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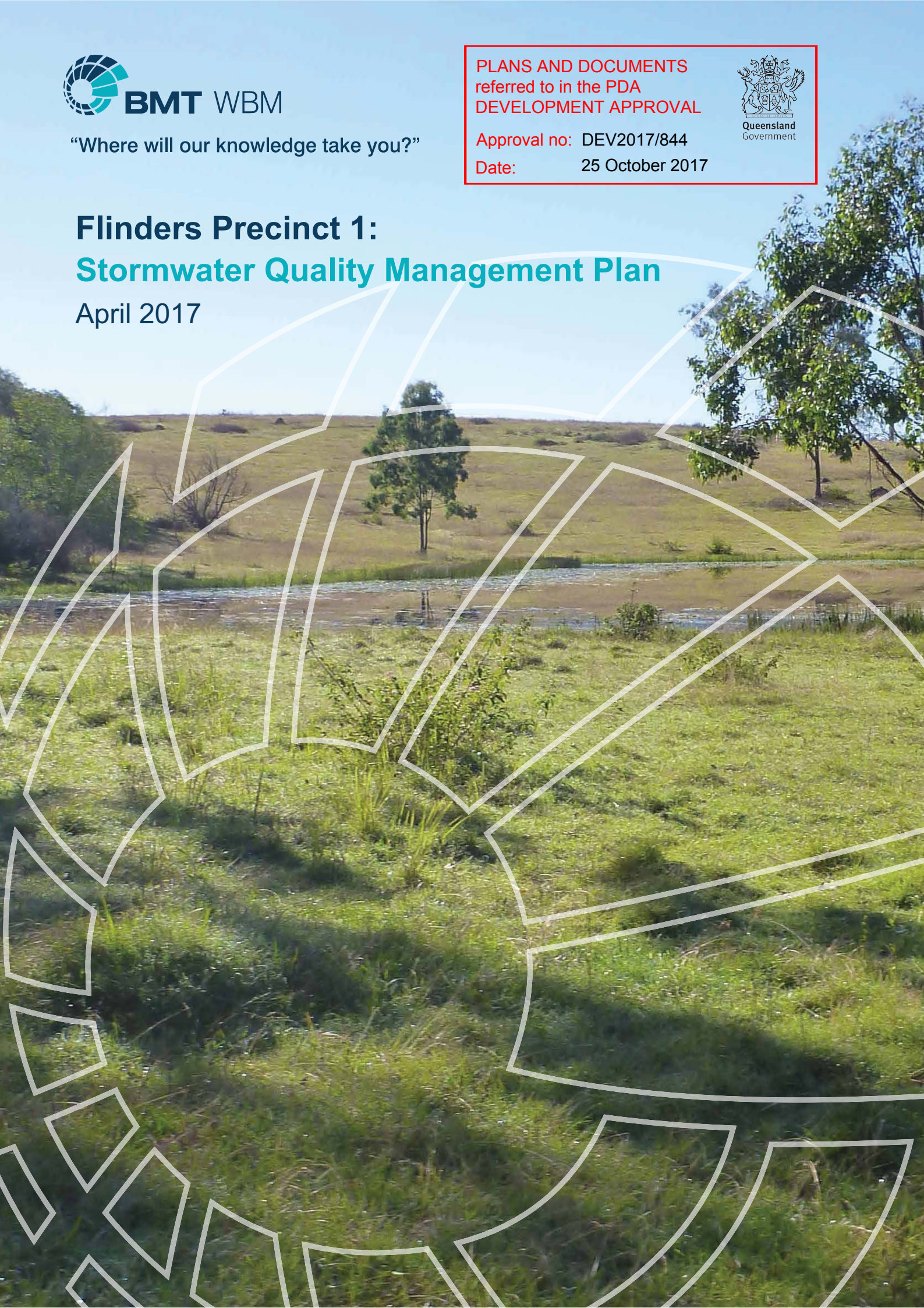
Queensland Government

Flinders Precinct 1:
Stormwater Quality Management Plan

April 2017



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Synopsis: This report represents the stormwater quality management strategy for the proposed Precinct 1 of the Flinders Master Planned Community.

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1	15 June 2016	Brad Dalrymple		Lucy Peljo	
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Summary

This Stormwater Quality Management Plan (SQMP) has been prepared by BMT WBM on behalf of Pacific International Development Corporation in support of the Flinders Master Planned Community (hereafter referred to as 'Flinders'). The proposed 4000 hectare Flinders development includes a 1000 hectare area known as Precinct 1, which is the focus of this SQMP (hereafter referred to as 'the site').

Flinders is located in Undullah, south-west of Logan City, and is contained wholly within the Greater Flagstone Priority Development Area (GFPDA). The site is located within the south-western portion of Flinders, and is bounded by Undullah Creek and Woollaman Creek.

The proposed development of the site will include a variety of land use precincts, including residential areas, town and neighbourhood centre areas, sports and recreational areas, open space and natural areas, and environmental protection areas. In addition to these land uses, a lake has been proposed within the site, incorporated to enhance amenity and provide recreational opportunities for local residents.

The 'Flinders Precinct 1: Concept lake management plan' (BMT WBM 2017) provides a management plan for the proposed lake.

Upon completion of the developed site, a portion of the site will drain to the proposed lake, whilst another portion will bypass the lake and drain to either Undullah Creek or Woollaman Creek.

This SQMP provides a water quality assessment for the proposed site development and describes the measures to be undertaken to achieve stormwater quality management objectives (SQMOs). The SQMOs are derived from the *State planning policy* (DSDIP 2014) and require reductions (relative to the developed site without treatment) in total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN) and gross pollutants (GP) loads of 80%, 60%, 45% and 90% respectively.

A stormwater quality management strategy consisting of education and bioretention basins has been proposed for the site. It is proposed that bioretention basins will be integrated into the open space areas immediately downstream of areas proposed for development. Further, downstream of high density areas, the inclusion of gross pollutant traps (GPTs) is recommended.

MUSIC modelling was undertaken for Precinct 1 for the following scenarios:

- Developed site without the proposed stormwater management strategy in place
- Developed site with the proposed stormwater management strategy in place. This management strategy is inclusive of education and integrated bioretention basins.

The modelling demonstrates that the proposed stormwater management strategy will achieve the prescribed SQMOs.

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1 Introduction

1.1 Preamble

This section describes the proposed development, lake, and the objectives and limitations of this report.

1.2 Proposed Development

The Flinders Master Planned Community (hereafter referred to as Flinders) is a 4000 hectare landholding being developed by the Pacific International Development Corporation. Flinders is located in Undullah, south west of Logan City.

Flinders includes an approximately 1000 hectare area known as Precinct 1 (hereafter referred to as 'the site'), which is located within the Greater Flagstone Priority Development Area (GFPDA). The site is proposed to accommodate approximately 18,000 residents in 7,280 dwellings. The location of Flinders (and the site) is illustrated in Figure 1-1.

The remainder of Flinders (to the west of the site), is referred to as the 'balance land'. The overall Flinders development will result in approximately 20,000 dwellings with 50,000 residents. Proposed land uses are further described in Section 2.5.

It is proposed that lakes will be integrated into Precinct 1 to enhance amenity for the benefit of the local community and to provide recreational opportunities for future residents. The lakes are proposed to be located in the south-east corner of the site at the headwaters of an unnamed creek.

1.3 Proposed Lakes

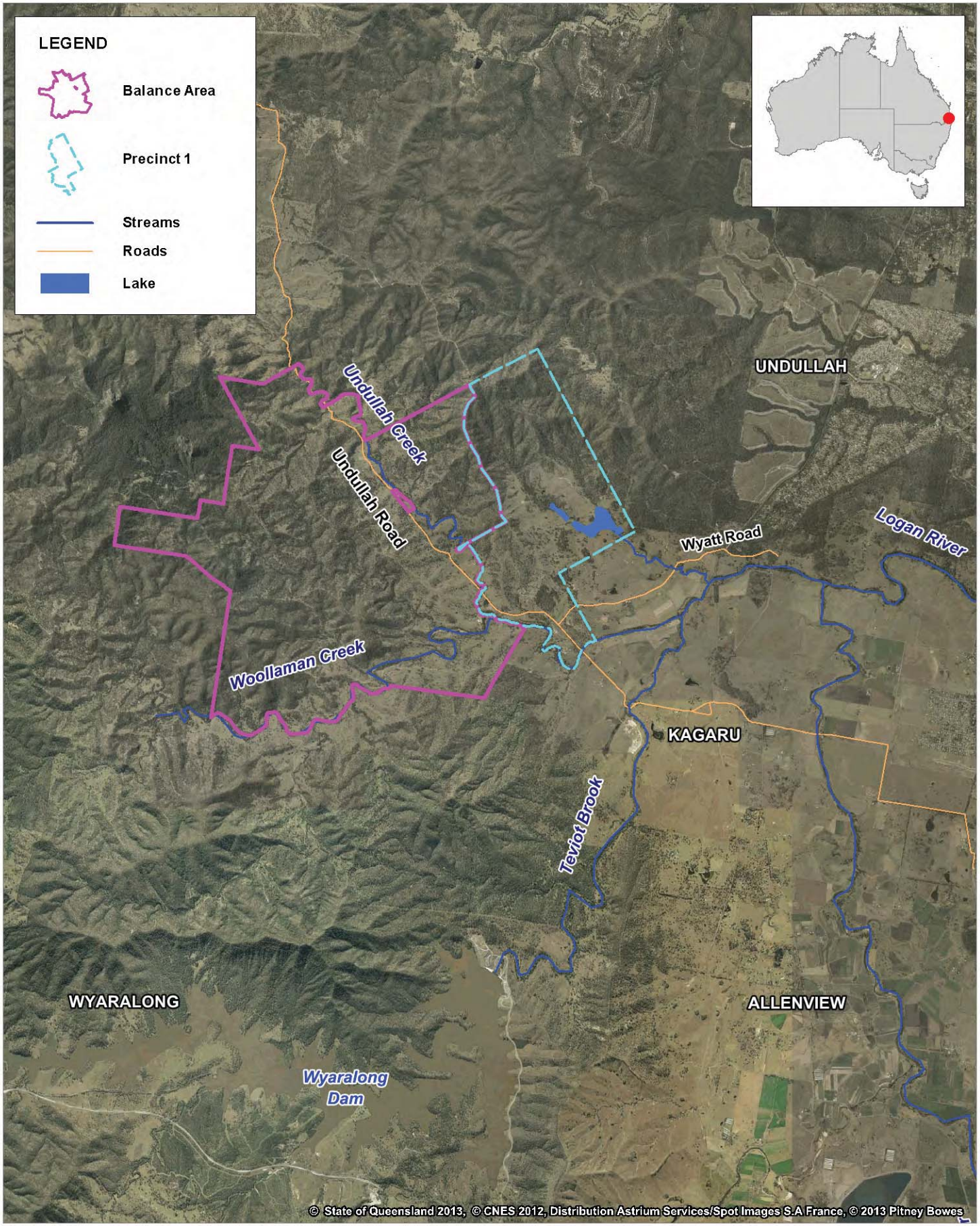
The lakes are intended to be constructed in the lowest area of the site as illustrated in Figure 2-2. It is to be formed by constructing a dam across the unnamed tributary upstream of the southern site boundary. The combined area is expected to be approximately 26 hectares.

It is anticipated that the lake will be predominantly open water with mostly fringing vegetation and some 'hard edge' treatments, including (for example) boardwalks and rock walls. Boat ramps, jetties, pontoons, canoe-launching facilities and other community facilities are also likely to be integrated with the lake to augment recreational values. Further details of lake description have been provided in the 'Flinders Precinct 1: Concept lake management plan' (BMT WBM 2017).

1.4 Report Objectives and Limitations

This report provides a conceptual stormwater quality management strategy for the site, demonstrating how the proposed development will satisfy given water quality objectives.

As a detailed layout plan for the site has not yet been prepared, this report provides a high-level assessment and recommended strategy only. This report is not intended to be a detailed and prescriptive document, however is intended to guide the direction of stormwater management on site and provide sufficient detail to inform the site layout plan. More detailed SQMPs will be required for each stage of the site.



Title:

Location of Site

Figure: 1-1

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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2 Site Details

2.1 Preamble

This section provides an overview of the site, including a description of existing land uses, topography, drainage and soils.

It should be noted that additional investigations will be required to more accurately characterise Precinct 1 prior to further design including, for example, land surveys and geotechnical investigations.

2.2 Location

The site is located in Undullah, and is wholly within the Logan City Council local government area (LGA). The site is located approximately 6 kilometres north-east of the Wyaralong Dam. The main access is currently via Undullah Road, situated approximately parallel with the western boundary of the site.

2.3 Existing Land Usage

The site comprises of large tracts of land being actively grazed by cattle. The agricultural land use is confined by the steeper topography of the Teviot Range, which is the upper catchment for the site. The upper catchment is undeveloped and features open forest woodlands.

Photos showing existing conditions of the site are provided in Figure 2-1 below.

2.4 Topography, Drainage and Soils

The site features steep, densely-wooded terrain to the north including peaks of the Teviot Range (also referred to as the Flinders Peak Group) up to 320 metres Australian High Datum (AHD). The site drains towards the south where topography becomes flatter towards its lowest point of approximately 25 metres AHD. A digital elevation model (DEM) showing the topography of the site is shown in Figure 2-2.

The site is located within the Logan River drainage basin. Two major creeks abut the western boundary of the site, including Undullah Creek which flows from north to south through the Flinders site and Woollaman Creek, which joins Undullah Creek along the southern boundary of the Flinders site.

Teviot Brook flows from Wyaralong Dam in a north-easterly direction past the south-east corner of Precinct 1. Woollaman Creek flows into Teviot Brook approximately 1.4 kilometres downstream of Precinct 1 and then flows into the Logan River a further 3.2 kilometres downstream of the confluence of these two waterways. The ultimate receiving environment for Precinct 1 is southern Moreton Bay.

The site drains to the south-east via an unnamed tributary to its junction with Teviot Brook, approximately 2.5 kilometres downstream of the Precinct 1 boundary and also downstream of the junction between Woollaman Creek and Teviot Brook.

Flinders features highly dispersive soils and many of the drainage corridors across the site are deeply eroded including cuts of approximately 3-5 metres in the upper to mid catchment and approximately 6+ metres in the lower catchment. In some areas of the catchment erosion is down

to sandstone bedrock. Eroded material covers the base of the drainage paths and creeks and has resulted in high turbidity in all waterways discharging from the site.

2.5 Proposed Land Use

The integration of lakes would require the construction of dams across an unnamed tributary.

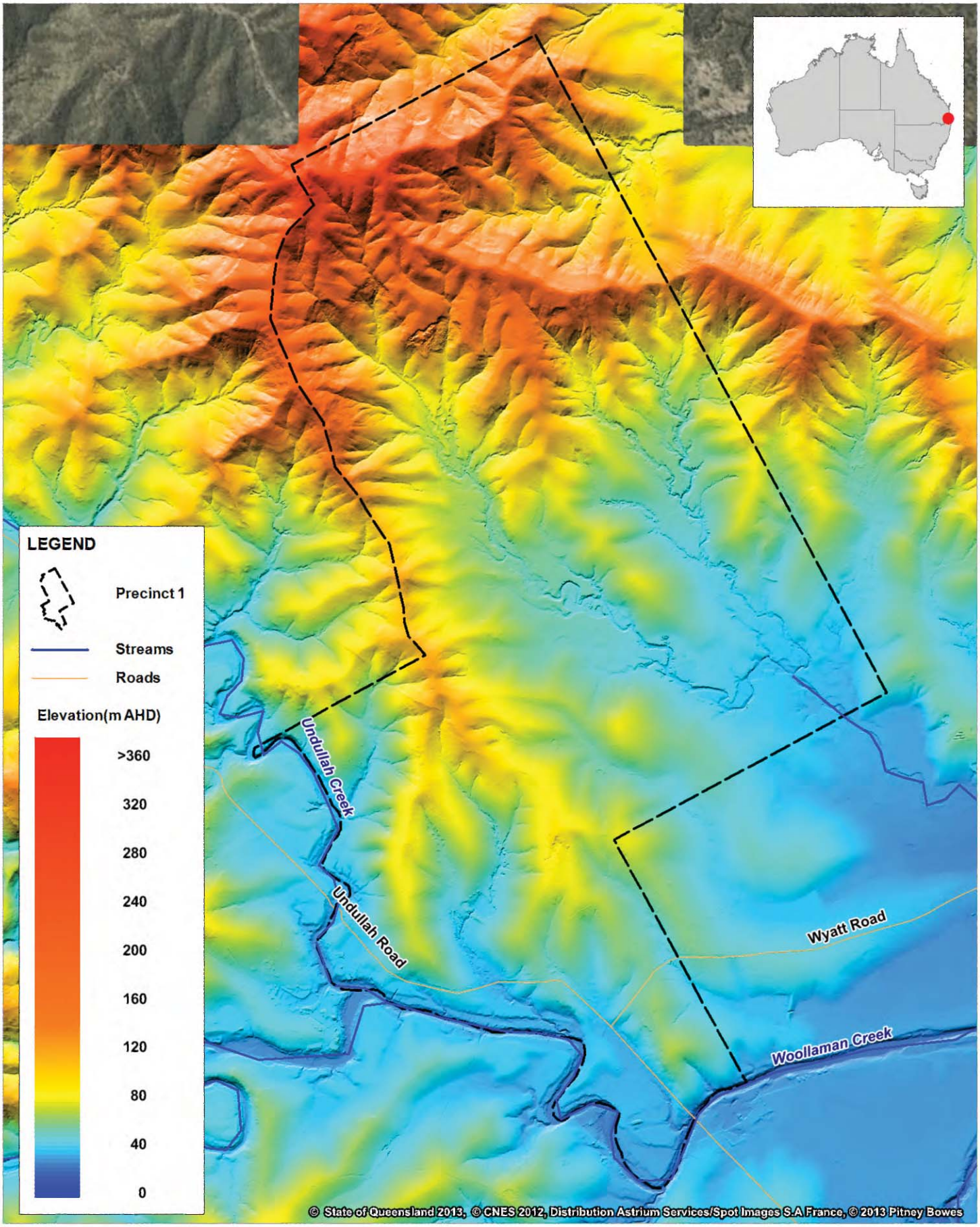
As identified in the land use plan provided (refer to Appendix A), the proposed development for Precinct 1 includes a variety of land uses which include the following:

- environmental protection zone
- natural areas
- open space corridors
- major linear park
- district recreational park
- district sports park
- outdoor recreational (golf course)
- urban living
- town centre
- neighbourhood centre.

The location of the lakes and the contributing catchment boundary is presented in Figure 2-3.

A conceptual layout plan of the development and associated land uses is provided in Figure 2-4. This has been adopted from information identified in Appendix A.

Figure 2-1 Photos of the site



Title:

Digital Elevation Model of Existing Topography

Figure: 2-2

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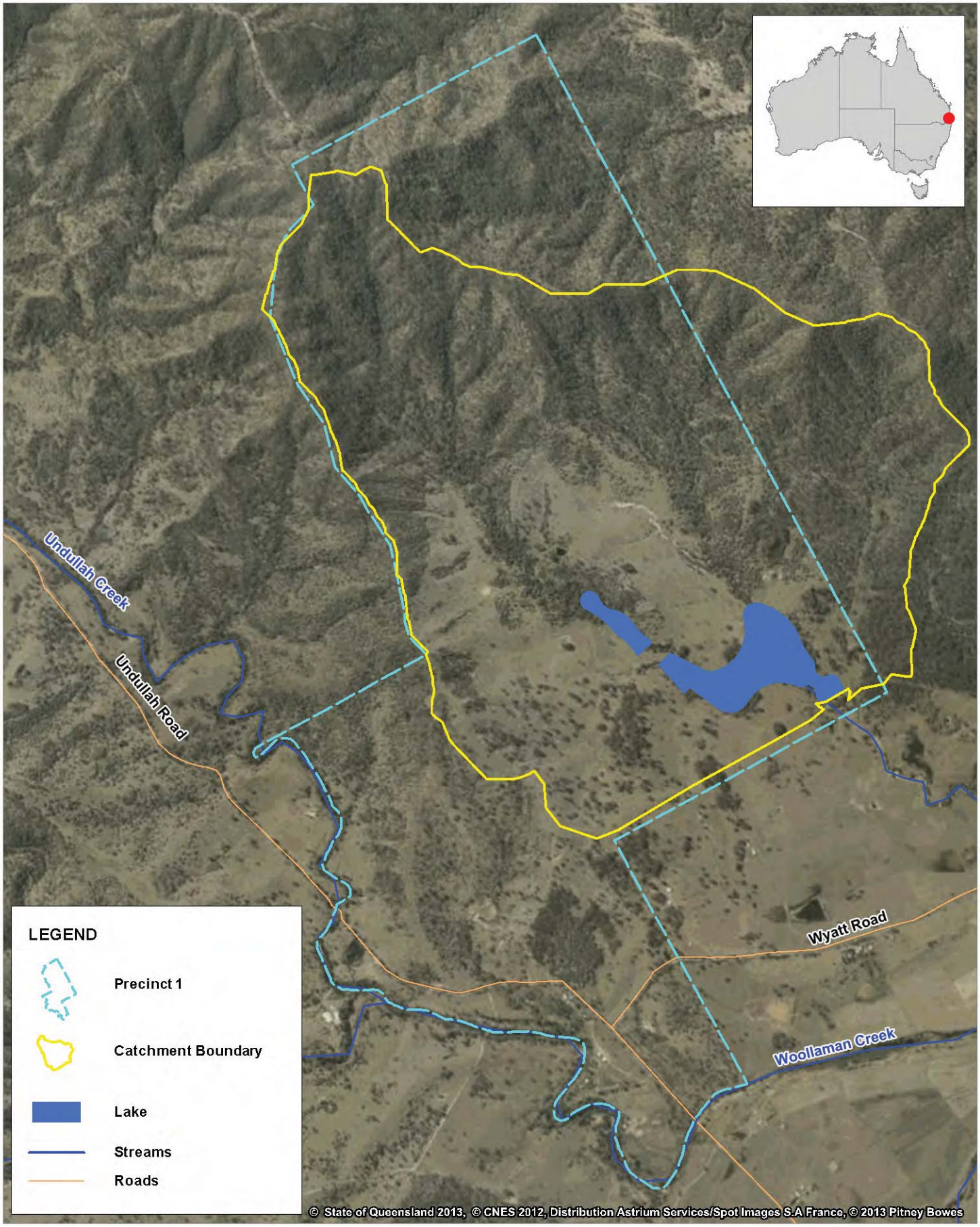

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Proposed Lake and Catchment Boundaries

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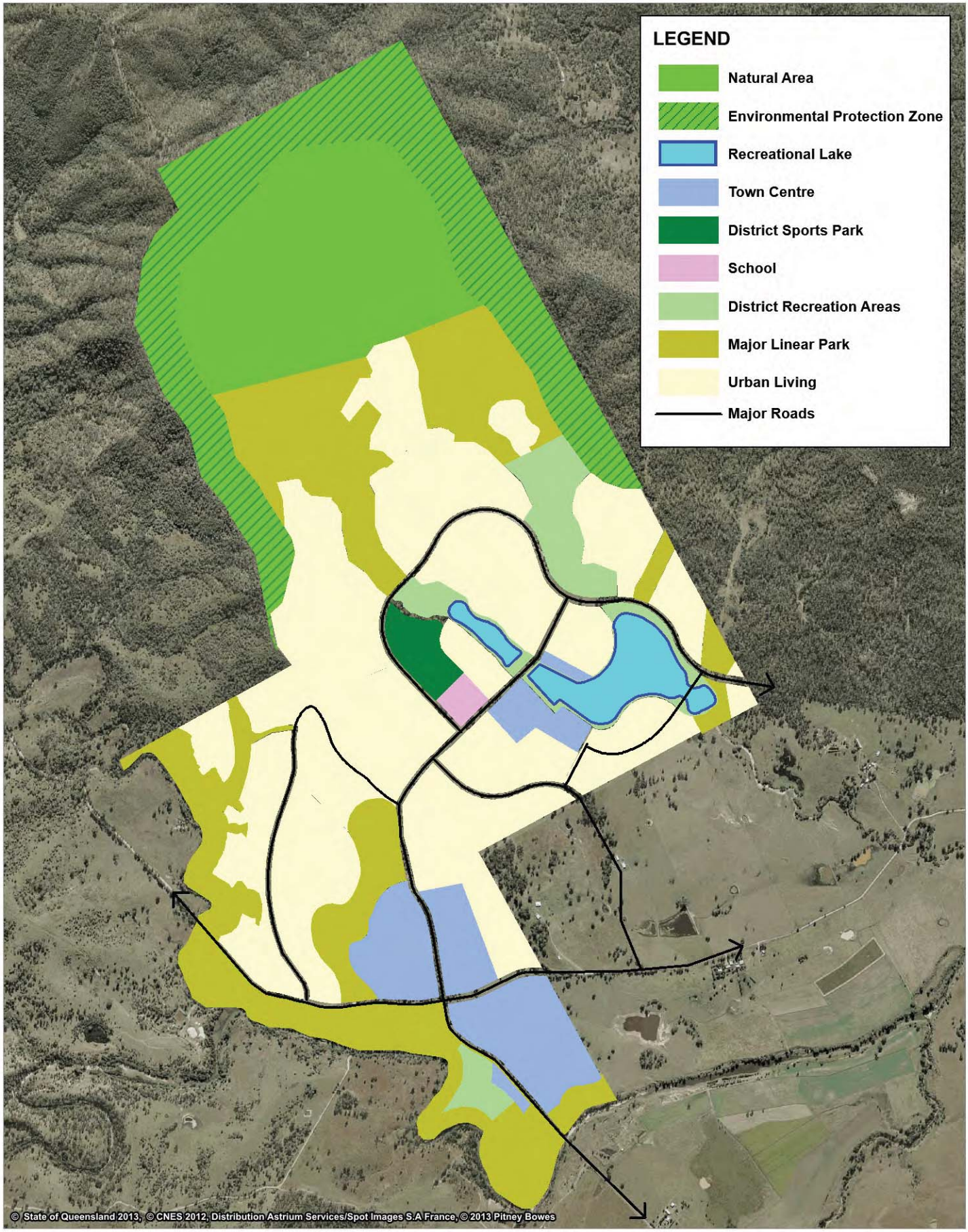

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Precinct 1 Proposed Land Use Plan

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3 Stormwater Quality Management Strategy

3.1 Preamble

This section proves a conceptual stormwater quality assessment of the proposed development within Precinct 1. This has been prepared so as to determine the size, location and performance characteristics of the proposed stormwater management strategy. This section explains how predicted stormwater pollutant loads from Precinct 1 will compare to the given stormwater quality management objectives.

3.2 Opportunities and Constraints for Water Quality Management

The development of the site presents a number of opportunities and constraints with respect to water quality management. These have been identified in subsequent Section 3.2.1 and Section 3.2.2.

3.2.1 Site Opportunities

There are a number of opportunities presented within Precinct 1 for the application of stormwater quality measures, including:

- **Site layout –** The layout of the site generally provides opportunity for the implementation of stormwater management measures (SMMs) to be integrated into the site without greatly encroaching on the proposed urban living , environmental protection or natural areas land uses.
- **Education –** Potential exists at this site for the integration of stormwater quality management information and education programs. Education has the potential for greater community custodianship of vegetated stormwater assets, creeks and other natural corridors.
- **Natural areas –** The waterway corridors upstream of the proposed lakes provide an opportunity for the addition of augmented treatment options to provide stormwater quality treatment for flow to the proposed lakes. These treatment options have been discussed further in Section 3.5 below.
- **Roof water reuse –** Runoff from roof areas within the neighbourhood and town centre land use areas has the potential to be collected and utilised to supplement water demand where appropriate for both domestic and commercial uses.
- **Channel/farm dam remediation –** Opportunity exists for the proposed development to minimise transported sediment loads through remediation of eroded channels and existing farm dams.

3.2.2 Site Constraints

The major constraints identified for Precinct 1 with respect to stormwater quality controls include the following:

- ***In situ* soil –** The Flinders site contains *in situ* soils which are dispersive in nature (Gilbert and Sutherland, 2012). This constraint will require consideration when developing the proposed stormwater management strategy. The proposed management and treatment of these soils has been outlined in a Soils Site Based Management Plan by Gilbert and Sutherland (2012) with updates by Wholistic Environment (2017).

- **Topography –** The steep topography limits the opportunity for SMMs such as 'at source' bioretention systems.
- **Site Layout –** For subcatchments were there is little open space or park land available, a percentage of urban neighbourhood, town centre or neighbourhood centre land use must be allocated to facilitate incorporation of the necessary SMMs.

3.3 Stormwater Quality Management Objectives

Stormwater quality management objectives apply to both the construction and operational phases of the development. These management objectives are described in subsequent Section 3.3.1 and Section 3.3.2.

3.3.1 Construction Phase

Performance criteria for the for the construction phase of the development of Precinct 1 have been adopted directly from the *State planning policy* (DSDIP 2014). These criteria are given in Table 3-1.

Table 3-1 Construction Phase Performance Criteria

Issue		Design objectives
Drainage Control	Temporary drainage works	1. Design life and design storm for temporary drainage works: • Disturbed area open for <12 months—1 in 2-year ARI event • Disturbed area open for 12–24 months—1 in 5-year ARI event • Disturbed area open for > 24 months—1 in 10-year ARI event 2. Design capacity excludes minimum 150 mm freeboard 3. Temporary culvert crossing—minimum 1 in 1-year ARI hydraulic capacity
Erosion control	Erosion control measure	1. Minimise exposure of disturbed soils at any time 2. Divert water run-off from undisturbed areas around disturbed areas 3. Determine the erosion risk rating using local rainfall erosivity, rainfall depth, soil-loss rate or other acceptable methods 4. Implement erosion control methods corresponding to identified erosion risk rating
Sediment control	Sediment control measure Design storm for sediment control basins Sediment basin dewatering	1. Determine appropriate sediment control measures using: • potential soil loss rate, or • monthly erosivity, or • average monthly rainfall 2. Collect and drain stormwater from disturbed soils to sediment basin for design storm event: • design storm for sediment basin sizing is 80th% five-day event or similar 3. Site discharge during sediment basin dewatering: • TSS < 50 mg/L, and • Turbidity not >10% receiving waters turbidity, and • pH 6.5–8.5
Water quality	Litter and other waste, hydrocarbons and other contaminants	1. Avoid wind-blown litter; remove gross pollutants 2. Ensure there is no visible oil or grease sheen on released waters 3. Dispose of waste containing contaminants at authorised facilities
Waterway stability and flood flow management	Changes to the natural waterway hydraulics and hydrology	1. For peak flow for the 1-year and 100-year ARI event, use constructed sediment basins to attenuate the discharge rate of stormwater from the site

The management strategy for achieving these criteria will be described as part of a detailed erosion and sediment control (ESC) plan. Details of the ESC plan have not been provided as part of this SQMP.

3.3.2 Operational Phase

Performance criteria for the operational phase of the development shall be in accordance with the *State planning policy* (DSDIP 2014). These criteria are provided in Table 3-2 below.

Table 3-2 Operational Phase Performance Criteria

Pollutant	Criteria
Total Suspended Solids	80% reduction
Total Phosphorus	60% reduction
Total Nitrogen	45% reduction
Gross Pollutants (5mm or larger)	90% reduction

The above criteria for pollutant load reductions are applicable for stormwater flow to both the proposed lakes and Undullah and Woollaman creeks.

The 'Flinders Precinct 1: Concept lake management plan' (BMT WBM, 2017) identifies that the load based targets presented in Table 3-2 may be insufficient to achieve a healthy lake environment. Additional treatments are subsequently proposed to be implemented to augment lake water quality. This is discussed further in Section 3.5.

3.4 MUSIC Modelling

Version 6.1 of the MUSIC modelling software has been used to assess the generation, transportation and management/treatment of flows and pollutant loads from Precinct 1. MUSIC modelling was undertaken for the following scenarios:

- Developed site without the proposed stormwater management strategy in place
- Developed site with the proposed stormwater management strategy in place.

Appendix B provides a detailed description of the MUSIC modelling methodology applied.

3.5 Proposed Strategy

A stormwater quality management strategy consisting of education, bioretention basins and other potential stormwater management measures (SMMs) has been proposed for the site. It is proposed that bioretention basins will be integrated into open space areas immediately downstream of areas proposed for development. Further, downstream of high density areas, the inclusion of gross pollutant traps (GPTs) are recommended. Bioretention basins have been adopted as the proposed SMM for the following reasons:

- These SMMs provide the greatest treatment per unit area compared to other best practice treatment measures.
- Bioretention basins are expected to be the most cost effective solution (i.e. lowest cost per unit of stormwater pollutant removed relative to other typical SMMs).
- Steep topography of the site limits opportunity for other 'at source' treatment devices to be successfully integrated.
- Bioretention basins can be readily integrated with other uses in parks and drainage corridors.

The proposed sub-catchment layout is illustrated in Figure 3-2, with the required total bioretention filter media area for each sub-catchment identified in Table 3-4.

For subcatchments where there is insufficient open space or park land available, sufficient land within the urban neighbourhood, town centre or neighbourhood centre land use must be allocated to facilitate incorporation of the necessary SMMs.

Table 3-3 provides a summary of the SMMs proposed for Precinct 1, with specific details of the proposed stormwater management measures (SMMs) presented in Section B.4.

As noted in Section 3.2, a number of additional treatment strategies are also proposed to be implemented to manage lake water quality. These are summarised in Figure 3-1.

It is anticipated that the implementation of these actions will be sufficient to achieve a healthy lake environment and comply with the lake water quality objectives identified in the 'Flinders Precinct 1: Concept lake management plan' (BMT WBM 2017). Further investigations are being undertaken into these additional treatment strategies to quantify the benefit of these solutions and compare the predicted water quality with the lake water quality objectives. Should the proposed measures be inadequate to meet the desired objectives, other potential treatment options will be considered, including, for example, integration of sedimentation basins at the upstream development boundary of the two creeks flowing into the proposed lake.

The stormwater management strategy may also be augmented with additional devices, including:

- Vegetated swales and buffer strips
- Streetscape bioretention systems
- Stormwater wetlands
- Sediment basins
- Gross pollutant traps – additional to being recommended in high density areas.

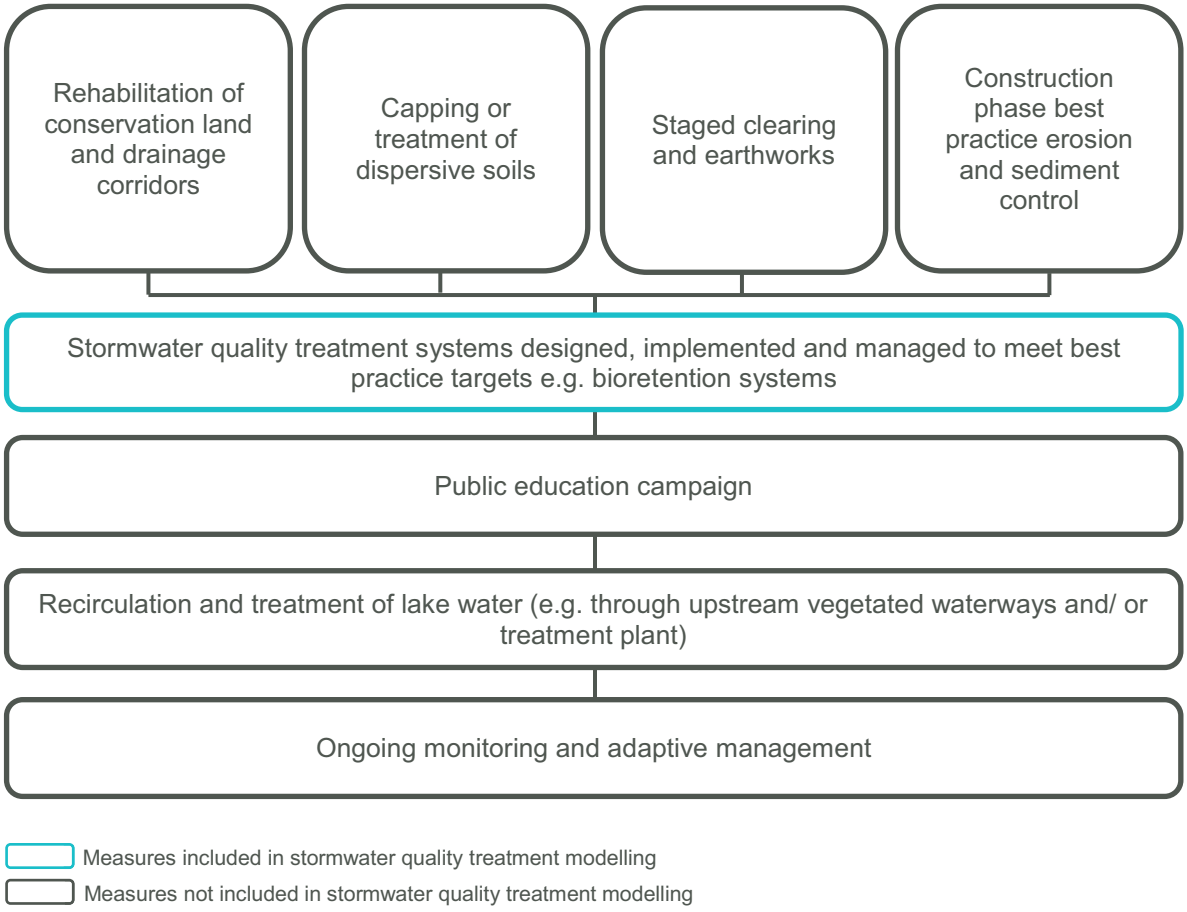


Figure 3-1 Operational Phase Stormwater Quality 'Treatment Train' (and additional Water Quality Management actions)

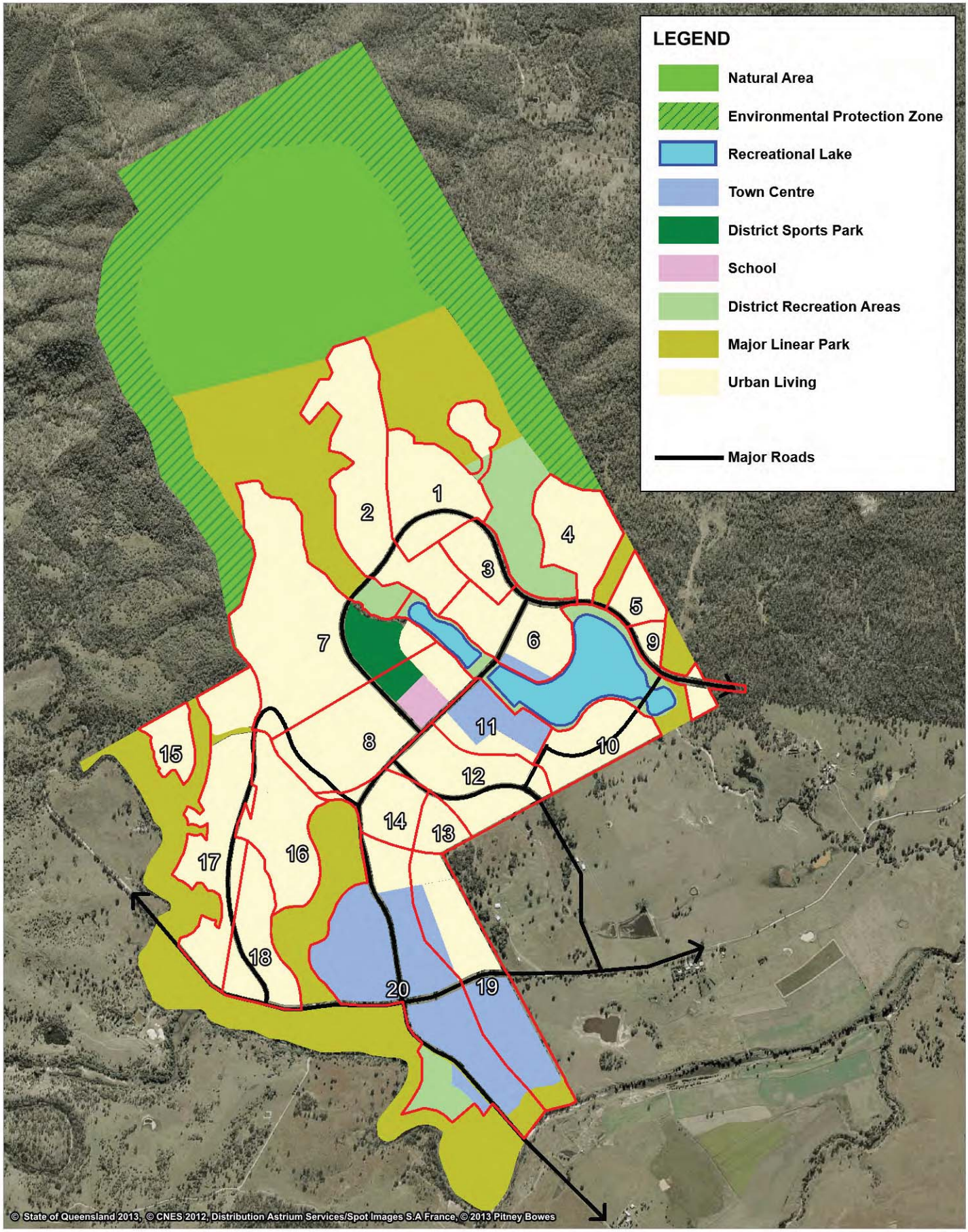
Table 3-3 Summary of Proposed Stormwater Treatment Strategy

Component	Description
Education	Signage installed at appropriate locations (e.g. near bioretention basins). No pollutant removal capacity has been assumed in modelling or assessment.
Bioretention Basins	Bioretention basins located in open spaces and near road reserves where possible. In instances where this is not possible, strategies as identified above (see Section 3.5) should be included to satisfy the desired objectives. Each subcatchment (identified in Table 3-4) below has been analysed and modelled in MUSIC with flow treated through bioretention systems, sized at either 0.80% or 0.85% of the contributing upstream catchment, dependent on land use (0.80% for urban neighbourhood areas and 0.85% for neighbourhood centre, town centre and public utilities areas). Each system has been assumed to have the following properties: • storage depth of 0.3 m • filter depth of 0.5 m • sandy loam filter media (saturated hydraulic conductivity 200 mm/hr, total nitrogen content 400 mg/kg, orthophosphate content 30 mg/kg) – As identified by Healthy Waterways (Healthy Waterways 2016) • vegetated with effective nutrient removal plants • zero exfiltration.

Table 3-4 Catchment Parameters

Catchment	Catchment Size (ha)	Required Bioretention filter media area (m^2)	Approximate Total Footprint (m^2) [1]
1	28.12	2250	4500
2	40.76	3261	6521
3	9.16	733	1465
4	18.35	1468	2937
5	6.66	532	1065
6	21.68	1742	3484
7	63.00	5040	10080
8	38.12	3050	6100
9	6.23	498	997
10	16.28	1303	2605
11	14.64	1222	2444
12	23.71	1897	3794
13	5.82	466	932
14	11.74	939	1879
15	6.92	553	1107
16	23.06	1845	2690
17	36.49	2919	5838
18	18.40	1472	2944
19	34.87	2900	5800
20	66.65	5640	11281

[1] *Total footprint area can be up to double that of the filter media area (to account for areas for addition of internal and external batters, maintenance access, etc.).*



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Proposed Sub-catchment Layout

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3.6 Model Results

The proposed management plan has been modelled using the MUSIC software, and results have been obtained, as described in Section 3.6.1 and Section 3.6.2. The results have been separated into discharges to the proposed lake, and to Undullah and Woollaman creeks.

3.6.1 Flows and Loads to Proposed Lake

The predicted annual flow and pollutant loads from the proposed development areas of the site entering into the proposed lake are presented in Table 3-5.

Table 3-5 Predicted Average Annual Flows & Pollutant Loads to Proposed Lake (1968 to 1977)

Parameter	Unmitigated Development	Developed Site With Treatment	% Removal	% Removal Target*
Flow (ML/yr)	1080	1030	4.4	-
TSS (kg/yr)	241000	40300	83.2	80
TP (kg/yr)	485	126	73.9	60
TN (kg/yr)	2200	1120	49.1	45
Gross Pollutants (kg/yr)	33400	0	100	90

* See Table 3-2

The results identified in the above Table 3-5 show that the proposed stormwater management strategy is predicted to achieve the operational pollutant load reduction targets for stormwater entering into the proposed lake.

3.6.2 Flows and Loads to Undullah and Woollaman Creeks

The annual flow and pollutant loads from the proposed development areas of the site entering into both Undullah and Woollaman creeks are presented in Table 3-6.

Table 3-6 Predicted Average Annual Flows & Pollutant Loads to Undullah and Woollaman Creeks (1968 to 1977)

Parameter	Unmitigated Development	Developed Site With Treatment	% Removal	% Removal Target*
Flow (ML/yr)	1,110	1,070	3.9	-
TSS (kg/yr)	247,000	42,800	82.6	80
TP (kg/yr)	481	123	74.5	60
TN (kg/yr)	2,260	1,190	47.6	45
Gross Pollutants (kg/yr)	33,900	0	100	90

* See Table 3-2

The results identified in Table 3-6 above, show that the proposed stormwater management strategy is predicted to achieve the operational pollutant load reduction targets for stormwater flow into both Undullah and Woollaman creeks.

The overall stormwater management strategy is predicted to achieve the required operational phase pollutant load reduction targets.

3.7 Construction and Establishment

The bioretention basins will need to be constructed and established in accordance with the guideline *Construction and establishment guidelines: swales, bioretention systems and wetlands* (Water by Design 2010a).

The appropriate construction and establishment of both the bioretention systems and the lake will be critical to maximising their ability to protect waterway and waterbody heath, and minimise operational issues (and maintenance requirements).

3.8 Maintenance

Maintenance of the bioretention systems should be undertaken in accordance with the guideline *Maintaining vegetated stormwater assets (*Water by Design 2012).

3.9 Asset Hand-over

It is anticipated that ownership and maintenance requirements of the proposed bioretention basins within the site will be 'handed over' to Logan City Council. Handover of the bioretention systems should be undertaken in accordance with the guideline *Transferring ownership of vegetated stormwater assets (*Water by Design 2012) except as otherwise determined by Economic Development Queensland's (EDQ) locally specific standards.

4 Stormwater Quality Monitoring

The following section outlines the proposed water quality monitoring requirements for:

- Stormwater discharged into the proposed lake.
- Stormwater bypassing the proposed lakes and being discharged into Undullah and Woollaman creeks.

4.1 Stormwater Quality Monitoring

4.1.1 Stormwater Discharge to the Proposed Lakes

Water quality monitoring is not recommended for stormwater discharge from this site to the proposed lakes. Monitoring of water within the proposed lakes is, however, recommended.

As per the 'Flinders Precinct 1: concept lake management plan' (BMT WBM, 2016), the design performance criteria for the operational phase of the proposed lakes have been based on the *Queensland water quality guidelines 2009* (DERM, 2009), the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC, 2000) and monitoring data from various lakes across South East Queensland (to ensure more realistic objectives).

4.1.2 Stormwater Discharge to Undullah and Woollaman Creeks

Water quality monitoring is not recommended for stormwater discharging from SMMs into Undullah and Woollaman creeks. Monitoring of SMMs is generally only required where uncertain or untested stormwater quality best management practices are being adopted. As bioretention systems are a well-researched SMM, stormwater quality monitoring is not considered to be required.

5 Conclusion

This plan provides a conceptual stormwater management strategy for the proposed development of Precinct 1 of the Flinders Master Planned Community.

A stormwater quality management strategy consisting of education and bioretention basins has been proposed for the site. It is proposed that bioretention basins will be integrated into open space areas immediately downstream of areas proposed for development.

MUSIC modelling predicts that given water quality objectives will be achieved. This strategy also outlines the approach to monitoring and maintenance of the SMMs proposed.

6 References

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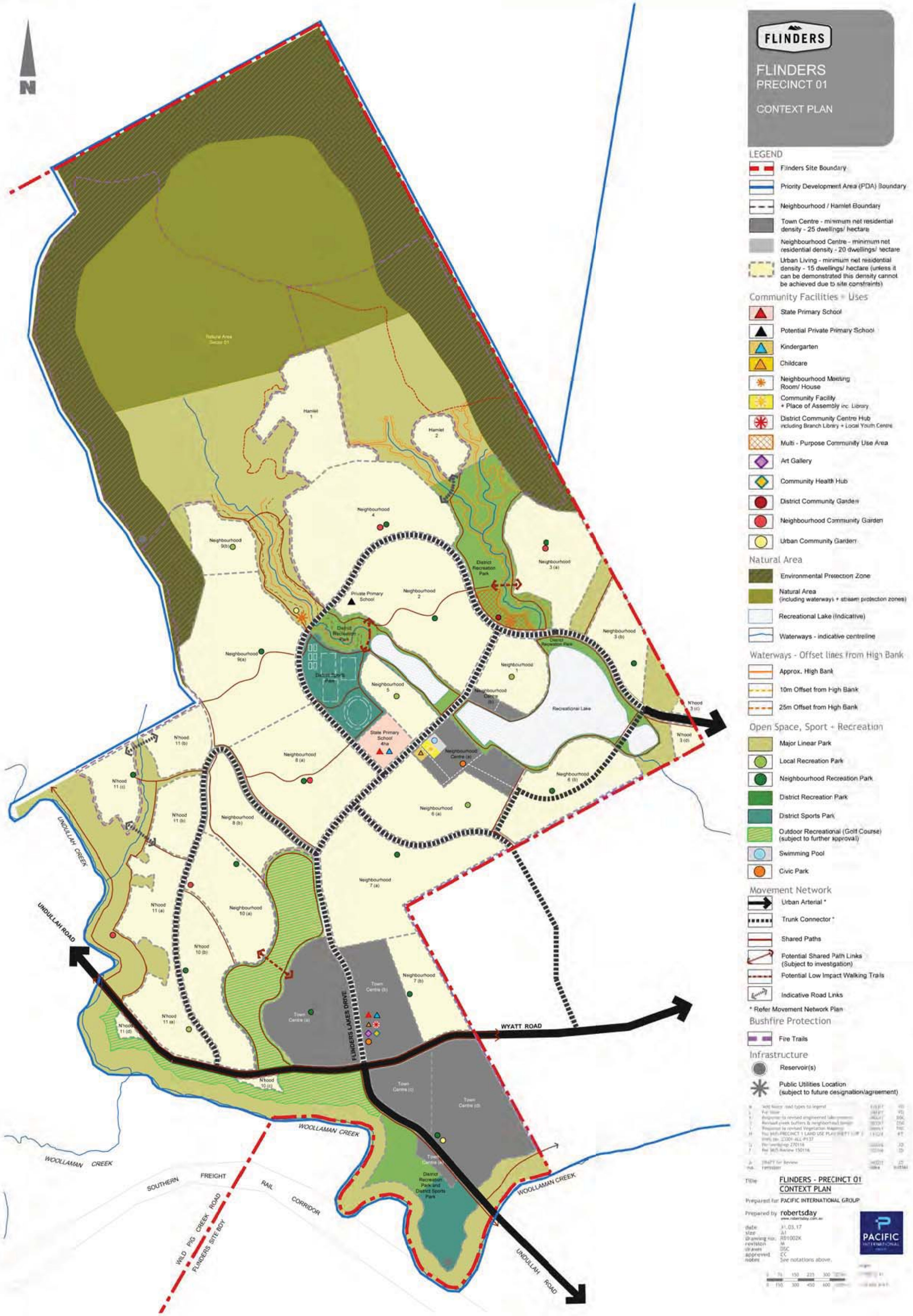
Appendix A Land Use Plan of Site



FLINDERS
FLINDERS
PRECINCT 01
CONTEXT PLAN
LEGEND
Flinders Site Boundary
Priority Development Area (PDA) Boundary
Neighbourhood / Hamlet Boundary
Town Centre - minimum net residential density - 25 dwellings/ hectare
Neighbourhood Centre - minimum net residential density - 20 dwellings/ hectare
Urban Living - minimum net residential density - 15 dwellings/ hectare (unless it can be demonstrated this density cannot be achieved due to site constraints)
Community Facilities + Uses
State Primary School
Potential Private Primary School
Kindergarten
Childcare
Neighbourhood Meeting Room/ House
Community Facility + Place of Assembly inc. Library
District Community Centre Hub including Branch Library + Local Youth Centre
Multi - Purpose Community Use Area
Art Gallery
Community Health Hub
District Community Garden
Neighbourhood Community Garden
Urban Community Garden
Natural Area
Environmental Protection Zone
Natural Area (including waterways + stream protection zones)
Recreational Lake (Indicative)
Waterways - indicative centreline
Waterways - Offset lines from High Bank
Approx. High Bank
10m Offset from High Bank
25m Offset from High Bank
Open Space, Sport + Recreation
Major Linear Park
Local Recreation Park
Neighbourhood Recreation Park
District Recreation Park
District Sports Park
Outdoor Recreational (Golf Course) (subject to further approval)
Swimming Pool
Civic Park
Movement Network
Urban Arterial *
Trunk Connector *
Shared Paths
Potential Shared Path Links (Subject to investigation)
Potential Low Impact Walking Trails
Indicative Road Links
* Refer Movement Network Plan
Bushfire Protection
Fire Trails
Infrastructure
Reservoir(s)
Public Utilities Location (subject to future designation/agreement)
Title FLINDERS - PRECINCT 01 CONTEXT PLAN
Prepared for PACIFIC INTERNATIONAL GROUP
Prepared by robertsday
PACIFIC INTERNATIONAL
N
Hamlet 1
Hamlet 2
Neighbourhood 4
Neighbourhood 9(b)
Neighbourhood 9(a)
Neighbourhood 2
Neighbourhood 3 (a)
Neighbourhood 3 (b)
Neighbourhood 1
Neighbourhood 5
Neighbourhood 8 (a)
Neighbourhood 8 (b)
Neighbourhood 6 (a)
Neighbourhood 6 (b)
Neighbourhood 7 (a)
Neighbourhood 7 (b)
Neighbourhood 10 (a)
Neighbourhood Centre (a)
Private Primary School
District Recreation Park
District Sports Park
State Primary School 4ha
Recreational Lake
Town Centre (a)
Town Centre (b)
Town Centre (c)
Town Centre (d)
FLINDERS LAKES DRIVE
WYATT ROAD
UNDULLAH ROAD
UNDULLAH CREEK
WOOLLAMAN CREEK
SOUTHERN FREIGHT RAIL CORRIDOR
WILD PIG CREEK ROAD
FLINDERS SITE BDY

Appendix B MUSIC Modelling Methodology and Results, and Treatment Strategy Details

As described in Section 3.4, MUSIC software has been used to assess the generation, transportation and management/treatment of flows and pollutant loads from the site.

This appendix provides a detailed description of the modelling methodology applied.

B.1 Software

The performance of possible stormwater treatment strategies in managing stormwater pollutants (during the operational phase) has been assessed using the MUSIC software package (Version 6.2) developed by the CRC for Catchment Hydrology and now supported by the eWater CRC. MUSIC is well suited to the assessments required for the proposed development, i.e. prediction of annual discharge of TSS, TP, TN and GP loads. The software has been specifically designed to allow comparisons to be made between different stormwater management systems and thereby function as a decision support tool.

B.2 Modelling Scenarios

The following two scenarios were modelled:

- **Developed case – unmitigated site**. The developed case without mitigation is essentially an assessment of what would occur if the site were developed without any integration of stormwater treatment devices or pollution control measures. For consistency, the unmitigated site has been modelled using identical source node parameters as that of the scenario for modelling the developed site incorporating SMMs.
- **Developed case – with SMMs**. This case is an assessment of the fully developed site with all SMMs installed and working at their design capacities. Treatment nodes have been incorporated into the model in the form of bioretention basins.

B.3 Source Nodes

The user is required to specify source nodes within MUSIC. The source nodes represent the pollutant generating areas of the site. A summary of the source node properties used in the MUSIC modelling (and the methodology used to derive them) is provided in the subsequent sections.

B.3.1 Source Node Properties

Land use categories were selected to represent, as accurately as possible, how the development will generate stormwater. The proposed land uses of the site are presented in Figure 2-4. As this is a conceptual stormwater management strategy lumped source nodes have been applied using the land use plan supplied (Refer to Appendix A).

Rainfall-runoff and pollutant export characteristics for the existing and developed site have been applied from the *MUSIC modelling guidelines* (Water by Design 2010b). The source node properties applied have been summarised in Table B-1.

Table B-1 Summary of Source Node Properties Applied in MUSIC Modelling

Parameter	Value		Comments
Assumed land usage for the proposed areas of the site	'Urban Residential' and 'Industrial'		• 'Urban Residential' pollutant export properties were modelled in accordance with the *MUSIC modelling guidelines* (Water by Design 2010b). For this conceptual design, these lumped catchments are representative of urban neighbourhood, town centre and neighbourhood centre areas (owing to densities identified in drawing RD1002-K, dated 31 March 2017 – refer to Appendix A)
Land Use	**Total Impervious Fraction**	**Area (ha)**	**Comments**
Catchments 1 to 20			
Total lumped urban neighbourhood (15 dwellings/ha)	55%	383.808	Impervious fraction in accordance with the *MUSIC modelling guidelines* (Water by Design 2010b).
Total lumped town and neighbourhood centres (25 dwellings/ha as per drawing RD1002-C, dated 26.11.15)	65%	95.328	Impervious fraction in accordance with the *MUSIC modelling guidelines* (Water by Design 2010b).
Other areas (i.e. open space corridors, natural area, environmental protection zone, district sport/recreational park)	0%	547.86	It has been assumed that these do not contribute to stormwater pollutant loads, and therefore these areas have not been modelled in MUSIC.

B.3.2 Meteorological Data

In accordance with Water by Design (2010b), meteorological data has been obtained for MUSIC from the Beaudesert Cryna Station (BOM Station no. 40014). Modelling of the site was performed over a period of ten years (from 1 January 1968 to 31 December 1977) at a 6-minute time step interval. Average potential evapo-transpiration data as described by Water by Design (2010b) has been adopted in the MUSIC modelling.

B.4 Proposed Treatment Strategy Elements

As outlined in Section 3.5, a stormwater quality management strategy consisting of education and bioretention basins has been proposed for the site. The individual elements of this strategy are described in the subsequent sections below. The stormwater treatment nodes specified in MUSIC essentially represent the stormwater treatment train.

B.4.1 Education

Education can increase people's understanding and acceptance of water quality issues and stormwater treatment devices. It is proposed that signage be installed at appropriate locations (e.g. adjacent to proposed bioretention systems). Through advanced awareness, it is possible that pollutant loads may be reduced at source level.

It should be noted that education will need to be ongoing, and relate to both pre and post development for all stakeholders.

Examples of educational signage to improve understanding of water quality issues are given in Figure B-1. No reduction in source pollutant loads have been assumed within the MUSIC model.

Figure B-1 Examples of Educational Signage

B.4.2 Bioretention Basins

A bioretention basin is a soil and plant-based stormwater management measure. A typical basin consists of a porous medium such as sandy loam. Vegetation is also established within the bioretention basin to promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants.

A series of bioretention basins are proposed to be incorporated throughout the development. The bioretention basins will receive stormwater flows from the urbanised residential areas from each of the subcatchments identified in Figure 3-2.

For the purposes of this conceptual stormwater management strategy, the approximate filter media area for proposed bioretention basins has been derived as a percentage of the development area (excluding the 'Other Areas' identified in Table B-1). All bioretention basins have been assumed to have a filter depth of 0.5m and an extended detention depth of 0.3m. The filter media for the bioretention system has been modelled as a sandy loam media of effective diameter 0.45 mm and a saturated hydraulic conductivity of approximately 200 mm/hr. The modelling assumes total nitrogen and orthophosphate concentrations of 400 and 30 mg/kg respectively (as identified by Healthy Waterways (Healthy Waterways 2016), and that they will be vegetated with 'effective nutrient removal plants'. The modelling also assumes a lined system, visually represented in Figure B-2.

Figure B-2 provides a conceptual cross section of a bioretention basin, illustrating the modelled properties of the system. Examples of bioretention basins are provided in Figure B-2.

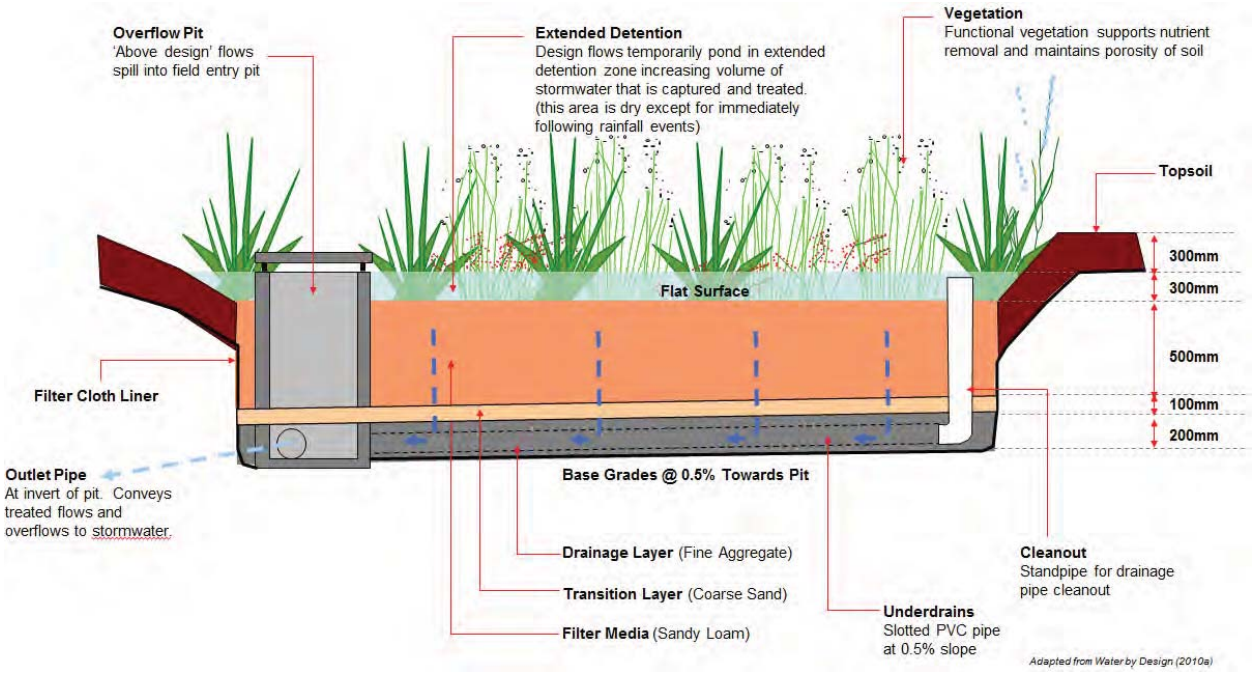


Figure B-2 Conceptual Cross Section of Bioretention Basin Properties

Figure B-3 Bioretention Basin Examples

B.4.3 Additional Potential Stormwater Management Measures

There are a range of additional stormwater management measures (SMMs) that could potentially be incorporated into the proposed treatment strategy to augment the bioretention basins. These include:

- Vegetated swales and buffer strips
- Streetscape bioretention systems
- Stormwater wetlands
- Sediment basins
- Gross pollutant traps.

Further details on each of the above SMMs are described in the subsequent sections below.

B.4.3.1 Vegetated swales and buffer strips

Swales are shallow channels lined with vegetation (usually grass) and are often used in combination with alternative kerb design to provide flow conveyance, minimising the use of piped stormwater drainage systems. Buffer strips are areas of vegetation through which runoff passes while travelling to a discharge point. Both vegetated swales and buffers tend to slow flow and retain sediment. Examples of streetscape swales in South East Queensland are shown in Figure B-4.

Figure B-4 Examples of Streetscape Swales in South East Queensland

B.4.3.2 Streetscape bioretention systems

Bioretention systems are plant and soil-based stormwater treatment devices systems into which polluted stormwater is directed for treatment. Stormwater infiltrates through the plant and soil environment of the bioretention systems where a combination of physical, chemical and biological processes treat pollutants.

Bioretention systems are flexible in size, shape and appearance, and can be readily integrated into a range of landscapes, including individual development sites, streetscapes, parklands and adjacent to riparian and bushland settings. Examples of small streetscape systems are shown in Figure B-5.

Figure B-5 Examples of Streetscape Bioretention Systems in South East Queensland

B.4.3.3 Stormwater wetlands

Stormwater wetlands are shallow vegetated water bodies which provide stormwater treatment via sedimentation, filtration and biological processes.

Examples of stormwater treatment wetlands in South East Queensland are presented in Figure B-6.

Figure B-6 Examples of Stormwater Treatment Wetlands in South East Queensland

B.4.3.4 Sediment basins

Sediment basins are typically open water environments that promote settling of sediments through the reduction of flow velocities and temporary detention. They are typically installed to remove coarse to medium sized sediment (i.e. 125µm or larger) and control and regulate flows entering downstream stormwater treatment devices (e.g. wetlands, bioretention basins) and receiving waterways. Examples of sedimentation basins are provided in Figure B-7.

Figure B-7 Examples of Sediment Basins

B.4.3.5 Gross pollutant traps

Gross pollutant traps (GPTs) can take a number of forms. The simplest form is a litter rack used to trap coarse litter at a discharge point. More sophisticated forms are gully pit litter baskets and sub-surface chambers that are used to capture litter and sediment. They are often used as a pre-treatment for a stormwater wetland. Although recommended for use in high density areas of this development, GPTs have not been included in modelling as sufficient detail is not available at this time. Examples of gross pollutant traps are provided in Figure B-8.

Figure B-8 Examples of Gross Pollutant Traps

BMT WBM Bangalow
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