
- Targeted stabilisation (local regrading/filling and revegetating, or rock and/or engineering structures) of scour pools and significant areas of instability.
- Scour protection at in-stream structures such as road crossing culverts and stormwater outlet headwalls.
- Ongoing monitoring of channel stability as development proceeds (including future adjacent precincts) to guide reactive management of channel stability. Particular attention should be given to those areas identified as currently eroding and those adjacent to infrastructure.
- Control of 63.2% AEP (1 year ARI) peak discharge from local development areas into the upper reaches of the P6 western waterway (i.e. minor attenuation of Q1 discharge to match pre-development Q1 for equivalent catchment area).

Unlike previous waterway stability concerns in the steep incised gully areas of Precinct 3B and 3C, there is no need for major works associated with drop structures, rock chutes or re-battering of steep banks in Precinct 6 as both the longitudinal and cross sectional profile of the waterways are comparatively broad and flat, presenting low erosion and instability risk (by comparison).

Figure 9 provides the overall precinct waterway stability management strategy that targets the degraded and/or future disturbance areas associated with development. Typical stabilisation techniques applicable to this strategy (and adopted in previous precincts onsite) area described in Section 4.3.1.

ID	CHAINAGE (APPROX.)	WATERWAY STABILITY MANAGEMENT
UPPER QUINZEH CREEK		
Q6	900-1000	Low flow channel evident with emergent wetland plants (now dry and died back). Surrounding area densely vegetated with grasses/shrubs. Monitor area as development progresses to assess resilience. No obvious instability at present.
Q7	1050	Future road crossing and culvert. Provide stabilized inlet/outlet and rehabilitate any areas disturbed by civil works in conjunction with open space/ecological corridor rehabilitation plan.
SOUTHERN TRIBUTARY ***(reproduced from P6 ROL1)***		
S2	550-570	Minor scour pool – fill, provide rock channel lining and interplant with grasses/flexible shrubs.
S4	600-630	Established scour pool with mature vegetation – reshape/batter scour pool edges, install rock lining and batter protection, revegetate banks and (depth dependent) plant emergent macrophytes in pool.
S5	630-750	Livestock/animal tracks merging with low flow channel – revegetate tracks, monitor stability of low flow channel following upstream development, and vegetate/stabilise where issues arise.
S7	850-880	Sediment deposition – revegetate and monitor establishment and longer term stability.
S8	880-930	Chain of ponds (scour pools) with establish trees – review habitat value with ecologist and undertake targeted works to stabilise banks, remove/relocated woody debris causing high energy flow, revegetate livestock damaged banks, and monitor zone following upstream development.
S10	980-1300	Intermittent livestock tracks/disturbance zones - revegetate livestock disturbed areas and monitor establishment/stability. Reshape/rock where issues arise.
S11	1300-1350	Ephemeral wetland/pond - review habitat value with ecologist and undertake targeted works to stabilise banks, decommission or stabilise track crossing at downstream edge, formalise ephemeral wetland vegetation, revegetate livestock damaged banks, and monitor zone following upstream development.
WESTERN WATERWAY		
W1	0-50	Low flow channel evident with isolated scour pool (dry) approx. 10m long, 3m wide surrounded by dense groundcover vegetation. Fill, provide rock lining and interplant with grasses/shrubs. Will likely form part of road crossing works (Q7 above).
W2	100-450	Broad grassed flow path with scattered trees. No defined low flow or scour zones. Minor livestock/feral pig disturbance locally. Occasional shallow flow path evident on animal trail but low gradient minimizes instability. Grazing of grasses evident from vegetation height. Monitor and plant disturbed areas if natural regeneration is slow.
W3	820-950	Minor low flow channel (periodically) but very localised and on very low gradient. Scattered shallow scour pools (dry) likely partly from livestock trail and disturbance. Low risk. Monitor and plant disturbed areas if natural regeneration is slow.
W4	1000-1120	Shallow low flow channel commences and extends upstream with gradual deepening and evidence of scour. Fallen logs increase scour locally (while still shallow). Surrounding area broad, flat and well grassed. Vehicle track crossing at CH1120 with localised washout of gravel. Local filling with non-dispersive soil and revegetation. Monitor stability and natural regeneration of vegetation surrounding. Where continued instability occurs in low flow, local rock scour protection may be required.
W5	1150-1200	Commencement of incised low flow channel with vertical sides and local undercutting of trees. Depth varies <0.5. to 1m. Soil appears to be weak/dispersive. Fallen logs may be exacerbating local scour in flow path. At CH1200, a significant head-cut exists ~0.8-1m deep and 5-6m across. No obvious steep or defined flow paths into this location. Soils may be an issue here. Cemented layer at ~0.6-0.8m depth which appears to have been weaker in wet period. Reshape and backfill with non-dispersive soil, revegetate and monitor stability. Rock may be required to manage grade change at head-cut.
W6	1200-1320	Upstream of head-cut at CH1200, flow path returns to broad, grassed area with intermittent shallow low flow definition. Grasses are not tall and may be grazed by livestock. Localised minor scour zones evident with minor undercutting of trees. Weaker soil layer also evident at CH1320 as seen at CH1200. Reshape and backfill scour with non-dispersive soil, revegetate and monitor stability.

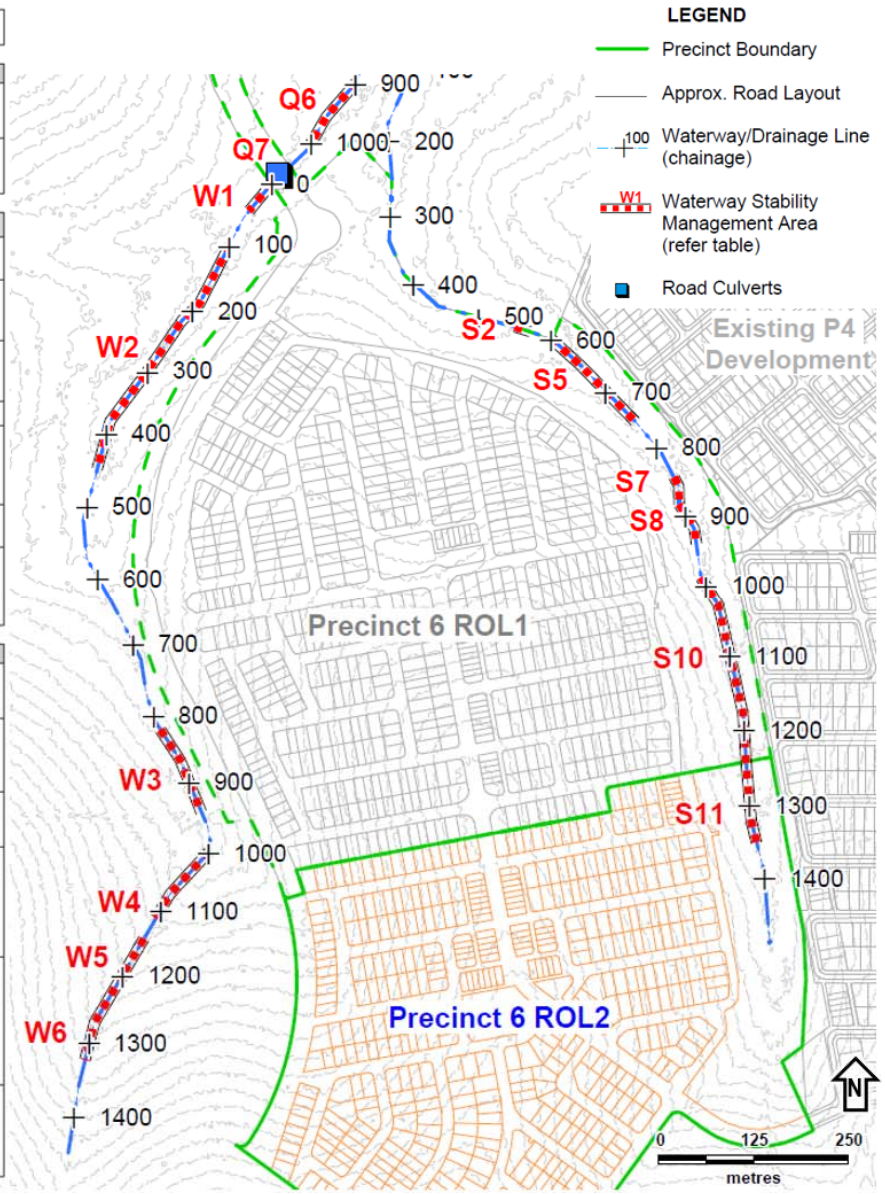


Figure 9: Waterway stabilisation management strategy

4.3.1 Stabilisation Techniques

Rock Protection

Scoured areas and incised channels can be reshaped to flatten vertical edges and placement of rock or rock mattress over geofabric to armour underlying soil. Integrate planting within rock voids where practical. Rock protection must be formed with depressed centre to ensure flows are directed into and through the area and set down slightly below the natural ground level to avoid flow redirection around the edges (creating new scour).



Revegetation

Areas with little or no vegetation cover should be replanted with a mix of locally established species to create both a soil anchor (via roots) as well as flexible grasses that can lay flat during flow (as a surface armouring) to create a stable flow path. This is most appropriate to broad low gradient flow paths (where rock channel linings are not required). The use of pinned down jute or coir mat (not net) prior to planting is required to create a short term soil stabiliser until vegetation is established. Revegetation should also form part of any rock protection works.



In addition to stabilisation, revegetation (and landscape planting of development edges) will be an important part of the management of iron bacteria in waterways. While being a naturally occurring phenomenon in waterways with no known health risks, iron reducing bacteria (and the slimy deposits/oily sheens that result) can be unsightly when adjacent to urban areas. Further, the modification to the frequency and amount of stormwater input to local waterways (and infiltration to groundwater) will have potential to increase the prevalence of the iron bacteria. Vegetative screening is therefore critical to managing the amenity of local waterways.

Stormwater Outlets



All stormwater headwalls to be provided with rock aprons configured appropriately (in accordance with QUDM) to the size and number of pipes. Where natural channel just downstream of apron is susceptible to further instability, aprons should be enlarged or lengthened beyond unstable area. Further, if instream stabilisation has been identified, the rock apron should be linked to this zone to avoid potential scour between two areas.

Ongoing Monitoring



Where no (or very minor) erosion exists or potential future scour areas may occur based on high bed shear values (refer to Figure 8 previously) consideration should be given to minimising intervention in these areas where surrounded by very stable and/or well vegetated waterways zones. The potential impact of accessing these zones to undertake remedial activities (i.e. with earthmoving machinery) would likely create greater disturbance than benefit. Therefore, in the first instance, these areas will be monitored over the course of Precinct 6 development as well as into the adjoining precinct(s) development to review if these areas are degrading further. Reactive and targeted remediation can therefore be undertaken as required.

The adoption of this approach in Precinct 1, 2 and 3 development areas indicates there is merit in limiting the intervention in degraded and disturbed waterways until development within the catchment has neared completion (unless major issues are evident prior). Allowing natural regeneration and succession of vegetation species within waterways (including weeds initially) has been shown to represent a beneficial and cost effective outcome for particular waterways. However, where overriding requirements for other fauna/flora management outcomes exist, these must be taken into consideration and adopted where necessary.

5 STORMWATER QUANTITY

5.1 FLOODING

Precinct 6A ROL2 is generally in accordance with the *Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017). No flood detention infrastructure is required as part of this precinct as it falls within the regional strategy that is managed by Flood Basin 15 (Fauna Way) (approved and constructed previously as part of Precinct 3B). No further flood impact assessment is therefore required as part of this stormwater management plan.

A review of the preliminary earthworks design of the proposed development area in relation to local flood levels is provided in Figure 10. This indicates that P6 ROL2 is well above the 1% AEP flood level being conveyed through the adjacent waterways to the southern tributary of Quinzeh Creek.

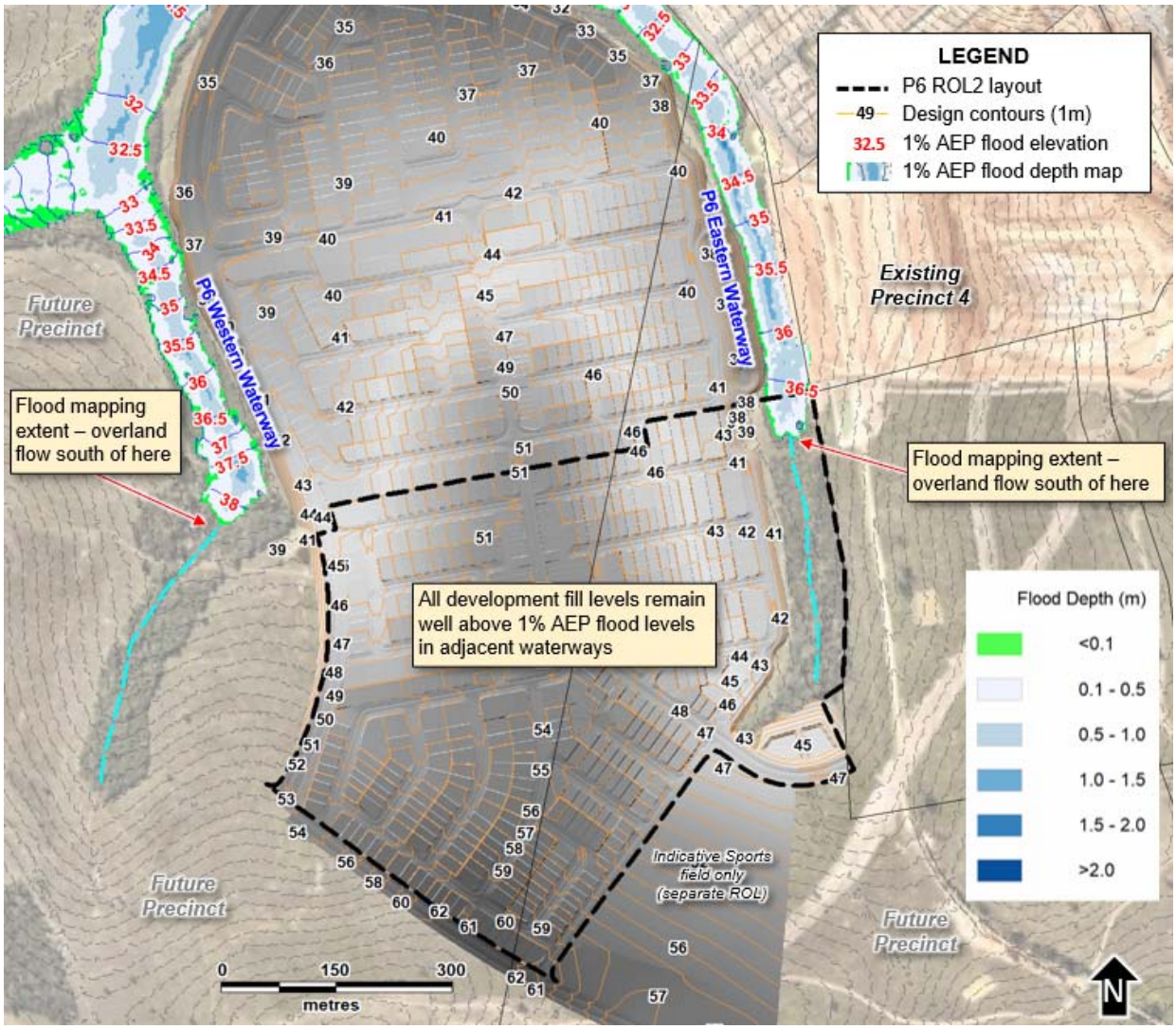


Figure 10: 1% AEP Flood levels and preliminary earthworks

5.2 WATERWAY STABILTY DETENTION

As noted previously in Section 4.3, the upper reaches of the P6 western waterway require post-development minor flow attenuation to manage the potential waterway stability issues outlined in Section 4.2.3. While this waterway will receive discharge from multiple future development precincts, the proposed approach to minor flow management (63.2% AEP / 1 Year ARI) is to maintain equivalent pre-development peak discharge from the respective development precincts for the critical duration at each location. The assessment below applies to the western stormwater treatment basin of P6 ROL2 (incorporating Sed 6C1 and Bio 6C2-6C3) which manages catchments 6C1, FUT1 and FUT2 in Figure 5 previously (totalling 24.8ha).

5.2.1 Hydrological and Hydraulic Assessment

XPSWMM was used to assess the pre and post development catchment discharge and derive an appropriately sized storage (co-located with local stormwater treatment basin) to achieve the objectives. The ensemble storms approach was used in line with ARR2019 using the latest rainfall data from the Bureau of meteorology (BOM). Temporal patterns, losses and pre-burst data was source from the ARR Data Hub (Appendix C).

5.2.2 Catchments

The assessment was undertaken on equivalent areas pre and post development to derive an appropriate detention storage. The overall catchment area of 24.8ha is based catchments 6C1 (13.2ha), FUT1 (4.0ha) and FUT2 (7.6ha) in Figure 11. Future development in adjoining precincts will therefore apply local detention storage at similar rates (m^3/ha). Catchment data used in XPSWMM for pre and post development are provided in Table 12. Rainfall losses adopted for modelling are from the ARR Data Hub and provided in Table 13.

Table 12: Catchment data

Parameter	Existing	Developed
Catchment Area (ha)	24.8 [1]	24.8 [1]
Slope (%)	4.5 [2]	3.5 [2]
% Impervious	0	60
Pervious Area (ha)	24.8	9.92
Impervious Area (ha)	0	14.88
Pervious Roughness (n)	0.08	0.035
Impervious Roughness (n)	n/a	0.015

Notes:

1. Catchment area assumed equal for pre and post development to define indicative unit rate of detention required for this and future adjoining precincts.
2. Catchment slopes reduced from pre-development through cut and fill earthworks.

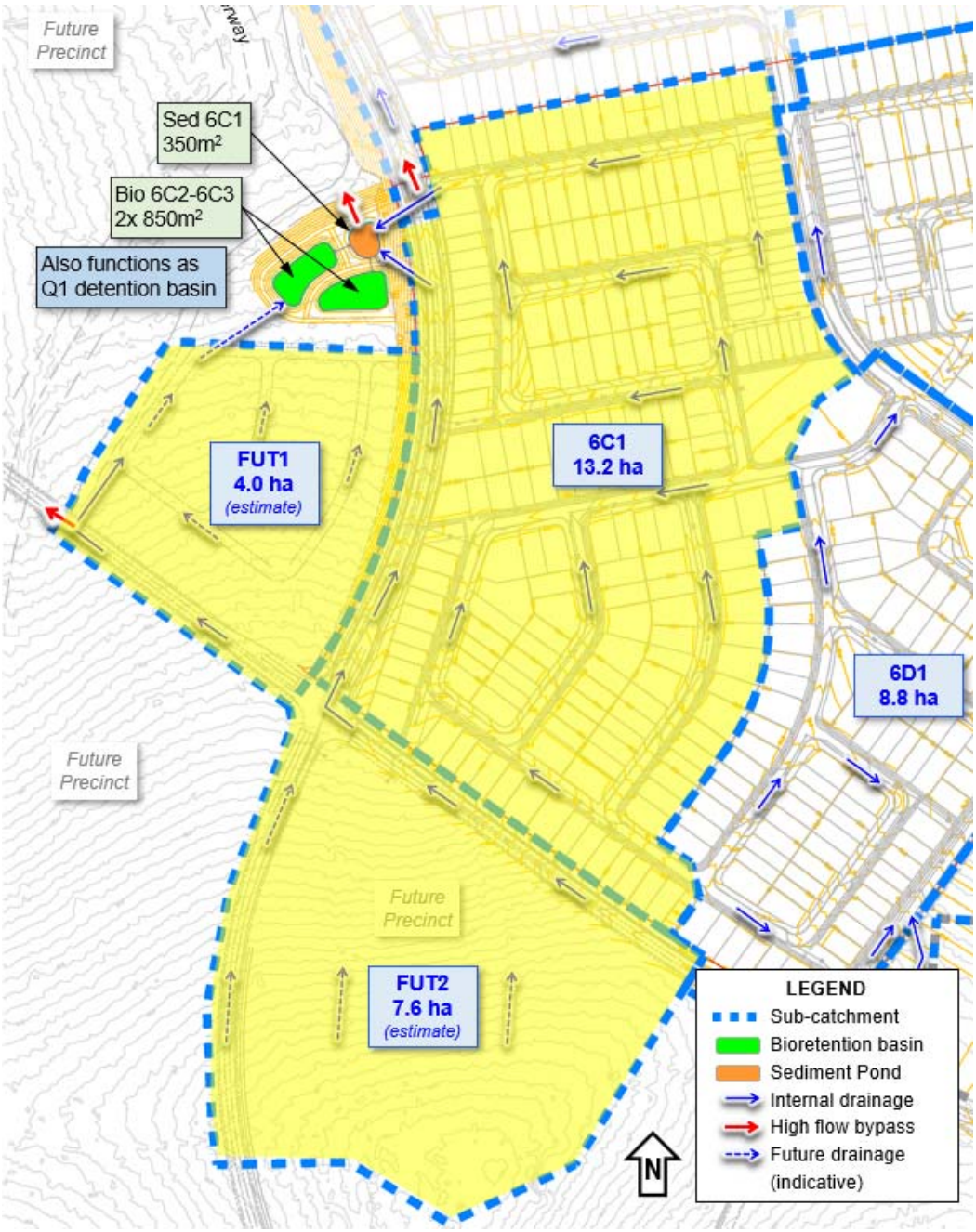


Figure 11: Western catchment layout (extract from Figure 5)

Table 13: Rainfall losses

	Pervious	Impervious
Initial Loss (mm)	26	1
Continuing Loss (mm/hr)	1.9	0

5.2.3 Detention storage

The preliminary assumptions for the stage-storage relationship for the western basin is based on the initial 0.3m depth being represented by the sediment pond and bioretention basins extended detention (assumed full to 0.3m depth at the commencement of design storm modelling), with the depth above this being dedicated to minor flood storage. Refined modelling of the detailed earthworks will occur as part of design with hydraulic model verification.

Table 14: Preliminary stage storage data

Depth (m)	Area (m^2)	Cumulative Volume (m^3)
0 (bio surface)	2100	0
0.3 (EDD) [1]	2100	630 [1]
0.31	4300	673
1	4300	3640
1.5	4300	5790

Notes:

1. $630m^3$ is representative of the stormwater treatment extended detention depth (EDD) of 0.3m assumed full prior to design storm modelling.

Table 15: Basin preliminary design

Parameter	Value
Basin floor (bio filter surface)	RL41.5
Bund	RL43.0
Bypass Weir	10m at RL 42.5
Stormwater quality	$350m^2$ sediment pond connected to 2x $850m^2$ bioretention basins (via culverts). *(0.3m extended detention depth over bioretention - assumed full at commencement of modelling)*
Outlets	2 x 1.2m x 1.2m pits at RL41.8 375 dia pipes from each pit at IL40.4 and 0.5% grade (with orifice plate in pit to reduce outlet area to equiv. 330mm dia pipe).

5.2.4 Results

Table 16 and Table 17 provide the discharge and water level results for the minor detention basin for P6 western waterway stability. Results are presented for both the 63.2% and 50% AEP to identify both waterway stability outcomes (63.2% AEP) and design water levels within the basin from the pipe drainage network inflows (50% AEP).

Flows greater than 50% AEP pipe discharge bypasses the basin within the road network as overland flow. All results are reported as the mean peak results for the full range of ensemble storms.

Table 16: Discharge results

	Discharge (m^3/s)		
Event	Existing	Developed (unmitigated)	Developed (mitigated)
63.2% AEP	0.62	4.08	0.59
50% AEP	0.82	4.49	0.71

Table 17: Basin water levels

Design Event	Basin Water Levels and Volume
63.2% AEP	RL 42.35 (0.85m depth) 2968 m^3
50% AEP	RL42.49 (0.99m depth) 3600m^3
50% AEP (pits fully blocked)	RL42.71 (1.21m depth) 4540m^3
All additional flows >50% AEP pipe discharge bypasses the basin within road network as overland flow.	

Notes:

1. All detention depths and volumes include the 0.3m extended detention depth over treatment that was assumed full at the commencement of design storm modelling (~630m^3).
2. Results based on mean peak for critical duration.

By providing in the order of 3000m^3 of storage over the stormwater treatment system (including ~630m^3 of extended detention), the local 63.2% AEP (1 year ARI) post development discharge can be mitigated to the pre-development peak for the equivalent area. This equates to approximately 120m^3 of minor flood storage per hectare of development (for future development of comparable characteristics).

6 EROSION AND SEDIMENT CONTROL

6.1 DESIGN OBJECTIVES

The management of stormwater runoff during the construction phase is a critical part of protecting the Yarrabilba waterways and drainage lines. Construction phase design objectives for Precinct 6 ROL1 are provided in Table 18 which are generally in accordance with the *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021) and the State Planning Policy (DSDIP, 2017).

Table 18: Construction phase stormwater quality

Issue	Desired outcomes
Drainage control	1. Manage stormwater flows around or through areas of exposed soil to avoid contamination. 2. Manage sheet flows in order to avoid or minimise the generation of rill or gully erosion. 3. Provide stable concentrated flow paths to achieve the construction phase stormwater management design objectives for temporary drainage works (part 2). 4. Provide emergency spillways for sediment basins to achieve the construction phase stormwater management design objectives for emergency spillways on temporary sediment basins (part 3).
Erosion control	1. Stage clearing and construction works to minimise the area of exposed soil at any one time. 2. Effectively cover or stabilise exposed soils prior to predicted rainfall. 3. Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised* using methods which will achieve effective short-term stabilisation.
Sediment control	1. Direct runoff from exposed site soils to sediment controls that are appropriate to the extent of disturbance and level of erosion risk. 2. All exposed areas greater than 2500 metres2 must be provided with sediment controls which are designed, implemented and maintained to a standard which would achieve at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less, and pH in the range (6.5–8.5).
Litter, hydrocarbons and other contaminants	1. Remove gross pollutants and litter. 2. Avoid the release of oil or visible sheen to released waters. 3. Dispose of waste containing contaminants at authorised facilities.
Waterway stability and flood flow management	1. Where measures are required to meet post-construction waterway stability objectives (specified in table B), these are either installed prior to land disturbance and are integrated with erosion and sediment controls, or equivalent alternative measures are implemented during construction. 2. Earthworks and the implementation of erosion and sediment controls are undertaken in ways which ensure flooding characteristics (including stormwater quantity characteristics) external to the development site are not worsened during construction for all events up to and including the 1 in 100 year ARI (1% AEP).

*Note: An effectively stabilised surface is defined as one that does not, or is not likely to result in visible evidence of soil loss caused by sheet, rill or gully erosion or lead to sedimentation water contamination.

6.2 MANAGEMENT STRATEGY

6.2.1 Local Erosion and Sediment Control

Erosion and sediment control (ESC) will occur on a development stage by stage basis in accordance with *Best Practice Erosion and Sediment Control* (IECA, 2008) to achieve the objectives listed in Table 1. This will involve a combination of:

- Erosion control - Ensuring that all exposed surfaces are stabilised as soon as possible and that erosion of un-stabilised areas of works are minimised
- Drainage control - Ensuring that provision is made to control all on site runoff to designated treatment areas and to enable appropriate bypass of external flows which do not require treatment
- Sediment capture - Ensuring that mobilised sediment is captured through a combination of source controls such as silt fences and appropriately designed sediment basins. Where possible sediment basins for construction will be located within the voids required for the future stormwater quality treatment systems (sediment basins, bioretention basins, wetlands etc.).

The details of the local erosion and sediment controls for bulk earthworks and for each stage of development are not provided in this report given the high level nature of the document. However, prior to any works commencing on a particular development stage in Precinct 6 ROL2, a site specific Erosion and Sediment Control Plan (E&SCP) will be documented for the development stage in question prior to works starting. This will occur as part of the operational works application but can be adjusted by the contractor and site supervisor prior to commencement of construction provided the E&SCP complies with Best Practice Erosion and Sediment Control (IECA, 2008) and delivers the objectives listed previously in Table 18.

6.2.2 High Efficiency Sediment (HES) Basins

Given the importance of managing construction runoff into the waterways downstream of Yarrabilba and the potential impact on the ecology and residents, HES sediment basins are being strategically adopted (where practical) across Precinct 6 ROL2. HES basins offer an improved technology for construction sediment management which essentially converts batch sediment basins into continuous flow treatment systems that respond in real time to storm events. The design sought to be achieved by HES basins that ensures at least 80% of the average annual runoff volume treated to 50mg/L TSS or less

The HES basin essentially comprises:

- Flocculent dosing system
- Inlet zone for mixing, flow distribution and efficient removal of coarse sediment
- Settling basin
- Outlet(s)

Implementation of HES basins have the potential to significantly reduce the fine and dispersive sediment load discharge from the site by a further 50% compared to traditional batch sediment basins.

6.3 MONITORING AND AUDITING

6.3.1 Principal Contractor

Site inspections and monitoring are to be undertaken by the principal contractor in accordance with Sections 6.17 and 7.4 of *the Best Practice Erosion and Sediment Control Document* (IECA, 2008) as detailed below. Best practice site management requires all ESC measures to be inspected at the following frequencies and include the following checks as a minimum:

Daily site inspections (during rainfall):

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- All site discharge points (including dewatering activities as appropriate)

Weekly site inspections (even if work is not occurring on-site)

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements
- Litter and waste receptors
- Oil, fuel and chemical storage facilities

Prior to anticipated runoff producing rainfall (within 24 hours of expected rainfall)

- All drainage, erosion and sediment control measures
- All temporary flow diversion and drainage works

Following runoff producing rainfall (within 18 hours of rainfall event)

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements

6.3.2 CPESC Compliance Audits

The ESC measures implemented at the site are proposed to be inspected on a bi-monthly to quarterly basis by a CPESC (Certified Professional in Erosion and Sediment Control) who is independent of the principal contractor and an audit report kept on file. The purpose of the audits to is to ensure the developer and the contractors are meeting

their obligations for ESC under the Environmental Protection Act (EP Act). The site will be assessed against these requirements in accordance with *Procedural Guideline: Standard work method for the assessment of the lawfulness of releases to waters from construction sites in South East Queensland EM1135* (DEHP, 2011).

The compliance audits will involve:

- Site inspection with the contractors to assess ESC actions on the site against the ESC plans and the requirements of EP Act and DEHP Procedural Guideline.
- Identifying non-compliances on the site, photographing and recording these for reporting.
- Where the rectification action is simple, these will be recorded and verbally communicated to the contractor for action.
- Review of any water quality and rainfall information for the site
- Compilation of a ESC Audit report which:
    - Identifies the ESC obligations;
    - ESC issue and non-compliances; and
    - Actions (simple) to be taken to rectify the issues and non-compliances.

The triggers for inspections and reporting by the CPESC are as follows:

- Prior to the commencement of clearing works in each catchment;
- Prior to the commencement of bulk earthworks;
- Prior to the commencement of civil works; and
- At regular monthly intervals during works.

7 CONCLUSION

A stormwater management strategy for Yarrabilba Precinct 6 ROL2 development has been prepared to meet the requirements of the *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2021) and Context Plan Area Strategy.

The strategy includes a range of stormwater treatment measures including sediment ponds and bioretention systems that manage the Precinct 6 ROL2 development area with consideration of future catchments also. These treatment systems integrate with the local urban and natural environment to ensure the stormwater quality objectives are achieved for the precinct while providing protection or enhancement to the local waterways and amenity. Sufficient space has been allowed for in the development layout for the stormwater treatment measures which have been verified via preliminary layout plans.

Site design has also ensured all development lots are above the local 1% AEP flood level and provided with adequate flow conveyance for external catchment discharge. No flood detention infrastructure is required as part of the precinct as the regional flood basin (at Fauna Way) has already been constructed downstream as part of existing Precinct 3B works.

Local waterway stability management has been integrated into the overall development by considering the current condition of receiving waterways and proposing protection and/or rehabilitation strategies that incorporate local scour protection works, revegetation and exploiting natural regeneration process where practical. Minor flow management (as Q1 detention over treatment basins) is proposed for the upper western waterway where localised instability risks are considered higher than for the majority of the lower gradient waterways in P6.

Setback to local waterway and vegetation corridors have guided the development layout with due consideration for future development expansion and waterway rehabilitation to the east and west of the subject site.

Construction phase stormwater management objectives have been established for the site, in accordance with State Planning Policy (DSDIP, 2017). Preparation of detailed erosion and sediment control plan(s) are required prior to works commencing plus ongoing staging and updates to these plans to ensure the ESC strategy responds to the changing site conditions. Audits will be completed during construction to ensure compliance with State Planning Policy and Environment Protection Act.

8 REFERENCES

DesignFlow (2021) *Yarrabilba Stormwater Infrastructure Master Plan*

DesignFlow (2021) *Yarrabilba General Waterway Condition Assessment*

DesignFlow (2021) *Yarrabilba Total Water Cycle Management Strategy*

DesignFlow (2017) *Yarrabilba (Quinzeh Creek) Flood Study - Version 1*

DSDIP (2017) *State Planning Policy*

IECA (2008) *Best Practice Erosion and Sediment Control*

Prosser and Slade (1994) *Gully formation and the role of valley floor vegetation, southeastern Australia*

Prosser et al (1995) *Flow resistance and sediment transport by concentrated overland flow in a grassland valley*

Water by Design (2010). *MUSIC Modelling Guidelines. SEQ Healthy Waterways Partnership.*

Water by Design (2018) *MUSIC Modelling Guidelines.* Water by Design, Healthy Land and Water Limited, Brisbane, Queensland. (https://waterbydesign.com.au/download/music-guideline-2018)

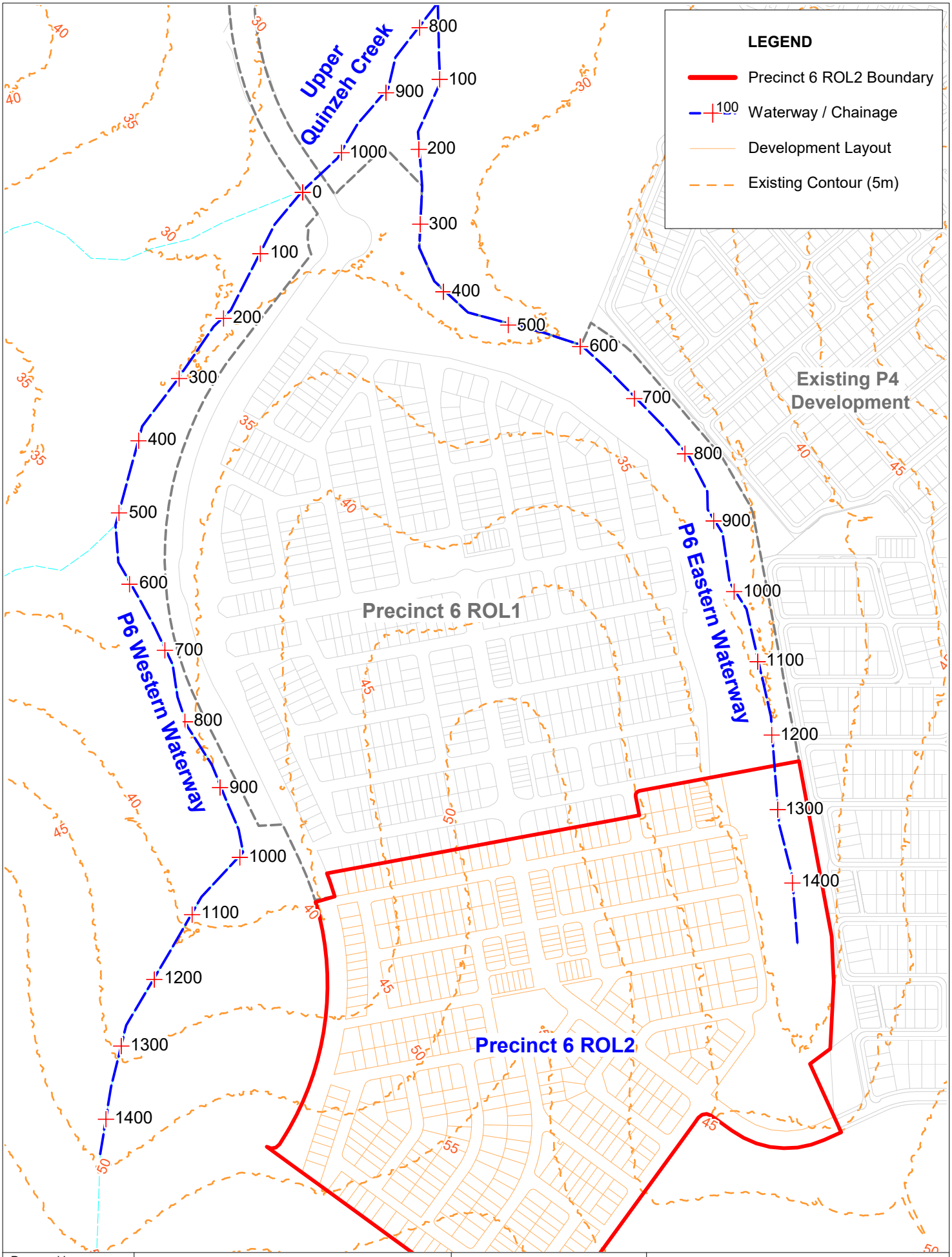
APPENDIX A FUNCTIONAL DESIGN PLANS

Appendix A Removed. Refer to approved functional design plans

APPENDIX B P6 ROL2 WATERWAY INSPECTION SUMMARY

The Precinct 6 ROL2 waterway inspection photo log summary is provided in the following sections with chainage references identified in Figure B1. All chainages commence at zero at the downstream extent/confluence of each tributary. Inspection was carried out 20 April 2017 (eastern waterway) and 28 August 2023 (western waterway).

Note: The eastern waterway assessment has been reproduced from the previous Precinct 4 and Precinct 6 ROL1 assessment information as this is common to all these development areas.



Prepared by: DesignFlow For: Lendlease	Project: 4494 Yarrabilba Precinct 6 ROL2 Stormwater Management Plan Client: Lendlease	N W E S Scale: 1 : 6,500 (A4) Date: 22 September 2023	**Waterway Inspection Reference Plan**

UPPER QUINZEH CREEK



CH0-200 Powerline easement is fully cleared (grasses and some immature regrowth remain), broad flat scattered boggy zones.



CH200-400 mapped wetland - upstream extent with standing water, lower extent damp only. Excellent vegetation coverage.



CH400-600 Dense wetland understorey, moderate canopy, broad, flat, profile, no defined channel. Standing water throughout, no instability.



CH600 Interim flood bund 16-INT (downstream side). Post-civil works so minimal established vegetation evident.



CH600-800 broad flat wetland zone, moderate/dense vegetation within standing water. Vegetation (u/s of flood bund 16-INT).



CH600-800 broad flat wetland zone, moderate/dense vegetation within standing water. Vegetation (u/s of flood bund 16-INT).

P6 EASTERN WATERWAY



CH0-500 open vegetation downstream transitioning into localised wooded zones, undefined low flow path within very broad flat waterway, scattered wet depressions throughout.



CH0-500 open vegetation downstream transitioning into localised wooded zones, undefined low flow path within very broad flat waterway, scattered wet depressions throughout.



CH500-600 moderate groundcover, clumps of trees, localised shallow pool and downstream sediment deposition area. Some livestock damage near pool.



CH500-600 moderate groundcover, clumps of trees, localised shallow pool and downstream sediment deposition area. Some livestock damage near pool.



CH600 stable pond, bare banks surrounded by mature and regrowth trees, some livestock damage to fringe.



CH600 stable pond, bare banks surrounded by mature and regrowth trees, some livestock damage to fringe.

P6 EASTERN WATERWAY



CH600-800 iron bacteria coloured low flow shallow channel surrounded by dense groundcover and moderate tree canopy. No significant instability within low flow.



CH600-800 iron bacteria coloured low flow shallow channel surrounded by dense groundcover and moderate tree canopy. No significant instability within low flow.



CH800-850 well grassed broad flow path with localised sediment slug interspersed (material from upstream chain of ponds/scour pool)



CH800-850 well grassed broad flow path with localised sediment slug interspersed (material from upstream chain of ponds/scour pool)



CH850-950 Chain of ponds surrounded by dense vegetation. Local areas of instability and/or livestock damage.



CH850-950 Chain of ponds surrounded by dense vegetation. Local areas of instability and/or livestock damage.

P6 EASTERN WATERWAY



CH950-1200 livestock disturbance, iron rich seepage within undefined low flow channel surrounded by dense ground and tree cover.



CH950-1200 livestock disturbance, iron rich seepage within undefined low flow channel surrounded by dense ground and tree cover.



CH1200-1300 dense grass surrounding iron rich low flow channel with pockets of livestock disturbance. Minimal instability issues.



CH1200-1300 dense grass surrounding iron rich low flow channel with pockets of livestock disturbance. Minimal instability issues.



CH1300-1350 moderate size pond ~30m x 50m (upstream of track crossing)



CH1300-1350 moderate size pond ~30m x 50m (upstream of track crossing)

P6 EASTERN WATERWAY



CH1350-1500 dense grass, regrowth and very low seepage evident in localised pockets (no defined channel)



CH1350-1500 dense grass, regrowth and very low seepage evident in localised pockets (no defined channel)

P6 WESTERN WATERWAY





CH0-50 Low flow channel evident with isolated scour pool (dry) approx. 10m long, 3m wide surrounded by dense groundcover vegetation. Fill, provide rock lining and interplant with grasses/shrubs. Will likely form part of road crossing works.





CH50-100 Low flow channel evident with emergent wetland plants (now dry and died back). Surrounding area densely vegetated with grasses/shrubs. Monitor area as development progresses to assess resilience. No obvious instability at present.

P6 WESTERN WATERWAY




CH100-450 Broad grassed flow path with scattered trees. No defined low flow or scour zones. Minor livestock/feral pig disturbance locally. Occasional shallow flow path evident on animal trail but low gradient minimizes instability. Grazing of grasses evident from vegetation height. Monitor and plant disturbed areas if natural regeneration is slow.




CH450-820 Shrub/tree density increases (compared to downstream) with grass cover (and height) increasing. Broad well vegetated flow path with minimal defined low flow channel in most parts. No obvious instability observed.




CH820-950 Minor low flow channel (periodically) but very localised and on very low gradient. Scattered shallow scour pools (dry) likely partly from livestock trail and disturbance. Low risk. Monitor and plant disturbed areas if natural regeneration is slow.

P6 WESTERN WATERWAY




CH950-1000 Localised open grassed area with lower tree density. Broad flat area likely shallow ponding in wet periods with scattered wetland plants now died back (now dry). Adjacent to former vehicle track crossing. No obvious scour or instability present.




CH1000-1120 Shallow low flow channel commences and extends upstream with gradual deepening and evidence of scour. Fallen logs increase scour locally (while still shallow). Surrounding area broad, flat and well grassed. Vehicle track crossing at CH1120 with localised washout of gravel. Local filling with non-dispersive soil and revegetation. Monitor stability and natural regeneration of vegetation surrounding. Where continued instability occurs in low flow, local rock scour protection may be required.




CH1120-1150 Sand deposition zone from upstream scour zone. Minor low flow channel evident but remains shallow.

P6 WESTERN WATERWAY




CH1150-1200 Commencement of incised low flow channel with vertical sides and local undercutting of trees. Depth varies <0.5. to 1m. Soil appears to be weak/dispersive. Fallen logs may be exacerbating local scour in flow path. At CH1200, a significant head-cut exists ~0.8-1m deep and 5-6m across. No obvious steep or defined flow paths into this location. Soils may be an issue here. Cemented layer at ~0.6-0.8m depth which appears to have been weaker in wet period. Reshape and backfill with non-dispersive soil, revegetate and monitor stability. Rock may be required to manage grade change at head-cut.




CH1200-1320 Upstream of head-cut at CH1200, flow path returns to broad, grassed area with intermittent shallow low flow definition. Grasses are not tall and may be grazed by livestock. Localised minor scour zones evident with minor undercutting of trees. Weaker soil layer also evident at CH1320 as seen at CH1200. Reshape and backfill scour with non-dispersive soil, revegetate and monitor stability.



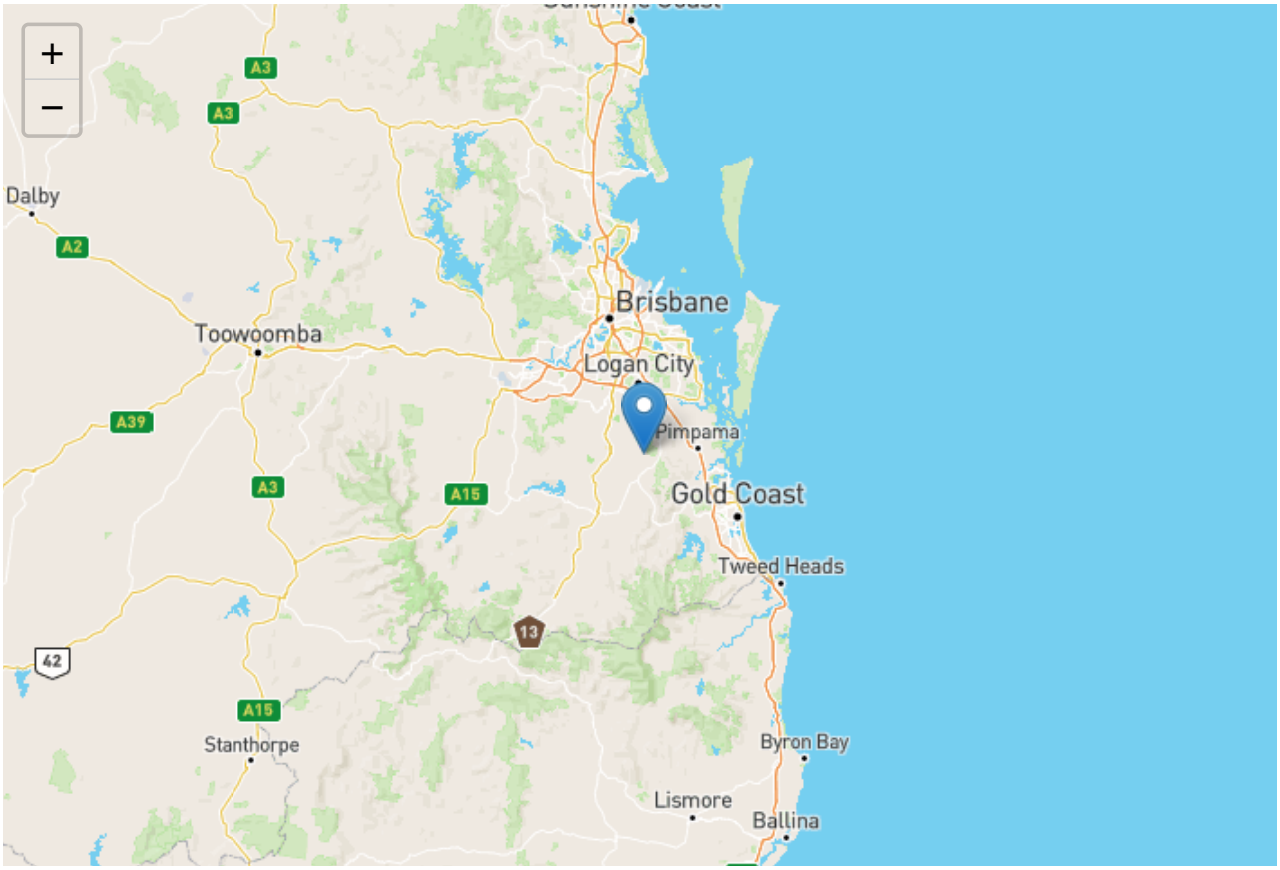

CH1320-1450 Broad grassed area with scattered to moderate tree cover. Minimal defined flow path definition in this area. Vegetation corridor ends at CH1450. Open grazing land beyond.

APPENDIX C ARR DATA HUB

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	153.126
Latitude	-27.833
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show





Data

River Region

Division	North East Coast
River Number	45
River Name	Logan-Albert Rivers

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26\ \text{x}\ 10^{-3}\ \text{x}\ Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141\ \text{x}\ Area^{0.213}\ \text{x}\ 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

ID	5092.0
Storm Initial Losses (mm)	26.0
Storm Continuing Losses (mm/h)	1.9

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECnorth.zip)

code	ECnorth
Label	East Coast North

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECnorth.zip)

code	ECnorth
arealabel	East Coast North

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-27.833&longitude=153.1257&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	20 September 2023 03:52PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.9 (0.027)	3.0 (0.062)	4.4 (0.076)	5.7 (0.085)	8.4 (0.105)	10.4 (0.116)
90 (1.5)	0.5 (0.014)	2.7 (0.049)	4.2 (0.063)	5.5 (0.071)	11.9 (0.128)	16.7 (0.158)
120 (2.0)	0.4 (0.009)	7.0 (0.115)	11.4 (0.155)	15.6 (0.181)	17.6 (0.170)	19.2 (0.163)
180 (3.0)	0.8 (0.017)	8.4 (0.122)	13.5 (0.161)	18.3 (0.185)	23.3 (0.194)	27.0 (0.196)
360 (6.0)	2.1 (0.033)	12.6 (0.141)	19.5 (0.180)	26.2 (0.203)	44.5 (0.281)	58.2 (0.320)
720 (12.0)	2.7 (0.033)	11.0 (0.093)	16.4 (0.113)	21.7 (0.125)	41.3 (0.194)	56.0 (0.229)
1080 (18.0)	2.3 (0.024)	11.9 (0.084)	18.3 (0.105)	24.4 (0.117)	36.4 (0.143)	45.4 (0.155)
1440 (24.0)	3.6 (0.033)	7.7 (0.048)	10.3 (0.052)	12.9 (0.055)	29.2 (0.101)	41.4 (0.125)
2160 (36.0)	0.0 (0.000)	4.6 (0.024)	7.6 (0.032)	10.5 (0.038)	22.7 (0.066)	31.8 (0.081)
2880 (48.0)	0.0 (0.000)	1.2 (0.006)	2.0 (0.008)	2.8 (0.009)	13.1 (0.034)	20.8 (0.048)
4320 (72.0)	0.0 (0.000)	0.1 (0.000)	0.2 (0.001)	0.3 (0.001)	4.7 (0.011)	8.1 (0.016)

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.2 (0.004)	0.4 (0.006)	0.5 (0.007)	0.5 (0.006)	0.5 (0.006)
90 (1.5)	0.0 (0.000)	0.2 (0.003)	0.3 (0.004)	0.4 (0.005)	1.0 (0.011)	1.5 (0.014)
120 (2.0)	0.0 (0.000)	0.8 (0.013)	1.3 (0.017)	1.7 (0.020)	1.3 (0.013)	1.0 (0.009)
180 (3.0)	0.0 (0.000)	0.2 (0.003)	0.4 (0.005)	0.5 (0.005)	0.8 (0.007)	1.0 (0.007)
360 (6.0)	0.0 (0.000)	0.6 (0.007)	1.0 (0.009)	1.4 (0.011)	4.0 (0.026)	6.0 (0.033)
720 (12.0)	0.0 (0.000)	2.1 (0.018)	3.6 (0.025)	4.9 (0.028)	8.6 (0.041)	11.4 (0.047)
1080 (18.0)	0.0 (0.000)	1.9 (0.013)	3.1 (0.018)	4.3 (0.021)	6.2 (0.025)	7.6 (0.026)
1440 (24.0)	0.0 (0.000)	0.1 (0.000)	0.1 (0.001)	0.2 (0.001)	4.2 (0.015)	7.2 (0.022)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.4 (0.001)	0.7 (0.002)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	20 September 2023 03:52PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	16.8 (0.475)	28.4 (0.583)	36.2 (0.622)	43.6 (0.646)	39.8 (0.497)	37.0 (0.411)
90 (1.5)	14.6 (0.365)	23.0 (0.415)	28.6 (0.430)	33.9 (0.437)	65.5 (0.704)	89.2 (0.846)
120 (2.0)	10.6 (0.244)	29.6 (0.488)	42.3 (0.578)	54.4 (0.634)	93.7 (0.905)	123.1 (1.044)
180 (3.0)	30.2 (0.614)	49.4 (0.713)	62.1 (0.740)	74.2 (0.750)	112.9 (0.938)	141.9 (1.030)
360 (6.0)	32.4 (0.520)	51.6 (0.580)	64.3 (0.592)	76.4 (0.592)	117.9 (0.745)	149.0 (0.818)
720 (12.0)	37.7 (0.460)	59.1 (0.499)	73.2 (0.504)	86.8 (0.500)	112.1 (0.527)	131.1 (0.536)
1080 (18.0)	21.8 (0.224)	51.6 (0.365)	71.4 (0.410)	90.3 (0.435)	109.2 (0.429)	123.3 (0.422)
1440 (24.0)	28.9 (0.264)	47.5 (0.296)	59.7 (0.303)	71.5 (0.303)	84.8 (0.294)	94.7 (0.286)
2160 (36.0)	12.6 (0.097)	24.8 (0.130)	32.8 (0.140)	40.5 (0.145)	60.3 (0.177)	75.0 (0.192)
2880 (48.0)	12.9 (0.090)	27.2 (0.129)	36.7 (0.141)	45.8 (0.147)	62.4 (0.164)	74.9 (0.172)
4320 (72.0)	0.2 (0.001)	10.6 (0.044)	17.5 (0.059)	24.1 (0.068)	45.7 (0.106)	62.0 (0.125)

Layer Info

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Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	62.6 (1.770)	98.4 (2.016)	122.1 (2.101)	144.8 (2.148)	135.1 (1.687)	127.7 (1.419)
90 (1.5)	51.1 (1.280)	76.1 (1.371)	92.7 (1.393)	108.5 (1.397)	190.8 (2.048)	252.5 (2.393)
120 (2.0)	37.0 (0.851)	76.9 (1.266)	103.4 (1.414)	128.7 (1.501)	190.3 (1.837)	236.4 (2.005)
180 (3.0)	70.6 (1.436)	108.2 (1.561)	133.0 (1.586)	156.9 (1.584)	241.6 (2.007)	305.2 (2.214)
360 (6.0)	59.6 (0.957)	106.5 (1.198)	137.6 (1.266)	167.3 (1.295)	245.1 (1.549)	303.4 (1.667)
720 (12.0)	88.8 (1.084)	125.2 (1.058)	149.3 (1.027)	172.4 (0.994)	220.3 (1.036)	256.2 (1.047)
1080 (18.0)	57.8 (0.594)	95.5 (0.676)	120.4 (0.693)	144.4 (0.695)	179.0 (0.704)	205.0 (0.702)
1440 (24.0)	77.7 (0.707)	103.3 (0.645)	120.3 (0.610)	136.6 (0.579)	166.3 (0.577)	188.6 (0.570)
2160 (36.0)	37.6 (0.290)	76.9 (0.405)	102.9 (0.440)	127.8 (0.457)	149.7 (0.439)	166.0 (0.425)
2880 (48.0)	44.2 (0.307)	75.2 (0.355)	95.7 (0.367)	115.4 (0.370)	147.8 (0.389)	172.1 (0.395)
4320 (72.0)	14.4 (0.088)	40.5 (0.169)	57.7 (0.195)	74.3 (0.210)	94.1 (0.218)	109.0 (0.220)

Layer Info

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Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**

2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Layer Info

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Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

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