1. Introduction

Urban development within the City of Rockingham (the City) has traditionally taken advantage of elevated land with sandy soils, limited surface water drains or watercourses, as well as generous clearance to groundwater. As the more suitable land has now largely been urbanised the focus has moved to areas which are more difficult to develop due to the presence of seasonal surface water inundation and/or geological complexity.

With a view to obtaining the best possible outcomes for the City, it is important that the City has a procedure which is supported at the higher level by a Council approved Local Planning Policy, which ensures that all development occurs with a focus on total water cycle management, and not just traditional 'end of pipe' drainage solutions.

2. Statement of Intent

This Planning Procedure supports the implementation of the objectives specified in *Planning Policy 3.4.3 - Urban Water Management* and applies specific rigor to strategic and statutory proposals for residential, commercial, industrial or rural-residential development by:

(a) Applying the objectives and requirements of Liveable Neighbourhoods (WAPC, 2009), WA State Government policies and guidelines;

(b) Ensuring that the objectives and intent of the approved Structure Plan and Subdivision Applications are appropriately implemented; and

(c) Ensuring that infrastructure is designed and constructed in accordance with adopted drainage standards consistent with best management practice.

The purpose of this Planning Procedure is to provide technical information on Urban Water Management for those proposing to develop land within the City and is applicable to all activities, works, services and programs conducted by the City, its contractors and consultants.

This Planning Procedure should also be read in conjunction with the following:

- Planning Procedure 3.4.1 - Public Open Space
- Planning Policy 3.3.15 - Bulk Earthworks
- Greening Plan (CoR, 2017)
- Engineering Policy PE1 - Street Verge Development
- Water Efficiency Action Plan (CoR, 2016)
- Planning Procedure No.1.24 - Landscape Assessment
- Planning Procedure No.1.25 - Engineering Assessment.

3. Planning Procedure

3.1 Urban Water Management Planning

Integrated land use and water planning is based on the principle of total water cycle management which holistically considers all aspects of water including drinking water, groundwater, stormwater runoff, wastewater, waterway health and water reuse. This informs sustainable urban planning and development decisions, and results in Water Sensitive Urban Design (WSUD).

3.1.1 Better Urban Water Management (BUWM)

Consistent with *Planning Policy 3.4.3 - Urban Water Management*, Table 1 outlines how land planning processes align with BUWM (WAPC, 2008) reporting to ensure WSUD is achieved.

Table 1 – Integrated Water Planning and Land Use Planning Process

Planning Trigger	Document Required	WSUD Context
District Structure Plan	District Water Management Strategy (DWMS)	Integrated Water Cycle Management (Regional/Catchment Scale, long-term water resource management and planning)
Local Structure Plan	Local Water Management Strategy (LWMS)	Water Sensitive Urban Design (local responses, built environment focus)
Subdivision Application	Urban Water Management Plan (UWMP)	Water Sensitive Urban Design (local responses, built environment focus)
Development Application (DA)	Stormwater Management Plan – Engineering Design – Landscape Design	Water Sensitive Urban Development (development scale, built environment focus)
Post-Development	Monitoring Report	Water Sensitive Urban Development (compliance)

3.1.2 Regional Context

The City can generally be classified into two separate catchment areas, each with their own unique characteristics; the Peel-Harvey Estuary catchment, and the Coastal Catchment (DWER, 2018) as shown in Appendix 1.

The Peel-Harvey Estuary catchment contains the Peel Main Drain, as well as a number of shallow rural subdrains, and the Serpentine River. The soils in this area are characterised by Bassendean Sands and Guildford Clays. The catchment experiences flooding from groundwater inundation during the winter months as well as riverine and localised rainfall flooding. There are a number of Conservation and Resource Enhancement Wetlands.

The Coastal catchment does not contain any natural drainage lines and is largely characterised by freely draining sandy soils associated with Safety Bay Sands and Tamala Limestone. There are a number of Conservation and Resource Enhancement Wetlands e.g. Lake Richmond.

4. Stormwater Management Principles

Stormwater management is dependent on a number of hydrological and geological factors. The following section outlines the requirements for stormwater management to be applied at each level of reporting (Table 1) with specific guidance for individual catchment areas where applicable.

4.2 Modelling Considerations

All stormwater management system designs shall be carried out by a suitably qualified person experienced in hydrologic and hydraulic modelling and design.

4.2.1 Storm Frequency Design Criteria

Hydrologic and hydraulic modelling shall be undertaken for the design of all stormwater management systems based on a small, minor and major rainfall event basis as outlined in *Australian Rainfall & Runoff (AR&R)* (Geoscience Australia, 2016) and presented in Table 2.

Table 2 – AR&R (2019) Design Criteria

Frequency Descriptor	AEP	EY	Land Use Design Criteria
Frequent/Small	63%	1 (Annually)	Applicable to all
Frequent/Minor	20%	-	Residential and Rural Residential
Rare/Minor	10%	-	Commercial and Industrial
Very Rare/Major	1%	-	Residential, Rural Residential, Commercial and Industrial
	0.2%	-	Hospitals, Emergency Services, Flood Evacuation Buildings and Civil Defence

4.2.2 Modelling Parameters

The City does not wish to prescribe fixed stormwater modelling parameters or standardised modelling methodology. It is essential, however, that applicants provide sufficient information to demonstrate the appropriateness of modelling parameters and assumptions to enable a proper consideration of the legitimacy of the modelling approach.

(a) Rainfall

(i) The Intensity Frequency Duration (IFD) design rainfall depths, should be created on a site by site basis using the BoM's online Design Rainfall Data System (2016).

(ii) The design rainfall temporal patterns for each frequency descriptor (Table 2) should be created on a site by site basis using AR&R's online datahub.

(b) Infiltration

(i) As infiltration properties vary depending on the lithology of in situ soils, site specific site investigations and modelling are necessary to determine stormwater storage volumes and drainage basin sizing. Field measurements of saturated hydraulic conductivity (infiltration tests) shall be undertaken by a suitably qualified person, e.g. Geotechnical Engineer, in accordance with recognised Australian Standards.

(ii) Appropriate soil moderation factors (DoW, 2004 - 2007) and long term clogging rates (John Argue, 2004) should be applied to the field measured infiltration tests to determine design hydraulic conductivity rates (m/day).

(iii) Where the depth to Maximum Groundwater Level (MGL) is less than 5.0m from the base of drainage infrastructure (e.g. drainage basin, underground storage), an infiltration model (e.g. MODRET, PONDS and PCSUMP – shallow water table) capable of accounting for the influence of a shallow water table on the calculated peak water levels is required. Where the depth to MGL is greater than 5.0m the use of a more simplistic model is considered appropriate.

(c) Runoff Assumptions

(i) Runoff assumptions should utilise latest methodology shown in Australian Rainfall and Runoff, Book 9 – Runoff in Urban Areas, Chapter 6: Modelling Approaches. This includes the use of impervious vs pervious areas in conjunction with Initial Loss (IL), Continuing Loss (CL) and Proportional Loss (PL) values.

(ii) Site specific fraction impervious runoff coefficients are to be calculated on a case by case basis with demonstration of their appropriateness to be provided.

(d) Other Parameters

(i) Appropriate stormwater and drainage design parameters shall be applied, where applicable, including but not limited to; depression storage, roughness coefficients (Horton's, Manning's 'n'), inlet and outlet losses and downstream conditions. Appropriate values must be determined on a site by site basis using existing and proposed site conditions.

(iii) Conveyance systems (open drainage channels, living streams, swales) must be designed using an integrated hydrologic and hydraulic stormwater and floodplain model (e.g. XP-Storm).

4.3 Design Considerations

4.3.1 Frequent/ Small Event Management

(i) Residential lots must manage small rainfall event runoff from constructed impervious surfaces within the lot boundary. Soakwells or other approved retention devices must be provided, where appropriate, and sized to contain the volume generated by the first 15mm of rainfall runoff as a minimum.

(ii) The use of soakwells and/or underground storage devices may be limited in areas with shallow depth to MGL, poor draining clayey soils and small lot areas (<300m^2). In these instances, a partial or direct lot connection to the road drainage system should instead be provided. This is to be assessed on a case by case basis.

(iii) In addition to the above, commercial and industrial lots must integrate Water Sensitive Urban Design (WSUD) into the development to provide treatment of the first 15mm of rainfall runoff from trafficable areas. WSUD can include elements such as bio-retention swales, rain gardens and tree pits.

(iv) Large developments must also integrate WSUD elements into the overarching stormwater and landscape design to capture and treat runoff from connected trafficable areas.

(v) All frequent event storages must be designed to completely emply, following the cessation of rainfall, within 12 hrs. This is consistent with the criteria specified in Engineers Australia (2006).

4.3.2 Minor Event Management

(i) Group housing, commercial and industrial lots must manage minor and major rainfall event runoff within the lot boundary. Underground or above ground storage shall be provided and sized to contain the volume generated by the critical 10% AEP event as a minimum. In circumstances where site conditions are constrained, it must be demonstrated that:

- Stormwater runoff is managed as much as practical within the lot; and
- The City's drainage infrastructure has sufficient capacity to cater for any off-site discharge via piped drainage or overland flow.

(ii) Municipal roads must maintain serviceability, amenity and road safety during rainfall events:

- The road reserve pit and pipe network must be designed for the critical 20% AEP event, as a minimum.
- Trapped pits are supported, where site conditions allow and expected contaminant runoff is minimal, promoting infiltration at source. Where trapped pits are not appropriate, e.g due to the presence of a shallow controlled groundwater level, benched pits are instead to be provided.
- The City is supportive of the DWER's approach to minimise piped drainage systems. Where roads abut Public Open Space (POS) or other landscaped areas, flush kerbing or kerb breaks shall be considered.

(iii) Retention/ detention storages must be sized to appropriately contain the minor flood event within a designated area without impacting POS useability or any adjacent road reserve. Storage sizing must be cognisant of existing and proposed site conditions and any downstream constraints.

(iv) All minor event retention/ detention storages must be sized to completely emply, following the cessation of rainfall, consistent with the criteria specified in Engineers Australia (2006). For the critical 20% and 10% AEPs the criteria is 36 and 48 hours, respectively.

4.3.3 Major Event Management

(i) Group housing, commercial and industrial lots may be required to manage the major rainfall event runoff within the lot boundary. Underground and/or above ground storage shall be provided and sized to contain the volume generated by the critical 1% AEP event. In circumstances where site conditions are constrained, it must be demonstrated that:

- Stormwater runoff is managed as much as practical within the lot; and
- The City's drainage infrastructure has sufficient capacity to cater for any off-site discharge via piped drainage or overland flow.

(ii) Flooding of the road pavement within the municipal road reserve is permitted, provided minimum safety requirements are met.

(iii) Minimum habitable floor levels must be consistent with the criteria specified in the Local Government Guidelines for Subdivisional Development (WAPC, 2017) and Decision Process for Stormwater Management in WA (DWER, 2017), and should be set:

- At least set at 0.3m above the adjacent 1% AEP flood level of the urban drainage system (roads, drainage basins); or
- At least 0.5m above the 1% AEP flood level of natural waterways, living streams or open drainage channels.

(iv) In major events, flooding within retention/ detention storages can overflow into useable POS and any adjacent road reserve, provided minimum public safety measures are met. Storage sizing must be cognisant of existing and proposed site conditions and any downstream constraints.

(v) All major event retention/detention storages must be sized to completely empty, following the cessation of rainfall, within 84hrs. This is consistent with the criteria specified in Engineers Australia (2006). For disease vector and nuisance insect management, to reduce the health risks associated with mosquito breeding, all stormwater must be fully infiltrated within 96 hours in accordance with BUWM.

4.3.4 Stormwater Infrastructure Design Criteria

Stormwater management system controls shall be cognisant of the City's design criteria as shown in Table 5.

The City does not support the use of fenced sumps as a permanent urban water management solution. The City will, however, consider sumps for temporary flood storage areas providing the following criteria are met:

(i) Where the sump is not at the catchment low point, storage capacity should be cognisant of the volume generated by the critical 20% AEP event in residential areas and critical 10% AEP event in industrial and commercial areas.

(ii) Where the sump is located at the catchment low point, storage capacity should reflect the volume generated by 1% AEP.

Table 5 - Stormwater Management Controls and Design Criteria

Stormwater Management Control	Design Criteria
Detention/Infiltration Basin	Maximum Permissible Batters: 1 in 8 for grassed areas 1 in 6 to 1 in 4 for landscaped area within POS 1 in 2 for terraced landscaped areas with retaining walls Maximum Flood Depths 1EY – 0.5m, 20% AEP – 0.9m, 1% AEP – 1.2m Invert Level To be a minimum 0.5m above the calculated MGL or CGL
Open Channel/Living Stream/Swale	Maximum Permissible Batters: 1 in 8 to 1 in 6 for grassed areas 1 in 6 to 1 in 4 for landscaped area within POS Grades: 0.5% to 4.0% Maximum Flood Depths: 1EY – 0.5m, 20% AEP – 0.9m, 1% AEP – 1.2m Invert Level To be a minimum 0.5m above the calculated MGL or CGL
Sump (Temporary Only)	Maximum Permissible Batters: 1 in 6 to 1 in 1.5 – fenced with no public access. Maximum Flood Depths: 1% AEP – 1.5m Invert Level To be a minimum 0.3m above the calculated MGL or CGL
Underground Storage	Minimum Separation to Constructed Surface: In accordance with manufacturers specifications to the satisfaction of the City. Location: Road Reserve – under verge and foot path areas only. POS – under detention/infiltration basins or turfed recreational space. Invert Level To be a minimum 0.3m above the calculated MGL or CGL

4.4 Peel-Harvey Estuary Catchment

Development within the Peel-Harvey Estuary Catchment (Appendix 1) is bound by criteria specified by both the Water Corporation and the DWER. It is recommended that proponents liaise with both the Water Corporation and DWER as early as possible for site specific guidance and design criteria.

Development proposals located in the Water Corporation's Mundijong Drainage District for the Peel Main Drain has traditionally required stormwater management systems to be designed on the basis of:

(i) A restricted off-site discharge rates of 3 L/s/gross ha for the 10% AEP storm event, and;

(ii) A restricted off-site discharge rates of 4.5 L/s/gross ha for the 1% AEP storm event.

The Water Corporation has published fact sheets to guide urban development within a rural drainage district as well as the design criteria for living streams in their assets.

District level planning in this area is to be informed by the *North East Baldivis Drainage and Water Management Plan (DWMP)* (DWER - in preparation). The DWMP will provide an assessment of catchment-scale water constraints and management opportunities informed by the *North East Baldivis Flood Modelling and Drainage Studies* (DoW, 2015).

Where there is no published criteria, adequate on-site detention and/or retention is required to maintain post development outflows relative to pre-development conditions, consistent with *Better Urban Water Management (BUWM)* (WAPC, 2008).

4.5 Water Dependent Ecosystems (WDEs)

Development proposals should identify any WDEs (e.g wetlands, watercourses, estuaries) and regionally significant vegetation/habitat to be protected. WDEs require specific water regimes to maintain their natural hydrological characteristics referred to as Ecological Water Requirements (EWRs).

(i) EWRs are to be quantified to understand how WDEs will be affected by their relationship to changes in surrounding land uses. Pre-development annual discharge volume and peak flow should be maintained post development, unless otherwise established through determination of EWRs for sensitive environments.

(ii) Appropriate buffers to urban development are to be provided consistent with any identified management and rehabilitation requirements of the WDE. This is to be assessed by both the DWER and the City.

(iii) The City will not accept direct discharge of urban drainage into WDEs. Appropriate water quality treatment measures are to be provided throughout the urban catchment and within vegetated buffers to capture small events.

5. Groundwater Management Principles

Groundwater management systems are required in areas where the MGL is at or within 1.2m of the natural surface that typically exist within the Peel Harvey Estuary Catchment (Appendix 1). The following section outlines the requirements for groundwater management in these areas.

5.1 Controlled Groundwater Levels

Development proposals must consider the existing groundwater regime to determine whether groundwater management is required. This includes installation of site specific observation bores that must be monitored for a minimum 18 month period to include two winters consistent with DWER standard practice.

Where groundwater management requires the establishment of a Controlled Groundwater Level (CGL), the following must be addressed in accordance with *Water Resource Considerations when Controlling Groundwater Levels in Urban Development* (DoW, 2013):

(i) Peel Harvey Estuary Catchment constraints and requirements;

(ii) Adjacent land uses and infrastructure;

(iii) Impacts to local and regional water-dependent ecosystems and water resources;

(iv) Contaminants that may be mobilised with released groundwater associated with historical land uses; and

(v) The system needing to be hydraulically sound and having a free-flowing outlet.

5.2 Subsoil Drainage

Where development proposals require subsoil drainage to control groundwater levels, the City requires the following design and construction standards to be met:

(i) Groundwater management systems to be designed using an appropriate model to predict the performance of the system. The level of detail required to be addressed should be consistent in the broader context of the BUWM planning and design process. Modelling must clearly demonstrate that clearances to groundwater are acceptable depending on the level of risk and amenity for all critical elements of the built form and infrastructure.

(ii) Imported fill must be tested in a NATA accredited laboratory to ensure the groundwater management system design criteria are met e.g. saturated hydraulic conductivity.

(iii) Subsoil outlets are to be free draining with a minimum invert level of 150mm above the base of the system into which it discharges.

(iv) Groundwater quality must be maintained or improved prior to offsite discharge into local and regional watercourses.

6. Water Sensitive Urban Design

The City recognises that there are multiple benefits associated with Water Sensitive Urban Design (WSUD) aside from water quality treatment. WSUD improves biodiversity, microclimate, aesthetics, urban greenery, human health and potentially act as an alternative water supply. WSUD measures are therefore encouraged and must be considered in all development proposals across the City.

6.1 Compliance with Environmental Quality Criteria

Development proposals within the Peel Harvey Estuary Catchment (Appendix 1) are bound by specific environmental water quality criteria. For the Serpentine River, which includes the Peel Main Drain, specific criteria are as follows:

(i) The annual Phosphorus load must not exceed 21 tonnes or concentrations of 0.1 mg/L (EPA, 2008);

(ii) The Phosphorus output target is 70 tonnes or 0.37 kg/ha/year (DoW, 2011);

(iii) The Total Nitrogen output target is 454 tonnes or 2.4 kg/ha/year (DoW, 2011).

WSUD measures must be incorporated in these areas to achieve the mandatory targets. The City requires demonstration of compliance through appropriate computer models, for example the DWER's UNDO tool, to be assessed relevant to the stage of planning and scope of the proposal, as supported by the DWER.

6.2 WSUD Measures

The City requires development proposals, as well retrofit projects, to consider WSUD measures early in the planning and design process. The table in Appendix 2 illustrates the different types of WSUD Best Management Practices (BMPs), adopted from the *Stormwater Management Manual for WA* (DoW, 2004 - 2007), that should be considered at various scales of development.

To achieve the objectives of WSUD, a treatment train approach incorporating a number of the measures in Appendix 2 is to be applied to maximise water quality improvement and overall performance.

The City does not currently have any standard designs or drawings for the BMPs in Appendix 2. It is therefore recommended that proponents engage with the City as early as practical to discuss specific requirements to be assessed on a case by case basis.

6.2.1 Biofiltration

Biofiltration systems must be designed in accordance with latest industry guidance that has been determined based on scientific rigour, in conditions appropriate to those experienced in the City. Biofiltration systems (swales, rain gardens and tree pits) shall be sized to retain the first 15mm of rain in accordance with *Decision Process for Stormwater Management in WA* (DWER, 2017) and must meet the requirements and design specifications outlined in the following:

- *Adoption Guidelines for Stormwater Biofiltration Systems (Version 2)* (CRCWSC, 2015)
- *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia* (Monash University, 2014)

Where amended soils are required to provide an appropriate filter media, the City encourages proponents to test in situ soils against published criteria. Alternatively, a landscape supplier manufactured material must be provided. For both scenarios, a soil sample analysis by a NATA accredited laboratory must be provided to the City to demonstrate compliance.

6.2.2 WSUD Construction and Site Management

Actions must be proposed to address management of construction activities, particularly litter and sediment management as well as vegetation and tree protection.
A Construction and Building Site Management Plan shall be developed to support subdivision and/or Development Application. The management plan should, at a minimum, consider:

(i) Protection of vegetation or wetlands;

(ii) Interim stormwater management measures;

(iii) Location of site entry;

(iv) Location of stockpiled materials;

(v) Control of sediment - fences should be erected around vegetated areas and WSUD infrastructure;

(vi) Erection of safety/construction fences;

(vii) Protection of WSUD infrastructure integrity in the period between civil construction and landscaping.

6.2.3 WSUD Monitoring and Maintenance

Under the BUWM (WAPC, 2008) framework, a monitoring program and maintenance regime must be outlined in an Urban Water Management Plan (UWMP), prepared as a condition of subdivision, to the satisfaction of the City.

The purpose of the monitoring program is to demonstrate the effectiveness of WSUD controls to ensure it is operating in accordance with its intended purpose and design. The post development monitoring program must confirm that there are no detrimental impacts to groundwater and surface water quality and at a minimum shall demonstrate that pre-development conditions are preserved.

Maintenance is required to ensure WSUD systems will function effectively, optimising their life span. Maintenance tasks for WSUD assets are similar to conventional drainage systems and parks. Maintenance should not be reactive e.g. fixing poorly performing assets. Effective maintenance requires time and resources to be allocated to actions that must be scheduled in response to planned inspections. Developers and the City are both responsible for maintenance.

7. Water Conservation and Sustainability

The City has been endorsed as a Waterwise Council under the Water Corporation and DWER's Waterwise Councils program.

The City's *Water Efficiency Action Plan* (2016) specifies a groundwater efficiency goal to reduce groundwater consumption by 10% based on the DWER's standard allowance of 7,500 kL/ha/yr. Development proposals should therefore consider an average irrigation rate of 6,750 kL/ha/yr where groundwater is proposed as a suitable fit-for-purpose water source. Landscape proposals shall be designed using waterwise principles including xeriscaping and hydrozoning.

Where practical, supplement potable and non-potable water supply using alternative sources of water e.g. rainwater tanks, grey water, treated wastewater, harvested stormwater.

At the lot scale, developments are encouraged to implement the Water Corporation's *Guidelines for Waterwise Homes and Gardens Criteria*.

8. Interpretations

8.1 Agency Acronyms

BoM - Bureau of Meteorology

Council - The Council of the City of Rockingham

CRCWSC - Cooperative Research Centre for Water Sensitive Cities

DoW - Department of Water (now the DWER)

DWER - Department of Water and Environmental Regulation (formerly the DoW)

IPWEA - Institute of Public Works Engineering Australasia

NATA - National Association of Testing Authorities

WAPC - West Australian Planning Commission

8.2 Definitions

Annual Exceedance Probability (AEP) - the probability of an event occurring or being exceeded within a year expressed as a percentage.

Best Management Practice (BMP) - Devices, practices or methods for removing, reducing or preventing targeted pollutants from reaching receiving waters and for reducing runoff volumes and velocities. Includes structural and non-structural controls.

Biofilter - (also known as biofiltration basin and rain garden) are excavated basins or trenches filled with porous filter media and planted with vegetation to remove pollutants from stormwater runoff. They use natural and physical processes to treat stormwater.

Controlled Groundwater Level (CGL) - The controlled (ie modified) groundwater level (measured in metres Australian Height Datum) at which drainage inverts are set. This level must maintain the hydrologic regimes of groundwater dependent ecosystems, such as wetlands, that are to be protected.

Ecological Water Requirements (EWRs) - EWRs are the water regimes needed to maintain ecological values of Water Dependent Ecosystems (WDEs) at a low level of risk.

Exceedances per Year (EY) - expresses the probability of how many times in any year that an event will occur.

Intensity Frequency Duration (IFD) - IFDs are Intensity–Frequency–Duration design rainfall intensities (mm/h) or design rainfall depths (mm) corresponding to selected standard probabilities, based on the statistical analysis of historical rainfall.

Maximum Groundwater Level (MGL) - To be determined through on-site measurement, monitoring and/or modelling and compared to the DWER's regional long-term monitoring records (if available).

Structural Practices - Structural stormwater quality and quantity best management practices are permanent, engineered devices implemented to control and improve stormwater quality and restore natural hydrological flows and velocities. Structural controls should be installed at or near the source of run-off/pollutant inputs, to prevent or treat pollution and manage the quantity of stormwater as high in the catchment as possible.

Total Water Cycle Management - water supply, stormwater, groundwater and sewage services are interrelated components of catchment systems, and therefore must be dealt with using an holistic water management approach that reflects the principles of ecological sustainability. Water efficiency, re-use and recycling are integral components of total water cycle management.

Treatment train - application of several types of stormwater best management practices in series or designed to achieve improved stormwater management.

Water Dependent Ecosystem (WDE) - WDEs are parts of the environment in which the composition of species and natural ecological processes are determined by the permanent or temporary presence of flowing or standing surface water or groundwater. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries, karst systems and groundwater-dependent terrestrial vegetation are all WDEs.

Water Sensitive Urban Design (WSUD) - The philosophy of achieving better water resource management outcomes in an urban context by using an integrated approach to planning and incorporating total water cycle management objectives into the planning process. The key elements of this design include protection from flooding; management of water quantity and quality to achieve ecological objectives; and water conservation, efficiency and re-use.

9. References

CRC for Water Sensitive Cities (2015) *Adoption Guidelines for Stormwater Biofiltration Systems (Version 2)*

Department of Water (2004-2007) *Stormwater Management Manual for Western Australia*

Department of Water (2011) *Hydrological Nutrient Modelling of the Peel-Harvey Catchment – Water Science Technical Series Report No. WSPT 33*

Department of Water (2013) *Water Resource Considerations when Controlling Groundwater Levels in Urban Development*

Department of Water (2015) *North-east Baldivis Flood Modelling and Drainage Studies – Report No. WST 73*

Department of Water and Environmental Regulation (2018) *Water Information Reporting* [Online] available: http://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx

Department of Water and Environmental Regulation (2017) *Decision Process for Stormwater Management in WA*

Engineers Australia (2006) *Australian Runoff Quality - A Guide to Water Sensitive Urban Design*

Environmental Protection Authority (EPA) (2008) *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System*

Geoscience Australia (2016) *Australian Rainfall & Runoff*

John Argue (2004) *Stormwater Drainage Design in Small Urban Catchments: A Handbook for Australian Practice*

Monash University (2014) *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia*

WAPC (2008) *Better Urban Water Management*

WAPC (2017) *Local Government Guidelines for Subdivisional Development*

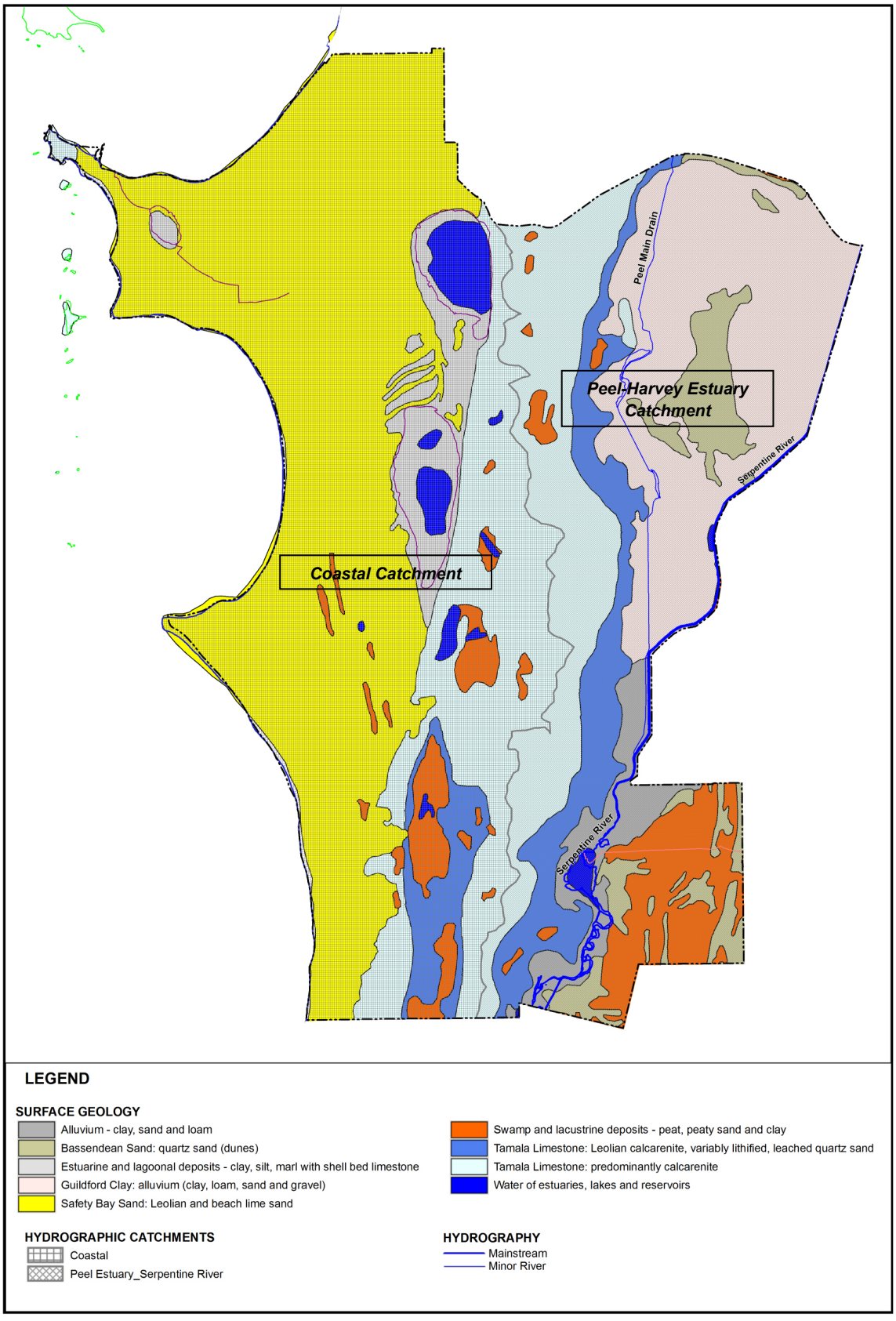
10. Authority

All development proposals shall have due regard to the information presented in this Planning Procedures to ensure compliance with the objectives specified in *Planning Policy 3.4.3 – Urban Water Management.*

11. Adoption

This Planning Procedure was endorsed by the Director, Planning and Development Services on March 2019.

APPENDIX 1: REGIONAL CONTEXT



APPENDIX 2: WSUD BEST MANAGEMENT PRACTICES

BMP	Scale			
	Lot	Street	Subdivision	Regional
Stormwater Storage & Reuse				
Managed Aquifer Recharge			✓	✓
Harvesting	✓	✓		
Rainwater Tanks	✓			
Infiltration Systems				
Soakwells	✓	✓		
Underground Storage		✓	✓	
Pervious Paving	✓	✓		
Trapped Drainage Pits		✓	✓	
Drainage Basins			✓	
Conveyance Systems				
Living Stream			✓	✓
Vegetated Swales	✓	✓	✓	✓
Kerb Treatments (e.g. flush)		✓		
Detention Systems				
Ephemeral Detention Basins			✓	
Green Roofs/Walls	✓			
Pollutant Control				
Gross Pollutant Traps	✓	✓	✓	
Hydrocarbon Management (e.g. Oil-Water Separators)	✓	✓		
Biofiltration				
Basins			✓	
Rain Gardens	✓	✓	✓	
Tree Pits	✓	✓		
Median Swales		✓	✓	