



Government of **Western Australia**
Department of **Water**



TOWARDS A WATER SENSITIVE CITY

GREATER GERALDTON WATER PLANNING AND MANAGEMENT STRATEGY



Essential Environmental



Australia

Prepared for:

CITY OF GREATER GERALDTON

Prepared by:

ENV Australia Pty Ltd
Level 7, 182 St George's Terrace
PERTH WA 6000
Phone: (08) 9289 8360
Fax: (08) 9322 4251
Email: env@env.net.au

&

Essential Environmental Services
PO Box 306
Floreath WA 6014
M: 0403 170 040
Fax: (08) 9204 5914
E: shelley@essentialenvironmental.com.au

Job Number: 09.201
Report Number: 10/009
Prepared by: Martin Anda, Shelley Shepherd and Paul Zahra
Status: Final
QA Review: Shelley Shepherd
Technical Review: Martin Anda
Content Review: Shelley Shepherd
Date: 9 May 2011
09 November 2013 (v2)

Updated by City of Greater Geraldton, January 2014



EXECUTIVE SUMMARY

The City of Greater Geraldton may experience a significant shortfall in water supply in the future if business-as-usual approaches are maintained, rainfall decline continues, large industrial development proceeds and population expands at the predicted rates.

This Water Planning and Management Strategy provides a framework for the management and use of water resources within the City of Greater Geraldton, particularly in areas of land use change and development. It outlines a vision and objectives for the sustainable use and management of water resources. It identifies key issues and proposes strategies to address the issues on a City-wide basis as well as at a more local level for specific land uses.

The Water Planning and Management Strategy will operationalise the relevant elements of the City of Greater Geraldton’s Plan for the Future, and set the tone for future strategies in related areas that contribute to the Sustainable Future City Vision.

Recommendations of this Water Planning and Management Strategy will primarily be implemented via incorporation into the City of Greater Geraldton Local Planning Strategy and City of Greater Geraldton local planning scheme, as well as through local operations and works schedules plus relevant management plans and strategies developed in collaboration with other agencies.

The City of Greater Geraldton’s Water Planning and Management Strategy aims to facilitate:

“a sustainable water future for the City of Greater Geraldton that utilises smart technologies to build a liveable green community which values efficient water use and is resilient to climate change.”

The Strategy’s aim is consistent with the 2029 and Beyond Community Charter and the community’s vision:

“Championing sustainable water solutions to become an ecologically proud community that values our precious water whilst maintaining a liveable and healthy environment for our City region.” “The Waterwise Coast”

This strategy recommends a series of actions (strategies) to be implemented in the immediate, short and medium term. These actions are organised by land-use type, and aim to address all aspects of the water cycle. Key opportunities for “quick wins” in the City of Greater Geraldton include:

- increased levels of water conservation to achieve a target of 100kL per person per annum, by minimising demand and increasing efficiency, via enhanced and targeted community education programs including in industrial areas;

- greater implementation of water sensitive urban design as part of the planning and development approvals process so that urban development achieves better management of water quality impacts and gives greater consideration to the use of water for all parts of the water cycle;
- improved efficiency of irrigation including waterwise planting in public open spaces to optimise the use of the limited available groundwater resources;
- reuse of wastewater from the Narngulu wastewater treatment plant.

Achieving a truly water sensitive city will require the development of solutions to support the three pillars of a water sensitive city (adapted from Wong & Brown 2009):

- Cities as Water Supply Catchments: meaning access to a range of different water sources at a diversity of supply scales;
- Cities Providing Ecosystem Services: meaning the built environment supplements and supports the functions of the natural environment; and
- Cities Comprising Water Sensitive Communities: meaning socio-political capital for sustainability exists and citizens decision-making and behaviours are water sensitive. (Blueprint 2013)

Long term opportunities which are recommended to be considered as part of future water planning and management within the City include:

1. Wave powered seawater desalination (reverse osmosis) plants (SWRO).
2. Managed aquifer recharge wastewater schemes at all Water Corporation waste water treatment plants to supplement public open space, oval and golf course irrigation.
3. Sewer mining plants in urban areas to supplement stormwater aquifer storage and recovery (ASR) schemes for irrigation of parks and gardens.
4. Third pipe (dual reticulation) schemes in residential areas, either by renovation or in new subdivisions.
5. Shallow sewerage to localised recycling plants in peri-urban and rural residential areas beyond sewer reticulation.
6. Wastewater hydroponic urban agriculture systems.
7. Nutrient recovery from wastewater through biosolids reprocessing and urine separation.
8. Superficial shallow aquifer to be used as a geothermal resource to reduce Geraldton's carbon footprint.

It is recognised that movement towards a water sensitive City will require coordination, cooperation and commitment of all stakeholders and the community to the vision and objectives of this strategy.

**"We must become the change we want to see"
(Mahatma Gandhi, 1869-1948)**

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1 INTRODUCTION

The City of Greater Geraldton is the thriving centre of the Mid-West Region of Western Australia. It's economy is primarily structured around mining, agriculture, fishing and tourism, and is growing organically. This, coupled with a number of proposed major projects in the area including the Oakajee Deepwater Port, is predicted to lead to substantial population growth throughout the next ten years. The City currently supports a population of more than 35,000 and aims to be able to support a population of 100,000 into the future (City of Greater Geraldton, 2009).

The City of Greater Geraldton has a Mediterranean climate, receiving the majority of its rainfall during the winter season and utilising the strong southerly breezes to cool the summer heat. It has a land area of approximately 1,800 sq km and is bounded by the Chapman Valley to the north and it is the gateway to the Abrolhos Islands to the west. The City contains two main networks of ephemeral streams that are important for local recharge, albeit sporadically, which support areas of biodiversity and environmental significance.

Like many urban areas around Western Australia, the City of Greater Geraldton recognises the critical importance of the role of water in its ability to change and support growth. The desire to acknowledge the increasing pressures on City's water resources, which include the impact of climate change as well as land use change, and develop a framework to better manage and use the precious water resources of the area, have led to the preparation of this Water Planning and Management Strategy.

This Water Planning and Management Strategy provides a framework for the management and use of water resources within the City of Greater Geraldton, particularly in areas of land use change and development. It outlines a vision and objectives for the sustainable use and management of water resources. It identifies key issues and proposes strategies to address the issues on a City-wide basis as well as at a more local level for specific land uses.

The Water Planning and Management Strategy will operationalise the relevant elements of the City of Greater Geraldton's Plan for the Future, and set the tone for future strategies in related areas that contribute to the Sustainable Future City Vision.

Recommendations of this Water Planning and Management Strategy will primarily be implemented via incorporation into the City of Greater Geraldton Local Planning Strategy and City of Greater Geraldton local planning scheme, as well as through local operations and works schedules plus relevant management plans and strategies developed by other agencies.

The key aspects of this Water Planning and Management Strategy and its linkage with key initiatives such as the Sustainable Futures Project and the Plan for the Future are depicted in Figure 1.



Figure 1: Key aspects and linkages of the Water Planning and Management Strategy

1.1 VISION

The City of Greater Geraldton’s Water Planning and Management Strategy aims to facilitate:

“a sustainable water future for the City of Greater Geraldton that utilises smart technologies to build a liveable green community which values efficient water use and is resilient to change.”

The Strategy’s aim is consistent with the 2029 and Beyond Community Charter and the community’s vision:

“Championing sustainable water solutions to become an ecologically proud community that values our precious water whilst maintaining a liveable and healthy environment for our City region.” “The Waterwise Coast”

1.2 OBJECTIVES

The objectives of the Greater Geraldton Water Planning and Management Strategy are to:

- Protect and enhance waterway catchments by recognising the need to maintain and improve water quality and natural hydrologic regimes as part of land use change and development;

- Maximise the efficient use and reuse of water by conserving water through efficiency and increasing water reuse and fit-for-purpose use; and
- Protect life and property from risk of flooding and disease through application of risk management approaches and implementation of appropriate standards.

The objectives of the Greater Geraldton Water Planning and Management Strategy are supported by the *State Water Strategy* (Government of Western Australia, 2003) and the *State Water Plan* (Government of Western Australia, 2007), which both identify the need for an increased focus on total water cycle management and water sensitive urban design to protect sensitive environments, improve the management of stormwater and increase the efficiency of the use of water.

Total water cycle management, also known as integrated water cycle management, is a holistic water management approach that reflects the principles of ecological sustainability and that recognises that water supply, stormwater, groundwater, and wastewater services are interrelated components of catchment systems. The consideration of the water cycle, together with water efficiency, re-use, and recycling are integral components of water sensitive urban design.

These relationships are depicted in figure 2 from the *State Water Plan* (Government of Western Australia, 2007)

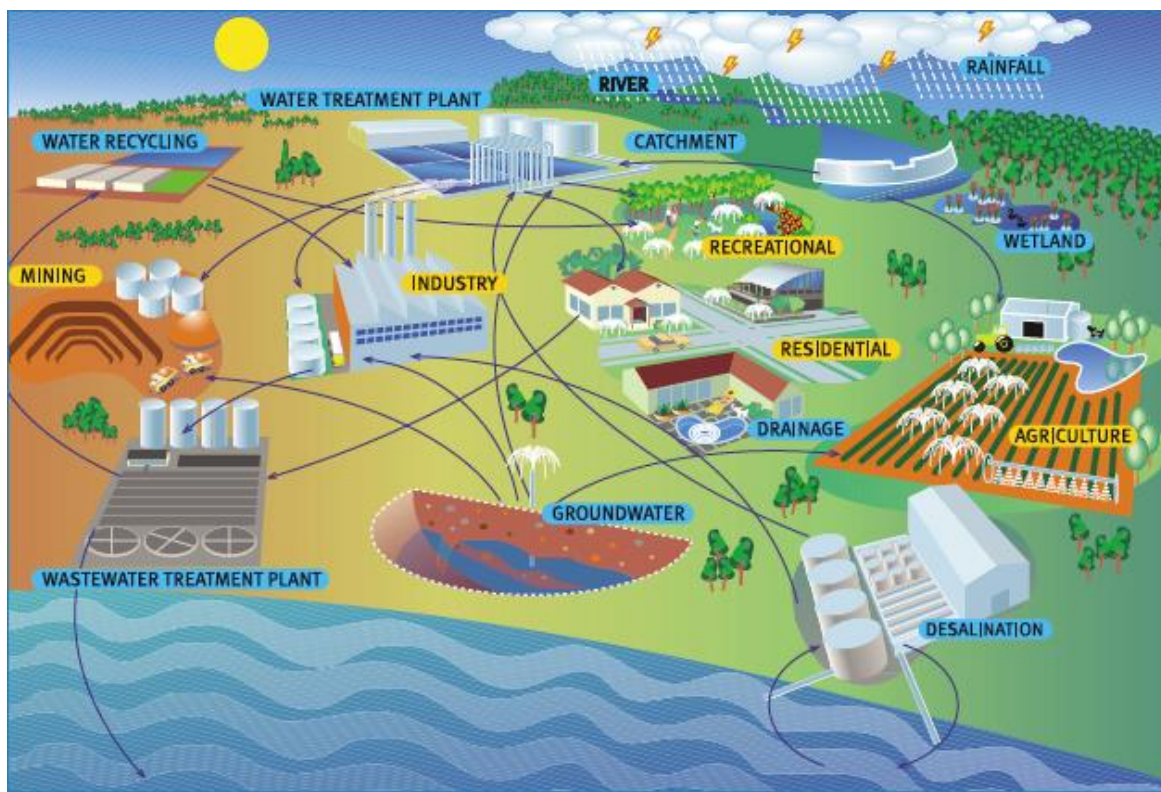


Figure 2: The water cycle in the built environment (Government of WA, 2007)

1.3 PRINCIPLES

The use of water sensitive urban design as part of the planning and development approvals process has been demonstrated to improve the management and use of water resources. These principles have been used to guide the development of this Water Planning and Management Strategy.

The Strategy will assist the City to apply the principles of water sensitive urban design as part of decision-making across the municipality. The principles, are as follows.

1. Maximise water use efficiency, reduce potable water demand, and maximise the use of wastewater and harvested water to provide fit-for-purpose water for all uses;
2. Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost 'in-system' management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from perforated pipes and stormwater pits installed above pollutant retentive material);
3. Retain, restore and enhance existing elements of the natural drainage system, including waterway, wetland and groundwater features, regimes and processes, and integrate these elements into the urban and rural landscape;
4. Minimise pollutant inputs to surface water systems, the groundwater and other receiving environments including the ocean;
5. Provide strategic and technically sound flood plan management for the protection to life and property from events that would occur in a 100 year average recurrence interval flood event;
6. Enhance social amenity through multiple use corridors, lot landscaping and integrating water management measures into the landscape to enhance visual, recreational, cultural and ecological values; and
7. Design water sensitive systems and landscapes which are reflective of the climate of the area and are resilient to change.
8. Water-sensitive infrastructure systems and technologies are to demonstrate cost effectiveness and generate a net welfare gain.

Modified from Department of Water's *Stormwater Management Manual for Western Australia*, 2004 - 2007.

Applying these principles will support the three pillars of that underpin a water sensitive city (adapted from Wong & Brown 2009):

- Cities as Water Supply Catchments: meaning access to a range of different water sources at a diversity of supply scales;

- Cities Providing Ecosystem Services: meaning the built environment supplements and supports the functions of the natural environment; and
- Cities Comprising Water Sensitive Communities: meaning socio-political capital for sustainability exists and citizens decision-making and behaviours are water sensitive. (Blueprint 2013)

1.4 USE OF DOCUMENT

The Strategy provides information to aid decision making by the City of Greater Geraldton and other key agencies responsible for the management of water resources. It is to be used by:

- Developers, to improve urban water management outcomes;
- Council, to aid planning and development decision making;
- The City, to inform asset management and maintenance activities; and
- Other agencies responsible for water resource management such as the Water Corporation and Department of Water - to prioritise actions consistent with the Strategy including the provision and management of water infrastructure.

1.5 STRATEGY DEVELOPMENT PROCESS

A collaborative approach was utilised in the development of the Water Planning and Management Strategy. The City of Greater Geraldton invited the Department of Water and Water Corporation to be on the Steering Committee, and community members, other agencies and stakeholders were actively engaged in the process through a series of stakeholder workshops. The workshops were successful in generating a shared understanding of the key water issues facing the municipality and the need to address these issues collectively.

The workshops also provided the opportunity to raise the awareness of options for total water cycle solutions within a local government context through presentations provided by Mr Wayne Prangnell from the Shire of Augusta Margaret River, who outlined the Shire's water recycling, greywater harvesting, stormwater management and water servicing projects. These ideas have been embedded in this Strategy where they are relevant to the City and supported by participants.

Collective support was developed for the proposed strategies, including recognition of the importance of a collaborative approach to addressing the key priorities and linking them to appropriate implementation mechanisms in order to deliver coordinated outcomes. It was recognised that delivering a better water future



for the City would require dedicated action from all sectors of Government, industry and the community.

2 POLICY FRAMEWORK

2.1 GUIDING LEGISLATION

The management of the water cycle in an urban and regional context is governed by a substantial number of acts and regulations, the most relevant of which are considered to be:

- Country Areas Water Supply Act 1947
- Country Towns Sewerage Act 1948
- Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974
- Rights in Water and Irrigation Act 1914
- Planning and Development Act 2005
- Water Agencies (Powers) Act 1984
- Water Services Act 2012
- Waterways Conservation Act 1976

2.2 STATE PLANNING POLICY FRAMEWORK

The Western Australian planning policy framework contains significant guidance to enhance the management of water resources as part of the planning and development process. Development and implementation of the Water Planning and Management Strategy is supported by many State policies. These include:

- Western Australian State Sustainability Strategy (2003);
- State Planning Policy No 2: Environment and Natural Resources (2003);
- State Planning Policy No 2.9: Water Resources (2006);
- State Planning Policy No 2.7: Public Drinking Water Source(2003);
- Liveable Neighbourhoods Edition 4 (2007);
- Better Urban Water Management (WAPC, 2008);
- Planning bulletin 92: Urban water management (WAPC, 2008); and
- Planning bulletin 64: Acid sulfate soils (WAPC, 2004).

The process to integrate water and land use planning including the water information required to inform decision-making as part of the land use planning system is outlined in *Better Urban Water Management* (WAPC, 2008) and discussed further in section 6.1.

The Department of Water also produces a variety of documents and guidance to aid the improved management and use of water resources. These include (but are by no means limited to) water quality protection notes and water quality protection guidelines. These documents (and other publications) are readily available on the Department of Water website (www.water.wa.gov.au).

2.4 LOCAL GUIDANCE

The City of Greater Geraldton also provides local guidance for the management of water resources via the following key documents:

- Geraldton Region Plan (1999)
- Greater Geraldton Structure Plan (2011)
- Greenough Local Planning Strategy (2008)
- Plan for the Future 2009 – 2014

The Plan for the Future 2009-2014 is a corporate policy and planning document that links the Corporate Vision with Outcomes, Strategies, Actions and Tasks. This strategic document provides a strong focus for the future activity of the City. Some of the actions related to water include:

- 1.3.4.17 Implement a water harvesting, conservation and re-use strategy
 - 1.3.4.18 Implement the ICLEI WaterSmart Program
 - 1.2.2.16 Develop and Implement a Stormwater Management Policy
 - 1.2.2.17 Develop and Implement a Water Sensitive Urban Design Program
 - 1.3.4.1 Develop Water Supply / Recycling Alternate sources
- Sustainable Future City Project - Strategic Statement of Intent for Water

In its November 2009 Draft Sustainable Future City Project Strategic Statement of Intent for Water, the City has proposed 19 theme areas for strategy development in its aim to ensure the best possible environmental, social and economic outcomes from its water management. The development of this Water Planning and Management Strategy is one of the key strategies for the theme.

- Waterwise Council

The Waterwise Council program helps councils in Western Australia adhere to the State Government's water efficiency measures and encourages improved water use management at a corporate and community level. The program is an initiative of the Water Corporation and the Department of Water, with support from the International Council for Local Environmental Initiatives (ICLEI). The City of Greater Geraldton is currently progressing towards achievement of the Waterwise Council criteria. Completion of the five criteria will see the City of Greater Geraldton having completed:

- An action plan that outlines actions to improve water management within the City's own operations (corporate) and improve water efficiency in the residential and non-residential sectors (community). The Plan is to be formulated on the basis of monitoring, supported by a gap analysis of issues affecting water use within the City and target goals for water consumption. It should include a review of the irrigation practices on council grounds and public open space and preparation of a water conservation plan (see below).
- Preparation of supporting policy including a waterwise verge policy and purchasing policy;
- Interaction with households and business ratepayers to promote water efficiency and encourage community involvement in other Waterwise Programs;
- Attendance by appropriate staff members at the Water Corporation's Waterwise Specialist training sessions; and
- No breaches of water licence terms or conditions or for scheme water usage.

- Water Conservation Plan

The City has worked with Department of Water to produce the City of Greater Geraldton Water Conservation Plan (Department of Water, 2010). The water conservation plan will help the City to best manage its water allocation by implementing strategies to conserve water in the irrigation of public open space while still retaining amenity. The plan will:

- increase the City's participation in sustainable water resource management;
- identify areas and develop strategies to conserve water;
- highlight any licence inconsistencies; and

- demonstrate to the community wise water use as a response to climate change.

As a condition of the groundwater licences issued to the City of Greater Geraldton by the Department of Water, the City implements a Public Open Space Irrigation Operational Strategy.

- The City is in the process of developing a number of local planning policies and design guidelines which address water issues. These will be consistent with the principles and objectives of the Plan for the Future, the Strategic Statement of Intent for Water and this Water Planning and Management Strategy.
- The City is developing a Project Management Framework to facilitate the consistent application of sound project management to the wide range of projects included in the City's Long term Financial Plan, 10 Year Capital Works Program and the 10 Year Strategic Community Plan. All capital works project proposals must demonstrate all levels of efficient and effective project management as set out in the City's Project Management Framework

3 ENVIRONMENTAL PROFILE

3.1 GEOLOGY AND LAND SYSTEMS

Greater Geraldton geology is typically characterised by 2 main systems, coastal land systems and inland land systems. These systems are detailed in Figure 4.

The coastal system forms the strip of land abutting the Geraldton coast, varying in width from 2 to 3 kilometres. The geology of the coastal system generally consists of sand over limestone and other red and yellow sand. In two small sections, at the deltas of the Greenough and Chapman rivers, alluvial sediments and silty sandy clays are present but are localised to the delta. The coastal system occupies less than ten percent of the entire Greater Geraldton locality, which is approximately 1800 square kilometres in size.

The inland land system is more complex and forms the remainder of the City of Greater Geraldton. The geology of the inland land system also contains some red and yellow sand closer to the coastal system. The geology of the north western portion of the study area is dominated by the Moresby Ranges and associated colluvium deposited at the base of ranges as a result of gravity. The geology is also dominated by rock debris, gravels, boulders over silty sands and mottled sandy clays (Geological Survey of Western Australia, 2000). Heavy rainfall in the inland land system has the potential to cause significant erosion impacts.

The topography of the City is dominated by the Moresby Ranges and river valleys of the Chapman and Greenough Rivers. Topography and slope are key considerations in the management of water resources. The available topographical contours are shown in Figure 5.

3.2 EXISTING LAND USE AND INFRASTRUCTURE

The existing land uses within the former City of Geraldton are detailed in Town Planning Scheme No. 3 (Geraldton), as shown in Figure 6. The existing land uses consist of predominantly residential uses, with small areas of commercial, port operations and industrial operations. The majority of the population and infrastructure for the City of Greater Geraldton is centralised around the Geraldton city centre.

The existing land uses within Greenough are detailed in Town Planning Scheme No 4, as shown in Figure 6. While the majority of the Greenough region comprises general farming uses, the area around Geraldton contains outer residential uses such as rural residential and a combination of heavy industrial and extractive industries.

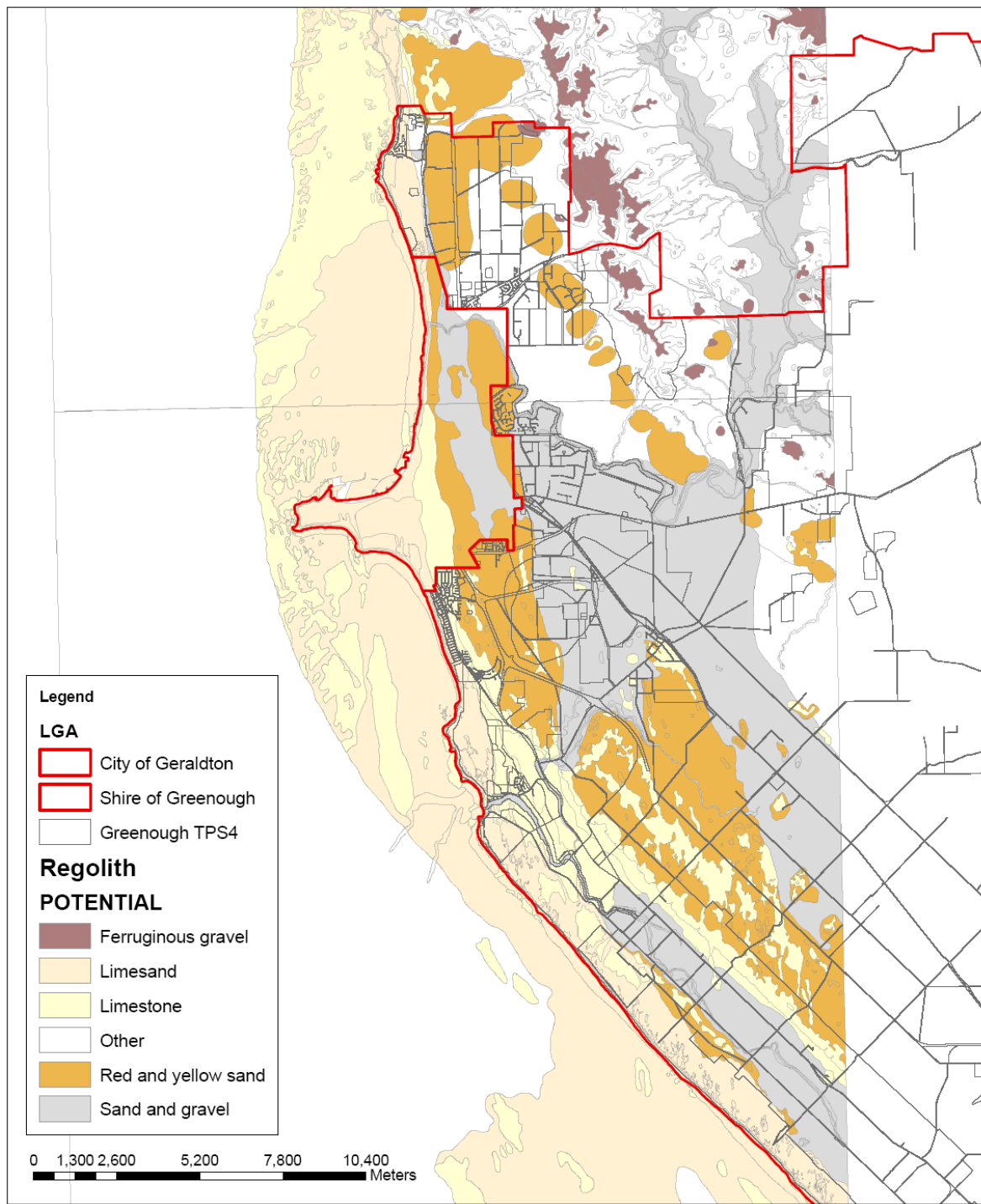


Figure 4: Greater Geraldton geology



Figure 5: Geraldton topography

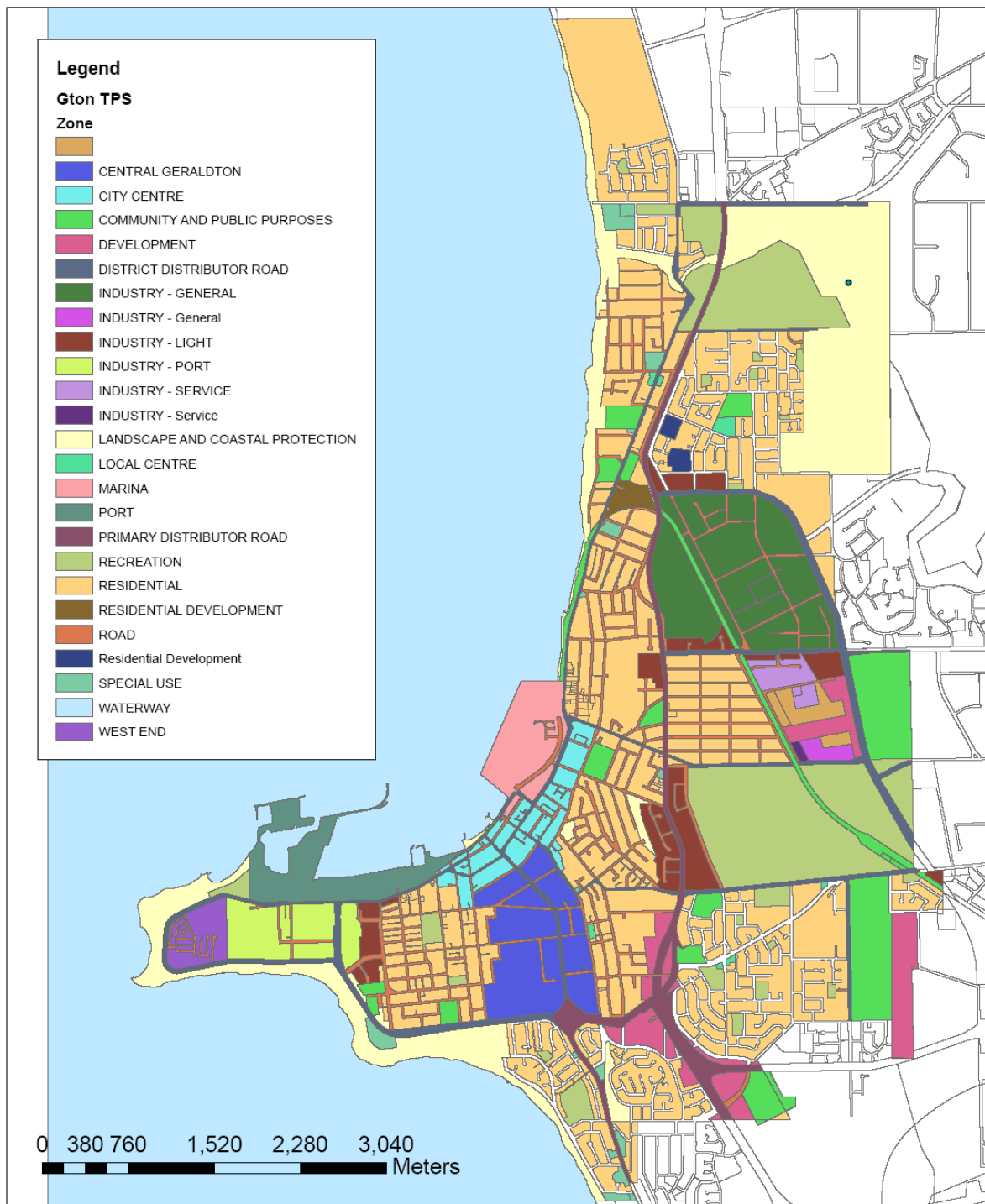


Figure 6: Town Planning Scheme No. 3 (Geraldton)

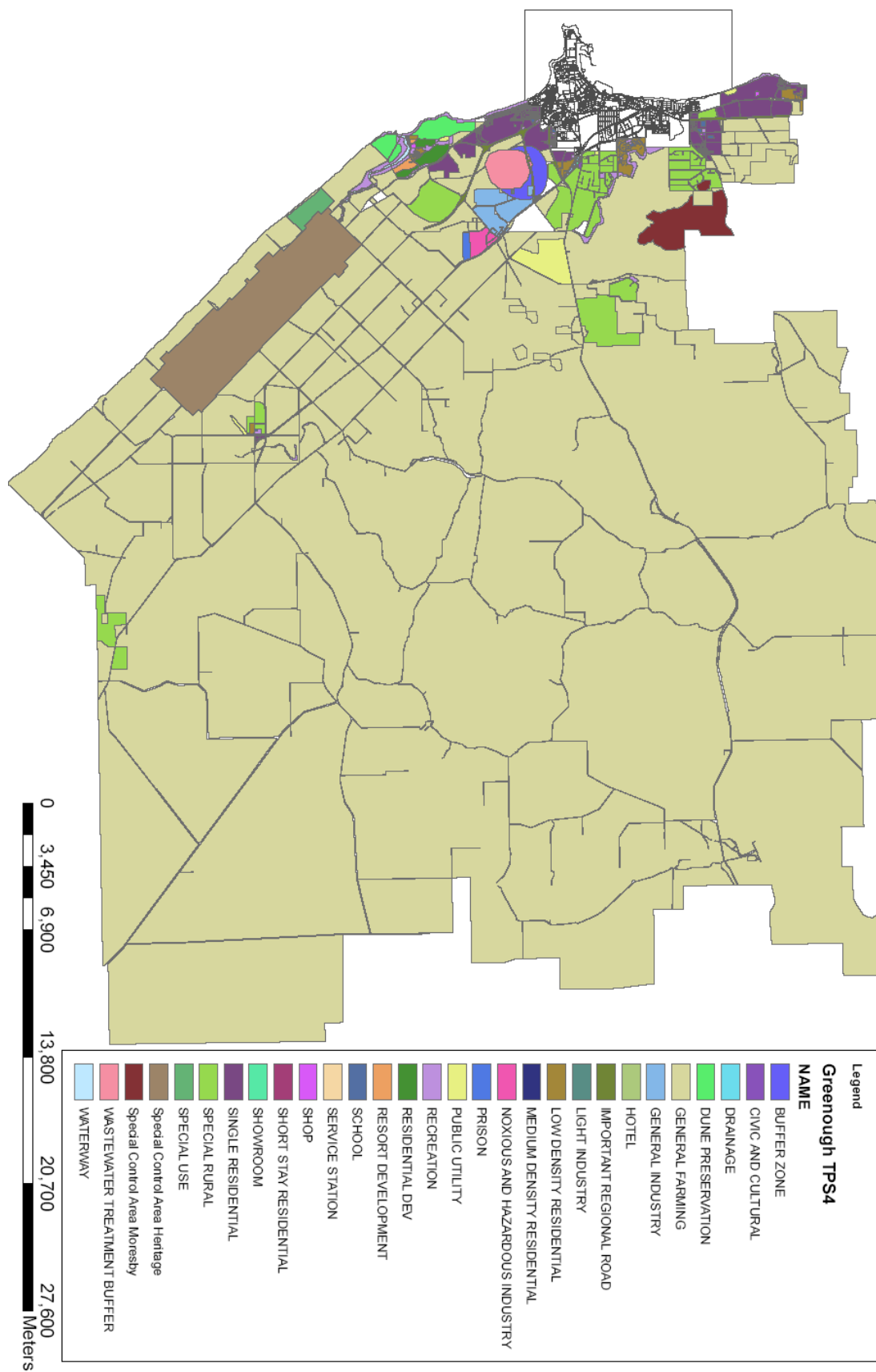


Figure 7: Town Planning Scheme No 4

3.3 POTENTIAL CONTAMINATION

The Department of Environment and Conservation's Register of Contaminated Sites recognises a number of potential contaminated sites across the City (Figure 8). Figure 8 does not differentiate between known and potential contamination sites, however, if the site is on the contaminated sites register they are assumed contaminated until proven otherwise.

3.4 SIGNIFICANT ENVIRONMENTAL ASSETS

The Greater Geraldton region holds a number of significant environmental assets including numerous waterways, coastal dune systems, remnant vegetation and Declared Rare Flora sites.

The Greenough River and the Chapman River are the two rivers with a number of tributaries flowing into these rivers, as shown in Figure 9.

Figure 9 also details the groundwater sub-areas and aquifers as defined by the Department of Water. These aquifers provide water for irrigation purposes. Drinking water for Geraldton is provided by the Allanooka groundwater sub-area which lies to the south of the City of Greater Geraldton.

There are no significant wetlands identified within the City; however, 'Rum Jungle' is a seasonally inundated dampland which is considered to have some environmental value. It is located on the northern urban development fringe of Geraldton and has an area of approximately 10 hectares. It backs onto the coastal dune system. The dampland has a well-developed low closed forest of *Casuarina obesa* with a sparse but weedy understorey (see aerial photograph Figure 5 at <http://florabase.calm.wa.gov.au/swale/geraldton.pdf>)

Figure 10 details the extent of remnant vegetation within the Greater Geraldton boundaries and the sites where Declared Rare Flora have been identified. Declared Rare Flora are species of flora which may become extinct, rare or are otherwise in need of special protection because of current and past land use practices. These are gazetted as "rare flora" under the *Wildlife Conservation Act 1950*. Figure 10 also shows that the majority of land has been cleared for farming purposes and most remaining remnant vegetation is largely found along water courses and river banks.

The Geraldton Regional Flora and Vegetation Survey (GRFVS) completed in 2010 aims to provide a regional context for land use planning and the environmental impact assessment of proposals affecting native vegetation in the Geraldton region. The GRFVS report provides information on vegetation types, mapped and described at the regional scale as Beard vegetation associations, and at the local scale as GRFVS plant communities.

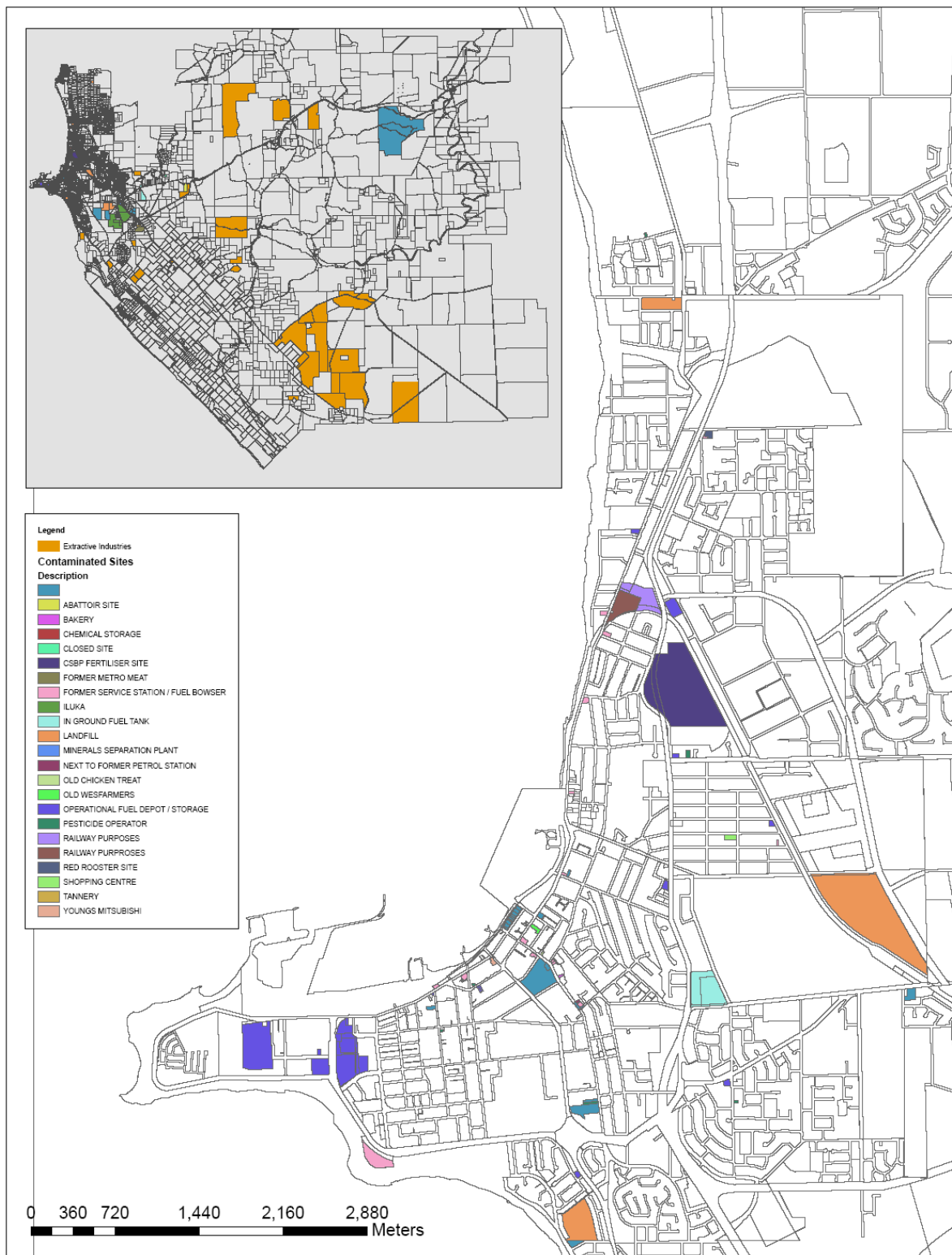


Figure 8: Potential contaminated sites and extractive industries across the City

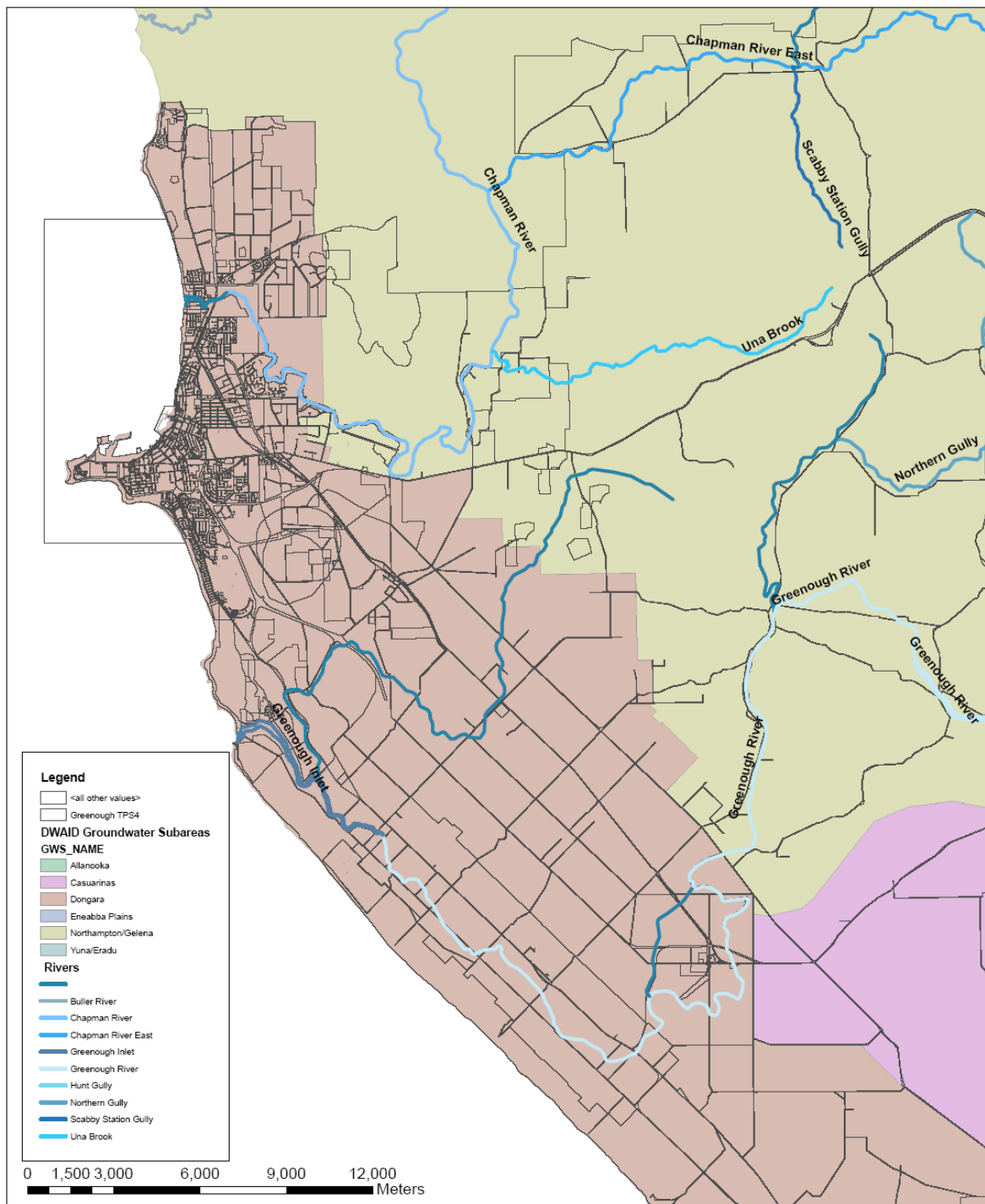


Figure 9: Geraldton rivers and groundwater subareas

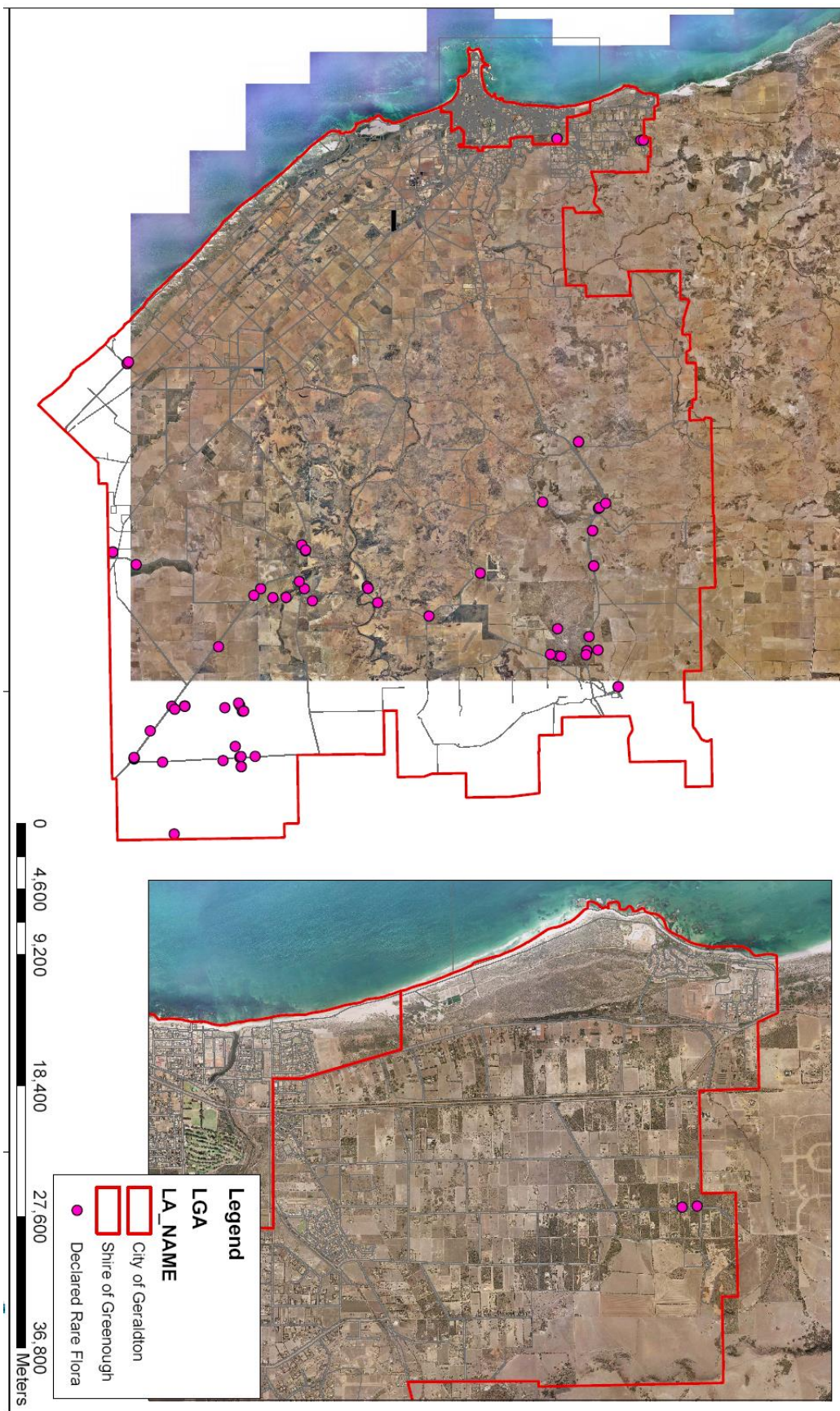


Figure 10: Geraldton and Greenough Declared Rare Flora

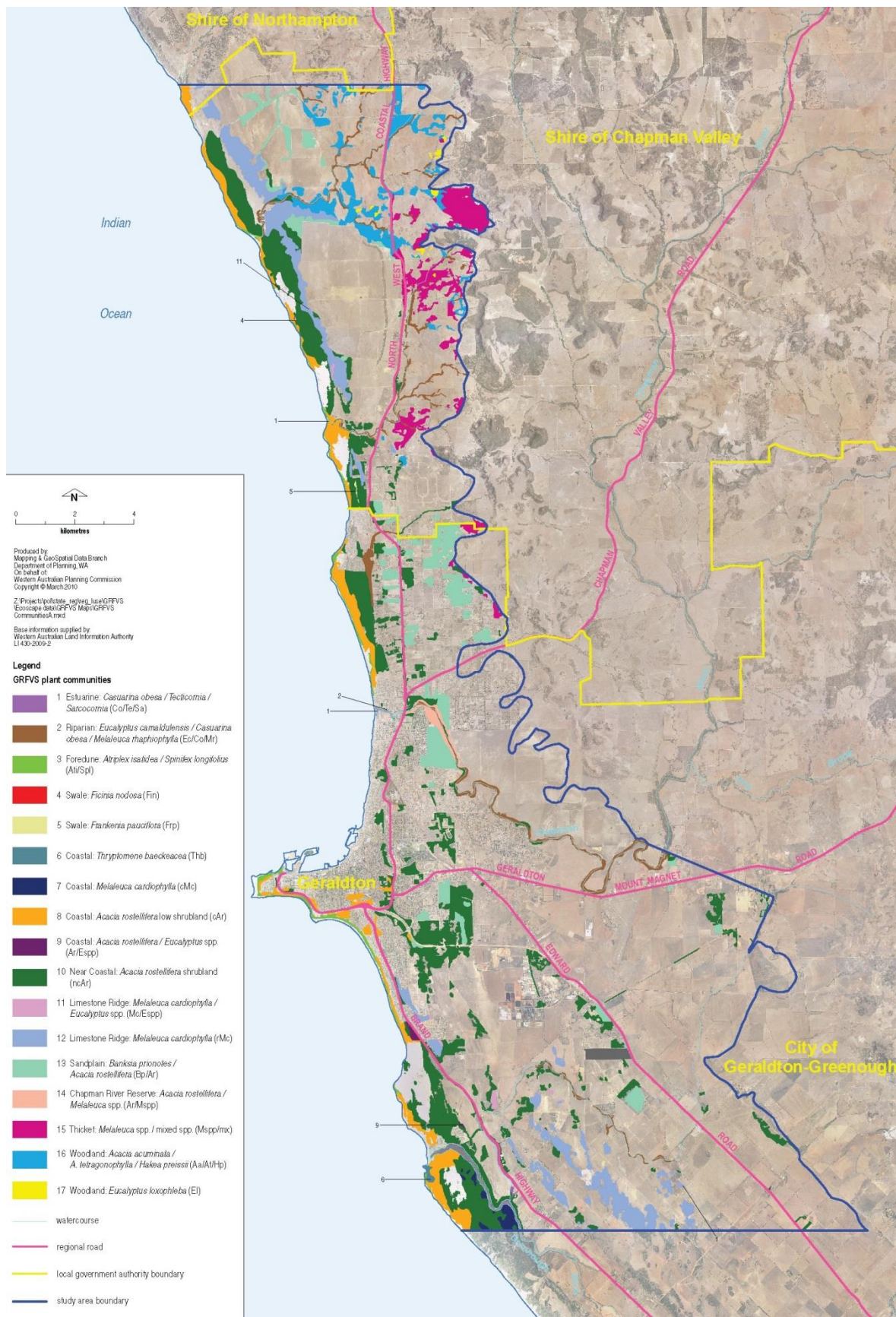


Figure 11: Geraldton Regional Flora and Vegetation Survey (WAPC, 2010)

The GRFVS provided a basis for the development of the City of Greater Geraldton's *Local Biodiversity Strategy (LBS)*. The LBS identifies that the remnant vegetation complexes associated with the Chapman River and the Greenough River are of significant conservation value (Figure 12).

3.5 SURFACE WATER SYSTEMS

The geology and land systems described in Section 2.1 also relate to the hydrography of the area. The most significant surface water systems in the region are the Greenough and Chapman Rivers. The Chapman River commences near Yuna approximately 60 kilometres north east of Geraldton. The Greenough River originates in the Yalgoo district approximately 240 kilometres north east of Geraldton and meanders through a diverse landscape to the river mouth located at Cape Burney 10 kilometres south of Geraldton. The surface water systems are detailed in Figure 13.

Surface water movement is more common in the inland land systems due to the heavy soils such as sandy clays. The coastal system is predominantly sand and limestone which allows for effective infiltration before surface water runoff can occur.

Surface water also occurs in the urban areas and is dealt with as stormwater. The management of stormwater is generally via the traditional network of pipes and sumps (figure 14), however more water-sensitive design of stormwater systems is occurring in some new urban areas, however opportunities in some areas are constrained by local soil types. Additional information on drainage is contained in section 4.4.

Studies have been completed on the Greenough and Chapman Rivers by the Department of Water (Kellogg Brown & Root Pty Ltd, 2006 & Waters and Rivers Commission, 1998, respectively). These studies examined the catchment hydrology, floodplain mapping, levels of flood protection and the development of land use controls.

The *Greenough River Flood Study* (Kellogg Brown & Root Pty Ltd, 2006) recommended the following non-structural strategies are implemented to appropriately manage flooding:

- Establish formal flood zones and development controls based on flood map series extents, within which guidelines for setting floor levels and locations of new buildings will apply;
- Develop formal guidelines and assessment procedures for existing buildings within the flood zone, to recommend local measures such as house raising or local levees and evacuation procedures;
- Consult with the Bureau of Meteorology and Department of Water to develop a suitable flood forecasting and warning system based on local weather conditions; and
- Construct buildings outside the area of inundation of the Annual Exceedance Probability (AEP) 1% flood event if possible, or must be built 0.5m above the AEP 1% flood event.



Figure 12: Areas of Conservation Value in City of Greater Geraldton and Shire of Chapman Valley

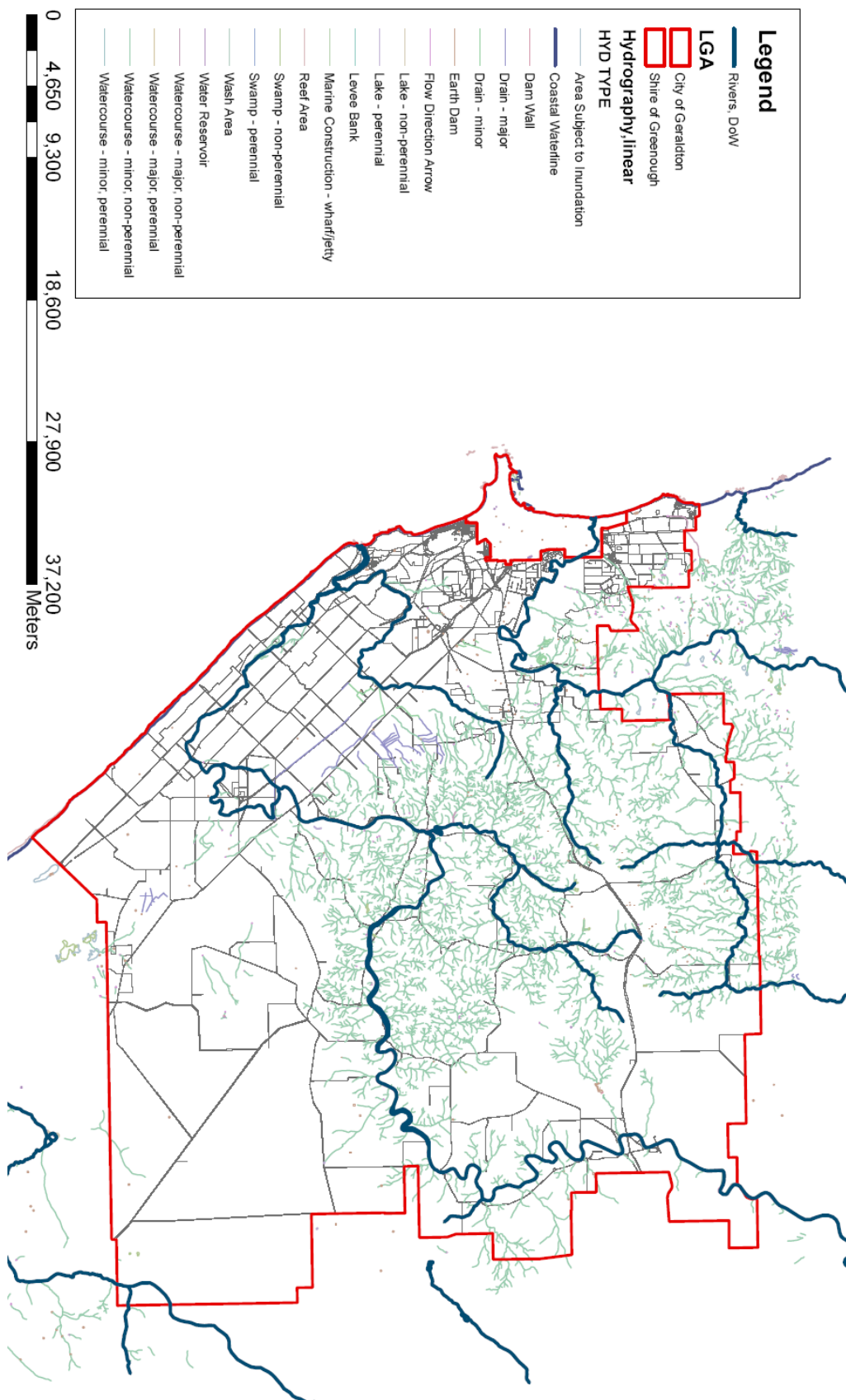


Figure 13: Geraldton and Greenough hydrography

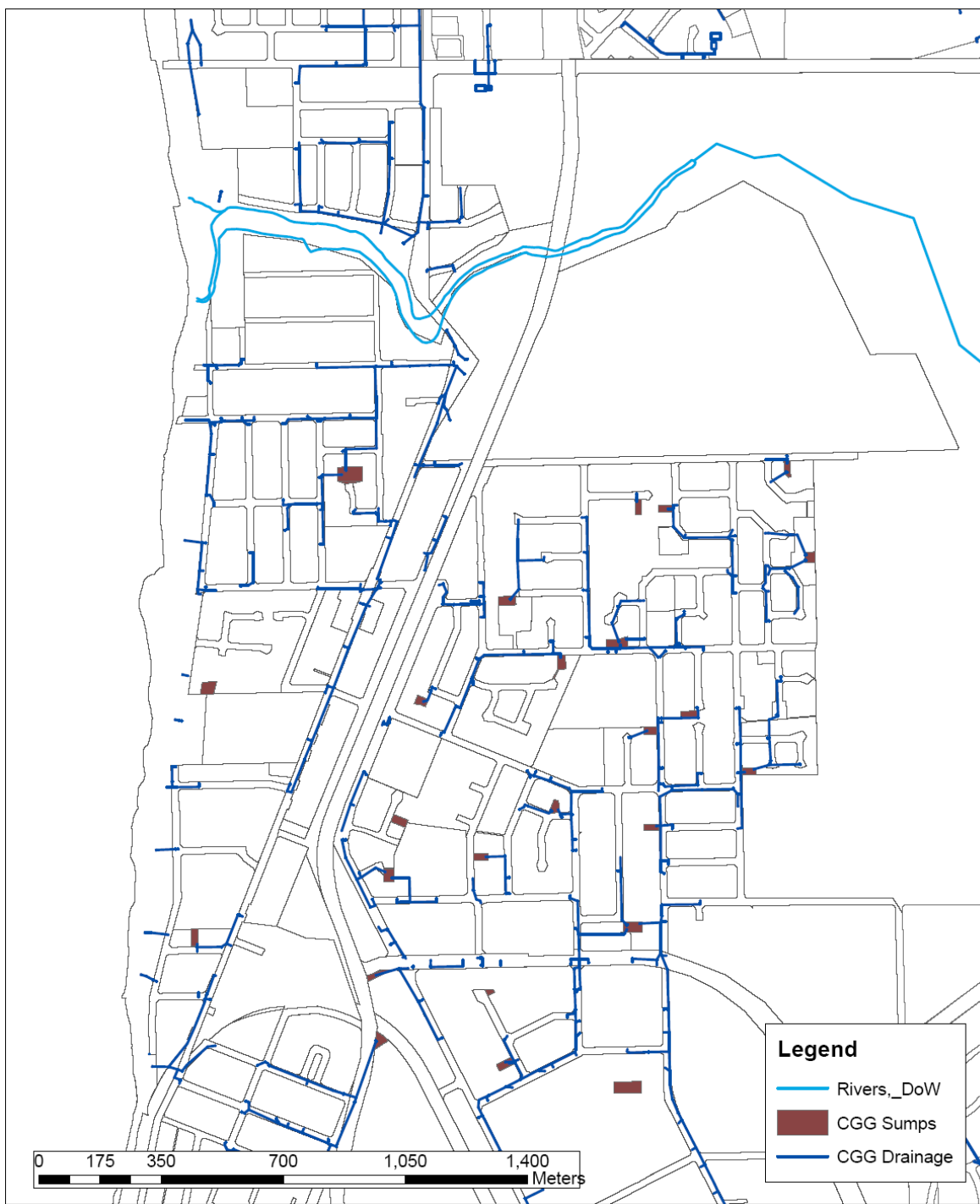


Figure 14: Bluff Point drainage system (pipes and sumps)

Other information is contained in the *Greenough River Estuary Management Plan 2005*, *Chapman Regional Wildlife Corridor Project Report and Implementation Plan 2001*, and the *Chapman River Estuary Management Plan 2010*.

3.6 GROUNDWATER

Groundwater in the City of Greater Geraldton is the major source of water for irrigation, industrial and commercial developments, agriculture and drinking water supply. The groundwater sub-areas are shown in Figure 9.

The main regional drinking aquifer lies to the south of the shire boundary, namely the Allanooka borefield. The Allanooka borefield is located in the Arrowsmith groundwater area in the Shire of Irwin. Further information on groundwater use is contained in section 4.2.

The Wicherina Water Reserve Public Drinking Water Source Area is located approximately 40 kilometres east of Geraldton near Eradu and 1-2 km south of the Geraldton – Mt Magnet Road. The Wicherina Water Reserve was proclaimed in 1989 under the *Country Areas Water Supply Act 1947* for the purpose of protecting the public drinking water source from potential contamination. No priority classification areas for source protection or protection zones have been assigned to the Water Reserve (Water Corporation, 2004).

The Wicherina wellfield historically supplied water to Mullewa, Eradu and the services along the pipeline between Geraldton and Mullewa as well as augmenting the Geraldton supply during peaking periods. In recent years, the Geraldton (Allanooka) scheme has supplemented the Wicherina Groundwater Scheme in order to reduce the abstraction of groundwater from the Wicherina wellfield and to improve the water quality of the scheme (Water Corporation, 2004).

According to Department of Water, groundwater levels across the majority of the existing Geraldton town centre are generally greater than 10m below natural ground level, although this varies considerably on a local scale. There are no known expressions of groundwater within any future development areas, with the exception of the Rum Jungle wetland. This wetland would need further investigation to determine the potential for future development to impact on its ecological values.

It is understood, based on reasonable evidence that groundwater generally flows towards the coast, becoming increasingly saline as it gets closer to the coast.

The Department of Water operates numerous surface water and groundwater monitoring sites throughout Western Australia and collects data on the quality and quantity of the State's water resources. The Water Information Reporting (WIR) system is a map-based tool that allows you to select sites of interest and obtain associated data, including borehole information, water quality, water levels, flow, and rainfall <www.wir.water.wa.gov.au> in Geraldton and across the region.

4 THE CURRENT WATER CYCLE PROFILE

In order to develop a total water cycle management strategy, it is necessary to review the status and context of all forms of water within the City of Greater Geraldton. Their interrelationships are then described via a water balance which aims to identify opportunities to achieve integrated water cycle objectives and better water use and management outcomes.

4.1 DRINKING WATER SUPPLY AND USE

The Water Corporation is the only licensed water service provider for Geraldton and surrounding areas. Its Geraldton Regional Water Supply (GRWS) Scheme provides potable water supplies to a total area of approximately 1,000 km² (375 km² of Greater Geraldton and 625 km² of adjoining rural areas) extending 80 km along the coastline between Dongara – Port Denison, in the south, to Buller in the north. In the east, the scheme boundary extends as far as Mullewa. Construction in 2007 enabled a further extension of the scheme to Northampton. Non-potable rural water is also supplied to approximately 1,440 km² of the Yuna Farmlands, east of Geraldton.

Currently most of the Geraldton regional scheme supply is drawn from the Allanooka, Mt Hill and Wye Farm borefields. These areas are centred approximately 50 km southeast of Geraldton. They withdraw water from parts of the locally unconfined Yarragadee Formation. Minor supplies are also drawn from the Wicherina Borefield to supply part of the Yuna Farmlands Rural Water Supply Scheme. The Allanooka Borefield was initially commenced in 1967 in the area adjacent to Allanooka Swamp, whilst the newer Mt Hill subarea was established in 1985. Further expansion occurred in the Allanooka – Mt Hill Borefield (Geraldton Groundwater Scheme) during the late 1990's and early 2000's and now consists of a total of 19 production bores.

Operation of the Geraldton Groundwater Scheme is managed under a Water Resource Management Operation Strategy as a condition of the Department of Water allocation licence (GHD, 2007a).

The Water Corporation has provided the following breakdown of customers connected to the GWRS scheme for 2012/13 (excludes Narngulu, Cape Burney, Walkaway, Northampton and Mullewa and rural residential areas):

- Residential 14,874
- Commercial 1,370
- Industrial 5
- Vacant Blocks 712
- Other 635

This data is represented in the bar graph of Figure 15.

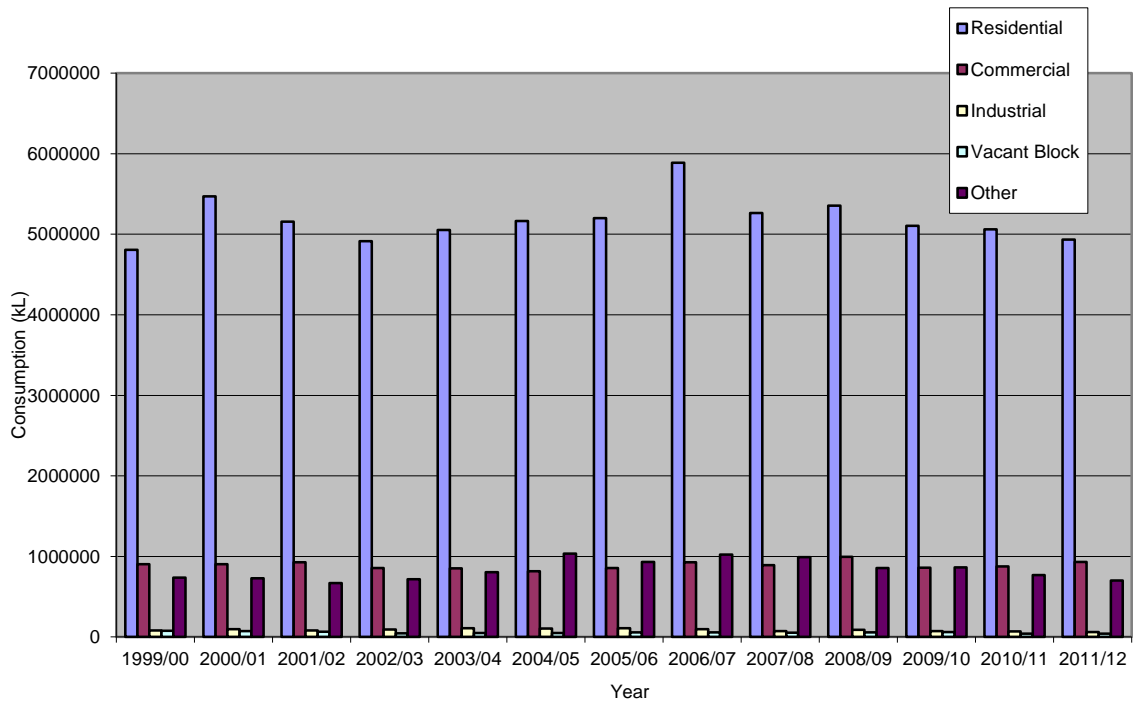


Figure 15: Total Scheme Water Consumption by Sector (Water Corporation, 2013)

Data provided by the Water Corporation in Geraldton indicates that recent average water consumption per residential connection is approximately 340 kL per annum (see Figure 15). Assuming an Australian Bureau of Statistics occupancy rate of 2.6 persons per dwelling, this equates to 130 kL per person per annum. This suggests a level of usage comparable to Perth (currently 132 kL per person per annum). Although the State Water Plan (DOW, 2009) recognises a target of 100kL kL per person per annum, the Water Corporation has set a revised target of 125 kL per person per annum by 2030 in Water Forever (Water Corporation, 2009).

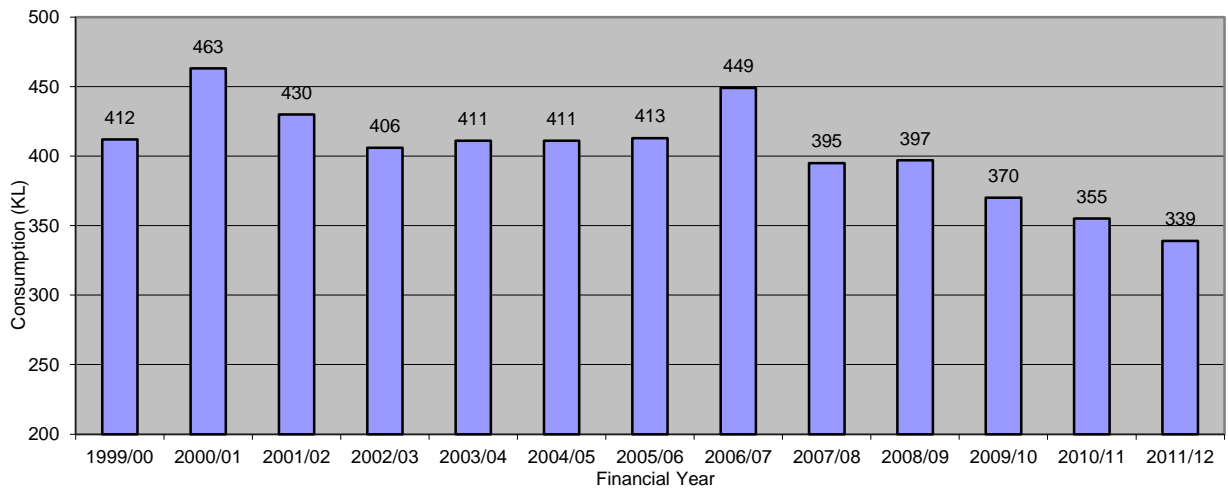


Figure 16: Average Residential Scheme Water Consumption (Water Corporation, 2013)

4.2 GROUNDWATER USE AND MANAGEMENT

Groundwater is the principal water resource for drinking and non-drinking uses across the City of Greater Geraldton. The groundwater resource for drinking water supply for Greater Geraldton is located outside the municipality, to the south, managed by the Department of Water (Figure 9).

The City utilises groundwater from local aquifers for non-potable uses, primarily for the irrigation of public open space.



4.2.1 Current situation

Groundwater is the largest source of irrigation water currently used by the City, meeting around 70% of the City's irrigation water needs.

The City's current irrigation demand is estimated at 0.689 GL/year to irrigate approximately 95 ha of land (DoW, 2010). When schools, sports clubs, the City of Greater Geraldton and other major water users are included, the total existing water demand is estimated at 2.285 GL/year to irrigate around 175 ha of land.

A summary of CGG water use and allocation by groundwater resource is summarised in Table 1 below:

Table 1: CGG POS irrigation with groundwater (source: Water Conservation Plan, 2010)

Water resource	Northampton - Sedimentary Gascoyne GW area GWL 155673	Perth - Superficial Swan Arrowsmith GW area GWL 158532
Water use (kL/yr)	14,936	673,568
Allocation (kL/yr)	28,125	665,390
Over/under (amount)	(13,189)	8,178
Irrigated area (ha)	3	91.92
Av water use/ha irrigated (kL/ha/yr)	4,978	7,238
# bores	2	73
# irrigated parks & reserves	2	46

The area of land to be irrigated in the future will depend largely on the results of a Public Open Space study (currently under-way) and the availability of irrigation water at a reasonable cost. It is estimated that around 131 ha could possibly be irrigated by the City in the future, requiring 1.723 GL of water annually. The overall irrigation demand in

Geraldton was expected to increase to 3.527 GL/year to irrigate around 270 ha of land by the Water Corporation in 1999 (Irrigation Strategy and Conceptual Design, p.7).

The City of Greater Geraldton worked with Department of Water to produce a *Water Conservation Plan*. Implementation of the Water Conservation Plan will help the City to better manage its groundwater water allocation. The Plan identifies the following broad groundwater questions and issues facing the City of Greater Geraldton over the next three to five years.

- Recharge can vary from area to area. Storm water capture and recharge occurs outside central Geraldton but none occurs in the central area;
- Over 30% of irrigation systems are performing poorly (generally the outdated systems in older public open space) and there is over abstraction in some areas;
- Large amounts of scheme water are currently being used at a cost of around \$100,000 during 2008/2009;
- Irrigated areas need to be mapped accurately and overlain with monitoring data regarding groundwater resources (including levels and quality);
- Categories/hydrozones/ecozones need to be identified and linked to service levels and appropriate turf species for the water quality of particular locations;
- Salinity in bore water is a very big issue (salt water intrusion and salinity ranges from 3,000-7,000 ppm). The City of Geraldton-Greenough will need a maintenance program to help manage irrigation with salty water.
- Need to ensure native vegetation is maintained;
- There is a need to develop better urban water management strategies – and make more reuse water available for developers. Opportunities to review water planning before the development phase in new developments should be identified;
- Consultation with industry and the community should be improved and include an analysis of the social and recreational requirements for each proposed space so that an appropriate design is identified that also takes into consideration fit-for-purpose water availability and efficient water use.
- Water use data is collected but it has only recently started being analysed.



The City of Greater Geraldton, as part of development of the Water Conservation Plan, has proposed objectives for water conservation and has drafted ten strategies that will be implemented to achieve the objectives. These strategies are discussed further in section 6.2.1.

As part of the review of irrigation practices undertaken as part of development of the Water Conservation Plan, the City has determined an optimum peak summer irrigation requirement of 54 mm/week for its grounds. This requirement should be applied in a manner that matches the moisture holding capacity of the soil. In the summer peak this translates to

- Two applications of 27 mm/week for loam soils;
- Three applications of 18 mm/week for loamy/sand soils; and
- Four applications of 13.5 mm/week for very sandy soils.

In the cooler months of the year, the frequency of watering decreases, but the same volume of water should still be applied each watering. For instance, a loam soil that receives two 27 mm applications per week in January will receive one 27 mm application per fortnight in September.

The capacity of the majority of the City's existing irrigation schemes is inadequate to achieve the desired 54 mm peak summer irrigation application. Existing schemes typically have the capacity to provide 20 - 35 mm/week of precipitation.

The average annual irrigation requirement adopted for this study is 1,305 mm/year. This is equivalent to applying 13,050 kL of water per hectare of land annually (Table 2, Water Corporation, 1999, Irrigation Strategy and Conceptual Design, p.6).

Table 2: Monthly Irrigation Requirements (Ref.: Water Corporation, 1999, Irrigation Strategy and Conceptual Design, p.6)

Month	Irrigation requirement (mm/month)
January	231
February	200
March	189
April	115
May	0
June	0
July	0
August	0
September	69
October	123
November	168
December	210
Total	1,305

A long-term groundwater deficit in the northern area of Geraldton (around the Eadon Clarke Complex and Spalding Park) and also in the central City area was identified in 1999.

There are currently 105 groundwater bores operated and maintained by the City.

Groundwater salinities range up to 7,300 mg/L, and are highest near the Chapman River around Spalding Park / Eadon Clarke Reserve, and around Wonthella Reserve. Small amounts of less saline water may be found as a lens on top of the brackish water, particularly in areas close to groundwater recharge sources such as drainage retention basins and the Wonthella WWTP.

During winter groundwater salinity is relatively low (between about 700 mg/L and 1800 mg/L) from several bores when they are not in use. The lower salinity water reflects groundwater just below the watertable that has been recharged locally. An area of lower salinity groundwater (less than 2,000 mg/L) occurs beneath and immediately down-gradient of the Wonthella WWTP, and is due to the infiltration of low salinity effluent from the plant. Low salinity groundwater occurs in the City centre within the upper part of the Tamala Limestone aquifer, probably resulting from enhanced groundwater recharge due to urbanisation.

As a result of relatively low annual rainfall (average 472 mm) and high evaporation (2,500 mm Class A pan evaporimeter), groundwater recharge from rainfall is low. From data presented by Hingston and Gailitis (1976), it is estimated that the average salinity of rainfall (including dryfall) is 29.3 mg/L, which at 5% recharge is concentrated to almost 600 mg/L by evaporation and transpiration while infiltrating downward to the watertable.

Analysis of pumping test data from bore 1/97 at the Wonthella WWTP (Rockwater, 1997) determined an aquifer transmissivity of 810 m²/day and a hydraulic conductivity of 53 m/day. Earlier work had determined hydraulic conductivities of 90 m/day (Rockwater, 1993) and 220 m/day (Hydro-Plan, 1995).

Estimates of the total current groundwater resource are presented in Table 3. The two estimation methods used indicate the total annual resource to 4.319 GL and 4.460 GL (analytical & modelling respectively). Typically, around 70% of the total resource is available for abstraction, giving about 0.300 GL/annum per kilometre of aquifer parallel to the coast. In 1999 the groundwater draw was estimated at 1.664 GL/year, being approximately 38% of the total resource, and 54% of the available resource (Water Corporation, 1999, Groundwater Assessment and Management Plan, p.7).

The City's stormwater drainage catchment plan in 1999 indicated that 44% of the area within the City of Greater Geraldton was either not drained to catchment sumps, or those sumps were redirected to ocean outlets or the Chapman River before significant groundwater recharge could occur. Wherever it is economically possible, stormwater should be diverted to vegetated bioretention basins and allowed to infiltrate into the ground. Particular areas of focus in this regard are Spalding Park, Mahomets Flats and the City centre area. Over time, additional swales and side entry soakwell pits can be installed

en route to retention basins and the latter converted to biofiltration basins in order to optimize recharge.

Table 3: Current annual groundwater resources within the Geraldton area (source: Water Corporation, 1999, Groundwater Assessment and Management Plan, p.7)

Component	Analytical method (GL/year)	Model (GL/year)
Throughflow from east	2.19	2.219
Rainfall recharge	0.564	0.558
Infiltration recharge (drainage sumps & WWTP)	1.565	1.491
River leakage	-	0.192
Total resource	4.319	4.460
Available resource (70%)	3.023	3.122

Approximately 0.606 GL of additional groundwater could be conserved on site each year if all stormwater catchment within the City boundary is captured and infiltrated. If this water was able to be harvested for reuse, this is equivalent to the irrigation demands of an additional 47 ha at 1,305 mm/year (Note that as the local superficial aquifer is unconfined, not all infiltrated water would be available for abstraction).

Several bores exhibit rising groundwater salinities. These bores are all located in areas with clayey sub-strata, principally within the high irrigation areas about Eadon Clarke Reserve and Wonthella Reserve.

The groundwater resource is being significantly overexploited in the area around Spalding Park and Eadon Clarke Reserve. The demand in this area does not currently seem too sustainable, with more water being abstracted for irrigation each year than appears to be recharged into the aquifer.



4.2.2 Future resources

In 1999 the total irrigation demand for Geraldton was estimated at 3.530 GL/year if all areas indicated as “future irrigated” on the Waterstudy Map were irrigated at the optimum rate.

Table 4 presents the future estimated groundwater resource within the City of Greater Geraldton.

Table 4: Future Groundwater Resources within the Geraldton area (source: Water Corporation, 1999, Groundwater Assessment and Management Plan, p.16)

Component	Existing annual volume (GL/year)	Future annual volume (GL/year)
Throughflow from east	2.219	2.641
Rainfall recharge	0.558	0.558
Infiltration recharge (drainage sumps & WWTP)	1.419	1.217
River leakage	0.192	0.219
Total resource	4.46	4.635
Available resource (70%)	3.122	3.245
Anticipated use through groundwater bores	1.664	2.1 – 2.5

The total annual resource was estimated at 4.635 GL in 1999, with 70% of this volume being available for use (3.245 GL/year). To achieve the maximum available resource of 3.245 GL/year, a relatively even spread of groundwater abstraction would be required. This may not be possible in reality. Groundwater salinity constraints restrict the use of groundwater in some areas.

4.3 WASTEWATER SYSTEMS

The Water Corporation has advised (in 2013) that:

- 10,945 customers connected to the Geraldton sewer area; and
- 344 customers connected to the Cape Burney sewer area.

The balance of premises, approximately 6,000, will be on septic tanks.

The GHD (2007b) wastewater conveying study explains that the Greater Geraldton wastewater system is comprised of five sewer districts: Waggrakine, Spalding, Geraldton, South Geraldton and Greenough. There are a total of 27 operational pump stations (including temporaries) in the greater Geraldton wastewater system. There are currently four operational wastewater treatment plants (WWTP) (figure 17):

- Geraldton North WWTP (605 kL/day) (Glenfield Beach), services most of Waggrakine;

- Geraldton No. 2 WWTP (1,944 kL/day) (Wonthella), which services the remaining seweraged areas;
- Narngulu WWTP (2,000 kL/day) is located within the Narngulu Industrial estate. The land adjoining the WWTP is used for rural and industrial purposes;
- Greenough on Sea WWTP (60 kL/day) services development in the Cape Burney area.

These four plants operate as follows:

- Geraldton North WWTP (Glenfield Beach) is an oxidation pond type plant, with disposal of effluent achieved via evaporation and infiltration to groundwater. The ponds have recently been duplicated in a plant upgrade. The previous plant capacity was 400 kL per day and the current capacity is approximately 850 kL per day. The current inflow is approximately 600 kL per day. In the future the Water Corporation is expected to come under increasing pressure from developers to relocate Geraldton North WWTP. Whilst a new site is indicated in the Greater Geraldton Structure Plan (WAPC 1999) for a WWTP in the Oakajee industrial area north of the Buller River, no timeframe has been set for any future relocation of this plant to the new site. Should such relocation occur in the future, funding arrangements may involve a combination of private sector and public (Federal, State, Local) sector contribution to meet the significant relocation costs.

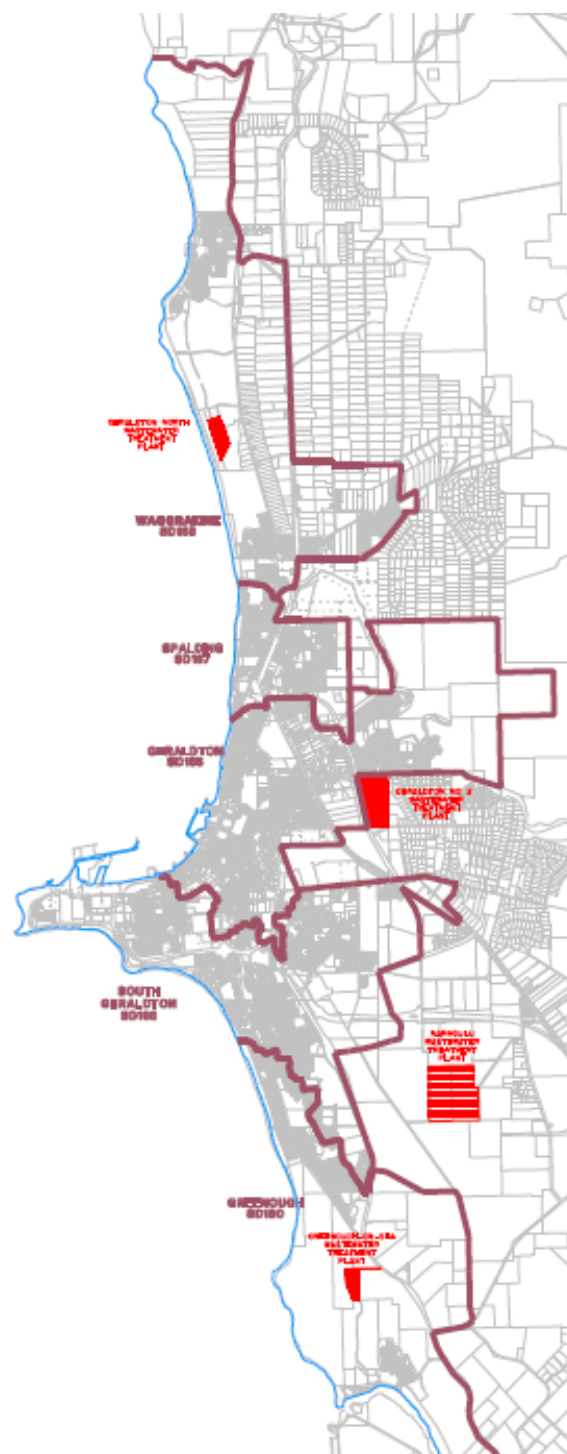


Figure 17: Geraldton waste water treatment plants

- Geraldton No. 2 WWTP (Wonthella) is currently operating around 2,000 kL per day. The Geraldton No. 2 WWTP is an aerated pond type plant with disposal of effluent achieved via evaporation and infiltration to groundwater. Some effluent is indirectly reused for irrigation purposes. The Water Corporation has an agreement with the City of Greater Geraldton to provide infiltration to the aquifer from the Geraldton No. 2 WWTP to meet the existing reuse demands. The minimum required inflow to meet current reuse demands is 2, 000 kL per day.
- Narngulu WWTP is a High Performance Aeration Lagoon (HPAL) type plant, the first such plant built by the Water Corporation, with disposal achieved via evaporation/infiltration to groundwater, and possible future reuse by industry or for irrigation purposes.
- Greenough on Sea WWTP, an oxidation pond type plant, treats flows from the Cape Burney area that is within the Greenough Sewer District. Current inflows to the WWTP, are approximately 60 kL per day. Effluent from the plant is disposed of via evaporation/infiltration to groundwater.. Greenough on Sea WWTP is limited by the size of the existing infiltration ponds, and as a registered WWTP, it can only treat up to 100 kL per day GHD (2007b).

These four WWTP can provide a valuable resource for the City as already demonstrated by the aquifer recharge from Wonthella WWTP No 2. The Water Corporation (2013) advised that groundwater use by the City, the Golf Club and Geraldton Turf Club from the recharge bore at WWTP No 2 was 180,000 kL in 2012/13. It will be important to expand this practice at Wonthella and commence recharge at the other three WWTP or some other form of reuse.



4.4 STORMWATER MANAGEMENT

The majority of the existing urban area of the City of Greater Geraldton is contained within the former City of Geraldton, surrounding the town centre and port. This area is generally characterised by traditional piped stormwater drainage systems which terminate in retention basins or an ocean outfall (Figure 15). Some of these systems have reached capacity and are experiencing problems with localised flooding and accordingly require significant redesign or upgrades.

The City of Greater Geraldton is now implementing stormwater management techniques which meet the principles of water sensitive urban design, as described in the Department of Water's *Stormwater Management Manual* (2004 – 2007) and are consistent with the Institute of Public Works Engineers *Local Government Guidelines for Subdivisional Development* (Ed 2.1, 2011).



The City has developed specifications for the design of stormwater drainage systems in new urban areas (including industrial and commercial development). These specifications refer substantially to the *Local Government Guidelines for Subdivisional Development*

(IPWEA, 2011) and contain site specific rainfall information and guidance for calculation of impervious areas by developers and consultants.

The City has also undertaken a review of eleven sumps in Bluff Point, Spalding, Strathalbyn, Rangeway, Geraldton and Utakarra to determine the opportunities for retrofit. The review identified that, due to hydraulic or technical reasons, four sumps couldn't be eliminated and retrofitting a further five would not be cost effective. The opportunity exists to build a case to retrofit two of the sumps and this will be further investigated by the City engineers.

The City is currently harvesting stormwater from the large grain storage sheds in the Geraldton Port precinct via an aquifer storage and recovery project. Rainfall is infiltrated via a series of vegetated basins. The stormwater is then slowly pumped out of the superficial aquifer at low pressure into a series of storage tanks for use in irrigating part of the foreshore public open space. The slow rate of pumping minimises the likelihood of saltwater intrusion into the aquifer.

4.5 WATER FOR THE ENVIRONMENT

The Greenough and Chapman Rivers are regionally significant waterways in terms of biodiversity, habitat provision, aesthetic values, cultural values and recreation in the Mid West region (Water and Rivers Commission, 2001a & b). The former Water and Rivers Commission completed waterways assessments of both rivers in 2001. These assessments documented the status of the foreshore environment, identifying major threats to the health of the waterways and recommending strategies for management. Although there is limited information on the flows necessary to maintain the environmental values of the waterways, the report notes that there are sections of both waterways which “have been recontoured by private landholders and a considerable number of dams blocking the flow” and that the “landholders need to be approached to determine the feasibility of restoring the function of the brook” (Water and Rivers Commission, 2001a & b).

There is a need for improved and coordinated management of the Greenough and Chapman Rivers to repair, minimise and prevent further degradation. General guidance is provided by the Department of Water's River Restoration Manual, which outlines the basic principles of how waterways function and provide guidelines to assist in the rehabilitation and long-term management of waterways in Western Australia. Additional information on a wide range of topics is also provided by the Department of Water's Water Notes and Water Facts.

Limited information exists with regards to other significant water-dependent ecosystems, however. The need to protect significant environments is recognised as a key objective of this Strategy. The recommended strategies and design objectives aim to enhance or maintain hydrological systems and this requires the consideration of environmental water requirements of key environmental assets and systems.



4.6 WATER BALANCE

From the above data the main items forming the water balance for the City of Greater Geraldton in 2011/12 can be summarised as follows:

- The Water Corporation supplied approximately 6.7 GL¹ of scheme water into Geraldton of which approximately 5 GL was for residential use. This figure excludes certain outer areas of Geraldton such as Narngulu, Walkaway and Cape Burney.
- This water was sourced from a 14 GL per annum licence from the Allanooka borefield in the Arrowsmith groundwater area, outside of the shire boundary to the south. The maximum available allocation is 18.5 GL and perhaps ultimately 20 GL. The Water Corporation (GHD, 2007) has estimated that 27 GL will be required within the next 30 years.
- The total capacity of the Water Corporation's four waste water treatment plants is currently 3 GL per annum.
- The City of Greater Geraldton's groundwater use for public open space for 2013 was just under 0.8 GL.

¹ NB 1 GL = 1,000 ML = 1,000,000 kL = 1,000,000,000 litres

- The City also uses scheme water on some areas of public open space where the groundwater is unavailable, too saline for irrigation or for shandyng with high salinity groundwater. Just over 0.2GL of potable scheme water was used for irrigation in 2013.
- Just under 0.2 GL of treated wastewater from WWTP No 2 was used by the City of Greater Geraldton for watering some public open space areas and turf clubs in 2008/09.

The above data demonstrates that there is a potentially significant shortfall in water supply if business-as-usual approaches are maintained, rainfall decline continues and population expands at the predicted rates within the City. This data is also presented in Figure 18.

It is interesting to note that the amount of wastewater generated in Geraldton is far more than the current irrigation requirements of the City of Greater Geraldton.

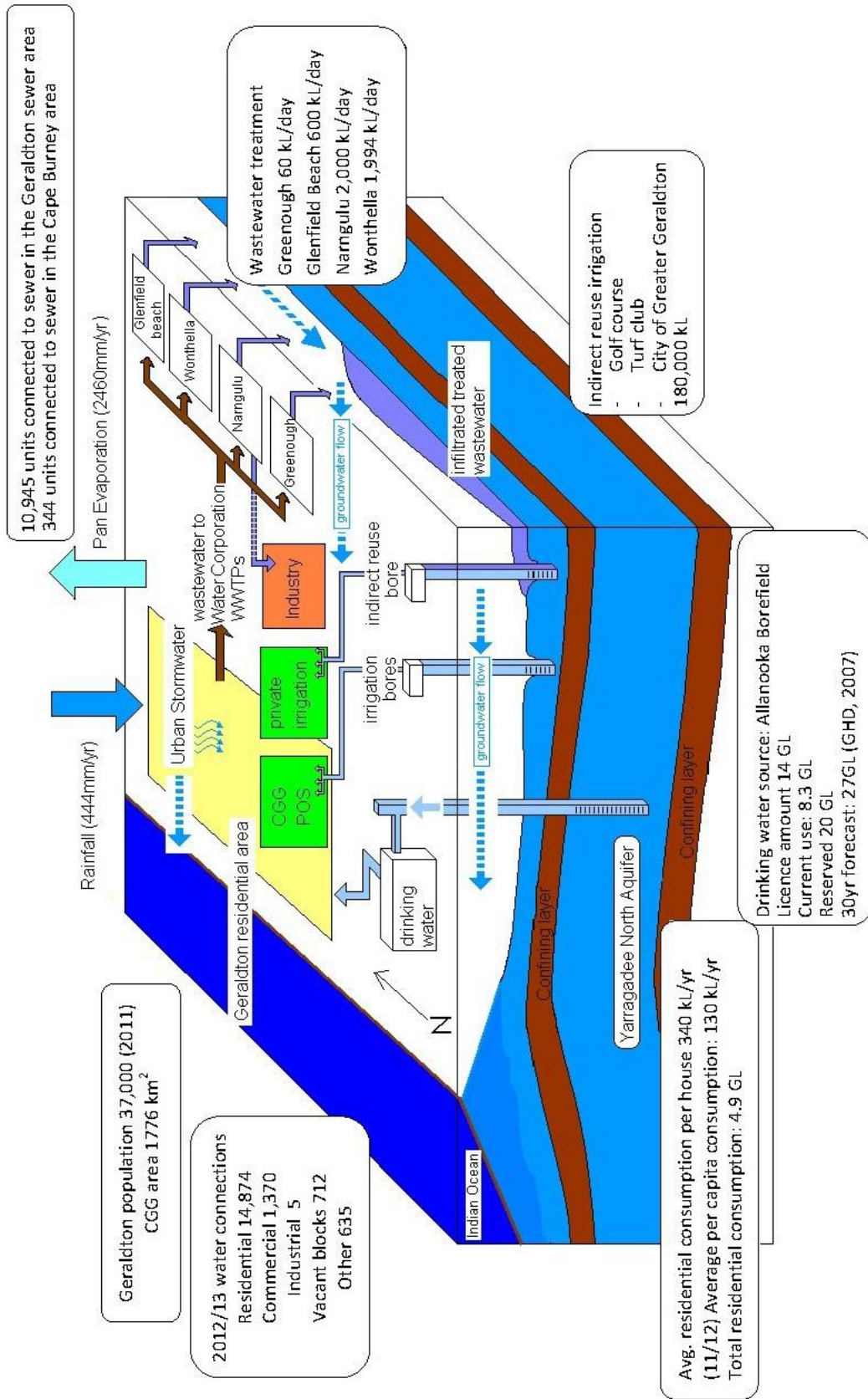


Figure 18: A simplified water balance diagram incorporating the various water streams in the City of Greater Geraldton

5 DRIVERS FOR CHANGE

5.1 POPULATION GROWTH

The population of the City of Greater Geraldton in 2011 was approximately 37,160.

The City of Greater Geraldton *Plan for the Future 2009-2014* suggests that “Greater Geraldton will have the capacity to sustain a population of 80,000 to 100,000 people.” Although this level of population growth is unlikely to occur in the next 10 years, several large resource projects and the development of the proposed Oakajee Deepwater Port are likely to increase the level of growth across Greater Geraldton.

The City is actively planning to accommodate a substantial growth in the population of the region as part of its Sustainable Future City Project.

5.2 FUTURE LAND USE CHANGE AND DEVELOPMENT

Guidance for land use change and development within the City of Greater Geraldton is largely provided by the Greater Geraldton Structure Plan (WAPC, 2011), the Geraldton Regional Centre Strategy (WAPC, 2005) and the Greenough Local Planning Strategy (2008). These documents identify existing and proposed areas for various urban land uses and industry as well as substantial areas for rural residential development, bounded by the Moresby Ranges and agricultural areas. Key areas identified for future land use change include:

- Narngulu industrial area and surrounding buffer, which may be appropriate for large commercial uses compatible with the noise contours from the Geraldton Airport;
- Residential areas proposed for Glenfield Beach, Sunset Beach, Waggrakine, Wandina, Rudds Gully and Cape Burney; and
- Expansion of rural residential areas around Woorree, Waggrakine and Strathalbyn.

The estimated growth in population and change in land use has the potential to impact on the environment and water resources. Inappropriate stormwater and wastewater management in the catchment may increase the potential for flooding and also lead to changes in groundwater levels due to changes in infiltration and an



increased demand. Land use change also has the potential to result in reduced water quality of groundwater and waterways from nutrient enrichment (eutrophication) and algae growth, erosion and sedimentation; changes in turbidity, oxygen, temperature which are greater than natural variability; or contamination from disturbance of acid sulfate soils. These impacts may be caused by ground disturbing activities, for example, agriculture and urban construction works, which contribute to land and water degradation processes. Additionally, industrial and commercial activities and infrastructure may release solid or liquid contaminants or discharges to the groundwater.

Other potential impacts include loss of biodiversity values including displacement of native fauna due to habitat destruction from urbanisation; invasion of weeds, pest species and feral animals; clearing of native vegetation; changes in fire regimes; and increases in human activity in the catchment and along waterways. Land use change is also associated with amenity issues including loss of visual amenity, heritage and cultural values; and mosquito and midge nuisance.

These significant issues need to be managed appropriately as part of land use change and development to minimise the potential impact on water resources to achieve the objectives and vision of a Water Sensitive City.

5.3 CLIMATE CHANGE

The National Climate Change Adaptation Research Facility has identified in its draft research plan for Settlements and Infrastructure (September, 2009, p22), the climate changes that are likely to impact operating infrastructure. These are, in order of confidence of prediction:

- *increasing temperature – widespread – all persons and infrastructure impacted to some degree;*
- *sea level rise – widespread and very significant for all coastal cities and settlements as well as estuarine systems – large populations, major infrastructure and high value assets directly impacted;*
- *more variable rainfall – spatial and temporal changes across different regions - shifts in seasonality, reduced rainfall occurrence (less rain days and more time between rain events) in some regions whilst intensity of rainfall when it occurs may increase with higher flood risk in other regions – large populations, major infrastructure and high value assets may be impacted on a regional basis; and*
- *reduced catchment runoff in many regions – result of increased temperature, reduced and seasonal shifts in rainfall combined with increased evapotranspiration indicate significant reductions in catchment runoff and water resources – direct impact on water security that will require increased water storages or alternative sources for major cities and regional towns.*

These impacts have potentially significant consequences for the City of Greater Geraldton.

In order to inform the City's response to the issue of climate change, the City, through its participation in the Batavia Regional Organisation of Councils (BROC), investigated the region's Climate Change Risks and Opportunities. The study by AECOM (December 2009) uses projections from the Intergovernmental Panel on Climate Change's (IPCC's) range of future greenhouse gas emissions scenarios. These projections for increased temperatures, reduced rainfall and sea level rise are presented below (Table 5).

Table 5: Projections used for the BROC climate change risk assessment process (AECOM, 2009)

Climate change	Specific climate variable	Current conditions	Projections for 2030	Projections for 2070
Increased temperatures	Average temperature	19.8 °C	+ 1.4 °C (21.2 °C)	+6.4 °C (26.2 °C)
	Days over 35 °C per year	38 days	+6 days (44 days)	+26 days (64 days)
Reduced rainfall	Average rainfall	449 mm	-9.5% (406 mm)	-43.7% (252.8mm)
	Annual dry days (days with <1 mm rainfall)	324.1 days	+2.9 days (327 days)	+13.4 days (337.5 days)
Sea level rise	Sea level rise	-	+0.2 metres	+0.7 metres
	Extreme sea level events (storm surge)	Factor of four increase in frequency for every 0.10 metre of mean sea level rise		

The Climate Change Risks and Opportunities report for BROC (AECOM, December 2009) identified a number of impacts on stormwater drainage and infrastructure, as well as water supply which may result from climate change. These include:

Stormwater, wastewater and drainage

- Inundation of stormwater and sewerage systems;
- More intense rainfall resulting in inflow and infiltration into wastewater networks;
- Increased peak flows and changes in groundwater levels;
- Reduced dry weather sewerage flows;
- Reduced/unreliability of power supply for sewage pumping and treatment if existing electricity suppliers cannot maintain pace with long term changes in climate;
- Changes in flood plains;
- Overload of existing flood defences;
- Exceeding drainage capacity;

- Reduction in drainage capacity due to sea level rise and storm surge; and
- Changes in mean and peak stream and river flows.

Water Supply

- Changes in mean and peak stream and river flows;
- Uncertain water availability;
- Insufficient water supply in some areas;
- Increased potential for water contamination;
- Salination of surface and groundwater supplies; and
- Changes in availability of groundwater available for irrigation.

The Climate Change Risks and Opportunities report also recommended a number of adaptation actions in response to the above issues as follows:

Stormwater, wastewater and drainage

- Avoid building new infrastructure in areas at high risk of climate change impacts;
- Develop contingency plans for infrastructure failure during and following extreme events;
- Review and update infrastructure design standards, codes and criteria to ensure that the latest information about climate change impacts are adequately considered at the design stage for new infrastructure;
- Consider triage maintenance to maintain network accessibility and reduce asset degradation while standards review takes place;
- Identify existing and planned infrastructure at the most risk from climate change and prioritise for adaptation action, including identifying critical infrastructure requiring immediate retrofit, upgrade or replacement;
- Carry out more frequent inspections and maintenance programs to deal with accelerated asset degradation; and
- Identify critical infrastructure requiring immediate retrofit, upgrade or replacement.

Water Supply

- Diversification of supply (e.g. options for desalination, renewable energy sources etc); and
- Use of development setbacks/buffers to prevent contamination of water supply.

Further to the 2009 study, the *Climate Change Adaptation Action Plan* was prepared by BROCC to guide the region's response to the issue of climate change (AECOM, 2010). Key water-related issues identified by the plan, in addition to those identified above, are as follows:

- Many areas of agricultural land are already degraded or are being poorly managed, increasing vulnerability to climate change;
- Mining operations currently use and are likely to require additional significant volumes of water and this could be an issue with reduced water availability in future;
- Current infrastructure design standards may not be appropriate for future climatic conditions due to changes in magnitude and frequency of events; and
- Predicted reductions in rainfall will have serious long term implications for the groundwater resource.

High priority water-related actions in the *Climate Change Adaptation Action Plan* are to:

- Conduct water audits across council facilities (including parks and buildings) to gain a comprehensive understanding of water usage patterns and opportunities for reductions;
- Establish water use targets and implement efficiency measures across all existing council operations and incorporate into all new tender documents;
- Prioritise drought tolerant species in all council-controlled planting and revegetation projects (e.g. street trees, bush revegetation) and progressively replace species with high watering requirements with more drought resistant ones;
- Implement priority recommendations of Towards a Water Sensitive City - Water Planning and Management Strategy currently being developed to increase resilience to future climate change;
- Promote the region as a leader in the use of innovative water and energy efficiency technologies;
- Investigate greywater reuse for all Council owned Buildings;
- Provide incentives to encourage residential and commercial uptake of rainwater tanks; and
- Continue to monitor changes in water-borne disease rates and adjust existing water testing programs if required.

Other points of note related to climate change which should be considered when making water resource decisions are:

- Community capacity to reduce water demand is substantial and has been demonstrated in various drought affected cities/regions.
- Desalination and potable re-use options require high energy consumption. If this energy cannot be provided by renewable energy sources, those options may conflict with climate change mitigation objectives.
- Reduced annual rainfall combined with increased extreme events will affect the quality and amount of drinking water supplies. This requires increases in storages or the use of alternative sources (groundwater, rainwater tanks, reuse or desalination), as well as reduced per capita use.
- Long lead times and substantial investment required for new distribution networks for both supply of water and wastewater disposal require new approaches to the assessment of feasibility and delivery of services including adaptive investigation, design and planning.
- Existing systems are unlikely to be able to be re-engineered to be able to accommodate major flows from extreme events, particularly when combined with impacts from storm surges and sea level rise in coastal areas. It is likely that the community will need to consider accepting lower standards of nuisance stormwater.

5.4 SCENARIOS FOR THE FUTURE

Climate change is likely to have a substantial impact on the water resources within the City of Greater Geraldton and the strategies which will be required to adequately adapt to the changing circumstances. Table 6 utilises two key scenarios from the BROCC report (AECOM, 2009) to scope possible futures required to successfully deliver adequate water and water services for the community and the environment. These scenarios are:

1. Rainfall declines by approximately 10% by 2030.
2. Rainfall declines by approximately 40% by 2070.

Table 6: Water-related response to improve outcomes for integrated water management for possible climate change scenarios

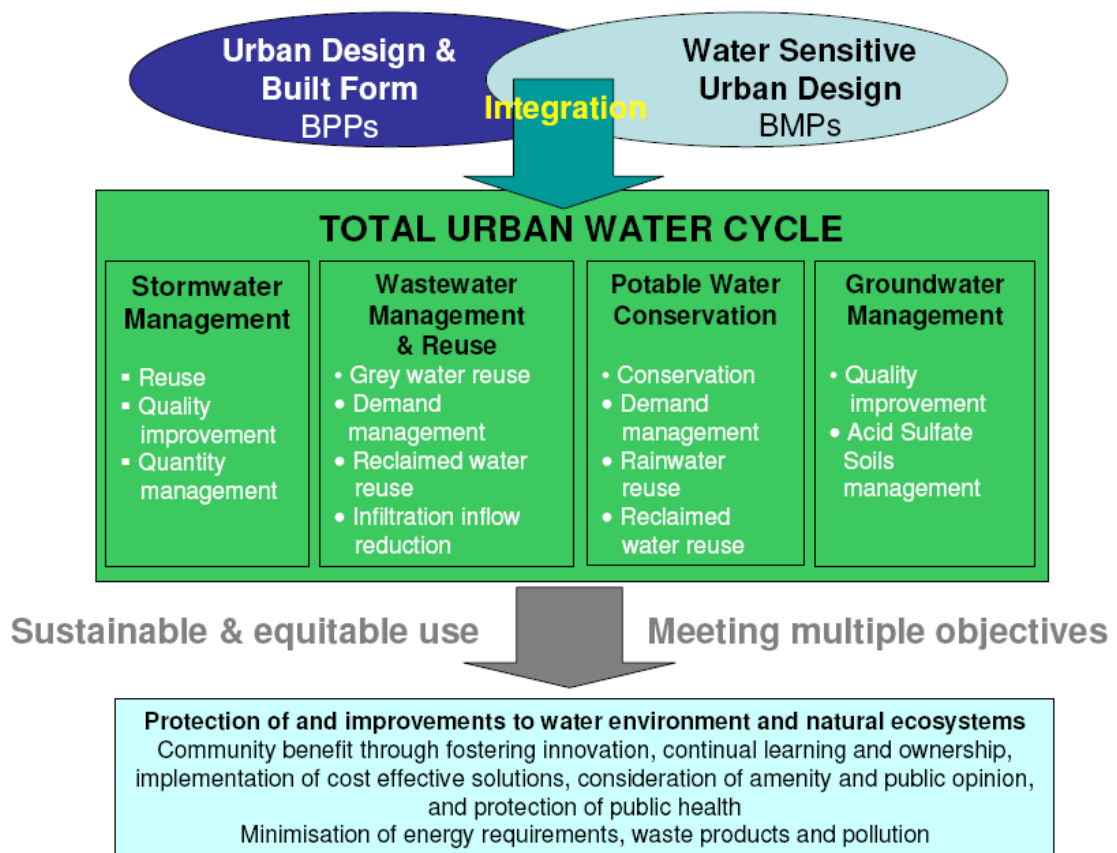
	Scenario 1: Rainfall declines by 10% (2030)	Scenario 2: Rainfall declines by 40% (2070)
Drivers	<ul style="list-style-type: none"> • BROC/AECOM/IPCC projection where average annual rainfall declines by 9.5% by 2030; • Plan for the Future population growth to 80,000; • Oakajee industrial development established; • Major iron ore deposits in production; • Large scale renewable energy projects underway (wind, wave, solar). 	<ul style="list-style-type: none"> • BROC/AECOM/IPCC projection where average annual rainfall declines by 43.7% by 2070; • Population doubling to 160,000; • Industrial, mining, manufacturing and renewable energy developments expanded.
Protection of significant environments	<ol style="list-style-type: none"> 1. Chapman River and Greenough River riparian areas revegetated and managed to cope with severe rainfall events 2. Remnant vegetation sensitive to changes in hydrology in decline 	<ol style="list-style-type: none"> 1. Coastal and estuarine areas impacted from sea level rise and increased storm surges 2. Chapman River and Greenough River riparian areas revegetated and managed to cope with severe rainfall events 3. Remnant vegetation assemblages adapt to reduced rainfall. Loss of biodiversity
Stormwater management	<ol style="list-style-type: none"> 3. Completion of better surface water management in rural areas through whole farm planning. 4. WSUD stormwater harvesting in all new developments since 2010. 5. Renovation of urban drainage infrastructure ASR systems, projects must be cost effective and demonstrate net welfare benefit. 6. Renovation of all urban retention basins to green spaces or recreation. 	<ol style="list-style-type: none"> 4. Implementation of keyline water harvesting systems in rural areas.

	Scenario 1: Rainfall declines by 10% (2030)	Scenario 2: Rainfall declines by 40% (2070)
Groundwater use and management	<p>7. Arrowsmith groundwater area and Allanooka subarea fully allocated.</p> <p>8. Broadscale water harvesting and infiltration systems implemented across the Arrowsmith groundwater area.</p> <p>9. Urban and industrial areas stormwater ASR schemes fully developed.</p>	<p>5. All groundwater areas in decline such that they are no longer viable as the principal regional water resource.</p> <p>6. Remaining groundwater retained as environmental asset.</p>
Drinking water supply and use	<p>10. Allanooka groundwater subarea fully allocated.</p> <p>11. Scheme drinking water for indoor uses only.</p> <p>12. Wave powered seawater desalination (reverse osmosis) plants (SWRO) established for city centre and Oakajee industrial area. (See SWRO extract from GHD 2007 for Water Corporation new water sources in the next section.)</p>	<p>7. Scheme drinking water for potable indoor uses only (kitchen and cold taps)</p> <p>8. Principal water resource is now wind and wave powered seawater desalination plants.</p>
Water conservation and efficiency	<p>13. Water Corporation Waterwise programs fully implemented across all scheme water areas</p> <p>14. Scheme water use reduced by 40% on a per capita basis.</p> <p>15. Rainwater tanks on all dwellings greater than 100 sqm roof area.</p> <p>16. Rainwater tanks on all industrial and commercial buildings.</p>	<p>9. Scheme water use reduced by 70% on a per capita basis.</p> <p>10. Waterwise gardens fully established across all residential areas.</p>
Water reuse	<p>17. Greywater reuse for outdoor uses on all single residential lots greater than 500 sqm.</p> <p>18. MAR wastewater schemes established at all Water Corporation WWTP to supplement POS, oval and golf course irrigation.</p> <p>19. Sewer mining MBR plants established throughout urban areas to supplement stormwater ASR schemes for irrigation of parks and gardens.</p> <p>20. Industrial areas renovated with third pipe schemes.</p>	<p>11. All residential areas renovated or established with third pipe schemes</p> <p>12. Peri-urban and rural residential areas beyond sewer reticulation have their own cluster-scale shallow sewerage to localised recycling plants.</p> <p>13. Large apartment, commercial and industrial buildings have on-site water recycling facilities.</p> <p>14. Wastewater hydroponic urban agriculture systems fully established.</p> <p>15. Nutrient recovery from wastewater fully established through biosolids reprocessing and urine separation.</p>

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6 OPPORTUNITIES FOR BETTER WATER OUTCOMES

As noted in the introduction to this report, the basis for creating water sensitive cities is the integration of urban planning with the management, protection and conservation of the whole water cycle in a way which protects and enhances the natural hydrological cycle and supporting environment. This can be achieved through the application of the principles of water sensitive urban design as outlined in section 1.3 and depicted in figure 19 below.



Adapted from Draft Australian Runoff Quality Guidelines, 2005

Figure 19: Integrated water cycle management.

The sustainable and equitable use of our water resources can be achieved via a number of mechanisms. The mechanisms which are relevant to the implementation of this strategy are outlined below.

6.1 IMPLEMENTATION MECHANISMS

There are a number of mechanisms and tools which are available to achieve the objectives of this Strategy. These include:

- Water source planning and delivery;
 - Drinking water – by setting efficiency targets (currently 15%, and potentially 40% reduction by 2070) in partnership with Water Corporation;
 - Wastewater – by negotiating with Water Corporation to increase current reuse from its existing level of 50% to 100% by 2030; and
 - Groundwater allocation by negotiating with the Water Corporation and the Department of Water that the current public drinking water allocation of 14 GL per annum (with 6 GL in reserve) is not increased to the 27 GL per annum recommended by GHD, 2007. Instead, plan around efficiency and reuse targets and also possibly augment future supply with wave energy seawater RO (eg CETO) by 2030. This will ensure that reserves are not compromised by climate change and enables future allocations for other users, eg industrial or agricultural.
- Planning and development approvals system (policy, strategic instruments and statutory controls) and incentives (see section 6.1.1), as well as working with local Builders to improve the number of homes built with 6-9 star ratings;
- Private-public partnerships, demonstration projects and grants – which are successful ways of developing capacity, gaining support of stakeholders including research organisations, establishing collaborative partnerships between agencies and breaking down administrative barriers;
- Local Government asset management – by integrating water sensitive retrofits into the scheduled upgrades and capital works of roads, parks and drainage infrastructure;
- Pricing, regulation and standards (e.g. water efficient appliances) – by working with the State Government to influence pricing policy and mandate changes to requirements such as the Building Codes of Australia to develop water efficiency codes; and
- Champions, community engagement and capacity building – by supporting successful community initiatives, rewarding best practice, demonstrating successful outcomes, encouraging water sensitive land developers and hosting visits of other local government champions.

It must be noted that some of these suggested options are outside the immediate jurisdiction of the City of Greater Geraldton. Implementation of this strategy will

therefore require the continued engagement, commitment and support of other key agencies and the community to deliver the City's visions for a water sensitive city.

The mechanisms which are able to be influenced or delivered by the City are discussed in the following sections.

6.1.1 Achieving better urban water management outcomes from new development

Achieving water sensitive urban design outcomes via the planning and development approvals system in WA was a primary objective of *Better Urban Water Management* (WAPC, 2008a) which was developed in partnership between the Departments of Planning, and Water and the Western Australian Local Government Association. *Better Urban Water Management* provides guidance on the implementation of total water cycle management policy contained in *State Planning Policy 2.9: Water Resources* (Government of WA, 2003).

Better Urban Water Management is an aid to planners and decision makers in the consideration of water issues during land use planning for greenfield and redevelopment areas where residential, commercial, industrial and rural residential uses and development are proposed, including in rural townsite areas (WAPC, 2008b).

Better urban water management should be achieved at a range of planning scales, delivered through a process of appropriate site investigation and response at each stage of the planning system, working toward an outcome which maintains or enhances the health of the catchment (pre-development environment), including maintenance of wetland and vegetation health. These outcomes should be demonstrated through compliance with defined design criteria. The method of addressing the criteria will vary according to the planning decision being made, and therefore the information required to support that decision. *Better Urban Water Management* describes these requirements at regional, district, local, subdivision and development stages (Figure 20).

Although the names of the water documents support the hierarchical decision-making process, planning may not always occur in this order or be reflective of the scale described. The application of the requirements of *Better Urban Water Management* should therefore be guided by the type of land use decision being made. This is outlined in *Better Urban Water Management* and in *Planning Bulletin 92: Urban Water Management* (WAPC, 2008b) as follows (table 7). Further guidance is provided in the Department of Water's guidance note series on their website. (<http://www.water.wa.gov.au/Managing+water/Water+and+land+use+planning/default.aspx>)

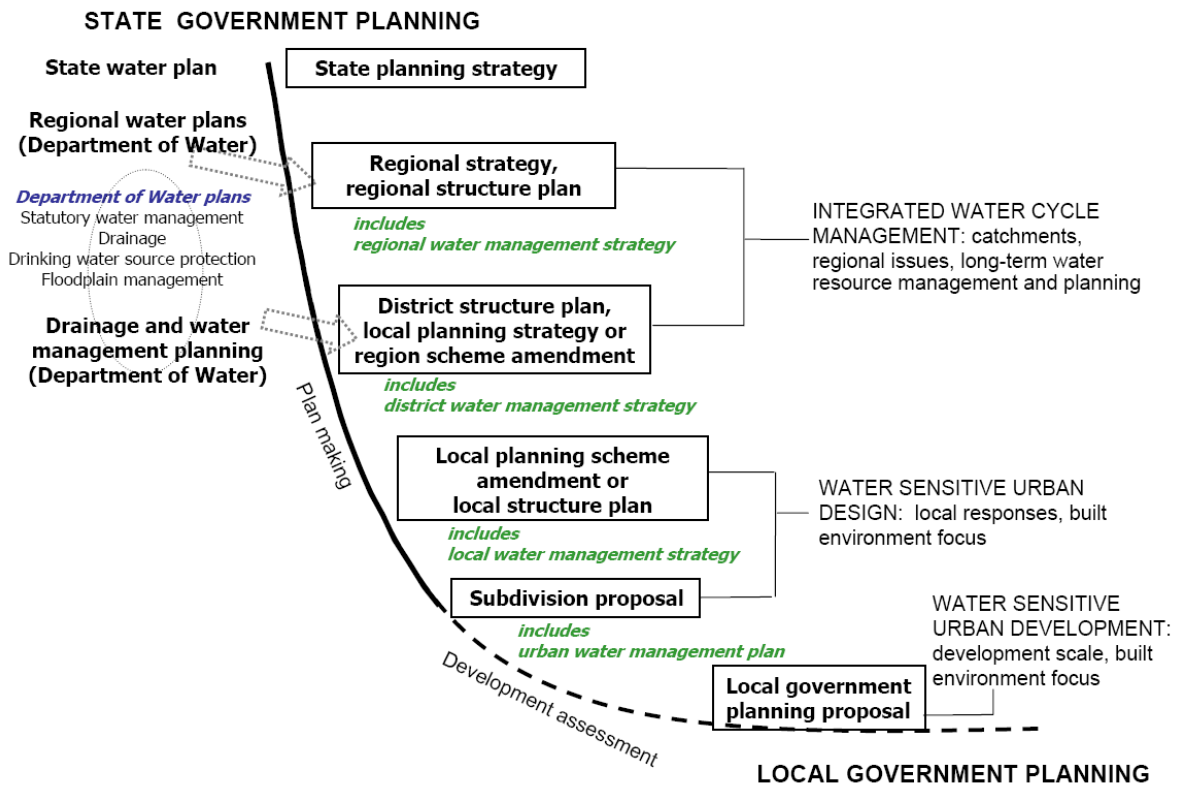


Figure 20: Process for integrating drainage planning with land planning as outlined in *Better Urban Water Management* (WAPC, 2008).

Table 7: Water management information to accompany planning actions (Source: Adapted from *Better Urban Water Management*, WAPC 2008a)

Land planning tool	Urban water management question	Water management report
Regional or sub-regional strategy, region scheme, regional or sub-regional structure plan	What are likely areas for land use change in the future that impact the use and management of water resources?	Regional water management strategy , incorporating a strategic drainage plan – summarised in chapter of planning document and attached as technical appendix
District structure plan, local planning strategy, region scheme amendment	Is this area capable of supporting urban development and if so, what areas are required for water management?	District water management strategy - summarised in chapter of planning document and attached as technical appendix
Local planning scheme amendment, local structure plan	How will the proposed urban structure address water use and management?	Local water management strategy - summarised in chapter of planning document and attached as technical appendix
Subdivision application	How will the final urban form use and manage water?	Urban water management plan – accompanies application ²
Subdivision approval with conditions	Does the proposal comply with relevant strategies and plans?	urban water management plan

² Where an approved local water management strategy does not exist, an urban water management plan will be required to be lodged with the subdivision application.

This water management strategy provides sub-regional or “district-level” information at the municipal scale (i.e. in support of the local planning strategy, Better Urban Water Management, Section 4.3, WAPC, 2008). It should be noted that district water management strategies are likely to be required to support future proposals for land use change to provide district-level information on the pre-development environment at the catchment scale.

The required information to support land use planning decisions is to be provided by the State Government, Local Government, service providers, catchment groups or landowners and consultants as appropriate. Generally, the proponent of the land use planning action is required to provide the supporting water management information.

The implementation of *State Planning Policy 2.9: Water Resources* and *Better Urban Water Management* requires a collaborative approach to the assessment and approval of planning proposals involving key stakeholders, with clearly defined roles and responsibilities. This clarity has developed with significant leadership from the Department of Water and the support of the Department of Planning, Local Government and the Western Australian Local Government Association, together with the Water Corporation.

Although *Better Urban Water Management* (WAPC, 2008) outlines the investigations and issues to be addressed at each stage of the planning process, the Department of Water has developed more detailed guidance on how to develop and what to include in an local water management strategies and urban water management plans, as well as information to aid compliance with urban water management conditions. This information is contained in:

- *Interim: Developing a Local Water Management Strategy* (DoW, 2008a);
- *Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions* (DoW, 2008b); and
- *Guidelines for District Water Management Strategies* (DoW, 2013).



6.2 TOOLS FOR BETTER WATER RESOURCE MANAGEMENT

Additional tools are available to aid the achievement of the objectives of this Strategy. These tools are broadly classified into tools for water conservation; stormwater and groundwater management; and wastewater management.

6.2.1 Water conservation tools

Efficient water use in new and existing developments can be achieved through approaches such as raising community awareness, regulation, market mechanisms, and financial incentives or assistance to facilitate change. The State Government has identified demand reduction and efficient use of potable water as a priority (*State Water Plan* Government of Western Australia 2007).

The *State Water Recycling Strategy* (Department of the Premier and Cabinet and Department of Water 2008) further identified the need for new housing developments to consider the use of alternative, fit-for-purpose, water supplies.

Water conservation objectives may be facilitated by the implementation and/or use of:

- [Waterwise Councils](#) and water conservation plans;
- Efficient water use in houses including [water saving fittings and products](#);
- The [Waterwise communities tool kit](#);
- The [Waterwise Land Development](#) Program;
- Non-drinking water options ([H2Options](#));
- [Your Home](#): Home Renovator's Guide; and
- [Best practice guidelines for public open space irrigation](#) (SA Water).

Local Government Water Conservation Plan

The *State Water Strategy* (Government of Western Australia 2003) introduced the concept of water users developing and implementing water conservation/efficiency plans as part of the water licensing process undertaken by the Department of Water and integrating water use efficiency measures into water users' daily operations. The City of Greater Geraldton has developed a Water Conservation Plan (DoW, 2010). The strategies in the plan are as follows:

- Strategy 1: Measure irrigated area and record water consumption to accurately determine water use;
- Strategy 2: Incorporate watering categories and hydrozones across irrigated turf areas;
- Strategy 3: Improve the performance of irrigation systems;
- Strategy 4: Implement improved irrigation scheduling practices;

- Strategy 5: Maintain irrigation systems at optimum performance;
- Strategy 6: Prepare and implement “water conservation design guidelines” for new or existing turf areas;
- Strategy 7: Investigate the use of alternative water sources such as stormwater and recycled water;
- Strategy 8: Monitor and manage water dynamics and quality;
- Strategy 9: Undertake turf maintenance practices that improve water efficiency; and
- Strategy 10: Communicate the outcomes of the water conservation plan to the community

The City’s Water Conservation Plan was finalised in March 2010.

Waterwise communities toolkit

To integrate and further develop options for household scale water conservation and recycling, an online Waterwise communities toolkit has been developed by the Department of Water, and is available at the Department of Water’s Website www.water.wa.gov.au.

The toolkit will promote water conservation and recycling to local government, developers and other users. It will provide access to information on both recycling and wise water use, including:

- The availability of shallow groundwater;
- The availability of sources for recycled water;
- Key land planning considerations;
- Alternative water solutions including rainwater tanks, community bores, greywater, landscaping; and
- Streamlined application and approval processes.

Waterwise Land Development Program

The Waterwise Land Development Program offers the land development and building industry the opportunity for making changes in their new developments. When implemented, these changes will be instrumental in helping conserve our State's water supply whilst assisting the community in making the best use of water as we work

towards developing water sensitive communities. This initiative follows on from the Water Corporation's already successful Waterwise Display Village Program and is directed at making land developments more water efficient and sustainable into the future.

The Water Corporation has worked closely with the land development industry in Western Australia to develop guidelines which will bring about the changes to meet these objectives. By influencing both subdivision and building stages of development, key strategies aimed at achieving best practice water outcomes can be implemented by land developers.

H2Options

Non-drinking water options (also known as H2Options) by the Water Corporation, provides guidance for developers considering alternative water supplies (non-drinking water), in addition to the existing processes for securing water supply, wastewater and drainage services within a development. This includes information about sources, service providers and the Water Corporation's policy on dual-reticulation.



Best practice guidelines for irrigation/ landscaping

To achieve better water efficiency in the open space management, table 7 outlines some best practice guidelines for the irrigation and landscaping of public open space.

For small irrigation schemes of less than 0.25 ha in size, irrigation with scheme water is recommended as being the most economical over a 20 year operating life. Reclaimed wastewater effluent irrigation is recommended for large sports grounds and landscaped areas where public access can either be well controlled (sports grounds) or is generally limited (landscaped areas such as the Rotary).

Table 8 Best practice guidelines for irrigation/ landscaping

Practice	Description
Water budget	A water budget should be developed to ensure that the amount of water applied to the turf is at optimal level to sustain turf quality whilst conserving water. This water budget also should be constantly reviewed to factor in changing climatic patterns.
Species selection	Drought tolerant species such as Kikuyu or Couch should be the preferred turf species. Other landscaping vegetation should be indigenous to the area and/ or drought tolerant as to allow for minimal irrigation to be required.

Practice	Description
Subsurface irrigation	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> • Eliminates water loss by wind, misting, poorly aligned sprinklers, evaporation • Can be scheduled to run at any time • The water is applied directly to the roots, where it is needed • Vandalism is reduced • Can be retrofitted into existing public open space <p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> • Higher capital cost • Not suitable for all soil types • Can be difficult to establish new turf • Roots may intrude into the drip lines and cause problems if not addressed
Irrigation control systems	<p>There are various control systems which have been developed which reactive to a particular variable in determining when to turn on the irrigation and for which length of time. They include:</p> <ul style="list-style-type: none"> • Weather based (using information gained from a local weather station or BOM) • Soil moisture based (sensors record the soil moisture and ensure that the soil moisture stays within a particular range by applying a preset irrigation event) • Rainfall (when a rainfall event occurs, the system shuts down)
Irrigation maintenance	<p>Very important to ensure that the system is operating efficiently. Such checks which should be conducted are:</p> <ul style="list-style-type: none"> • Pressure and flow • System components (eg sprinkler heads, pumps, filters) • Vegetation not clogging sprinkler heads • Sprinkler nozzles are not clogged with debris
Audit of irrigation system	<p>An audit of the system should be conducted once every three to five years to ensure that the system is operating efficiently, there is even distribution of water and the application of water is still suitable for the turf.</p>

Source: *Code of practice: irrigated public open space* (SA Water, n.d)

Home Renovator's Guide

The [Home Renovator's Guide](#) provides advice on how to renovate a home and includes specific information regarding appliances, plumbing, rainwater and wastewater. This guide recognises that there is no distinction between good design and environmentally friendly design. It highlights the huge range of innovative 'green' products available, providing tips and checklists to help decision making.

Water Language for Geraldton

To engage the community towards a Water Sensitive City, a water language for Geraldton (Figure 21) of community-friendly water words can help develop understanding, trust and acceptance towards a City comprising water sensitive communities.

Stormwater management systems should include structural (fixed or engineering) solutions as well as non-structural controls (“soft” solutions such as education programs, management and maintenance practices and programs, catchment management plans and activities, and town planning controls).

State Government stormwater management policy is outlined in the *Decision Process for Stormwater Management in WA* (DoW, 2009) and the *Stormwater Management Manual for Western Australia* (DoW, 2004 - 2007), which also contains technical information to facilitate the appropriate design and construction of best management practices (Chapter 9). Key best management practices for improved stormwater outcomes are listed in Table 9, together with an indication of the scale of application. These techniques should be incorporated into the planning and development of all new urban areas, consistent with the strategies and design criteria outlined in section 7.

Table 9: Stormwater best management practices to be integrated into the planning and design of development in Greater Geraldton

	Structure Plan area	Precinct	Street	Residential lot	Commercial and Industrial lot
On site detention and/or retention	✓	✓	✓	✓	✓
Water wise and nutrient wise landscaping	✓	✓	✓	✓	
Maximise permeable and semi permeable surfaces	✓	✓	✓	✓	✓
Amended topsoils	✓	✓	✓	✓	✓
Rainwater tanks for harvesting, detention and re-use	✓	✓	✓	✓	✓
Permeable pavements	✓	✓	✓		✓
Landscaped infiltration structures	✓	✓	✓		✓
Raingardens	✓	✓	✓		✓
Hydrocarbon management and sediment traps	✓	✓	✓		✓
Conveyance bioretention systems	✓	✓	✓		
End of catchment treatment structures	✓	✓			
Maintain or improve ecology and channel morphology of existing waterways	✓	✓			
Non structural strategies such as interpretive signage and community engagement	✓	✓			
Non structural strategies such as public education campaigns and materials	✓				

Stormwater and groundwater management systems must also consider areas of potential and actual acid sulfate soils and/or contamination. Although the mapping does not cover the City of Greater Geraldton, guidance to address acid sulfate soils is contained in *Planning bulletin 64: Acid sulfate soils* (WAPC, 2004). Contamination should be addressed consistent with the requirements of the Department of Environment Regulation, as outlined in their guideline series (<http://www.der.wa.gov.au/your-environment/acid-sulfate-soils/69-ass-guidelines>).

Better stormwater management leads to improved groundwater quality and quantity. To gain the greatest possible benefit from the groundwater resource, five key steps are recommended to guide the development of an appropriate groundwater use strategy.

These are:

- Reduce water demands;
- Design borefields carefully, with a larger picture in mind;
- Monitor groundwater usage;
- Use alternative water sources where possible; and
- Increase groundwater recharge, eg by harvesting and directing rainwater from roofs and carparks into areas where recharge will be beneficial.

6.2.3 Wastewater management

The Water Corporation has developed an easy-to-follow process for when developers are considering alternative (non-drinking) water supplies in new developments called [H2Options](#). Alternative water supplies includes treated wastewater that can be used to irrigate Public Open Space or returned to homes via ‘third pipe’ (dual reticulation) for toilet flushing, washing machines and garden irrigation.



The Department of Health prepared the [Guidelines for the Non-potable uses of Recycled Water in Western Australia](#) in August 2011. These guidelines are designed to provide a planning and implementation framework in line with the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006. They provide guidance for the preparation of the required:

- Application for approval of a recycled water reuse scheme;
- Water quality management plan;
- Health risk assessment;
- Operation and maintenance plan;
- Monitoring and reporting plan.

The Department of Health released the [Code of Practice for Greywater Reuse in Western Australia](#) in 2010. This manual provides guidance for householders to install their own home greywater recycling system.

Other guidance for the management of wastewater are provided by;

- Australian Guidelines on the Use of Recycled Water: Managing Health and Environmental Risks (Phase 1), Environment Protection and Heritage Council (2006);
- Australian Drinking Water Guidelines (ADWG) National Health and Medical Research Council (2006);
- Government Sewerage Policy - Draft Country Sewerage Policy; and
- Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units.

Other information is available on the Department of Health website (<http://www.public.health.wa.gov.au/1/635/2/water.pm>).

7 WATER RESOURCE MANAGEMENT STRATEGY

This section contains recommendations for particular strategies to improve the management and use of water resources within the City of Greater Geraldton. Many of these recommendations were derived through stakeholder input as part of the scoping workshops. The strategies are linked to mechanisms for implementation and roles, responsibilities and timing are proposed where possible.

In order to develop an effective framework for implementation, the strategies have been separated into those which should be applied across the whole municipality, and those which are specific to particular land use types. This framework was considered by workshop participants to be effective, given the different water use and management characteristics of the various land uses and the opportunities available to achieve outcomes, given the land use context.

The recommended timing for implementation of the actions is contained within the implementation tables. It roughly translates into:

Immediate	2010 – 2011
Short term	2011 - 2014
Medium term	2014 - 2020
Long term	2020 - 2030

The following recommendations are proposed.

7.1 CITY-WIDE RECOMMENDATIONS

7.1.1 Strategies

The following strategies should be implemented across the City to address the city-wide water management issues which are common to all areas of the municipality. The mechanisms recommended for implementation of the strategies are discussed in section 6.1 and identified in section 7.1.2.

1. Manage water according to the water cycle to infiltrate and harvest rainwater and stormwater, aiming to reuse the water as many times as possible, including wastewater reuse.
2. Continue to review drainage infrastructure in existing areas and identify opportunities to retrofit water sensitive urban design technologies including aquifer storage and recovery and improved management of water quality, and incorporate cost effective opportunities that demonstrate net welfare gain into the Council capital works program.

3. Protect and enhance significant ecosystems through the establishment of ecological water requirements which seek to maintain hydrological and hydro-geological regimes of waterways, wetlands and remnant vegetation.
4. Investigate and map the quality and availability of local groundwater resources for non-potable use.
5. Support demonstration projects for supply and use of non-drinking water for fit-for-purpose use.
6. Develop clear policy direction for planning, design and operation of non-drinking water sources.
7. Adopt the strategies (see section 6.2.1) and implement the recommendations of the City of Greater Geraldton Water Conservation Plan (2010).
8. Aim to reduce average water consumption in the City to meet the State Water Plan target of 100 kL/person/year including not more than 60 kL/person/year of scheme water where there is access to an alternative source of non-drinking water.
9. Promote water efficiency measures and waterwise practices within the community and workplace including behaviour change and installation of more water efficient fittings, fixtures and irrigation systems as well as changes in landscape and gardens which are reflective of the rainfall cycle of the area.
10. Retain the natural landform wherever possible to minimise changes in hydrology.
11. Inform and educate the existing and future urban community, in particular through schools, to develop an understanding and appreciation of the local natural environment and the need to reduce water use.
12. Develop a holistic incentives package for water sensitive outcomes which includes State and local government, developers and landowners. Consider provision of start-up funding for local environmental projects, such as planting days and guided bushwalks.
13. Develop a local planning policy for better urban water management. Provide support via guidance for landscaping and public open space requirements.
14. Implement the recommendations for the improved management of the Greenough and Chapman Rivers contained in the *Greenough River Foreshore Assessment* (WRC, 2001a) and *Chapman River Foreshore Assessment* (WRC, 2001b).

Using rainwater tanks to reduce household water consumption

The average household scheme water consumption for Geraldton is currently 400 kL per annum. The State Water Plan provides a target of 100kL per person per annum and the Water Corporation has a target of 125 kL per person per annum by 2030.

A house in Geraldton connected to Water Corporation scheme water consuming the city average of 400 kL per annum will be paying between 72 and 97 cents per kL. The total annual bill will typically be in the order of \$350. This water use is roughly split 50/50 between inside and outside uses.

The opportunity exists to capture and re-use rainwater to reduce the amount of scheme water used. There are a number of benefits to households from rainwater tanks. These include: reducing the annual water bill; mitigating the effects of water restrictions on lifestyle, amenity and property values; improving the taste of water in areas of poor water quality; and providing a sense of community mindedness.



There are a few factors to be considered when deciding to install a rainwater tank.

- Approximately 80% of Geraldton’s average rainfall falls between May and September, while approximately 90% of the residential use outside the house (watering gardens etc) occurs from October to April. A rainwater tank is therefore unlikely to provide sufficient quantities for external use without costly and impractical storage.
- Rainwater tanks are more effective, however, when they are connected into the house to provide water for toilet flushing, washing machines and some hot water systems.
- The optimal size of rainwater tanks is dependent on the level of water demand and the roof catchment area of the building. Consideration should also be given to the available space and the costs of installation. A 2.5 to 3kL tank has been found to provide optimum cost-benefits for an average residence resulting in a total scheme water saving of around 20%.

There are pitfalls in simply comparing rainwater tanks installed by individual households with large scale water supply options. Rainwater tanks remain a largely decentralised source of water, with costs and levels of service varying dramatically depending on location and individual household circumstances.

Nevertheless, rainwater tanks need to be considered for their effectiveness alongside other water efficiency options. Water efficient shower roses for example have been shown to be the most effective demand management measure with both water and energy saving benefits. Indoor water savings can be 10-25% (for much lower up front costs than a rainwater tank) and energy use is 47% less than a traditional shower rose. Greywater reuse as a substitute for scheme water irrigation can save up to 30% whereas the rainwater tank, as mentioned above, can save up to 20%. A greywater diversion system can be installed for as little as \$2,000 whereas the rainwater tank cost is approx \$6,000.



7.1.2 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Manage water according to the water cycle to infiltrate and harvest rainwater and stormwater, aiming to reuse the water as many times as possible	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Through all actions of Council and stakeholders	Immediate and ongoing	City of Greater Geraldton together with key stakeholders
Identify opportunities to retrofit water sensitive urban design technologies that are cost effective and demonstrate net welfare gain.	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management and maintenance	Immediate and ongoing	City of Greater Geraldton
Protect and enhance significant ecosystems through the establishment of ecological water requirements	Protection of significant environments Stormwater management Groundwater use and management	Management planning	Medium term	Departments of Environment and Conservation and Water
Investigate and map the quality and availability of local groundwater resources for non-potable use	Groundwater use and management Water reuse	Groundwater management planning	Short term	City of Greater Geraldton together with the Department of Water
Support demonstration projects for supply and use of non-drinking water for fit-for-purpose use	Groundwater use and management Stormwater management Groundwater use and management Water supply and use Water reuse	Demonstration projects with contributing funding	Short term	City of Greater Geraldton together with landowners and the Water Corporation
Develop clear policy direction for planning, design and operation of non-drinking water sources	Water supply and use Water reuse	State Government policy	Immediate	State Government
Adopt the strategies and implement the Water Conservation Plan	Groundwater use and management Water supply and use Water reuse	City of Greater Geraldton operations	Short term	City of Greater Geraldton

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Reduce average water consumption to meet the State Water Plan target	Water supply and use	Waterwise programs, product rebates and community education	Short term	State Government, City of Greater Geraldton and the Water Corporation
Promote water efficiency measures and waterwise practices within the community and workplace	Water supply and use	Waterwise programs	Immediate and ongoing	City of Greater Geraldton and the Water Corporation
Retain the natural landform wherever possible to minimise changes in hydrology	Groundwater use and management Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate and ongoing	City of Greater Geraldton
Educate the community about the local natural environment and the need to reduce water use	Protection of significant environments Groundwater use and management Water supply and use	Community education programs including “Ribbons of Blue”	Short term	City of Greater Geraldton, Department of Environment and Conservation and the Water Corporation
Develop a holistic incentives package for water sensitive outcomes	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals, rebates, asset management and maintenance	Short term	City of Greater Geraldton together with State and Federal Government and the Water Corporation
Develop a local planning policy for better urban water management	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system	Immediate	City of Greater Geraldton
Implement the Greenough and Chapman Rivers foreshore assessment plans	Protection of significant environments	Planning and development approvals system Land use/ management practices	Ongoing	City of Greater Geraldton and landowners

7.1.3 Design criteria

Any new development or redevelopment within the City of Greater Geraldton should aim to meet the following specified design criteria using appropriate best management practices.

- Developments should aim to achieve a water consumption target of less than 100 kilolitres per person per year (kL/person/year) as per the State Water Plan (2007) for consumers within Geraldton and, where a non-drinking water source is available, should achieve a target of not more than 60 kL/person/yr scheme water.
- Waterwise landscaping and irrigation to be implemented in both private and public open spaces.
- The one-year one-hour average recurrence interval event should be retained at source through the use of retention (soakage) or storage devices at the street or subdivision level.
- The post-development critical one-year average recurrence interval peak flow and volume should be consistent with pre-development flows at the discharge points of all plan and/or development areas.
- The one year critical duration average recurrence interval event shall be retained within the development at source, preferably within the lot or road reserve, through the use of retention or storage devices such as rainwater tanks, raingardens and other bioretention areas integrated into the urban form. *The Stormwater Management Manual for Western Australia* (Department of Water 2004–07) contains guidance for the appropriate design of retention systems.
- Flows from developed areas must be attenuated in flood detention/storage areas, incorporated into the development possibly in public open space, and located outside defined floodways. Where the one year critical duration average recurrence interval event has already been retained (i.e. part of the initial losses), this volume does not need to be accommodated again in the detention/storage areas.
- Runoff from events greater than the 1 in 1 year average recurrence interval event and up to the 5 year average recurrence interval event are to be conveyed in an underground piped drainage system which is designed to maximise infiltration through the use of lined bottomless pits and permeable joints, to low point infiltration areas integrated into public open space before discharge into the receiving environment.
- Roads and public open spaces are to be designed to cater for the surface overflow for more severe storm events with habitable floors at least 0.5 m above the 100 year average recurrence interval flood or storage level at any location.



- Any existing detention/retention infrastructure within the redevelopment area must be retained or replaced with equivalent in both size and performance.
- Floodways are to be defined and are to contain the regional 100-year average recurrence interval event flow. Floodways which convey the regional 100-year average recurrence interval event flow may not be developed or obstructed in any way. Residential development may not occur within floodways.
- Any areas subject to flooding or inundation will require imported clean fill to establish habitable floor levels no less than 0.5 m above the 100 year average recurrence interval event flood level and flood storage equivalent to the filled area may be required to prevent flooding of other adjacent areas.
- Treatment train approaches are to be developed and implemented to manage water quality, including:
 - Non-structural measures to reduce applied nutrient load;
 - On-site retention/infiltration of one year critical duration average recurrence interval event. All surface areas used to accommodate one year events should be vegetated (more than turf) to avoid “swampy” areas; and
 - Bioretention swales and raingardens to be sized at two percent of the constructed impervious area from which they receive runoff, or as agreed by the Department of Water and City of Greater Geraldton.
- Water quality treatment systems and stormwater management structures should be designed in accordance with the *Stormwater Management Manual for Western Australia* (Department of Water, 2004-07) and *Australian Runoff Quality: A guide to water sensitive urban design* (Engineers Australia, 2006).
- To reduce health risk from mosquitos, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.

7.1.4 Tips for meeting design criteria

Outlined below are some suggested tips for meeting the design criteria which should be met by all proposed urban development areas within the City of Greater Geraldton.

- The pre- and post-development peak flows and volumes, detention volumes required to manage surface water flows from major events, and hydraulic grade lines are to be determined using appropriate modelling software.
- Flood detention/storage areas shall be incorporated into public open space within the development area and located outside defined floodways.



- Post-development flows from 5- to 100-year average recurrence interval events may be greater than pre-development flows, only where it can be demonstrated (at district or local water management strategy stage) and agreed by the Department of Water that the pre-development hydrologic, hydraulic, geomorphic and ecological characteristics of the downstream catchment and ‘receiving environment’ can be protected and maintained.
- Protection of catchment ecological function, geomorphic stability and water quality maintenance are to be achieved through adopting a treatment train approach including non-structural measures to reduce applied nutrient loads and the onsite retention of the greater volume of one-year-one-hour average recurrence interval event or the three month critical duration event.
- Water quality treatment systems and water sensitive urban design structures must be designed in accordance with the *Stormwater management manual for Western Australia* (Department of Water 2004–07) and *Australian runoff quality: a guide to water sensitive urban design* (Engineers Australia 2006).
- Proponents for new developments should develop and present the strategies for water quantity and quality management in the local water management strategy and urban water management plans to support applications for the planning approvals required for the development to proceed.
- Engineering drawings submitted to the City for new development approvals are to be supported by clear and auditable documentation, providing details of proposed staging, implementation and monitoring of the surface and groundwater quantity and quality management strategies

A decision framework to aid the identification of appropriate water sensitive design strategies for individual planning and development proposals is contained in Figure 22.

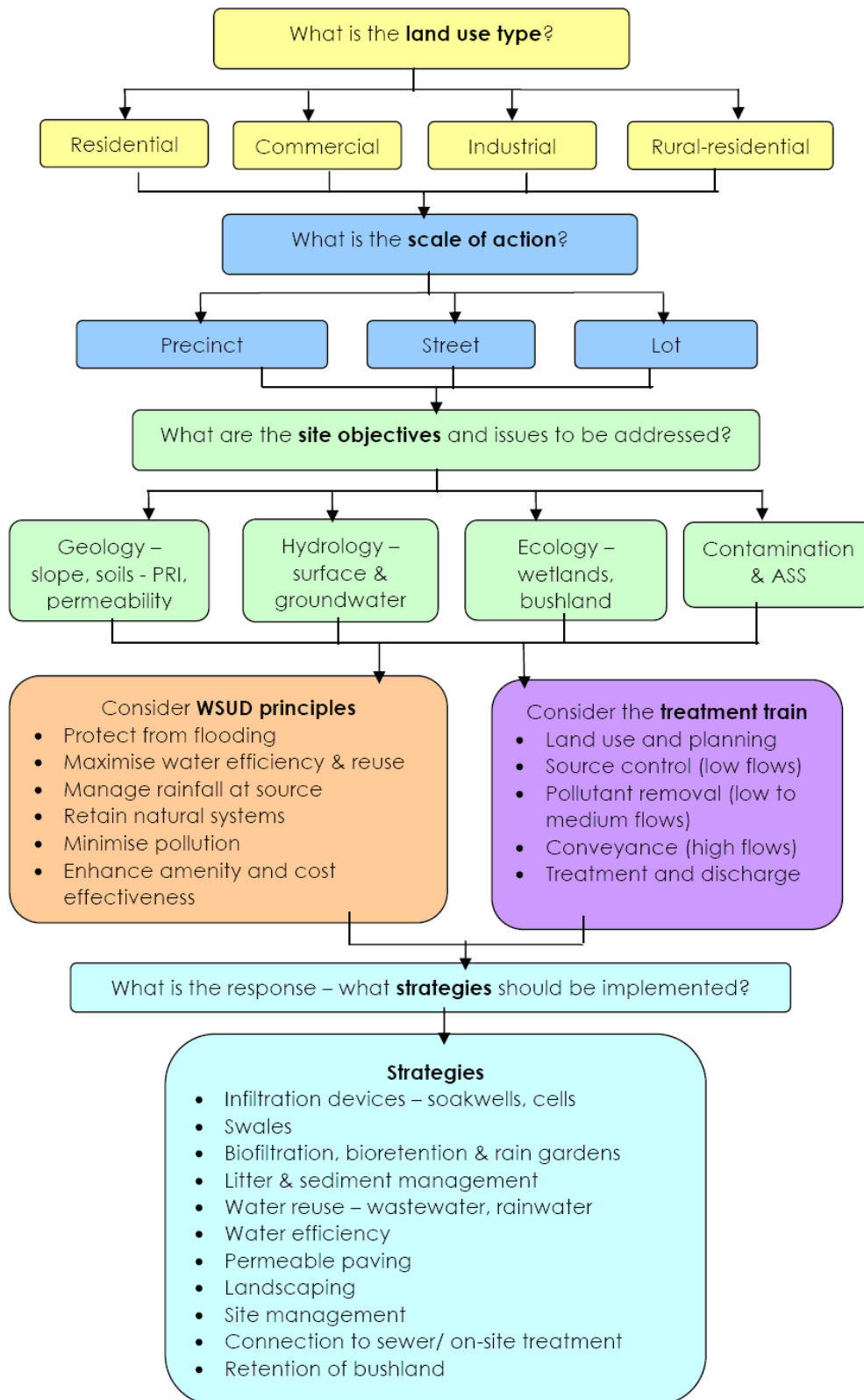


Figure 22: Decision process for water sensitive design strategies for planning and development proposals

7.2 EXISTING RESIDENTIAL, INDUSTRIAL AND TOWN CENTRE AREAS

7.2.1 Key issues

The following key issues have been considered when developing strategies to improve water management and use in existing residential, industrial and town centre areas.

Protection of significant environments

- Limited remnant vegetation remains within the existing urban area. There is a need to retain as much remnant vegetation as possible and identify opportunities to enhance linkages between environmentally sensitive areas.
- Limited information is available regarding the ecological water requirements of the Greenough and Chapman rivers or the wetland at Rum Jungle.

Stormwater management

- There is a perception that there are limited opportunities to improve water management outcomes in existing areas due to the cost associated with retrofitting and the lack of incentives or understanding of the need for improvements.
- Localised flooding in some areas requires modification or upgrades to existing stormwater systems.
- Areas of the Chapman and Greenough Rivers are subject to erosion and sedimentation from stormwater entering these waterways.
- Some projects have been identified which will improve stormwater outcomes including stormwater harvesting, however funding is required for their implementation.

Groundwater use and management

- Some existing urban areas contain septic tanks. These need to be identified where groundwater is proposed to be used as an alternative source and connected to sewer or nutrient attenuating on site wastewater systems, where relevant.
- Some groundwater bores are subject to seawater intrusion and are therefore becoming saline. This will impact on the availability of water for irrigation of coastal public open space.
- There are a number of registered contaminated sites in the area which may have implications for the groundwater quality.



Drinking water supply and use

- There is a perception that the value placed on water and the level of understanding of the availability of water is highly variable across the community.
- Although there is significant potential for increased water savings within the community as a result of behaviour change, there appears to be a lack of available knowledge and skills to facilitate the conservation and efficient use of water by the community.
- Industry also needs to address water conservation.

Water reuse

- There are significant regulatory and cost impediments to increased lot-scale or precinct-scale water reuse.
- There are varied opinions within the community and across agencies regarding the cost/benefit of rainwater tanks.

7.2.2 Strategies

The following strategies should be implemented to improve water management outcomes in existing urban areas, in addition to the “city-wide” recommendations (section 7.1.1).



1. Identify vegetation linkages including riparian zones and rehabilitate to restore and provide a buffer for significant environments and improve the management of sediment and erosion.
2. A cost-benefit analysis should be undertaken for the installation and retrofit of rainwater tanks in Geraldton. The analysis should consider characteristics such as roof size, water use option (e.g. plumbed into toilets), and financial savings in water and electricity and greenhouse gas benefits.
3. Expand the Water Corporation’s “waterwise” education campaign to target high-water using areas in the northern suburbs of Geraldton. This may also reduce the pressure on the capacity of existing infrastructure to service growing urban areas, lengthening the time required prior to upgrading the system.
4. Scope the feasibility of providing incentives for the installation of rainwater tanks, greywater management systems for ex-house use and retrofitting of waterwise fittings and fixtures.
5. Develop demonstration projects to showcase “waterwise” gardens and verges in Geraldton and offer training sessions or seminars to help retrofit existing gardens

and verges with waterwise plants and irrigation systems. This will undoubtedly engender important State and possibly Federal Government support for funding initiatives.

6. Undertake an audit of water usage in all public open space areas, particularly where potable water is currently being used for irrigation. Identify opportunities for modification to landscaping and irrigation systems to reduce water consumption and improve efficiency including waterwise planting. Aim to integrate water quality management and infiltration of stormwater into public open spaces to increase groundwater recharge for future localised use.
7. Expand stormwater harvesting within the port precinct and consider implementation of similar projects in other industrial areas or precincts with large roof areas and/or hardstand such as the central business district where it is cost effective and the corresponding water catchment provides sufficient flow rates to substantially contribute to reducing reliance on the potable water supply.
8. Consider viable opportunities for retrofitting existing drainage systems, for example, retrofitting existing retention basins to better manage water quality and optimise utilisation of the land, in particular, Lot 2735 Drew Street, Spalding and 141 Verticordia Street, Strathalbyn;
9. City of Greater Geraldton to lead by example and ensure any new Council building demonstrates water sensitive design elements.



7.2.3 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Restore and provide buffers for significant environments	Protection of significant environments	As part of new development Management plans for key environments	Ongoing	Landowners Department of Environment and Conservation Conservation groups
Rainwater tank cost-benefit analysis	Water supply and use Water reuse	Government partnership	Immediate	State government and City of Greater Geraldton
Expand the Waterwise program to target high water-using suburbs	Water supply and use	Agency partnership	Immediate	Water Corporation and local government
Incentives for installation of waterwise fittings and fixtures	Water supply and use Water reuse	Existing programs New incentives programs	Short term	Federal, State and local government
Demonstrate waterwise gardens and verges	Water supply and use Water reuse	As part of new development Council-managed land	Immediate	Developers, working with City of Greater Geraldton
POS audit for better irrigation management and waterwise planting	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management and water conservation planning	Immediate	City of Greater Geraldton
Expand stormwater harvesting in the port precinct	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management	Short term	City of Greater Geraldton
Consider sump retrofits that demonstrate cost effectiveness and net welfare gain.	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management	Intermediate	City of Greater Geraldton

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
New council buildings to demonstrate water sensitive design elements.	Stormwater management Groundwater use and management Water supply and use Water reuse	Council to lead by examples as part of Council developments	Short term	City of Greater Geraldton policy and commitment

7.3 NEW RESIDENTIAL DEVELOPMENT

7.3.1 Key issues

The following key issues have been considered when developing strategies to improve water management and use in new residential areas.

Protection of significant environments

- Limited remnant vegetation remains within the City of Greater Geraldton. There is a need to retain and protect remaining vegetation in public open space and identify opportunities to enhance linkages between environmentally sensitive areas.
- Limited information is available regarding the ecological water requirements of the Greenough and Chapman rivers or the wetland at Rum Jungle.
- There is limited information regarding the presence of acid sulfate soils.

Stormwater management

- Hydrogeological conditions, particularly near the coast, generally provide favourable conditions for infiltration of stormwater. Stormwater management should be consistent with State requirements for water sensitive design including infiltration at source and management of water quality.
- The majority of innovation in stormwater management is driven by developers rather than the City. Solutions are often those which are the most economically viable.
- There is a need to develop a shared understanding of “minimum” requirements for water sensitive management of stormwater including standards and requirements for incorporation into public open space.
- The design of best management practices should be responsive to the particular hydrological, geological and climatic conditions of new development areas. Effective systems are those which are planned and designed early in the planning and development system and which have involved coordinated input from planners, engineers and maintenance operators.

Groundwater use and management

- There is a lack of understanding of the availability and quality of local groundwater resources which are required for irrigation of new areas of public open space.

Drinking water supply and use

- Fragmented land ownership and development on the “fringe” provides a challenge for timely and cost effective provision of services.

- There is a perception that there is a substantial drinking water resource which will be available in the longer term.

Water reuse

- Significant new development is proposed which will require water for irrigation of public spaces but there is limited access to traditional water sources (groundwater). The City believes that the wastewater from Narngulu, Greenough on Sea and Geraldton North wastewater treatment plants should be made available to irrigate future areas of public open space in proximity to these treatment plants.
- Investigation would need to be undertaken to identify the opportunities and approvals required for development of water reuse options.

7.3.2 Strategies

The following strategies should be implemented to improve water management outcomes in new urban areas, in addition to the “city-wide” recommendations (section 7.1.1).

10. Ensure district structure plans are supported by district water management strategies consistent with the requirements of *Better Urban Water Management* (WAPC, 2008) and achieve the criteria contained in this Strategy (section 7.1.3).
11. Ensure local structure plans are supported by local water management strategies consistent with the requirements of *Better Urban Water Management* (WAPC, 2008) and achieve the criteria contained in this Strategy (section 7.1.3).
12. Urban water management plans should be prepared to support any application for subdivision consistent with the requirements of *Better Urban Water Management* (WAPC, 2008) and any approved local water management strategy and demonstrate the achievement of the design criteria in this Strategy (section 7.1.3).
13. Ensure information requirements including monitoring is reflective of the scale of planning and the characteristics of the site.
14. Consideration should be given to the geomorphic and site description criteria identified by the Department of Environment Regulation to determine if acid sulfate soils are likely to be present. Action should be taken as appropriate, consistent with the Department of Environment Regulation’s acid sulfate soils guideline series.
15. All new development to meet the State Water Plan target of 100 kL/person/year including not more than 60 kL/person/year of scheme water where there is access to a source of non-drinking water.

16. Water reuse options should be investigated using a collaborative approach which involves all stakeholders with a commitment to address current barriers to the achievement of innovative solutions, including the use of recycled wastewater from existing wastewater treatment plants as a potential future water source.
17. Consider options for decentralised supply of water and wastewater, particularly in areas on the fringe of development.
18. Develop “minimum” requirements for water sensitive management of stormwater including standards and criteria for incorporation into public open space. Educate industry on the cost/benefit of water sensitive urban design outcomes in comparison to traditional development.
19. Investigate tools and incentives for better urban water management such as density bonuses or rebates.
20. Promote waterwise landscaping and irrigation systems and onsite wastewater management.
21. Work with developers to showcase best practice in stormwater management, water efficiency and water reuse and raise awareness within industry and the community through promotional activities including newsletters, websites, competitions and marketing.
22. New public open spaces to be designed to minimise water use with waterwise landscaping and use of smart irrigation systems, retaining and restoring existing natural bushland to maximise linkages between environmental assets wherever possible.



Opportunities for improved water management outcomes in the locality of Glenfield.

Glenfield is earmarked as a future residential area and planning for the development is progressing quickly. Planning at the local scale should be supported by a Local Water Management Strategy which outlines the objectives and criteria for water conservation and efficiency; water reuse; and stormwater and groundwater management, consistent with the recommendations of this Water Planning and Management Strategy.

Opportunities which could be explored in Glenfield include:

- Installation of water efficient fixtures and fittings, together with smart irrigation systems and xeriscaped landscaping in private gardens (via landscaping packages) and public open space. If a reticulated supply of non-drinking water isn't provided, rainwater tanks should be plumbed into toilets and laundries. This will enable the resident community to reduce its water use to less than 100kL/person/year.
- Treatment of stormwater quality via raingardens contained in lots, streets (tree pits or median swales) and in multiple use public open space corridors.
- Retention of bushland and landform to minimise changes to microclimates.
- Promotion of the “water sensitive” aspects of the development including generation of educational material for buyers regarding xeric landscaping, smart irrigation systems, rainwater tanks (or 3rd pipe system), raingardens, and functionality of public open spaces.



The above opportunities should be outlined in detail in urban water management plans, which should be prepared to support any application for subdivision.

7.3.3 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
District structure plans and decisions on land use change to be supported by district water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton together with the Department of Water
Local structure plans to be supported by local water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton together with the Department of Water
Applications for subdivision to be supported by urban water management plans	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	WAPC and City of Greater Geraldton
Ensure information and monitoring requirements are reflective of site conditions	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate and ongoing	City of Greater Geraldton together with the Department of Water
Consider acid sulfate soils	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate and ongoing	Developers, working with the Department of Environment Regulation
New development to meet State Water Plan target for water use	Water supply and use Water reuse	As part of the planning and development approvals system	Immediate and ongoing	Developers, working with Water Corporation and City of Greater Geraldton

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Address barriers to achievement of water reuse opportunities	Stormwater management Groundwater use and management Water supply and use Water reuse	As part of the planning and development approvals system via proposals and demonstration projects	Short term	City of Greater Geraldton together with State Government and Water Corporation
Consider decentralised supply of water and wastewater, particularly on the fringe of development	Stormwater management Groundwater use and management Water supply and use Water reuse	As part of the planning and development approvals system via proposals and demonstration projects	Short term	City of Greater Geraldton together with State Government and Water Corporation
Develop guidance for developers on minimum requirements for stormwater	Stormwater management Groundwater use and management	City of Greater Geraldton planning policy and engineering requirements	Immediate	City of Greater Geraldton
Investigate planning incentives for better urban water management outcomes	Stormwater management Groundwater use and management Water supply and use Water reuse	City of Greater Geraldton planning policy	Short term	City of Greater Geraldton
Require rainwater tanks, plumbed in-house in all new developments	Stormwater management Water supply and use Water reuse	City of Greater Geraldton planning policy and development requirements	Short term	City of Greater Geraldton
Promote waterwise landscaping and irrigation and on-site wastewater systems	Stormwater management Groundwater use and management Water supply and use Water reuse	City of Greater Geraldton planning policy and development requirements	Short term	City of Greater Geraldton
Showcase best practice water sensitive urban design solutions	Stormwater management Groundwater use and management Water supply and use Water reuse	As part of the planning and development approvals system via proposals and demonstration projects	Short term	City of Greater Geraldton together with developers

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
New POS to be waterwise and retain bushland and remnant vegetation	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate	City of Greater Geraldton
Priority stormwater retrofit projects that are cost effective and demonstrate net welfare gain.	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management	Intermediate	City of Greater Geraldton

7.4 NEW INDUSTRIAL AND LARGE COMMERCIAL DEVELOPMENT

7.4.1 Key issues

The following key issues have been considered when developing strategies to improve water management and use in existing residential, industrial and town centre areas.

Protection of significant environments

- Limited remnant vegetation remains within the City of Greater Geraldton. There is a need to retain and protect remaining vegetation in public open space and identify opportunities to enhance linkages between environmentally sensitive areas.
- Industrial areas have the potential to release pollutants into the landscape, particularly in unsewered areas.
- There is limited information regarding the presence of acid sulfate soils within the City.

Stormwater management

- Industrial and commercial areas are generally highly impervious. This provides an opportunity for the capture of stormwater but also requires appropriate flood management;
- Stormwater systems must not be used for the discharge of industrial wastes or toxic substances

Groundwater use and management

- There are a number of registered contaminated sites within the proposed industrial areas which may have impacted on the existing quality of the groundwater resource
- There is a lack of understanding of the availability and quality of local groundwater resources which could be used for non-potable uses within the industrial area.
- The Narngulu waste water treatment plant currently infiltrates its wastewater to groundwater for subsequent public open space reuse.

Drinking water supply and use

- Planning for the long term supply of water to Oakajee may provide the opportunity to develop a decentralised supply option.

Water reuse

- Regulatory challenges are present for water reuse options, depending on the level of environmental and health risks. There are opportunities to develop significant water sources from non-drinking water alternatives.

- The opportunity exists to supply the Narngulu industrial estate with a non-potable water supply from the Narngulu waste water treatment plant and to consider the concept of industrial ecology in the planning and development of the estate.

7.4.2 Strategies

The following strategies should be implemented to improve water management outcomes in new industrial and commercial development areas, in addition to the “city-wide” recommendations (section 7.1.1).

23. Ensure district structure plans are supported by district water management strategies consistent with the requirements of Better Urban Water Management (WAPC, 2008) and achieve the criteria contained in this Strategy (section 7.1.3).
24. Ensure local structure plans are supported by local water management strategies consistent with the requirements of Better Urban Water Management (WAPC, 2008) and achieve the criteria contained in this Strategy (section 7.1.3).
25. Urban water management plans should be prepared to support any application for subdivision consistent with the requirements of Better Urban Water Management (WAPC, 2008) and any approved local water management strategy and demonstrate the achievement of the design criteria in this Strategy (section 7.1.3).
26. Ensure information requirements including monitoring is reflective of the scale of planning and the characteristics of the site.
27. Consideration should be given to the geomorphic and site description criteria identified by the Department of Environment Regulation to determine if acid sulfate soils are likely to be present. Action should be taken as appropriate, consistent with the Department of Environment Regulation’s acid sulfate soils guideline series.
28. Require areas of public open space to be included in industrial areas which retain remnant vegetation, incorporate stormwater management techniques and provide a community function.
29. Consider reticulated non-potable supply within the Narngulu industrial estate, supplied from the Narngulu waste water treatment plant.
30. Require an appropriately sized rainwater tank to detain frequent events for both in- and ex-building non-potable use or connection to the reticulated non-potable water supply network.
31. Minimise impervious areas by using pervious paving and direct stormwater from pervious areas to vegetated garden areas.

32. Ensure connection of work areas including washdown bays, to deep sewerage and identify wastes permitted to be discharged to the system. Where sewerage is not available, appropriate wastewater management systems must be installed which are capable of treating all types of pollutants likely to be present.
33. Consider coordinated water recycling from industrial operations and “closed-loop” waste streams to achieve water management and use outcomes consistent with industrial ecology principles.

7.4.3 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
District structure plans and decisions on land use change to be supported by district water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton
Local structure plans to be supported by local water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton
Applications for subdivision to be supported by urban water management plans	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton
Ensure information and monitoring requirements are reflective of site conditions	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate and ongoing	City of Greater Geraldton together with the Department of Water
Consider acid sulfate soils	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Immediate and ongoing	Developers, working with the Department of Environment aRegulation
Require areas of POS which are to be waterwise and retain bushland and remnant vegetation	Protection of significant environments Stormwater management Groundwater use and management Water efficient plans for POS	As part of the planning and development approvals system	Immediate	City of Greater Geraldton

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Consider reticulated non-potable water supply in Narngulu sourced from the Narngulu wastewater treatment plant	Water supply and use Water reuse	As part of the planning and development approvals system	Short term	Developers, working with Water Corporation and City of Greater Geraldton
Require rainwater tanks in all new developments	Stormwater management Water supply and use Water reuse	City of Greater Geraldton planning policy and development requirements	Short term	City of Greater Geraldton
Minimise impervious areas through use of pervious paving and raingardens	Stormwater management Groundwater use and management	As part of the planning and development approvals system via development guidelines	Short term	City of Greater Geraldton
Ensure connection of work areas including washdown bays to deep sewerage	Protection of significant environments Stormwater management Groundwater use and management	As part of development approvals (sites may require industrial waste permit)	Short term	City of Greater Geraldton
Consider coordinated water recycling from industrial operations consistent with industrial ecology principles	Water supply and use Water reuse	Structure planning and centralised management of Narngulu and surrounding areas	Short term and ongoing	City of Greater Geraldton together with industry

7.5 RURAL RESIDENTIAL AREAS

7.5.1 Key issues

The following key issues have been considered when developing strategies to improve water management and use in both existing and new rural-residential areas.

Protection of significant environments

- Limited remnant vegetation remains within the City of Greater Geraldton. There is a need to retain and protect remaining vegetation on private land in rural-residential areas through the use of building envelopes, landscape protection areas, clearing restrictions and covenants, consistent with the City's Local Biodiversity Strategy.
- Inappropriate land management in rural-residential areas has the potential to impact on the health of the Greenough and Chapman rivers through loss of riparian vegetation, fire management, high nutrients, weeds and erosion.

Stormwater management

- Retention of stormwater on site maximises infiltration and recharge of the aquifer. Consideration must be given to the potential for erosion and sedimentation.

Groundwater use and management

- Limited information exists regarding current use, quality and availability of local groundwater resources in rural residential areas.
- Most areas are unsewered, and this has the potential to impact on the quality of groundwater resources and the health of the Greenough and Chapman rivers.

Drinking water supply and use

- Some of the existing rural-residential areas are not supplied with scheme water and therefore relies on direct access to groundwater via unlicensed bores and rainwater tanks.
- The cost and logistics of supplying reticulated drinking water to rural-residential areas are substantial and probably prohibitive.

Water reuse

- Individual wastewater management systems require ongoing maintenance to reduce offsite impacts.

7.5.2 Strategies

The following strategies should be implemented to improve water management outcomes in existing and new rural-residential areas, in addition to the “city-wide” recommendations (section 7.1.1).

34. Ensure local structure plans are supported by local water management strategies consistent with the requirements of Better Urban Water Management (WAPC, 2008) and achieve the criteria contained in this Strategy (section 7.1.3).
35. Identify and protect remaining remnant vegetation, consistent with the findings of the Geraldton Regional Flora and Vegetation Survey and the City’s Local Biodiversity Strategy. Require revegetation of disturbed areas as part of development approvals.
36. Ensure the land is capable of supporting the proposed land use, having consideration of the capacity of the soils to retain nutrients, manage erosion and waterlogging, and infiltrate rainfall events.
37. Consider opportunities for “urban-garden” type development which facilitates the co-existence of communities and food production.
38. Develop a strategy for coordination of development and achievement of objectives in areas of fragmented land ownership.
39. Promote use of wastewater management systems which provide a non-potable water supply for appropriate use and have nutrient attenuating properties to protect existing river and groundwater systems.
40. Establish demonstration sites which display best practice stormwater management, including protection of remnant vegetation, and water reuse and efficiency technologies.

Rural residential areas

Water sensitive design and practice in rural residential areas provides an opportunity to maximise the use of wastewater and provide fit-for-purpose water for all uses.

The development of rural residential areas such as on the slopes of the Moresby Ranges, presents an opportunity for demonstration of wastewater reuse and nutrient cycling practices including:

- Permaculture type development that facilitates the co-existence of communities and perennial food production.
- Cluster-scale decentralised management of wastewater.
- Water recycling schemes that provide a non-potable water supply
- Wastewater management systems that have nutrient attenuating properties to protect existing river and groundwater systems.



These ideas have been successfully implemented in many areas, for example, the semi-rural urban permaculture landscape of Village Homes in Davis California below:



The third pipe non-potable water supply under development in Armadale, Perth and



Localised water reuse at Currumbin Ecovillage in NSW.



7.5.3 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Local structure plans to be supported by local water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton
Identify and protect remaining remnant vegetation consistent with the Geraldton Regional Flora and Vegetation Surveys and the City's Local Biodiversity Strategy	Protection of significant environments Stormwater management Groundwater use and management	Structure planning and development approvals Covenants and management agreements	Immediate and ongoing	City of Greater Geraldton together with landowners
Ensure the land is capable of supporting the proposed use having consideration of the capacity of the soils to retain nutrients, manage erosion and waterlogging and infiltrate rainfall events	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	Immediate and ongoing	City of Greater Geraldton
Consider opportunities for "urban garden" development	Stormwater management Groundwater use and management Water supply and use Water reuse	Structure planning and development approvals	Medium term	City of Greater Geraldton

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Promote appropriate nutrient retentive wastewater management systems which provide non-potable water supply	Protection of significant environments Groundwater use and management Water supply and use Water reuse	Structure planning and development approvals	Short term	City of Greater Geraldton
Establish demonstration sites which display best practice stormwater management including vegetation protection, water reuse and efficiency technologies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Council education program and Water Corporation waterwise program	Medium term	City of Greater Geraldton together with the Water Corporation

7.6 RURAL, RESOURCES (MINING) AND AGRICULTURAL AREAS

7.6.1 Key issues

The following key issues have been considered when developing strategies to improve water management and use in rural, resources and agricultural areas.

Protection of significant environments

- Limited remnant vegetation remains within the City of Greater Geraldton. There is a need to retain and protect remaining vegetation in public open space and identify opportunities to enhance linkages between environmentally sensitive areas, consistent with the City’s Local Biodiversity Strategy.
- Limited information is available regarding the ecological water requirements of the Greenough and Chapman rivers or the wetland at Rum Jungle.
- There is limited information regarding the presence of acid sulfate soils.
- There are a number of basic raw material areas which threaten areas of remnant vegetation including certain parts of the Greenough and Chapman rivers.

Stormwater management

- Retention of stormwater on site maximises infiltration and recharge of the aquifer. Consideration must be given to the potential for erosion and sedimentation.

Groundwater use and management

- Limited consideration is given to the allocation of groundwater resources on the basis of “highest and best use”.
- There are a number of registered contaminated sites, extractive industries, as well as areas of existing agriculture and horticulture which may have implications for the groundwater quality.
- Identification of priority agricultural land requires an understanding of the availability of groundwater resources for irrigation, although this is also subject to the Department of Water’s first in, first Served policy of groundwater licence allocation.



Drinking water supply and use

- Existing horticultural and agricultural irrigation practices generally result in high groundwater usage and limit remaining availability of allocations for future land uses.

Water reuse

- Limited information exists regarding opportunities for coordinated water reuse schemes as most practices are at the individual lot/house scale.

7.6.2 Strategies

The following strategies should be implemented to improve water management outcomes in rural, resources and agricultural areas, in addition to the “city-wide” recommendations (section 7.1.1).

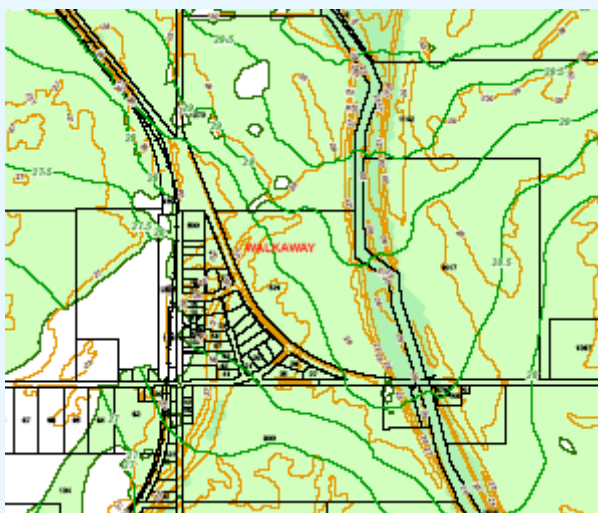
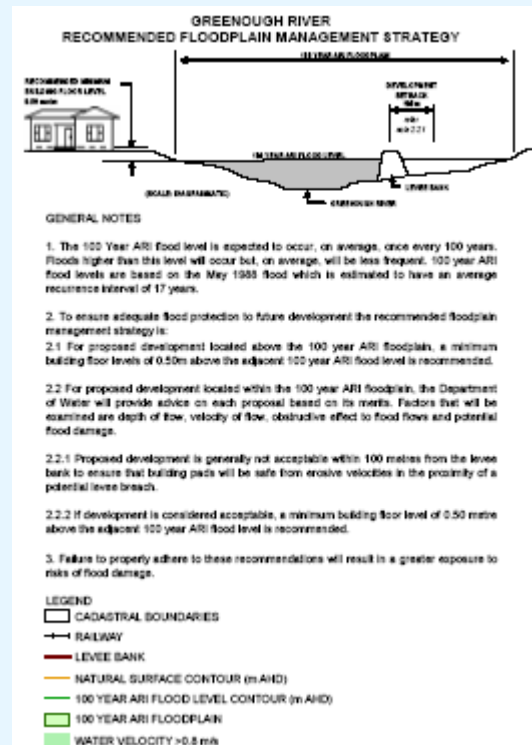
41. Planning for future priority agricultural areas and horticulture should consider the availability and quality of existing water resources and require demonstration of efficient practices and technologies.
42. Achieve better surface water management outcomes in rural areas through whole farm planning.
43. Investigate opportunities for implementation of keyline water harvesting systems in rural areas.
44. Require retention of remnant vegetation and revegetation, particularly in riparian areas, as part of the development approvals process.
45. Require total water cycle solutions to be implemented in isolated areas.



Opportunities for improved water management outcomes at Walkaway.

The Walkaway town site is situated near the Greenough River. Accordingly, there is an imperative to ensure that any development does not impact on the floodway of the Greenough River.

There are some limitations on the reticulated water supply. Any future development can be achieved through an extension of the Allanooka supply main. Further development may need to demonstrate access to a sustainable supply of water (rainwater and/or groundwater) for drinking water. It is recommended that separate on-lot systems are installed for potable and non-potable water needs such as toilets, laundry and irrigation needs, which could be supplied by recycled grey water or wastewater systems. Water efficient fittings and appliances will aid in the conservation of drinking and non-drinking water supplies.



Opportunities should be sought to revegetate riparian areas and ensure appropriate sediment and nutrient management of stormwater flows so they do not impact on the quality of the Greenough River.

Additional management measures for the Greenough River are outlined in the Greenough River Estuary Management Plan 2005 Update, Shire of Greenough.

7.6.3 Implementation

Strategy	Issue	Implementation mechanisms	Timing	Responsibility
Consider water availability and efficiency technologies when considering priority agriculture areas and proposals for horticulture	Protection of significant environments Stormwater management Groundwater use and management	Structure planning and development approvals	Immediate and ongoing	City of Greater Geraldton
Achieve better surface water management outcomes through whole-farm planning	Protection of significant environments Stormwater management	Farm planning	Medium term	City of Greater Geraldton together with the Department of Agriculture and Food
Investigate opportunities for keyline water harvesting	Stormwater management Groundwater use and management Water supply and use Water reuse	Development approvals	Medium term	City of Greater Geraldton
Retain remnant vegetation and require revegetation, particularly in riparian areas	Protection of significant environment Stormwater management	Structure planning and development approvals	Short term	City of Greater Geraldton
Require total water cycle solutions in isolated areas	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Development approvals	Short term	City of Greater Geraldton

7.7 STRATEGIC PROJECTS

The following outcomes are considered to be desirable for the City of Greater Geraldton if it is to become a truly water sensitive city. These are essentially long term demonstration project options, which will require substantial planning and commitment (including funding) from all stakeholders, if they are to be implemented. Options to be considered as part of future water planning and management within the City include:

1. Wave powered seawater desalination (reverse osmosis) plants (SWRO).
2. Managed aquifer recharge wastewater schemes at all Water Corporation waste water treatment plants to supplement public open space, oval and golf course irrigation.
3. Sewer mining plants in urban areas to supplement stormwater aquifer storage and recovery schemes for irrigation of parks and gardens.
4. Residential areas to be renovated or established with third pipe schemes.
5. Peri-urban and rural residential areas beyond sewer reticulation to have cluster-scale shallow sewerage to localised recycling plants.
6. Wastewater hydroponic urban agriculture systems.
7. Nutrient recovery from wastewater through biosolids reprocessing and urine separation.
8. Superficial shallow aquifer to be used as a geothermal resource to reduce Geraldton's carbon footprint.



8 ACTION PLAN

It is recognised that this Water Planning and Management Strategy contains many individual strategies which are recommended to be implemented to facilitate movement of the City of Greater Geraldton towards a water sensitive city. These actions have been characterised broadly in terms of land use, as the land use planning system is considered to be a key mechanism which is able to bring about changes in water management systems and achieve water sensitive design outcomes.

The strategies considered to be highest priority are those which are identified as “immediate”. These are replicated in Table 10 and may be considered to represent an action plan for improving water management within the City of Greater Geraldton.

Due to the number of strategies which are considered to be high priority, it is unlikely that all will be able to be implemented immediately, particularly where they require additional resources or the coordinated action of a number of agencies. It is therefore recommended that further work (possibly in the form of an implementation workshop) is undertaken to assess the strategies in Table 9 (as well as the remainder of section 7 if desired) to develop a shared understanding between key stakeholders regarding the priority strategies and the role of each agency in implementing them.

The following questions may be helpful to inform the decision making process, including the development of a business case for investment. The recommended decision rules are:

1. Does the project/strategy solve an immediate problem?
2. Does the project/strategy provide for long term water security of the City of Greater Geraldton?
3. Can the project/strategy be funded within current or imminent budget planning?
4. Does the project/strategy support the water vision?
5. Does the project/strategy provide capacity building opportunities and/or demonstration value?
6. Does the project/ strategy provide a cost effective solution that will achieve real water saving/ substitution outcomes?

It is recognised that movement towards a water sensitive City will require coordination, cooperation and commitment of all stakeholders and the community to the vision and objectives of this strategy.

**"We must become the change we want to see."
(Mahatma Gandhi, 1869-1948)**



Table 10: Recommended priority strategies for immediate implementation

	Strategy	Issue	Implementation mechanisms	Responsibility
1	Manage water according to the water cycle to infiltrate and harvest rainwater and stormwater, aiming to reuse the water as many times as possible	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Through all actions of Council and stakeholders	City of Greater Geraldton together with key stakeholders
2	Identify opportunities to retrofit water sensitive urban design technologies, for example stormwater harvesting to aquifer storage and recovery (ASR)	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management and maintenance	City of Greater Geraldton
3	Develop clear policy direction for planning, design and operation of non-drinking water sources	Water supply and use Water reuse	State Government policy	State Government
4	Promote water efficiency measures and waterwise practices within the community and workplace	Water supply and use	Waterwise programs	City of Geraldton and the Water Corporation
5	Retain the natural landform wherever possible to minimise changes in hydrology	Groundwater use and management Stormwater management Groundwater use and management	As part of the planning and development approvals system	City of Geraldton
6	Develop a local planning policy for better urban water management	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system	City of Greater Geraldton
7	Rainwater tank cost-benefit analysis	Water supply and use Water reuse	Government partnership	State government and City of Greater Geraldton

	Strategy	Issue	Implementation mechanisms	Responsibility
8	Expand the Waterwise program to target high water-using suburbs	Water supply and use	Agency partnership	Water Corporation and local government
9	Demonstrate waterwise gardens and verges	Water supply and use Water reuse	As part of new development Council-managed land	Developers, working with City of Greater Geraldton
10	POS audit for better irrigation management and waterwise planting	Stormwater management Groundwater use and management Water supply and use Water reuse	Council asset management and water conservation planning	City of Greater Geraldton
11	District structure plans and decisions on land use change to be supported by district water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	City of Greater Geraldton together with the Department of Water
12	Local structure plans to be supported by local water management strategies	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	City of Greater Geraldton together with the Department of Water
13	Applications for subdivision to be supported by urban water management plans	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	City of Greater Geraldton and WAPC
14	Ensure information and monitoring requirements are reflective of site conditions	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	City of Greater Geraldton together with the Department of Water

	Strategy	Issue	Implementation mechanisms	Responsibility
15	Consider acid sulfate soils	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	Developers, working with the Department of Environment and Conservation
16	New development to meet State Water Plan target for water use	Water supply and use Water reuse	As part of the planning and development approvals system	Developers, working with Water Corporation and City of Greater Geraldton
17	Develop guidance for developers on minimum requirements for stormwater	Stormwater management Groundwater use and management	City of Greater Geraldton planning policy and engineering requirements	City of Greater Geraldton
18	New POS to be waterwise and retain bushland and remnant vegetation	Protection of significant environments Stormwater management Groundwater use and management	As part of the planning and development approvals system	City of Greater Geraldton
19	Identify and protect remaining remnant vegetation consistent with the Geraldton Regional Flora and Vegetation Surveys and the City's Local Biodiversity Strategy	Protection of significant environments Stormwater management Groundwater use and management	Structure planning and development approvals Covenants and management agreements	City of Greater Geraldton together with landowners
20	Ensure the land is capable of supporting the proposed use having consideration of the capacity of the soils to retain nutrients, manage erosion and waterlogging and infiltrate rainfall events	Protection of significant environments Stormwater management Groundwater use and management Water supply and use Water reuse	Planning and development approvals system, consistent with SPP 2.9: Water Resources	City of Greater Geraldton
21	Consider water availability and efficiency technologies when considering priority agriculture areas and proposals for horticulture	Protection of significant environments Stormwater management Groundwater use and management	Structure planning and development approvals	City of Greater Geraldton

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report (“the report”) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV. Australia Pty Ltd (ENV) (“scope of services”). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report (“the data”). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (“conclusions”) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions. Also it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

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