Capel Townsite

District Water Management Strategy

Prepared for Shire of Capel
May 2013

Cardno
Shaping the Future

Capel Townsite District Water Management Strategy

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1 Introduction

In response to substantial population growth the Shire of Capel (SoC) has recently produced a *Capel Townsite Strategy* and *Capel Local Structure Plan* (LSP), pursuant to the *Shire of Capel Town Planning Scheme No. 7* (SoC 2007).

The Capel Townsite (study area) is located approximately 200km southwest of Perth, within the south-western corner of the SoC and is bounded by Bussell Highway to the west, the Capel Nature Reserve to the southwest and rural hinterland to the north and west. The locality of the study area is shown within **Figure 1.** An aerial photograph illustrating the current townsite and cadastral boundaries is shown in **Figure 2**. The Capel Townsite is intersected by the Capel River and is a component of the Geographe Bay Catchment.

It is important that the manner in which stormwater runoff from urban zoned areas are to be managed to avoid flooding and protect the environment are clearly documented early in the planning process to provide the framework for actions and measures to achieve the desired outcomes at subdivision stage. The development of a District Water Management Strategy (DWMS), with the provision of groundwater data, is considered to be the appropriate mechanism to establish the concept designs and management measures for flood mitigation and effective stormwater management for the *Capel Townsite Strategy* and *Capel Structure Plan* (SoC 2008).

Whilst the majority of the study area has been developed for urban purposes including residential, industrial and recreational uses, significant land parcels in the south-east of the study area remain undeveloped and are the subject of current planning processes. Changing land uses from rural to urban can have implications for the types and quantity of pollutants released to local surface and groundwater, which can in turn affect the ecological health of downstream receiving environments.

This DWMS aims to outline the water management strategies most appropriate for the environmental constraints and opportunities of the study area.

1.1 Principles and Objectives

The purpose of this DWMS is to provide guidance in the preparation of LWMS's and UWMP's and to demonstrate that the water resources in areas to be developed can be managed in such a way that the risks posed to water resources by development and to the development by the surface water and groundwater characteristics of the proposed development are acceptable.

To establish the key principles and objectives to guide the urban water management across the Capel Townsite, guiding documentation from a number of sources were consulted. The relevant State Government policies include:

- *State Water Strategy* (Government of WA 2003).
- *Planning Bulletin No. 64: Acid Sulphate Soils* (WAPC 2007).
- *Environmental Protection (Swan Coastal Lakes) Policy* (Government of WA 1992).
- *Draft Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2005).
- *Greater Bunbury Region Scheme* (Government of WA 2007).
- *Statement of Planning Policy No. 2: Environment and Natural Resource* (WAPC 2003).
- *Statement of Planning Policy No. 2.9: Water Resources* (WAPC 2006).
- *Statement of Planning Policy No. 3: Urban Growth and Settlement* (WAPC 2006).

In addition to the above policies, there are a number of published guidelines and standards regarding the water discharge characteristics that urban development should aim to achieve. These are key inputs that relate either directly or indirectly to the Capel Townsite and include:

> National Water Quality Management Strategy (ANZECC 2000).

> Liveable Neighbourhoods Edition 4 (WAPC 2007).

> Better Urban Water Management (WAPC 2008).

> Stormwater Management Manual for Western Australia (DoW 2007).

> Development of Sampling and Analysis Programs (DoE 2001).

> Geographe Bay Coastal Catchment Land Capability Assessment for Managing the Impact of Land Use Change on Water Resources (Acacia Springs et al. 2005).

> Draft Water Quality Improvement Plan (WQIP) for the Vasse Wonnerup Wetlands and Geographe Bay (DoW 2009).

> The Impact of Residential Urban Areas on Groundwater Quality: Swan Coastal Plain, Western Australia (Gerritse et al. 1990).

> Stormwater Management Guidelines – Capel Townsite CBD (Opus 2007).

> Capel River – Surface Water Management (Beckwith Environmental Planning 2006).

> Capel Town Site Strategy (SoC 2008).

2 Proposed Development

The *Capel Townsite Strategy* (SoC 2008) sets out the long-term planning directions for the Capel Townsite, applies State and regional planning policies, and provides the rationale for the zones and other provisions.

Planning at a local level is guided by the higher level strategic planning (at both Regional and District levels). The *Capel Townsite Strategy* is a formal policy pursuant to the *Shire of Capel Town Planning Scheme No. 7* (SoC 2007) and is intended to further detail developments outlined in the Regional and District planning process.

The *Capel Townsite Strategy* has been developed based on environmental, geotechnical and hydrological considerations and encompasses the principles and objectives outlined in the *Shire of Capel Land Use Strategy* (SoC 1999) and the Scheme. The key elements of the *Capel Townsite Strategy* include:

> Expanding the facilities and support services provided to the community to cater for an approximate threshold of 8000 people.

> Expanding industrial and commercial precincts to provide additional employment opportunities.

> Providing explicit townsite boundaries to ensure a compact and well integrated townsite that also protects surrounding mining and agricultural interests and environmental assets.

> Progressive development of the townsite through the increase of residential densities, urban infill and short-term, medium-term and long-term urban expansion.

2.1 Local Structure Plan

The currently proposed Capel LSP is shown in **Appendix A.** This is the proposed land use layout upon which this DWMS has been formulated.

Development of the townsite will progress at a number of distinct spatial and temporal scales. Urban infill areas are anticipated to be developed within 10 years. Some larger Greenfield sites are expected to begin development within approximately 5 years, while others are not estimated to begin for another 20 years. For the purpose of this DWMS, the development categories for the townsite expansion are:

> Small urban infill developments of less than five lots.

> Urban infill developments of greater than five lots (include the areas labelled in the LSP as Urban Infill A, B, C and D).

> Greenfields developments (labelled in the LSP as ST1, ST2, MT1, MT2, LT1, LT2, LT3 and the South East Capel Structure Plan).

> Industrial Greenfield development (labelled in the LSP as MT3).

> Commercial infill developments.

All developments within the townsite are expected to follow the water management philosophy detailed within this DWMS. However, it is not always practical to require the same design criteria and management measures of a small urban infill development as a Greenfield development. Design criteria given in **Section 4** and management measures in **Sections 5**, **6, 7**and **8** outline the general philosophy for the site, but also provides guidance differentiating design criteria and management measures required for each of the five development scales. It may be appropriate for some urban infill developments to have the same design criteria and compliance requirements as small urban infill developments of less than five lots. Any change to the design criteria and compliance requirements of new urban infill developments that contain close to five lots shall occur at the discretion of the SoC.

3 Pre-development Environment

3.1 Climate

The Capel region experiences a Mediterranean climate, which is characterised by a hot dry summer period (November to April) and mild wet winters (June to September). The average annual rainfall is 810mm, normally received between April and November (BoM 2010). Rainfall varies from the coast to the headwaters, with approximately 90% falling between April and October (BoM 2010).

3.2 Geotechnical

3.2.1 Topography

The study area gently slopes towards the Capel River. Topographic contours indicate that the surface elevation generally slopes downwards towards the west. The site surface elevation is approximately 16m Australian Height Datum (AHD) around the southern and eastern perimeter of the study area, falling to 12m AHD adjacent to Bussell Highway. The topographic contours of the study area are shown in **Figure 3.**

3.2.2 Regional Geology

The Capel Townsite is situated within the Perth Basin, approximately 6km west of the Whicher Scarp (Churchwood and McArthur 2008). The Whicher Scarp is a feature of erosion that represents the inland limit of marine transgressions in the early Pleistocene to late tertiary period.

The superficial sediments of the Perth Basin consist of coastal dune, beach, shallow marine and alluvial deposits from the Pleistocene to recent periods. They discontinuously overlie Mesozoic sequences, principally the Leederville Formation and are referred to colloquially as basement sequences (Churchward and McArthur 2008). The key elements of the geological profile that are located within and surrounding the study area include:

> Colluvial Deposits: these deposits are typically 1m - 2m thick and consist of mostly fine to silty, poorly sorted sand.

> Guildford Formation: is generally 8m - 10m thick and is characterised by heavy brown and grey mottled clay and sandy clays.

> Unconformity (a break in the sequence of strata that represents a period of time when no sediment was deposited): erosional surface caused by marine transgression.

> Leederville Formation: this formation typically consists of cretaceous sediments characterised by brown, fine to medium sand with traces of weathered feldspar.

Soils

The Capel Townsite is comprised of four landform units are shown in **Figure 4** and these include the Pinjarra system, Bassendean system, Abba system and Spearwood system. These are further described in the following paragraphs.

The Pinjarra system land unit is associated with the Capel River and adjoining areas and is largely poorly drained alluvium over sedimentary rocks. This land unit also forms the primary land unit system to the north east of the study area. The soils vary from semi-wet soils, grey deep sandy duplexes, brown loamy earths, pale sands and clays. The soil units located within the study area that are associated with the Pinjarra system are:

> P10 – comprised of non-saline waterlogged soils located within the Capel River channel.

> P6c – located within the southern exterior of the study area and characterised by brown loam over clay.

> P1a – typically grey sand over non-alkaline clays, located within the northern extent of the study area.

The Bassendean land unit extends either side of the Pinjarra system associated with the Capel River. This system is associated with the existing southern and eastern portion of the town and is comprised of the following soil units within the study area:

> B1, B1a, B1b and B2 – these soil units are characterised by well drained, pale deep sands.

> Bw – occurs sporadically within the study area and is typified by non-saline waterlogged peaty soils.

The Abba system is associated with the Capel River and the adjoining floodplain. Within the study area, it is generally prevalent within the south and southeast and is comprised of the following soil units:

> ABw – poorly drained flats and depressions with wet to semi wet soils.

> AB1 – very low rise plains of a semi-wet nature with pale deep sands.

The Spearwood system is located within the northern and north-western extent of the study area. The soil units identified within the study area that are associated with the Spearwood system include:

> S2b – generally comprised of lower slopes of dune ridges with occasional limestone outcrops, shallow to deep yellow-brown sands.

> S4b – flat to gently undulating sand plain typified by moderate deep yellow brown and grey-brown sands.

Twenty-two groundwater monitoring bores were installed by Cardno within the study area. The lithology of the soil profile and depth to groundwater was documented during bore construction. The soil bore logs are shown in **Appendix B**. The important feature to note on these profiles is the depth to the clay profile, which is shown in Figure 5. Local testing has founds soils with a permeability of 7.2×10^{-2} mm/hr (*Pers Comm.* Bob Evans 14/12/2010). However, clay soils typically have low infiltration rates, ranging from 10^{-6} – 10^{-2} mm/hr (Fetter 2001) and reinforces the need for geotechnical investigations (see **Section 9.1**).

The classification of these clay soils is an important consideration for future Local Water Management Strategy (LWMS) and Urban Water Management Plan (UWMP) documents because of the restrictions to development caused by reactive soils (see Australian Standards 2870-1996). Geotechnical investigations should be conducted prior to development to determine the site specific depth to clay and the infiltration rates across the site.

3.2.3 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are naturally occurring soils that contain iron pyrite minerals. If disturbed by dewatering, drainage or soil excavation, the pyrites can oxidise and release acids. An overview of the ASS risk potential on the Swan Coastal Plain is provided in the *WAPC's Planning Bulletin Number 64* (WAPC 2007). A review of the mapping revealed that the soils underlying the Capel tonwsite generally have a "moderate to low risk of ASS occurring within three metres of the natural soil surface". The Capel River and adjoining riparian zones are classified as having a "high to moderate risk of ASS occurring within three metre of the natural soil surface". The ASS risk mapping for the study area is shown in **Figure 6.**

The DEC's guideline *Identification and Assessment of Acid Sulphate Soils* (DEC 2004) included the following environmental features relevant to the study area as locations where ASS is known to have developed or have the appropriate combination of environmental factors to promote the development of ASS:

> Areas depicted on geology and/or geomorphological maps as geologically recent (Holocene) such as wetlands, floodplains and waterlogged areas.

> Areas depicted in vegetation mapping as wetland dependant vegetation such as reeds and paperbarks (Melaleuca spp.) and areas where the dominant vegetation is tolerant of salt, acid and/or water-logging conditions (e.g. swamp-tolerant reeds, rushes and paperbarks).

> Areas depicted in geological descriptions or in maps as bearing sulphide minerals.

> Areas known to contain peat or a build up of organic material.

> Areas where the highest known watertable is within 3.0m Below Ground Surface (BGS).

> Any areas in Western Australia (including inland areas) where a combination or all of the following pre-disposing factors exist: organic matter, iron minerals, waterlogged conditions or a high watertable and/or sulphidic minerals.

During a desktop assessment of the study area the presence of a number of the above characteristics were identified, however a recent site inspection (September 2009) indicates that these characteristics are primarily associated with the Capel River and the adjoining riparian zone. This denotes that the majority of the study area proposed for further development is likely to be categorised as having little to no risk of ASS occurring within 3.0m BGS.

3.3 Flora

The Capel Townsite lies within the Drummond Botanical Subdistrict of the south-western Botanical Province as recognised by Diels (1906) and later developed by Gardner (1942) and Beard (1979 and 1980). Beard (1990) described the Drummond Botanical Subdistrict as being a low-lying coastal plain with sandy soils and swampy deposits and having a warm dry Mediterranean climate. Vegetation of the Drummond Botanical Subdistrict is typically Banksia low woodland on leached sands, Melaleuca wetlands in areas of poorer drainage and *Eucalyptus gomphocephala* / *E. marginata* / *Corymbia calophylla* woodlands on soils with a higher nutrient content (Beard 1990).

The *Capel River Action Plan* (White and Comer 1999) involved an assessment of the vegetation communities adjacent to and surrounding the Capel River. Based on the findings of the assessment four distinct vegetation communities were identified and can be described as follows:

> Flooded gum Eucalyptus rudis woodland over Astartea fascicularis, swamp peppermint Agonis linearifolia scrub – this community type is restricted to the riparian fringe and low lying areas.

> Marri Corymbia calophylla forest over soapbush Trymalium florbundum, heart-leaf poison Gastrolobium bilobum scrub and sword-sedges Lepidosperma species – this community type is generally located a marginal distance from the riparian fringe.

> Agonis flexuosa, marri Corymbia calophylla woodland – this community is generally found in the middle and lower reaches of the Capel River.

> Freshwater paperbark Melaleuca rhaphiophylla, flooded gum Eucalyptus rudis open woodland – this community type is generally located along the lower reaches of the Capel River.

The majority of the study area is either developed for residential and industrial uses or cleared and partly cleared for agriculture. The most significant vegetation found within the study area is that along the foreshore of the Capel River (see **Figure 2**) The majority of this has been zoned multiple use foreshore reserve within the *Capel Townsite Strategy Structure Plan* (see **Appendix A**).

3.4 Fauna

A search was undertaken of the *Department of Environment and Conservation's Threatened Fauna Database* which includes species that are declared as 'Rare or likely to become extinct' (Schedule 1), 'Birds protected under an international agreement' (Schedule 3) and 'Other specially protected fauna' (Schedule 4). In addition, a search was also performed of the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) *Protected Matters Database* (Commonwealth of Australia 1999) which allows for the protection of fauna at a species level, described as 'Critically Endangered', 'Endangered' or 'Vulnerable'. There were 21 species identified in the database searches, the majority of which are bird species. The majority of the species identified are recorded as being unlikely to occur in the study area. Conservation significant vertebrate species potentially occurring within the subject site are provided in **Appendix C**, with a brief description on the potential for each of the species to be present in the subject site.

3.5 Environmental Assets

The Capel River is a key feature of the Capel Townsite and is the largest and only non-ephemeral river within the Geographe Bay catchment area. Due to its regional significance, the Capel River has been classified as a preliminary ecological linkage within the *Greater Bunbury Region - Ecological Linkages Plan* (EPA 2003).

The *Capel River Action Plan* (White and Comer 1999) provided an assessment of the riparian vegetation bordering the Capel River. This resulted in a 'C' classification denoting that the river is eroded and infested with invasive weed species. Subject to this finding, a large proportion of the Capel River riparian and floodplain zones have been identified for foreshore protection within the *Greater Bunbury Region Scheme* (WAPC 2007) and *Capel Townsite Strategy* (SoC 2008). Within the study area, the Capel River is also protected by a Public Foreshore Reserve which encourages recreational activities and provides preservation of local native riparian species.

The study area contains a series of wetlands (**Figure 7**). The *Geomorphic Wetlands Database* (WALIS 2007) dataset indicates that four Resource Enhancement wetlands (REW) and 13 Multiple Use wetlands (MUW) encompass the extent of the study area (refer to **Table 1**). Many MUWs occur on private land and whist some are in poor condition they provide important functions within the natural drainage system by assisting in the mitigation of flood flows and reducing nutrient and sediment transportation. Wetlands that are designated REWs usually have some native vegetation remaining but are also often used for grazing and/or agistment. Given that much of the study area features clayey soils (denoting soils with a low permeability), stormwater drainage and infiltration will need to be given careful consideration prior to construction to ensure that potential impacts (e.g. erosion, localised flooding) to the Capel River and surrounding wetlands are avoided.

Table 1 Geomorphic Wetlands

Wetland Category	UFI Indicator
Resource Enhancement	683, 680, 681, 792
Multiple Use	682, 685, 794, 795, 797, 798, 799, 800, 801, 802, 804, 827, 15213

The Capel Nature Reserve lies immediately south-west of the study area and is classified as an 'A' class reserve for the purposes of protection of declared rare and priority flora and threatened ecological communities (Commonwealth of Australia 1999).

Other areas of important remnant vegetation exist throughout the study area which contains some areas of intact native vegetation. Given the extensive clearing that has already occurred throughout the region these areas of high conservation value (and of poorly represented vegetation complexes) have been identified for conservation pursuant to the *Shire of Capel Town Planning Scheme No. 7* (SoC 2007) and the *Greater Bunbury Region Scheme* (WAPC 2007).

3.6 Hydrology

A DWMS requires a good understanding of the quantity and quality of the surface water across and the groundwater beneath the study site. A sound understanding of the site hydrology enables appropriate management strategies to be determined.

The groundwater levels across the site are required to determine the most appropriate post-development land use (e.g. areas with shallow water table are more suitable for Public Open Space (POS) than for dwellings or flood storage).

The quality of the groundwater leaving the site will affect the environmental health of the surface water body it drains into, as does the quality of the surface runoff. Understanding the quality of this water is the first step to managing it to acceptable water quality standards.

The quantity of the surface runoff is the most visually obvious constraint to management, yet it should be considered equally as important as the groundwater quantity and quality, and surface water quality. The management of surface runoff rates and volumes are important to protect areas from flooding and from potential erosion.

3.6.1 Surface Water Quantity

An understanding of the existing surface runoff throughout a proposed development site is required, so that an effective post-development stormwater management strategy can be designed. In the regional context, the surface runoff from the site will flow in a westerly direction. With the exclusion of the Capel River, the study area is predominantly at the top of the catchment, with very little inflows from upstream catchments.

The stormwater and drainage systems located within the Capel Townsite have been developed over many years and involve a combination of pipe systems and vegetated open channels. Drainage infrastructure is implemented in the study area in accordance with the *Report on Capel Townsite - Drainage Strategy* (SoC 2007). Additional information pertaining to the existing drainage infrastructure within the Capel Townsite is available in the *Capel Townsite Drainage Plans* (Cardno 2009).

The dominant feature of the Capel drainage system is the Capel River and the associated natural inflow water channels. The majority of stormwater discharge is currently directed into the river and inflow channels with limited nutrient or pollutant removal. There are however, some roadside swales that provide detention and removal of sediments within the special residential zone.

Land in the south-west of the town, including the industrial area, drains to the west of Bussell Highway (SoC 2008). At present this drainage lacks effective piping or treatment.

The surface water runoff is estimated using the *Capel Townsite Drainage Plans* (Cardno 2009) and accurate data on topography, infiltration rates and vegetation.

3.6.1.1 Capel Townsite Pre-Development Modelling

The Capel Townsite is divided into a total of 56 pre-development catchments, as shown in **Error! Reference source not found.**, which covers an area of 1150ha. Catchment characteristics such as slope and area are provided in **Appendix D**, together with a full description of the modelling methodology.

A multi-storm analysis for the 5 year and 100 year Average Recurrence Interval (ARI) storm events was conducted in XPSWMM. This was conducted in order to determine the critical duration event that produces the largest peak discharge from each catchment. The peak discharge flow rates for each catchment are provided in **Appendix D**. Stormwater flowpaths within the study area are shown in **Figure 8.** Peak flows discharging from the study site as well as six key culverts have been provided in **Table 2**. The location of these discharge points and culverts are shown in **Figure 9.**

Table 2 Pre-Development Discharges Exiting the Site and Exiting Culverts

Discharge Point	1 year – 1 hour ARI Peak Discharge (L/s)	5 year ARI Peak Discharge (L/s)	100 year ARI Peak Discharge (L/s)
Catchment CC	89	140	256
Catchment DD	41	158	284
Catchment B	52	96	194
Catchment C	56	191	395
Catchment D	235	485	937
Culvert 2	419	1851	3510
Culvert 3	663	2410	4500
Culvert 4	728	2678	4796
Capel River*	808	4714	9573
Catchment VV	83	219	570
Culvert 1	618	1297	2568
Culvert 5	725	1667	3123
Culvert 6	493	1082	2146
Catchment EEE	13	19	44
Catchment MM	0	24	58
Catchment W	1456	3458	7241

* This is the total runoff within the river, excluding any baseflow from upstream catchments.

3.6.1.2 Major Flood Event Mapping

The Department of Water have recently prepared the *Capel River 100 Year Flood Analysis* (2009) which illustrates the 100 year flood level within the Capel River. In general, the floodplain has been bounded by the foreshore reserve of the LSP and follows the 6m AHD topographic contour line. **Figure 8** shows the 100 year floodway mapping.

3.6.2 Surface Water Quality

Measuring the water quality of the surface runoff from the study area is difficult as the runoff is sheet-flow; there are few defined channels or drains collecting the runoff for it to be sampled. Another alternative is to measure the water quality of the receiving water body, both upstream and downstream of the study area.

A study into the water quality of the Capel River was conducted in 1999 where samples were collected upstream and downstream of the Capel Townsite (White and Comer 1999). The results of a regular water quality program within the Capel River have recently been summarised in the *Vasse Wonnerup Wetlands and Geography Bay: Water Quality Improvement Plan* (DoW 2010). The following paragraphs summarise the results of these studies.

The pH measurements recorded for the Capel River between 1996 and 1998 were generally within acceptable criteria (White and Comer 1999). Results for conductivity within the Capel River illustrated a pattern similar to many southwest waterways. Water was moderately brackish during the summer months and it became increasingly brackish with the onset of the first winter rains. Conductivity typically decreased over the course of the winter as salts were diluted by fresh rainwater. From spring to the end of the year, conductivity steadily increased in response to evaporation which concentrates existing salts in the water column.

Turbidity measurements recorded for the Capel River between 1997 and 1998 indicated low to moderate readings, reflecting relatively stable conditions in the water (White & Comer 1999). The median winter concentrations of phosphorus and nitrogen for the 1998 to 2007 period were below the default trigger values for lowland rivers (DoW 2010).

It is important that the proposed development prevents further degradation of these water bodies, by utilising strategies to manage nutrient use and exportation from the study area (DoW 2010). The water quality management strategies to be implemented in SoC are detailed in **Section 6.2** and **Section 7.2**.

3.6.3 Groundwater Levels

The study area lies within the Capel – Ludlow Subarea of the Busselton – Capel Groundwater Area (Hirchberg, 1989). The typical hydrology of the area consists of a superficial aquifer containing unconfined groundwater at a depth of between 2m – 4m BGS. Recharge to the aquifer is predominantly from downward infiltration of rainfall and flow is northwest towards the coast.

Directly underlying the superficial aquifer and separated by a consolidated layer of limestone is the Leederville Aquifer. Near Ludlow this aquifer is thought to be between 70m – 100m deep. The Yarragadee Aquifer lies below the Leederville and can be described as a confined aquifer to a maximum depth of 1400m in the east. The flow pattern for groundwater within this aquifer is similar to the overlying aquifers, with flow trending towards the coast.

Two registered bores located approximately 5km from the study area were identified through search of the DoW *Registered Groundwater Bore Database.* The groundwater bores, BN6S and EW6, are superficial bores located to the southeast and south of the study area, respectively. Measurements from bore BN6S are available from 1987 to 2009 and they indicate that groundwater levels fluctuate between 10.4m AHD and 8.6m AHD. Further south, bore EW6 has records from 2007 to 2008 which demonstrated a seasonal variation between 24.4m AHD and 22.2m AHD. A summary of the data previously recorded from these bores is documented in **Appendix E**.

Monthly groundwater level monitoring is currently being conducted by the Shire at 22 bores installed by Cardno within the study area. This will continue for a period of 18 months. The bores were installed with 3m of slotted screens to a depth greater than 2m below the groundwater level to ensure seasonal variation is captured. To date, monitoring has captured one winter peak, with measurements indicating that maximum groundwater levels within the townsite occur in October.

The measured maximum groundwater levels (MGLs) and corresponding depths to groundwater for the 22 bores installed by Cardno are shown in **Table 3.** It is not possible to calculate the AAMGL through correlation with long-term DoW bore data because these bores were not operational during October 2009. At the conclusion of the monitoring period, two winter peaks would have been recorded, which will provide clearer broad scale MGLs for the site. It would be advantageous for bore BN6S to be recommissioned to provide comparable long-term data during the planning of future developments. However, it is also important to note that correlation of local groundwater levels with regional levels is less precise in clay soils due to the possibility of measuring perched groundwater instead of the actual permanent groundwater layer.

Table 3 Measured Maximum Groundwater Levels and Corresponding Depth to Groundwater (October 2009)

Bore ID	MGL (mAHD)	Depth to Groundwater (m)
SC1	6.16	6.16
SC2	5.40	7.41
SC3	7.54	4.56
SC4	6.28	6.85
SC5	12.63	1.40
SC6	12.33	4.80
SC7	13.45	0.24
SC8	12.87	0.10
SC9	12.62	0.79
SC10	15.22	0.39
SC11	14.74	0.66
SC12	12.99	0.67
SC13	17.02	0.88
SC14	19.13	4.33
SC15	23.82	0.34
SC16	19.55	2.02
SC17	15.17	1.56
SC18	14.84	1.48
SC19	5.13	9.86
SC20	14.27	0.44
SC21	13.59	0.93
SC22	10.69	0.94

The locations of the groundwater monitoring bores, measured MGLs and corresponding depth to groundwater levels are shown in **Figure 9.**

3.6.4 Groundwater Quality

At the date of production of this report there has been one groundwater investigation conducted by Cardno for groundwater quality in the study area. The single occasion groundwater quality investigation was conducted on the 15th and 16th of June 2010 at the 22 groundwater bores described above. Results from this monitoring occasion are provided in **Appendix F**.

In order to provide an indication of the relative concentrations of nutrients and physio-chemical parameters within groundwater, comparison with the default trigger values for slightly disturbed ecosystems for lowland rivers in South Western Australia (ANZECC 2000) are made in the following sections.

The default trigger values are applicable to concentrations within surface water features and are thus not specifically intended for application to groundwater concentrations. However, as there are no nationally published trigger values available for groundwater quality, a comparison of nutrient concentrations and physio-chemistry parameters within groundwater are made to the default trigger values to provide some context to the measured concentrations.

Discussion of nutrient concentrations will refer to their relative concentration in comparison to the default trigger values. The terms ‘Low’, ‘Moderate’, ‘High’ and ‘Very High’ are used in the following manner:

> 'Low' – nutrient concentration below, equal to or marginally above the default trigger value.

> 'Moderate' – nutrient concentration up to 5 times the default trigger value.

> 'High' – nutrient concentration between 5 and 10 times the default trigger value.

> 'Very High' – nutrient concentration more than 10 times the default trigger value.

Three bores (SC7, SC8 and SC9) within the study site displayed 'Low' levels of Total Phosphorus (TP), whereas many of the remaining bores had 'Very High' TP concentrations. Total Nitrogen (TN) was also 'Moderate' to 'High' amongst many of the bores. Four bores (SC5, SC14, SC21 and SC22) had pH levels within the desired range, with all other bores having lower (more acidic) water quality. Dissolved Aluminium, Copper, Nickel and Zinc were also elevated at a number of bores. Bores SC2, SC11, SC13, SC14, SC17 and SC22 were found to exceed dissolved metal trigger values for two or more metals.

3.7 Summary of Existing Environment

In summary, the environmental investigations conducted to date indicate that:

> Topographic contours indicate that the surface elevation generally slopes downwards towards the west. The site surface elevation is approximately 16m AHD around the southern and eastern perimeter of the study area, falling to 12m AHD adjacent to Bussell Highway.

> The landform systems associated with the study area include Pinjarra, Bassendean, Abba and Spearwood with many of these featuring shallow clay profiles.

> There is a moderate to low risk of ASS occurring within three metres of the natural soil surface across the Capel Townsite and a high to moderate risk of ASS occurring near the Capel River.

> Surface runoff flows in a westerly direction towards the Capel River with very little inflow from upstream catchments.

> Vegetation typically found within the site comprises of Banksia low woodland, Melaleuca wetlands and *Eucalyptus gomphocephala* / *E. marginata* / *Corymbia calophylla* woodlands.

> Twenty-one significant vertebrate species potentially exists within the site.

> The peak flows have been determined for every catchment within the study area, as well as the discharge points from the site and six culverts (**Figure 8**).

> Water quality within the Capel River is generally within guidelines.

> Maximum groundwater levels underlying the site are between 0.1m and 9.86m BGS.

> Nutrients and dissolved metals were found to exceed trigger values at a number of groundwater bores throughout the study area.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this DWMS and future management strategies must achieve. The objectives and design criteria are both general water management philosophies that reflect state-wide principles and are site specific, taking into account the local environment. The water management strategy covers all aspects of water use, including stormwater management, groundwater management and water consumption.

4.1 Water Conservation

It is widely thought that the local climate is undergoing a drying trend, and that as the Shire's population grows and demands for potable water sources increase, significant attention should be focused on the manner in which the resources currently available are utilised.

This consideration is acknowledged and therefore use of water within the development will be minimised wherever possible. This can be accomplished through minimising water requirements within POS areas. In this regard, the DoW recommends a target of 7500kL/ha/year of water be adopted for irrigation of POS areas.

Individual households can also contribute to water conservation. The state water strategy has set a water consumption target of 100kL/person/year (total household consumption). Compliance with this target is required by the Shire of Capel and further detail concerning the implementation of this target is provided in **Section 5**.

4.1.1 Design Criteria

The design objectives for water conservation are:

> Minimise water requirements for establishment of POS.

> Minimise water requirements for POS maintenance.

> Achieve a target of 7500kL/ha/year of water is used for irrigation of POS areas.

> Minimise net use of water by maximising fit-for-purpose use.

> Achieve a water consumption target of 100kL/person/year (total household consumption).

Small urban infill developments of less than five lots and some urban infill developments are not anticipated to contain POS areas. In this instance, all design criteria pertaining to water conservation within POS are not applicable. These criteria are also not applicable for commercial infill developments that do not contain POS areas. The household water consumption target applies to all development categories, though demonstration of compliance for small urban infill developments, commercial developments and the industrial Greenfield development shall differ, as detailed in **Section 5**.

4.2 Groundwater Management

Developments have the potential to alter groundwater levels through a combination of reduced infiltration capacity (more impermeable areas such as roads and houses) and altered extraction rates (bores used for irrigation and reduced uptake due to tree clearance). It is important that the pre-development groundwater levels are maintained as any alteration could impact on the environment; particularly for downstream surface water body recharge and to support groundwater ecosystems.

Given that residential developments can have implications for the types and quantity of pollutants released to the local surface water and groundwater, and that the work undertaken to develop the land has the potential to mobilise nutrients introduced by former land uses, it is important that groundwater is adequately managed to minimise the risk to downstream receiving environments.

The *Stormwater Management Guidelines - Capel Townsite* (Opus 2007) has provided an overarching philosophy for groundwater management in the Capel Townsite. These have been considered during development of the criteria proposed in **Section 4.3.1**.

4.2.1 Design Criteria

The adopted principles for best practice management of groundwater levels and quality are:

> Minimise changes to the underlying groundwater levels as a result of development.

> Habitable floor levels should have a clearance from the Annual Average Maximum Groundwater Level (AAMGL) or Controlled Groundwater Level (CGL) of at least 1.2m.

> Where subsoil drainage is proposed, the CGL can be set equal to the AAMGL or at the clay layer where the AAMGL is below the clay layer.

> Habitable floor levels should have a clearance from the phreatic groundwater surface of at least 0.8m.

> Minimise the risk of nutrient enrichment of the Capel River and other downstream receiving surface water bodies from groundwater sources.

> The groundwater leaving the study area should at least be the same, or better, than the water entering the study area.

As indicated, small urban infill developments of less than five lots, some urban infill developments and some commercial infill developments are not anticipated to include POS. Additionally, it is unlikely that groundwater monitoring bores will be installed for small scale and single lot developments making it difficult to demonstrate compliance with criteria concerning groundwater quality (see **Section 10** for more information regarding groundwater monitoring). Therefore, whist these developments are not required to demonstrate compliance with the design criteria that requires groundwater leaving the study area to be "at least the same, or better, than the water entering the study site," developers must be able to demonstrate that treatment of groundwater runoff and/or groundwater leaving the site has been considered.

4.3 Stormwater Management

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DoW 2007); with the *Decision Process for Stormwater Management in WA* (DoW 2009) providing guidance as to how urban development can achieve compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual of WA*. The above documents and the *Stormwater Management Guidelines - Capel Townsite CBD* (Opus 2007) provide guidance to define the specific objectives and design measures for stormwater management within the townsite.

4.3.1 Stormwater Quality

Water quality treatment systems and water sensitive urban design structures must be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW 2007) and *Australian Runoff Quality* (Engineers Australia 2006). *Better Urban Water Management* (WAPC 2008) advocates a water quality management principle where existing surface and groundwater quality be maintained as a minimum, and preferably improved prior to discharge from the development area. Through consideration of these guidelines, the primary objective for the Capel Townsite is to avoid further deterioration of water quality within the Capel River.

4.3.1.1 Design Criteria

The key design criteria that will be adopted to maintain stormwater quality include:

> Treat all runoff prior to discharge by retaining the 1 year – 1 hour ARI events on site as close to source as possible.

> Apply appropriate structural and non-structural measures to reduce applied nutrient loads.

> Where surface water quality treatment is used, the surface area of bio-treatment structures should be a minimum of 2% of the connected impervious area.

> Surface water quality treatment structures should not be located within the foreshore reserve.

In addition to the general criteria above, all Greenfields developments and the industrial Greenfield developments are required to treat runoff with Gross Pollutant Traps (GPTs) prior to discharge to basins or offsite. Commercial infill developments are required to treat runoff with sediment traps prior to discharge into the council system.

4.3.2 Stormwater Quantity

Stormwater retention and detention structures must be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW 2007) and *Australian Rainfall and Runoff* (Engineers Australia 1997). In addition, structures must comply with current SoC Drainage Policies.

4.3.2.1 Design Criteria

The key design criteria that will be adopted to manage stormwater quantity include:

> Retain the 1 year – 1 hour ARI event on site, preferably as close to source as possible.

> Detain flows from the 5 year ARI storm event through to the 100 year ARI storm event to maintain pre-development peak flow rates.

> Minor roads remain passable in the 5 year ARI storm event.

> Major roads remain passable during 100 year ARI storm event.

> Habitable floor levels should have a clearance from the 100 year ARI water level in flood detention structures and the Capel River of 0.5m.

> Habitable floor levels should have a clearance from the 100 year ARI water level within roads of 0.3m.

Small urban infill developments, some smaller urban infill developments and commercial infill developments are not anticipated to contain POS areas and are unlikely to accommodate flood detention structures within the development area. Those developments that do not contain POS are consequently not required to "detain flows from the 5 year ARI storm even through to the 100 year ARI storm event." Stormwater quantity criteria regarding the possibility of minor roads and major roads are not applicable to developments that do not contain any road reserves.

5 Water Conservation Strategy

5.1 Water Source Allocation, Infrastructure and Fit-for-purpose

Water is a valuable resource that must be managed sustainably. Conservation of water through fit-for-purpose use and best management practices is encouraged so that water is not wasted. The term fit-for-purpose describes the use of water that is of a quality suitable for the required use of that water. Further consideration of fit-for-purpose principles is required during the LWMS and UWMP stages.

5.1.1 Scheme Water

The townsite has access to a reticulated water supply drawn from the Yarrigadee aquifer by the Water Corporation (SoC 2008). The bore currently operates at approximately 60% capacity and as such, the Water Corporation is proposing to construct a new bore during the following 5 years to supply future demand.

Scheme water shall be supplied and utilised by all new developments. However, conservation of the potable scheme water can be achieved by using lower quality water such as groundwater, recycled water or grey water for uses that do not require high quality water e.g. irrigation, toilets, washing machines etc. In addition, the Shire of Capel has advised that scheme water cannot be utilised to irrigation POS areas (p*ers. comm.* Bob Evans, 10/12/10).

5.1.2 Groundwater

Enquiries with the DoW indicate that the townsite is located within the Busselton Capel groundwater area, and the Busselton Capel sub-area. Within this sub-area the superficial aquifer is 64% allocated and requested, with approximately 2,423,010kL available (*Pers. Comm.* B. McCawley 25th June 2010).

It is recommended that groundwater be utilised for the irrigation of POS areas, which shall decrease the overall scheme water use and is an appropriate fit-for-purpose application. Unfortunately, some POS areas may be unable to utilise groundwater for irrigation due to the variable quantity and quality of groundwater underlying the Capel Townsite. In these instances alternative approaches to landscape design may need to be considered and would need to be approved by the Shire. The appropriate approvals for allocation and bore construction should be sought from DoW.

It is possible for groundwater to supplement lot scale outdoor irrigation. The appropriate approvals must be sought from the Shire prior to installation of lot scale groundwater bores.

5.1.3 Rainwater

Collection of rainwater from roof surfaces can be undertaken, with this water stored within rainwater tanks for later use. This water is of high quality; however, in urban environments it is advised that this water is considered non-potable.

In Perth, 90% of the rainfall occurs in the seven month period from April to October. The remainder of the year has little rainfall but collection is still possible. Thus, collected rainwater is not often available for irrigation (which is not required in winter) but is available to supplement internal building non-potable uses. The water efficiency strategy requires that the rainwater is used in washing machines, toilets and hot water systems.

All residential, industrial and commercial lots should be able to utilise rainwater tanks for storage. Information can be provided to the lot purchaser by the developer at point-of-sale. In addition, the use of rainwater tanks can be mandated by the Shire through the building licence. If rainwater tanks are to be included in the proposed water conservation strategy, it should be stated within the more detailed LWMS and/or UWMP. Requirements for rainwater tanks are to give regard to town planning scheme and health requirements.

5.1.4 *Grey Water*

Grey water can be described as all the waste water used in the home besides the water from toilets and cannot include kitchen water without additional treatment. This water has moderate concentrations of solids and nutrients. Grey water can be used for subsoil irrigation and in some other non-potable water uses. It is noted that there is the potential of nutrient leaching if the water is used for irrigation.

Grey water reuse is generally encouraged by the SoC, but adoption of this method would be approved on a case-by-case basis. Nutrients from grey water systems could potentially contaminate surface water bodies located nearby. Therefore, grey water systems are not recommended to be utilised by developments immediately adjacent to the Capel River.

5.1.5 *Recycled Water*

Waste water can be recycled and used as potable or non-potable water (depending on the quality of the treatment). The wastewater treatment plant operated by the Water Corporation presently discharges tertiary treated water into the Iluka Wetlands.

Treated water has the potential to be utilised for a number of purposes if it becomes available for use within the townsite. Treated water of this quality could be used to replace some potable water uses (e.g. toilets, washing machines). However, this would require retrofitting of the townsite's distribution system to incorporate a third pipe network, which is not expected to occur. Instead the treated water may more likely be utilised for irrigation of ovals and POS.

5.2 Development Scale Water Conservation

All small urban infill developments, urban infill developments and Greenfield developments are encouraged to adopt applicable development scale water conservation measures. The water conservation management objectives established in **Section 4.1.1** could be achieved by implementation of the following management measures:

- Retention of remnant native trees within POS areas. This will reduce demands for water particularly during establishment of POS areas.
- Minimal proportion of the POS areas should be turfed and hydrozoning could be applied to the remaining POS area.
- Provision of some smaller lot sizes that will require less landscaping.
- Turf species should be low water and nutrient requiring.
- The most appropriate non-potable water source can be used for irrigation of POS turf areas instead of potable water.
- Managing irrigation practises within POS areas to minimise losses to evaporation (e.g. amount applied is not excessive, timing irrigation to avoid wastage, etc.).
- The adoption of Xeriscaped POS gardens where garden beds are landscaped using 'waterwise plants'. These are local native species from regions with similar climates that require less water inputs than exotic species.
- The irrigation of POS areas should be limited to a maximum of 7500kL/ha/year.

5.3 Lot Water Conservation

Significant reductions in water usage can be achieved through implementation of measures at a lot scale. These measures include internal and external water saving devices and practices. Devices or practices where efficiencies can be made by the lot owners are discussed below.

5.3.1 *Water Efficient Appliances*

Significant reduction in internal water use can be achieved with the use of water efficient appliances. The following **Table 4** gives an example of the water uses of typical appliances versus water efficient appliances. These water use rates should be used in any future water balance investigations.

Table 4 Water Efficient Appliances (Australian Government 2009 & Melbourne Water 2003)

Appliance	Water Use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Flush	40 Litres/Flush
Shower Head	15-25 Litres/Flush	6-7 Litres/Flush
Taps	15-18 Litres/Flush	5-6 Litres/Minute

The water conservation strategy proposes that all dwellings and businesses use water efficient appliances. This can be encouraged by state and local government rebates, as well as education and additional incentives from developers.

5.3.2 *Water Efficient Gardens*

Studies by the Water Corporation (2003) have found that 56% of the water consumed by a lot, with a typical dwelling, is used on the gardens. Therefore, reductions in water irrigation by employing water efficiency measures can significantly reduce the total water usage of the lot. The following water efficiency measures should be used on lot gardens:

> Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300mm for garden beds (for the entry statement only).

> The irrigation system shall be designed and installed according to best water efficient practices. The controller must be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse droplets or be subterranean.

> Installing adequate irrigation control systems to ensure that water can be applied selectively.

> Utilise sub-surface irrigation where appropriate.

> Limiting the amount of turfed area.

> The turf species used should be a genotype endorsed by the UWA Turf Industries Research Steering Committee (e.g. Cough grass – *Cynodon dactylon*).

> Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454.

> Use fit-for-purpose water for irrigation (i.e. groundwater or recycled greywater).

5.3.3 *Educational Programs*

Educational programs for the community can increase the success of water conservation strategies. Appropriate education programs have already been outlined in the *ICLEI Water Campaign Local Action Plan* (SoC 2007). In line with the ICLEI, developers should provide educational material to all landowners regarding lot scale water conservation.

5.3.4 Total Lot Water Consumption

A water balance investigation can determine the water conservation measures required to meet the total household consumption target of 100kL/person/year. All urban infill developments and Greenfield developments are required to include a water balance investigation as part of the LWMS and UWMP processes.

Small urban infill developments of less than five lots, commercial infill developments and the industrial Greenfield development are not required to conduct a water balance to demonstrate compliance with the target of 100kL/person/year. Instead, these developers are required to demonstrate uptake of water efficient appliances and water efficient gardens, and educate landowners and business owners of lot scale water conservation measures provided in **Section5.3**.

6 Groundwater Management Strategy

6.1 Groundwater Level

The groundwater management criteria provided in **Section 4.2.1** can be achieved through the methods described below. Which method(s) are to be used to meet the groundwater management criteria must be determined at the LWMS and UWMP stages.

6.1.1 *Sub-soil Drainage*

The groundwater level can be controlled by implementing a network of sub-soil drains. Sub-soil drains are installed to reduce the risk of groundwater rising above an unacceptable level (which must be specified within the LWMS and UWMP). In addition, the LWMS and UWMP are required to determine the appropriate CGL for the development. Sub-soil drainage intending to lower groundwater (rather than control groundwater rise into imported fill) should not be located where water dependent ecosystems would be affected and discharge from sub-soil systems should be treated as per surface water runoff.

6.1.2 *Controlled Groundwater Level*

The CGL is the invert level of the subsoil drainage (*pers comm.* Bill Till, DoW). The CGL can be set equal to the AAMGL or where the AAMGL is below the clay layer, the CGL can be set no lower than the clay layer. The CGL may be guided by the regional AAMGL in this document, however a more detailed assessment should account for clay layer elevations provided in detailed geotechnical investigations and may include refinement of the AAMGL estimates where site-specific monitoring has occurred (DoW 2009).

A phreatic groundwater surface will form between each subsoil drain. Therefore the actual groundwater level may be higher than the CGL. The phreatic groundwater surface must be determined through calculations of subsoil drainage systems at detail design UWMP stage. Clearance of the phreatic surface from the habitable floor level should be a minimum of 0.8m.

6.1.3 Sand Fill

For areas of land with a shallow depth to groundwater, a layer of sand can be placed on the natural ground surface to increase the depth from the surface to the groundwater. The sand fill will not alter the natural groundwater level fluctuation; it will simply raise the lot level higher so that there is sufficient clearance to groundwater.

For the areas where no subsoil drainage is proposed, the finished earthworks levels must be at least 1.2m above the AAMGL. For the areas where subsoil drainage is proposed the finished earthworks level must be at least 0.8m above the phreatic surface.

Sand fill may also be used to meet geotechnical site classifications for residential slabs and footings (as per the Australian Standards AS2870-1996). The geotechnical site classification should be appropriate for residential slabs and footings.

6.1.4 Encourage Infiltration

The increased imperviousness of a development will reduce infiltration and this has the potential of lowering the average groundwater level when compared to the pre-development environment. To satisfy the criteria of maintaining the average groundwater level to provide water for vegetation and wetlands, infiltration should be encouraged though techniques such as soakwells, bottomless junction chambers, porous pavement, swales and vegetated retention areas. These techniques should be further supported by appropriate geotechnical investigations and their design presented in LWMS and UWMP documents.

6.2 Groundwater Quality

The main objective of the management of groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by either reducing the total nutrient load into the groundwater that originates from newly developed areas, or by improving the groundwater via treatment of the surface runoff prior to infiltrating to the groundwater.

All developments are expected to consider the management strategies described below to achieve water quality objectives.

6.2.1 Public Open Space

Native vegetation is recommended to be utilised in POS areas, keeping turfed areas to a minimum. Minimising the turfed area will reduce the fertiliser requirements and therefore, the nutrient load that could be transported to the wetlands via surface runoff and/or groundwater. Fertiliser requirements of turfed areas can be further reduced by importing topsoil with high phosphorus retention (PRI) and using turf species that have low water and nutrient requirements such as:

- Cynodon dactylon, Cynodon x, Cynodon transvaalensis.
- Paspalum vaginatum.
- Stenotaphrum secundatum.
- Pennisetum clandestinum (Water Corporation 2008).

In addition to utilising low nutrient requiring turf species, other fertiliser management strategies can include:

- Nutrient application rates should be matched to the seasonal requirements of the vegetation species.
- Soils tested to determine residual nutrient concentrations.
- Plant tissue testing.
- Utilising a fertiliser of the most optimal type and constituent for the specific vegetation species.
- Utilising slow release fertilisers (DoW 2007).

6.2.2 Gardens

Lot scale gardens have the potential to leach nutrients into the groundwater. This is particularly a concern for areas within the Capel Townsite area where agriculture was the dominant historical landuse. Nutrient leaching from garden areas can be reduced through:

- Utilisation of native vegetation species.
- Minimising the use of fertilisers to establish and maintain vegetation.
- Utilisation of soils with appropriate PRI for landscaped areas.

6.2.3 Bio-pockets

Vegetated retention areas are used to infiltrate low flow events from nearby impervious areas. The vegetation and the infiltration process within the soil column will remove a large portion of contaminants before it reaches the groundwater. The vegetation species selected should be native, have a low nutrient requirement with the ability to survive for a long period of time in dry conditions. Examples of appropriate species have been provided in **Table 5**. The vegetation may require occasional trimming and harvesting to encourage further growth and nutrient uptake. The soils imported to line these retention areas should be high PRI soils. These measures will ensure that the runoff that infiltrates to the groundwater will be of acceptable quality.

Table 5 Plants Species Suitable for Swales and Bio-pockets

Species	Height (m)	Planting Density (Qty/m^2)	Comments
Carex appressa	1.0	6-8	Not suitable for sandy soils with low water holding capacity
Ficinia nodosa	0.6	4-6	Salt tolerant, sandy conditions
Juncus kraussii	0.6-2.3	8-10	Salt tolerant
Juncus usitatus	0.5	8-10	Not suitable for sandy soils with low water holding capacity
Lyginia imberbis	0.4-0.7	6-8	Sand or peaty sand, dry or seasonally wet

6.2.4 Educational Programs

The most optimal performance from the designed water quality treatment system can be achieved through educating the community on how the system works. If people understand how their actions could damage the water quality system (e.g. dumping chemical waste into the drains that end up draining to a wetland) they could be less likely to continue their actions. Appropriate education programs have already been outlined in the *ICLEI Water Campaign Local Action Plan* (SoC 2007). Education programs can target school children, home owners, businesses, developers and maintenance staff. A few examples of education topics are:

> Fertiliser application.

> Liquid chemical removal (oils, chemical, paints).

> Solid waste removal options (fridges, TVs, furniture).

> Littering.

> Weed identification and removal.

> Recognising damage to the water quality treatment system.

7 Stormwater Management Strategy

Developments typically have a high proportion of impervious surface area (roads, paths and roofs) when compared to the pre-development environment. The increased imperviousness results in:

> Increased total volume of runoff leaving the site.

> Increased maximum runoff rate (peak discharge).

> Decreased time for runoff to occur.

The basic principle of contemporary stormwater quantity management is to slow down the stormwater runoff and infiltrate low flows, mimicking the existing environment. This ensures lower peak discharges and lower volumes of runoff in main drainage corridors, which otherwise could lead to flooding.

The effective management of urban stormwater quality typically focuses on the treatment of frequent, low intensity stormwater events. These small but frequent flows account for the vast majority of nutrient loads and represent the best opportunity for water quality improvement.

The design criteria specified in **Section 4.3.2** can be achieved through the use of various Water Sensitive Urban Design (WSUD) strategies. Combining a number of WSUD techniques into a treatment train is the most effective manner in which to meet stormwater quality design criteria (**Section 4.3.1**). Treatment trains incorporate multiple WSUD techniques to ensure primary, secondary and tertiary treatment of stormwater is achieved. Examples of possible WSUD techniques are discussed in the following sections and should be further investigated and negotiated with the SoC and DoW presented in LWMS and UWMP documents.

7.1 Lot Drainage System

Rainfall of the front and backyard of lots (garden areas) will either infiltrate directly at source or in large rainfall events a portion of the runoff may discharge off the lot. The runoff from roof and paved areas can be reduced at source by infiltration using soakwells and/or captured using rainwater tanks. Lot soakwells and rainwater tanks are seen as the first structural controls in providing treatment trains as recommended in *Liveable* Neighbourhoods (WAPC 2007).

The adoption of rainwater tanks to provide storage and water conservation benefits is encouraged by the SoC, but will not be mandated at this stage. Stormwater modelling conducted for this DWMS has assumed the broad scale use of soakwells to retain the 1 year – 1 hour ARI storm event at source (See Appendix D). However, areas with low clearance to groundwater and/or clay may not be able to accommodate a soakwell of this capacity. In the event that lots do not provide enough storage for the 1 year – 1 hour ARI event, downstream flood storage requirements provided in Section 7.3 may be undersized and will need to be revised at future planning stages.

7.2 Development Drainage System

Proponents are responsible for developing the strategies for water quantity and quality management in the LWMSs and UWMPs, to achieve support for the planning approvals required for the proposed development to proceed. Proponents should liaise with the SoC to discuss proposed water management strategies and receive further guidance on site-specific requirements of the local authority prior to the completion of any LWMS or UWMP. The following paragraphs describe the structural and non-structural measures that may be utilised by developments to meet the stormwater design criteria given in **Section 4.3**.

7.2.1 Gross Pollutant Traps

Stormwater runoff can transport nutrients and gross pollutants (such as cans, bottles, packaging, etc) to downstream water bodies. A GPT is considered a primary level treatment system, removing a proportion of these large pollutants (and depending on the design) can remove a proportion of the smaller particles such as sediments. The accumulated pollutants in the GPT must be regularly removed to ensure the efficiency of the device. GPTs are best suited to developments with high gross pollutants loads such as commercial developments, retrofitting built environments where there is no available space for a natural pollutant removal measure such as a wetland, or for collecting gross pollutants during the construction period phase of the development.

The location of Gross Pollutant Traps within wetlands or associated buffer areas should only be considered where no other options exist and the undertaking of such action or planning of such infrastructure is required to be in consultation with the SoC, DEC and DoW.

7.2.2 *Swales and Buffer Strips*

Swales and buffer strips are vegetated conveyance corridors. They typically have slopes of between 1% and 4%. This gradual slope combined with the increased roughness provided by vegetation reduces the stormwater runoff rate and the removal of sediments and nutrients. The swales also provide some storage (up to the 1 year – 1 hour ARI event) and infiltration capacity, thus reducing the total volume of runoff.

7.2.3 *Flush Kerbing*

Contemporary street drainage uses hard kerbing and pits draining the stormwater runoff to a sub-surface pipe network. This pipe network quickly transports the runoff through the development causing increased peak discharges from the area when compared to the pre-development peak discharge. Flush and intermitted kerbing allows most of this runoff to be directed to roadside swales, where it is more slowly conveyed or infiltrated. Flush kerbing is encouraged by the SoC and should be utilised where possible to allow rainfall events to flow into roadside swales and buffer strips.

7.2.4 *Bio-retention Swales*

Bio-retention Swales (or ‘rain gardens’) are a combination of vegetated swale and pipe network. Water infiltrates through a vegetated porous soil medium and into a pipe, which then conveys the stormwater to another swale, a bio-pocket or a flood detention structure. The stormwater in the swale takes time to infiltrate through the soil medium and into the pipe network, thus reducing the peak discharge from the development. A geotechnical investigation is required to determine whether the natural soils have an adequate infiltration rate or, if local soils do not support infiltration, to outline the necessary characteristics of any imported soils.

Bio-retention swales also provide water quality treatment. The swales provide water quality treatment by removing fine sediments, trace metals, nutrients, bacteria and organics (Davis *et al.* 1998). If designed well and maintained, bio-retention swales can be a very effective strategy for removing nutrients and conveying surface runoff (FAWB 2008). However, the technology is relatively new and as yet there are limited built working examples in Western Australia.

7.2.5 *Bio-pockets*

Bio-pockets retain runoff and only release water through infiltration or evapotranspiration. These are typically vegetated and used to store the runoff from the 1 year – 1 hour ARI rainfall event. Bio-pockets are typically located alongside roads at the edge of lots.

Vegetation within the bio-pocket provides water quality treatment. Bio-pockets would capture most minor and first flush events and sizing them to capture the 1 year – 1 hour event would result in treatment of over 98% of the average annual stormwater runoff volume in Perth (WAPC 2004). Unlike a wetland, bio-pockets are not designed to be permanently wet and therefore meet criterion set by the SoC (Opus 2007). Instead, stormwater will infiltrate into the underlying soil medium. A geotechnical investigation is required to determine whether the natural soils have an adequate infiltration rate or, if local soils do not support infiltration, to outline the necessary characteristics of any imported soils.

Where bio-retention swales or bio-pockets are the primary treatment method, the surface area of these structures should be sized at least 2% of the connected impervious area.

7.2.6 *Porous Pavement and Non-porous Area Reduction*

The majority of rain that fails on non-porous pavement will form surface water runoff. The use of porous pavement or reduced area of non-porous pavement area can have a significant reduction in the total volume and peak discharge of the runoff. Such areas are unlikely to be suitable for heavily trafficked pavement, however they may be used to assist in retaining the 1 year – 1 hour event onsite instead of utilising vegetated areas (provided the vegetated area is greater than 2% of the connected impervious area). A geotechnical investigation is required to determine whether the natural soils have an adequate infiltration rate or, if local soils do not support infiltration, to outline the necessary characteristics of any imported soils.

7.2.7 *Bottomless Junction Chamber*

Bottomless junction chambers are similar to soakwells as they allow infiltration of runoff from roads at drainage pipe junction chambers. However, this infiltrated water is untreated and has the potential to transport some contaminants into soil and groundwater (although the soil profile will treat some of the contaminants). The use of bottomless junction chambers result in a reduction in the total stormwater runoff volume. Bottomless junction chambers are only suitable in locations with high infiltration rates and where the superficial aquifer is lower than the pipe junction inlet. A geotechnical investigation is required to determine whether the natural soils have an adequate infiltration rate or, if local soils do not support infiltration, to outline the necessary characteristics of any imported soils.

7.2.8 *Flood Detention Structures*

Flood detention structures are designed to store runoff during large rainfall events (i.e. 5 year and 100 year ARI) and are typically incorporated into POS areas. The area designed to detain the 100 year ARI storm event can be used for recreational purposes for the majority of the year. In detaining or 'holding back' runoff, the FSA is designed to reach maximum capacity in a large storm event and discharge excess runoff at a reduced rate equal to the pre-development peak flows.

7.2.9 Educational Programs

The most optimal performance from the designed water quality treatment system can be achieved through educating the community on how the system works. If people understand how their actions could damage the water quality system (e.g. dumping chemical waste into the drains that end up draining to a wetland) they could be less likely to continue their actions. Appropriate education programs have already been outlined in the *ICLEI Water Campaign Local Action Plan* (SoC 2007). Education programs can target school children, home owners, businesses, developers and maintenance staff. A few examples of education topics are:

- Fertiliser application.
- Water use/saving techniques.
- Liquid chemical removal (oils, chemical, paints).
- Solid waste removal options (fridges, TVs, furniture).
- Littering.
- Weed identification and removal.
- Recognising damage to the water quality treatment system.

7.3 Detention and Retention Requirements

The Capel Townsite DWMS has utilised flood detention basins to ensure post-development peak discharges are maintained at pre-development conditions. In order to adhere to the design criteria stated in **Section 4.3**, the flood detention basins were sized to detain the peak discharge per hectare from 5 year ARI storm events and 100 year ARI storm events. The modelling methodology employed is detailed in **Appendix D.**

The XPSWMM computational modelling program was used to calculate the rate of runoff generated by each catchment. **Figure 10** illustrates the boundaries of post-development catchments and the detention areas. Many of these catchments do not experience a change in land use between pre-development and post-development and will not require storage. Results from these post-development catchments are only found in **Appendix D**, whereas the re.sults for catchments that are proposed to undergo modification are also provided below in **Table 6**

Detention basins are nominally designed to have 1:6 side slopes and a depth of 1m and may be modified in future detailed designs as appropriate. At this DWMS stage, the volume required to retain the 1 year – 1 hour ARI storm event from road reserves (i.e. not from lots) within each catchment has been included within the basin volume given in **Table 6.** Future drainage designs may recommend the separation of the 1 year – 1 hour flow into other vegetated treatment structures (e.g. bio-pockets). This will decrease the volume of detention structures, but will increase the overall surface area required for successful detention and retention of stormwater.

The locations of detention and retention structures will be affected by the structure plan layout, the final approach to earthworks across the site and the nature of the downstream receiving environment. It is most likely that detention structures will be located at the low point of each individual catchment, precinct, structure planning or development area. Further, it is recommended within the design criteria that retention structures (which take minor frequent events) be located higher in the catchment, as close to source as possible. The locations of these structures should be specified within the LWMS through consideration of the LSP and earthworks plan (as stated in **Section 9.3**). All detention and retention structures would be constructed during the subdivision stage.

Table 6 Detention Structure Dimensions

Catchment	Area (ha)	Basin Area (m^2)	Surface Area (m^2)	Volume (m^3)
2	47.7	9000	11420	10185
3	24.1	8500	10855	9655
4	32.0	2000	3215	2585
7	25.3	2500	3845	3150
8*	51.4	0	0	0
9	16.2	3500	5065	4260
10	2.4	300	860	555
11	5.2	700	1480	1065
13	16.2	2500	3845	3150
14	8.2	1000	1905	1430
17	24.1	5500	7425	6440
19	34.4	5000	6840	5895
21	23.6	10000	12545	11250
22	84.3	22000	25705	23830
24	16.2	4000	5660	4805
25	19.8	300	860	555
27	10.0	1500	2575	2015
28	8.2	400	1025	690
30	7.7	1000	1905	1430
31	4.5	550	1255	880
32	7.9	1000	1905	1430
33	4.6	450	1105	755
35	3.2	1400	2440	1880
36*	4.8	0	0	0
37	2.0	500	1180	815
39	1.8	210	700	430
40	1.6	350	925	625
42	2.0	400	1025	690
46	3.4	20	270	120
48	10.8	3800	5425	4590
52	7.0	1000	1905	1430
54	8.2	600	1330	940
56*	55.1	14500	17535	15995

Catchment	Area (ha)	Basin Area (m^2)	Surface Area (m^2)	Volume (m^3)
60	5.4	25	290	135
61	4.6	1200	2175	1665
62	1.3	140	570	330
63	6.2	15	250	110

*Some of these catchments do not require any additional storage to achieve pre-development peak flow conditions because of their pre-development land uses. Catchment 8 was previously dominated by industry and by changing the primary land use to residential, stormwater runoff was reduced. Similarly Catchment 36 is mostly road in the pre-development scenario with decreasing runoff in post-development due to a land use change to residential. Catchment 56 requires a large volume of storage due to a change in land use from rural to industrial.

Peak flows discharging from the townsite as well as six key culverts have been provided in **Table 7** which allows for comparison with the pre-development peaks flows provided in **Table 7**.

Table 7 Peak Discharges Exiting the Site and Exiting Culverts

Discharge Point	1 year – 1 hour ARI		5 year ARI		100 year ARI	
	Pre-dev Peak Discharge (L/s)	Post-dev Peak Discharge (L/s)	Pre-dev Peak Discharge (L/s)	Post-dev Peak Discharge (L/s)	Pre-dev Peak Discharge (L/s)	Post-dev Peak Discharge (L/s)
Catchment 3	130	0	198	0	540	391
Catchment 9	108	0	287	90	589	305
Catchment 15	180	229	485	490	934	939
Culvert 2	419	220	1851	1582	3510	3343
Culvert 3	663	588	2410	2312	4500	4601
Culvert 4	728	514	2678	2407	4796	4815
Catchment 54	83	65	219	180	570	455
Capel River*	808	173	4714	620	9573	1250
Culvert 1	618	597	1297	2311	2568	5406
Culvert 5	725	159	1667	1311	3123	2722
Culvert 6	493	392	1082	719	2146	1885
Catchment 62	13	0	19	12	44	42
Catchment 39	0	0	24	17	58	61
Catchment 38	1456	1459	3458	3401	7241	7210

* This is the total runoff within the river, excluding any baseflow from upstream catchments.

7.3.1 Demonstration of Compliance

In general, the storage volumes provided in **Table 6** will accomplish the design criteria given in **Section 4.3.2**. However, with the design of detailed structure plans for new developments, these volumes will require refinement. To ensure compliance with the design criteria provided in **Section 4.3.2**, developments that encompass the majority of the area contributing to these discharge points or culverts should demonstrate that they maintain the pre-development peak discharge provided in **Table 7.** Otherwise developments must maintain the pre-development peak discharge per hectare given for that catchment in **Appendix D**.

Developments are also required where applicable to demonstrate that post-development wetland water regimes should also be as per pre-development wetland water regimes where applicable.

8 Wastewater Management

Most developed areas within the Capel Townsite are sewered and connected to the Capel Wastewater Treatment Plant. Low density lots along Layman Road are serviced by on-site effluent disposal systems (*Pers.Comm.* Bob Evans).

There is capacity within the reticulated system to include some areas of the proposed development. However, upgrades to the system may be required in the future as all future developments are expected to be deep sewered (*Pers. Comm.* Bob Evans).

9 Matters to be Addressed in the LWMS

It is anticipated that the future LWMS or UWMP documents will provide significantly more detail regarding a number of aspects of stormwater management. The LWMS and UWMP documents should be prepared in accordance *Better Urban Water Management* (DoW 2008) and DoW guidelines for preparing these documents (DoW 2008; Dow 2008). These will include (but are not limited to): Geotechnical investigation.

- Demonstration of compliance.
- Design and location of drainage structures.
- Water consumption strategies.
- Non-structural measures.

9.1 Geotechnical Investigation

A geotechnical investigation will need to be conducted to confirm the regional geological mapping discussed in the DWMS. A number of test pits will be required to be installed at depths just below the ground surface (usually ~2.5m) to determine the soil characteristics and how this could impact on the proposed development. The investigation should include appropriate locations for onsite disposal of stormwater (flood detention structures and soakwells), soil types, suitability of soils for development and if treatment is required, settlement tests, bearing ratios and the hydraulic conductivity, which governs infiltration rates (as discussed in **Appendix D**).

9.2 Demonstration of Compliance

Modelling of local road drainage networks will need to be undertaken to demonstrate compliance with water quantity management criteria. Calculations supporting sizing of treatment retention structures and flood detention structures will need to be provided, such that detailed designs can proceed from this point, and future water planning stages (i.e. UWMP) can demonstrate compliance with the design criteria via appropriate computational modelling of the proposed design.

Small urban infill developments and some urban infill developments are not anticipated to contain POS areas and therefore, are unlikely to accommodate flood detention structures. Without any POS, these developments are only required to undertake computational modelling if the 1 year – 1 hour ARI storm event is not retained by each lot, but by some development drainage system (i.e. bio-pockets).

9.3 Design and Location of Drainage Structures

This DWMS has provided preliminary volume requirements for flood detention structures and vegetated retention structures (see **Section 7.3**). These are based on broad-scale assumptions (detailed in **Appendix D**). It is expected that as future investigations are undertaken, the designs developed will accommodate any constraints identified. The preliminary flood detention structure configurations should be reviewed to ensure that the stormwater management system can achieve all of the required objectives and blend into the surrounding environment. The DWMS has not provided indicative locations for these structures. The DWMS has recommended retention structures be located upstream, close to the source, and flood detention structures be located prior to, but nearby, the catchment discharge. Such details and design refinements should be presented in the future LWMS.

The future design of LWMS and UWMP should give regard to and demonstrate that the guidelines within the *Stormwater Management Manual for Western Australia* in respect to disease vector and nuisance insect management have been given consideration.

9.4 Water Consumptions Strategies

A number of potential measures have been discussed that can assist in achieving the state water conservation target (see **Section 4.1.1**). It is expected that future LWMS documents will clarify which measures are proposed to be integrated into the future built system. Additionally, Greenfields developments and most urban infill developments must verify that the measures will achieve the objective through an appropriate water balance.

Further investigation should be undertaken into the viability of the potential water sources available, where these are proposed to be utilised. The LWMS will need to provide a more detailed assessment of likely water requirements to maintain POS areas. A licence will need to be submitted and approved by the DoW for extraction of groundwater for non-potable uses.

9.5 Non-Structural Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual of Western Australia* (DoW 2007). Some measures will be more appropriately implemented by the Shire, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the POS within it.

It is expected that future LWMS and UWMP documents will provide reference to measures such as public education. It is also expected that future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. rubbish removal from swales and vegetated retention structures), timing (e.g. who will be responsible for carrying out the actions), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions).

Given that approval from the SoC and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

9.6 Fauna and Flora Investigations

Flora and fauna habitat surveys are required to be undertaken as part of the preparation of the LWMS. The survey assessment and recommendations should ensure that the impacts to rare and threatened flora and removal of key habitat of threatened species are avoided or relevant government approvals are received where necessary.

Clearing of native vegetation is prohibited unless the clearing is authorized by a Clearing Permit obtained from the DEC or is of a kind that is exempt.

10 Monitoring

10.1 Pre-Development Monitoring

The pre-development monitoring program should be conducted for at least 18 months prior to development. It should be tailored to the development, quantifying the development's surface water quality and groundwater levels, fluctuation and quality. In addition, pre-development monitoring shall include determining wetland water levels and regime in conjunction with groundwater monitoring. Sampling and Analysis Plans (SAPs) and results from any pre-development monitoring shall be included in future LWMS documents.

10.1.1 Surface Water

Better Urban Water Management (WAPC 2008) recommends that ambient water quality conditions be determined prior to development to define post-development water quality targets. Water quality targets should be based around guidelines contained within the *National Water Quality Management Strategy* (ANZECC 2000) with some consideration of ambient water quality measured within the Capel River. As detailed in **Section 3.6.2**, water quality within the Capel River can be measured and has previously been investigated by White and Comer (1999) and the SoC. The investigation by White and Comer (1999) was not restricted to the Capel Townsite and cannot be used to determine water quality targets directly for the townsite. Therefore, it is recommended that site specific water quality data be used to further define targets within the LWMS.

The upstream and downstream ambient water quality should be investigated because runoff currently discharges into the Capel River and it is likely that some post-development flows will also discharge into the Capel River via the SoC's drainage system. Upstream water quality should be taken in the Capel River prior to reaching the study area of this DWMS, while downstream water quality should be collected at or just beyond the study area boundary.

All Greenfields developments and the industrial Greenfield development are required to conduct a water quality monitoring program that includes upstream and downstream monitoring within the Capel River. Where appropriate data already exists at time of development, this can be utilised. Urban infill, small urban infill and commercial developments are not required to monitor water quality within the Capel River due to their smaller size.

10.1.2 Groundwater

Groundwater should be monitored to determine the site specific AAMGL, annual fluctuation and groundwater quality prior to development. The data collected during a groundwater monitoring program should include groundwater levels, sampling of physio-chemical parameters *in situ*, laboratory analysis of nutrients and nutrient species.

All Greenfields developments and the industrial Greenfield development are required to conduct a groundwater monitoring program. These programs will require the installation of an appropriate number of bores to correctly characterise the pre-development environment and allow direct comparisons in the post-development environment. Urban infill, small urban infill and commercial infill developments are not required to monitor groundwater, but may instead utilise the groundwater levels derived from the 22 bores installed during this DWMS.

10.2 Post-Development Monitoring

The post-development monitoring program should be conducted for at least two years from practical completion. It should be tailored to the development, quantifying the development's impact on surface water quality, surface water flows, groundwater levels, seasonal fluctuation and quality. Reporting of the final results will occur on completion of the monitoring program and these findings will be included in future UWMPs. The monitoring results can then provide:

> Post-development comparisons to demonstrate compliance with design objectives and criteria.

> A trigger for contingency action, as per the contingency action plan.

> An interim internal assessment tool of the monitoring program.

The monitoring program should be designed in conjunction with DoW advice and consistent with the *Stormwater Management Manual for Western Australia* (DoW 2007) to ensure data is of an appropriate standard for analysis and interpretation. Monitoring sampling should follow Australian Standards AS/NZ 5667 series of water quality sampling guidance notes. A NATA accredited laboratory is required to perform water quality testing (DoE 2001), and analytes selected should be consistent with those pollutants of concern identified during pre-development monitoring.

11 Implementation Framework

The DWMS is a key supportive document for the Capel Townsite Expansion. The development of the DWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with the total water cycle management approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future LWMS/UWMP documents.

11.1 Roles and Responsibilities

This DWMS provides a framework that future developers of the land can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and SoC policies and have been endorsed by the SoC. The responsibility for working within the framework established within the DWMS rests with developers, although it is anticipated that future LWMS/UWMP documents will be developed in consultation with the SoC and DoW and in consideration of other relevant policies and documents. Future LSPs will need to be supported by a LWMS and will require approval from the SoC and DoW.

11.2 Funding

As the DWMS area constitutes multiple landholdings, the cost of developing and implementing management strategies outlined in this DWMS will be shared by the developers. The SoC has not advised of any funding contributions required for the development to discharge to the existing regional stormwater network. However, it is anticipated that developers will work with the SoC to reach a mutually agreeable outcome where required.

11.3 Review

The next stages of development are anticipated to be structure planning through an LSP. Where a LSP is produced these should be supported by a LWMS. The LWMS will largely be an extension of the DWMS, as it should provide designs and measures for water management from the options proposed within this DWMS.

The next stage of development following the LWMS is lot planning through subdivision. It is recognised that certain elements of the DWMS and LWMS will not be finalised until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the SoC through policy (or modification of these where necessary) or awareness programs, such as those outlined in the Shire's ICLEI Water Campaign (SoC 2007).

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