Non-Potable Water Action Plan

City of Kalamunda

Contents

Introduction

The purpose of the Non-Potable Action Plan is to provide potential mitigation solutions for the risks associated with securing a long term non-potable water (non-drinking water) source to sustain the forecasted growth and changing climate in the City of Kalamunda (the City).

The City operates under the Department of Water and Environmental Regulation (DWER), license to take water allocation under the *Rights in Water and Irrigation Act 1914* (RIWI).

The groundwater sources which the City currently extracts water from are now fully allocated, consequently the City cannot apply for an increase on its license to take water for future growth areas of the City.

The City is facing the following key issues as it grows and expands:

- Expanding and improving the area of sporting fields and public open space (POS) to meet the needs of the growing and changing population requiring more and more water for irrigation.
- Growing subdivision in the City (especially in the foothills), new POS is created, including high quality parks requiring continued irrigation.
- Irrigation water has been traditionally sourced using groundwater via bores. These must be used in accordance with licence conditions including volume taken. The State, DWER is actively seeking to reduce aquifer use as this resource is currently under threat.

Many of Perth's natural values, such as urban wetlands and bushland are also dependent on groundwater. With groundwater availability limited to the north and south of Perth, improved water efficiency, water-sensitive urban design and alternative water supplies will be required to support the development of new urban, industrial and fresh food production areas.

Perth and Peel @3.5 million Western Australian Planning Commission

Effective ongoing management of these significant water sources requires careful consideration, as there are land uses that impact the quantity and quality of water that enters the underground aquifer. Further management is required to rationalise current water use to reduce unnecessary consumption, including greater use of alternative non-potable supplies for irrigation purposes.

Background Information

Perth's drying climate is having a marked effect on the reduction of groundwater and surface water availability. At the same time as demand for water is increasing.

The Perth metropolitan area has a Mediterranean climate with hot dry summers and cool wet winters. The annual long-term average rainfall for Perth is 850mm, but over the last ten-year period the average rainfall has declined to 705mm.

The annual potential evaporation is 1,750mm, with evaporation generally exceeding rainfall from September to April.

A drying climate as experienced in Perth is represented by the following (*Figure1)*

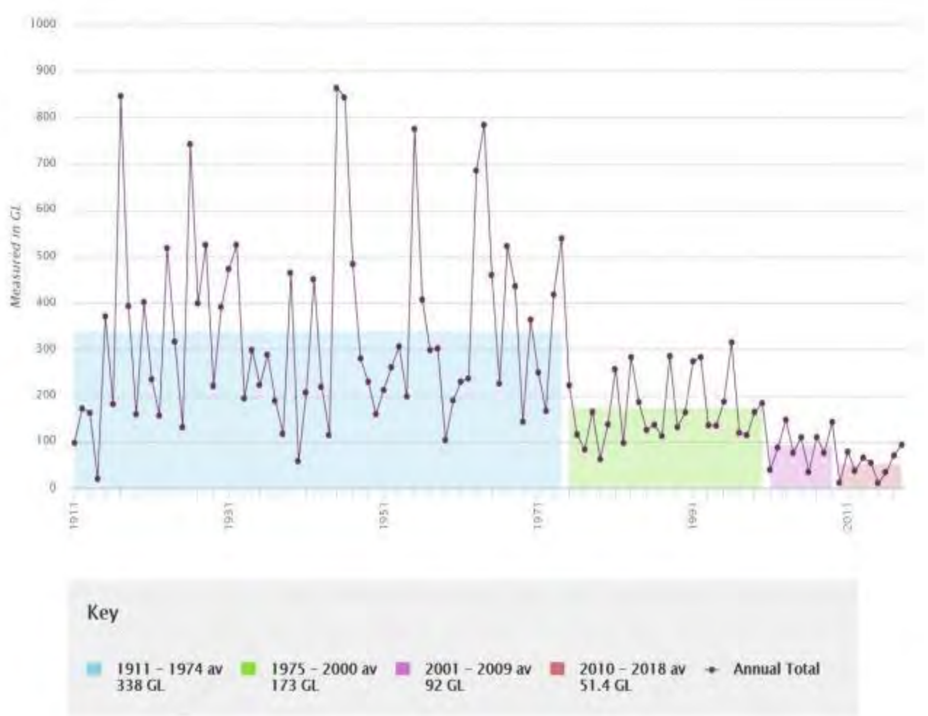

Figure 1: Stream Flow Decline displayed in Giga-litres Source: Water Corporation Historical Stream Flow Data. The above graph demonstrates the decline in stream flow, the numbers on the vertical axis are represented in Giga-litres.

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Groundwater Storage Depletion

Figure 1 represents a substantial decline in the average stream flow run-off between 1911-1974 (average 338Gl) and 2010-2016 (average 51.4Gl). This has a significant impact on ground water levels as represented in (*Figure 2)*: Groundwater Storage Depletion.

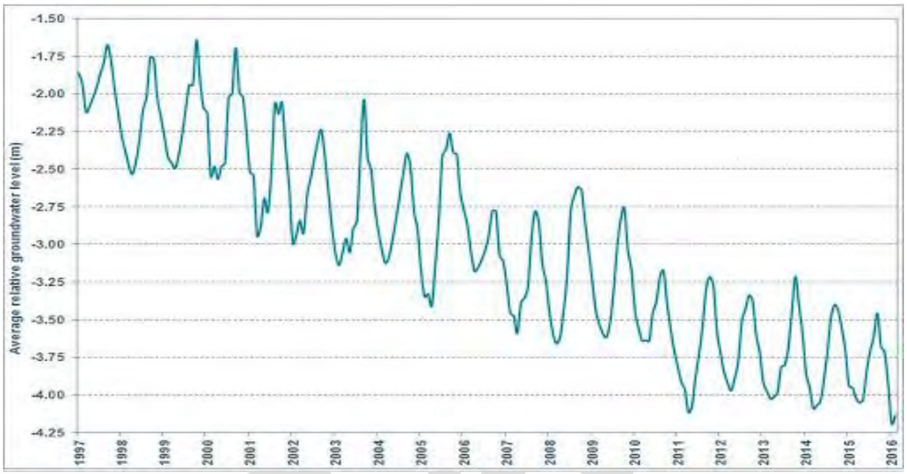


Figure 2*: Source: Draft Perth-Peel Regional water plan 2010-2030 Department of Water*

The Draft Perth-Peel Regional Water Plan 2010-2030 prepared by DWER identifies the potential groundwater available in the following table.

Groundwater Availability by 2030 Gl/y			
2030 Demand Scenario	Wet Climate	Median Climate	Dry Climate
Constrained demand(250Gl/y)	-37	-74	-107
10% reduction	-12	-49	-82
20% reduction	13	-24	-57

Licensed Private Use Effect of Demand on Groundwater Availability-Perth Source: Draft Perth-Peel Regional water plan 2010-2030 Department of Water.

The above table indicates even with a 10% reduction on current use and a wet climate, the supply gap will be 12Gl (12 billion litres) by 2030.

As the treated wastewater allocation becomes less available due to the successful use of Managed Aquifer Recharge (MAR) by the Water Corporation, harvested stormwater will form a significant alternative solution to reducing the supply demand gap.

State Government Strategic Outlooks

Department of Water and Environmental Regulation
Water Wise Perth Action Plan 2030 Targets

Targets (to be achieved by 2030)

- Reduce average annual potable water supplied to 110kl per person.
- Increase community engagement and knowledge about water by 15% (from 6.2 in 2018 to 7.1 out of 10 water knowledge questions answered correctly by 2030, as measured by the Waterwise Cities Community Tracker).
- 100% of Perth and Peel Councils achieve Waterwise Gold status.
- 50 or more land and water assets are retrofitted to improve local community access to green spaces.
- 100% of irrigated open space has been audited and is adopting Waterwise management practices.
- 10% less groundwater is used across the region.
- Recycled and alternative water supplies will make up 45% of the projected gap between future water demand and supply.
- Best practice Waterwise policies are integrated into all State urban water policies, guidelines and technical advice notes.
- 100% of government-led urban development in Perth and Peel to be Waterwise.

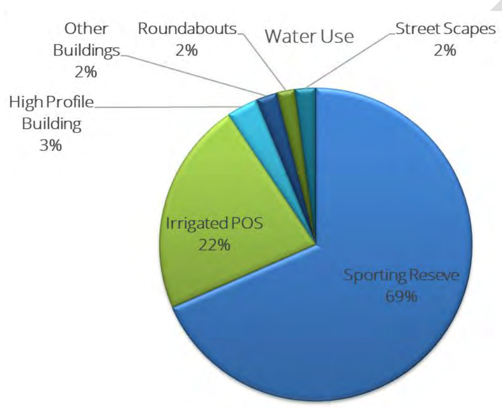
A summary of State Government outlooks is provided in (Appendices A, B, C, D).

City of Kalamunda "Strategic Alignment"
Priority 2: Kalamunda Clean and Green
Objective 2.1 - To protect and enhance the environmental values of the City.
Strategy 2.1.1 - Enhance our bushland, natural areas, waterways and reserves.
Priority 2: Kalamunda Clean and Green
Objective 2.2 - To achieve environmental sustainability through effective natural resource management effective natural resource management.
Strategy 2.2.1 - Facilitate the appropriate use of water and energy supplies for the City.
Strategy 2.2.2 - Use technology to produce innovative solutions to reduce power and water usage.
Priority 3: Kalamunda Develops
Objective 3.2 - To connect community to quality amenities.
Strategy 3.2.1 - Optimal management of all assets.

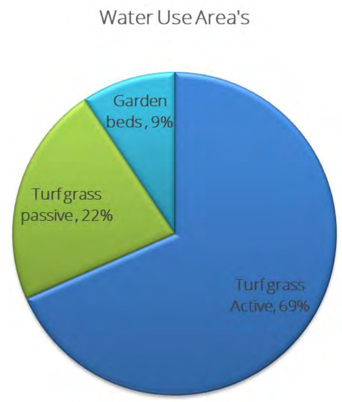
Current Water Use

Potable Water Use

The City currently operates 40 potable water supplied automatic irrigation systems which use on average 65,000kl per year. These water a total area of 18 hectares; the following (Chart 1) demonstrates where the water is being used:



The following (Chart2) demonstrates as a percentage, what type of green space is being irrigated:



Interpreting and understanding the data:

Chart 1 demonstrates as a percentage, where the water is being used. The areas are categorised, as per Park's service standards.

It is important to identify that 69% of the total potable water being used is on Sporting reserves, this includes the active sports surfaces of Kostera and Ray Owen Reserves.

The following high prolife buildings rely exclusively on potable water to sustain the gardens surrounding the buildings (example *Figure 3*).

- Kalamunda Library
- Jack Healy Centre
- Kalamunda Zig Zag Cultural and Visitor Centre

Figure 3: Kalamunda Zig Zag Cultural and Visitor Centre

Natural grass sports surfaces require approximately 10,000kl Per Ha to replace the grasses evaporation/transpiration and to recover from wear associated with use. The City's current allocation of 7,500kl Per Ha is inadequate for sport surfaces and necessitates water being reduced in non-active areas to top up the short fall. Non-active areas of grass can be sustained within the City's current water allocation.

Irrigated Public Open Spaces represent 22% of the total potable water used. The following sites rely solely on potable water for the reserves:

- Robert Hewson
- Fennel Court
- John Maclarty
- Tilla Court
- Ray Owen BMX
- Stirk Park (Playground Area)
- Kostera memorial

Streetscapes and roundabouts in Chart 1 represent a combined total of 4% of the total potable water use. These areas rely solely on potable water to maintain them in summer.

How Water Licencing works in the City of Kalamunda

The City of Kalamunda has three water license areas which are identified in the following image (*Figure 4*).

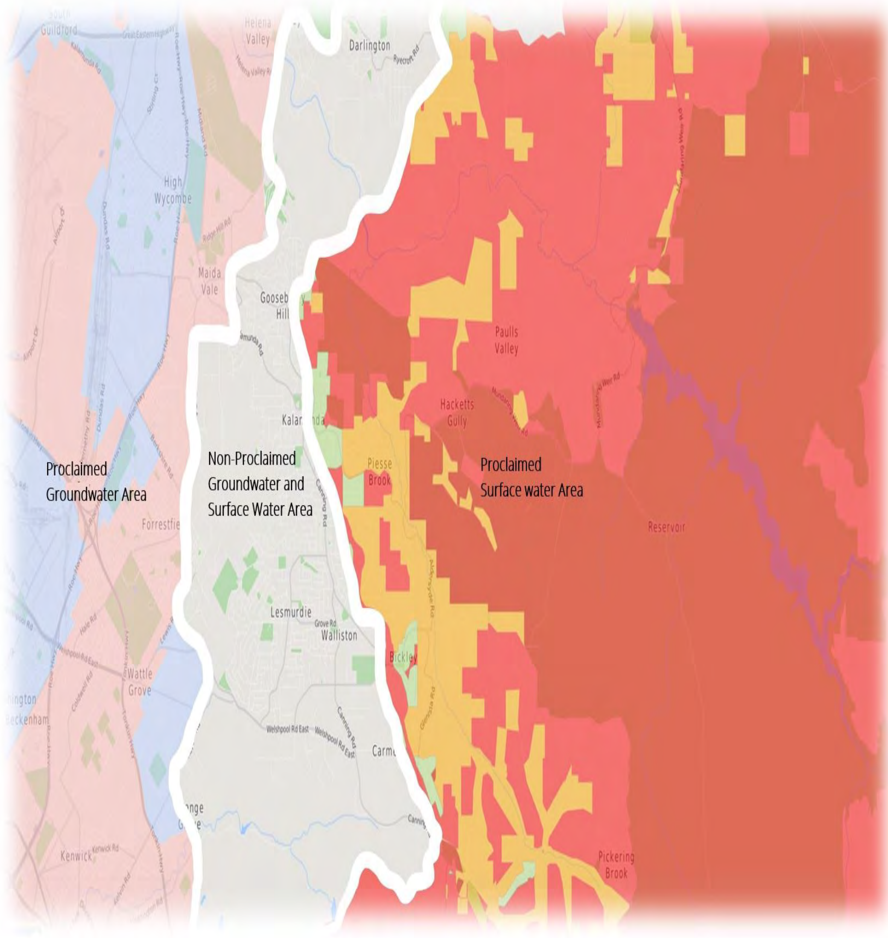


Figure 4: Licenced water zones City of Kalamunda
***"Proclaimed"** is defined as water sources that have associated license allocations which are regulated by DWER.*

Water License Area Characteristics

1. **Proclaimed Surface Water Area- East of the Darling Scarp (*Figure 5*)**

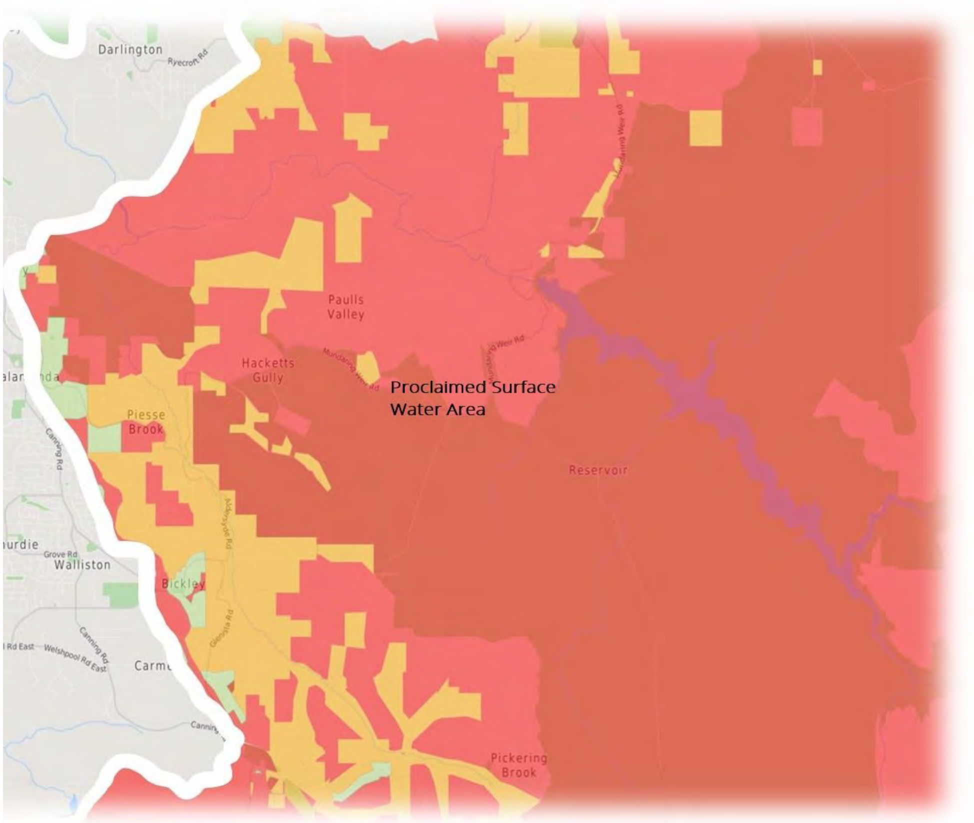


Figure 5: Proclaimed Surface Water Area

The following surface water catchments are located within the municipal boundary of the City of Kalamunda:

1. Mundaring Weir/ Helena River Catchment, (Appendix B)
2. Victoria Dam Catchment, (Appendix C)
3. Canning River Catchment, (Appendix D)

Fundamentals of the Surface Water Catchment Area

- The Surface Water Area is defined by the City as rural east with most of the area located in the South East Ward.
- Limited groundwater is available in this area.
- This area is not a proclaimed groundwater area (no bore licenses area required).
- Surface water is proclaimed, (construction of new dams and stormwater harvesting is prohibited).
- There has been some success using surface geophysics to locate geology at depths up to 120m in fractured rock that yield higher than typical volumes of water for the Perth hills environment.

Population Forecast to 2036

Current population of 3,423; forecasted growth at 2036 is 3,991.

The City has one green reticulated asset in the area, Pickering Brook Sports Club Oval (*Figure 6*).

A capital works project was undertaken in 2015 which included the installation of a new automatic irrigation system, the project successfully found a new groundwater source in fractured rock at a depth of 90m.

Given the low projected population growth and the lack of green city assets, this area is considered low risk for future non-potable water requirements.

Non-Potable Water Risk Assessment for the Surface Water Catchment Area.

	Future Level of Risk Mitigation			
Risk	**Consequence**	**Likelihood**	**Risk Rating**	**Notes**
City of Kalamunda falls to secure a long term Non-Potable water source to sustain future growth.	Reputation - Unsubstantiated, low impact, low profile or "no news" item	Rare – Projected Growth of this area is very low	Low	forecasted growth is low and the City has secured a long-term water resource for its green reticulated asset in the area

Figure 6: Pickering Brook Sports Club

2. Non-Proclaimed Surface Water and Ground water Area- Darling Scarp (*Figure 7*)

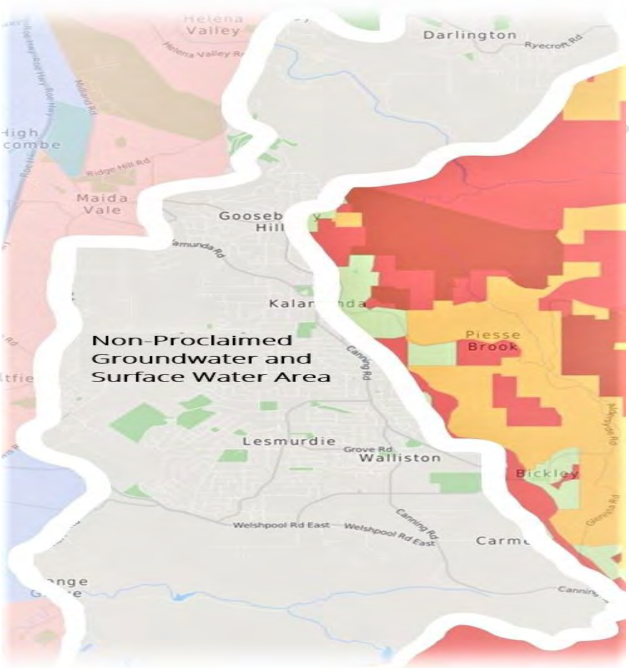


Figure 7: Non-Proclaimed Surface Water and Ground Water Area

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Fundamentals of the Non-Proclaimed Surface Water and Ground Water Area

- The Non-Proclaimed Surface Water and Groundwater Area is located across the following council ward boundaries, South East Ward, North Ward and the South West Ward.
- Very limited groundwater is available in this area.
- This area is not a proclaimed groundwater or surface water area.
- There has been no recorded success using surface geophysics to locate deeper fractured rock aquifers.
- There is a heavy reliance on potable water to supplement irrigation system requirements.

Population forecast to 2036

Current population 19,708; forecasted population to 2036, 21,283.

Water use for the Non-Proclaimed Surface Water and Groundwater Area (Darling Scarp)

Due to the lack of available groundwater in this area, irrigation systems rely on what is known in the industry as a 'shandy mix', a combination of potable, ground or surface water is used to fill an intermediate irrigation supply tank with water which is then pumped onto the playing surface from the tank. An example of this type of system is Kostera Oval (*Figure8*).

Non-Potable Water Risk Assessment for the Non-Proclaimed Surface Water and Ground water Area - Darling Scarp

	Future Level of Risk Mitigation			
Risk	**Consequence**	**Likelihood**	**Risk Rating**	**Notes**
The City fails to secure a long term non-potable water source to sustain future growth.	Reputation – substantiated, public embarrassment, moderate impact, moderate news profile.	Possible – Green space in this area relies on potable water, use of potable water is out of the City's control.	High	Forecasted growth is low however, the City has significant green assets in this area relying on potable water.

Figure 8: Kostera Oval Kalamunda

Proclaimed Ground Water Catchment Area (*Figure 9*)

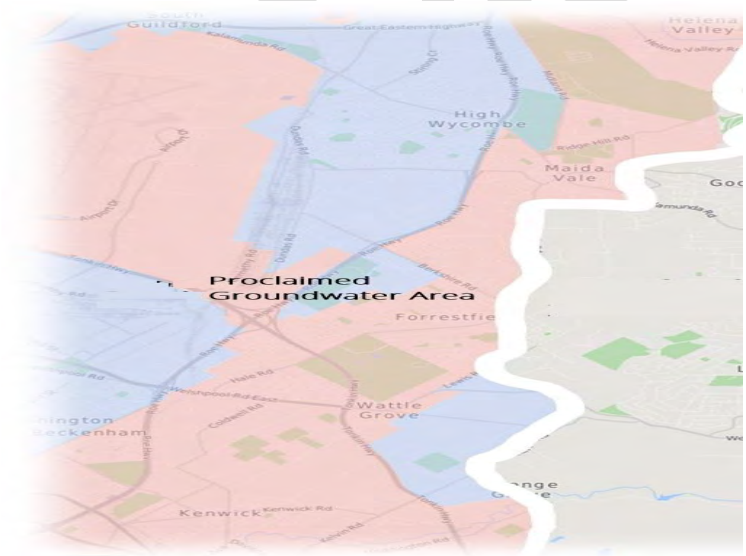

Figure 9: Proclaimed ground water Catchment Area

Fundamentals of the Proclaimed Groundwater Catchment Area

- The Proclaimed Groundwater Catchment Area is defined by the line east of Kelvin, Holmes and Watsonia Roads, and John Farrant Drive; and is located across all council ward boundaries.
- Groundwater is available however the license area is fully allocated as such the City must operate within its existing license to take water.

Population Forecast to 2036

Current population 38,492; forecast population to 2036, 50,905.

Current Water Use

The City operates under a DWER license to take water allocation under the *Rights in Water and Irrigation Act 1914* (RIWI).

The City is required to report annually on its water license use as per the conditions of the license to take water.

The City has two water extraction licences which are characterised as follows:

- Global Superficial Aquifer (Sallow Aquifer) Licence - covering the entire water license. (Total Municipal boundary).
- Leederville Aquifer (located deeper under the Superficial Aquifer) Groundwater Licence - covering the entire water license. (Total Municipal boundary).

An example of a sporting field located in the proclaimed groundwater catchment area can been seen in (*Figure 10*)

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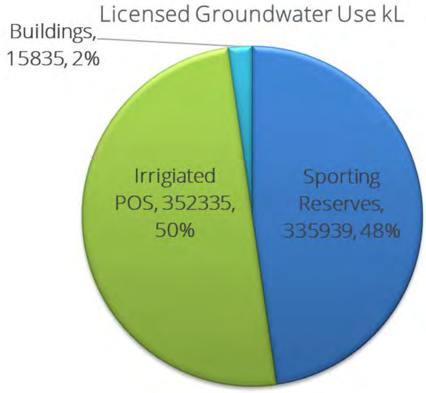
The following chart (Chart 3) demonstrates how water is utilised within the proclaimed groundwater catchment area.



	Future Level of Risk Mitigation			
Risk	**Consequence**	**Likelihood**	**Risk Rating**	**Notes**
The City fails to secure a long term non-potable water source to sustain future growth.	Reputation – substantiated, public embarrassment, moderate impact, moderate news profile	Likely – forecasted growth is high and ground water licenses are fully allocated.	High	An alternative non-potable water supply will be required for green space development.

Figure 10: Hartfield Park Hockey fields

Future Growth for the Proclaimed Groundwater Catchment Area

The following are water desktop projections for the future growth areas of the City of Kalamunda.

The water budget definitions as follows:

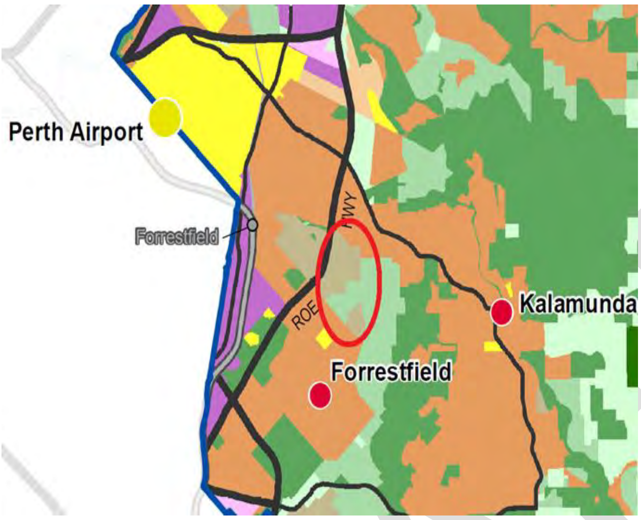
1. High water use means sports fields active POS.
2. Medium water use (7,500kl), means passive open space, turf grass.
3. Low water use (3,500kl), means low water consuming plants.
4. Non-irrigated means non-irrigated space, bushland/native areas.

Forrestfield North

POS water requirements, assuming 10% of total development area, currently estimated at 37 ha, water budget as follows:

- High water use 10,000kl per ha, total of 6ha equals 60,000kl.
- Medium water use 7,500kl per ha, total of 8 ha equals 60,000kl
- Low water use 3,500kl per ha, total of 10 ha equals 35,000kl
- Non-irrigated, total of 13ha, total estimated water requirement is 155,000 kl

Maida Vale South



Maida Vale South area approximately 175ha

- At 20 households per hectare and 2.6 persons per dwelling equals 3,500 households and 9,100 persons.
- At 15 households per hectare and 2.6 persons per dwelling equals 2,625 households and 9,100 persons.
- At 450m^2 lots (175 hectares – 30% for roads, POS and drainage and 2.6 persons per dwelling equals 2,722 households and 7,077 persons.

POS water requirements, assuming 10% of total area, water budget as follows:

- High water use 10,000kl per ha, total of 3ha equals 30,000kl
- Medium water use 7,500kl per ha, total of 5ha equals 37,500kl
- Low water use 3,500kl per ha, total of 5 ha equals 35,000kl
- Non-irrigated, total of 4.5ha

Total estimated water requirement is 102,500kl

Crystal Brook

Crystal Brook area approximately 185ha

- At 20 households per hectare and 2.6 persons per dwelling equals 3,700 households and 9,620 persons.
- At 15 households per hectare and 2.6 persons per dwelling equals 2,772 households and 7,220 persons.
- At 500m^2 lots (185 hectares – 30% for roads, POS and drainage and 2.6 persons per dwelling equals 2,480 households and 6,448 persons.

POS water requirements, assuming 10% of total development area, water budget as follows:

- High water use 10,000kl per ha, total of 3ha equals 30,000kl.
- Medium water use 7,500kl per ha, total of 5ha equals 37,500kl.
- Low water use 3,500kl per ha, total of 5 ha equals 35,000kl.
- Non-irrigated, total area of 5.5ha.

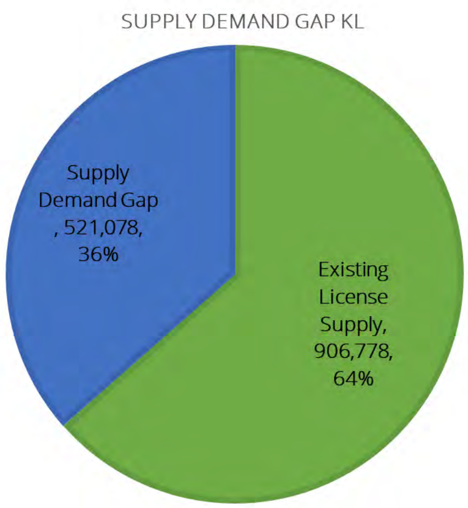
Total estimated water requirement is 102,500kl.

Total combined estimated water demand for Forrestfield North, Maida Vale South and Crystal is, 360,000kl.

The City operates under the DWER license to take water allocation under the *Rights in Water and Irrigation Act 1914* (RIWI).

The critical point is that the groundwater sources that the City currently extracts water from are now fully allocated. Consequently the City cannot apply for an increase on the license to take water for the future growth areas of the City. If an alternative Water Strategy is not implemented, based on projections for the above developments combined with the current potable water use of 65,000kl, the City will have a supply demand gap of 425,000kl.

Due to the State Government's proposed 10% decrease on the existing licenses to take water, the City will be facing a further 96,078kl reduction on the existing license. This will take the total supply demand gap to 521,078kl (Chart4 below).



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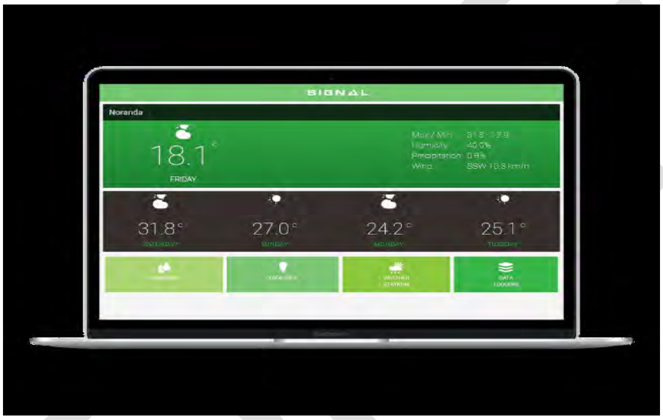
Closing the Supply Demand Gap

Recommend Solutions

Centralised Irrigation Control

A centralised irrigation control system can be described as an IT system that allows for the scheduling and management of an irrigation installation from a single location. These systems are especially designed to allow for the management of an irrigation system at one or more sites via a centralised computer.

The City has operated a centrally controlled system for the last five years, with selected sites being added on an annual basis. Currently the City has approximately half of its sites on the central control system, including all major irrigation systems.



Example of the City's central control systems homepage

The benefits of centralised irrigation control:

- Water saving - the centralised control systems make the management of an irrigation installation simple, precise and efficient.
- Centralised control - allows for better water management.
- A centralised control system can produce a 10% saving on water.
- Saving on time - the programming of a set of controllers at one or several sites requires a lot of time.
- Each time that a program is altered or the system stopped for any reason, a site visit in person would need to occur. The task is made far simpler with the centralised control system.

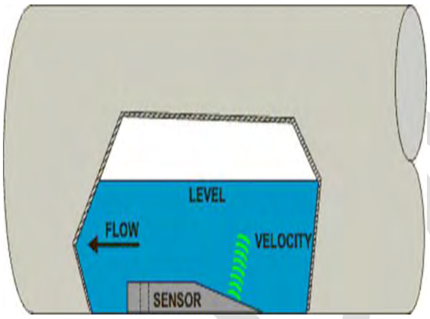
Automated Stormwater Flow Monitoring

The City recently installed Doppler Ultra-sonic water sensors at Stirk Park (Kalamunda) and Crumpet Creek in Forrestfield.

An Area-Velocity Flow Meter continuously measures both Level and Velocity to calculate flow volume in an open channel or pipe.

The implementation of a stormwater monitoring program, using Doppler Ultra-sonic water measurement technology will provide real time water flow data.

This data will be used to determine the potential of alternative water sources using stormwater. The data will also be used to inform catchment management plans and strategic asset management plans.



Doppler Ultra Sonic Water Sensor


Doppler Sensor installed at Crumpet Creek

Irrigation System Auditing

Irrigation audits collect data, verify systems are working as designed and identify opportunities to improve water-use efficiency, (catch cup test method example below).

The purpose of undertaking irrigation audits:

- Analyse water requirements and irrigation use in the context of each sites' unique conditions.
- Develop irrigation schedules based on water requirements, quality and availability.
- Make maintenance recommendations to keep the irrigation system working reliably and cost effectively.
- Estimate potential dollar and water savings from implementing innovative irrigation technologies, products and practices.


Catch cup test method

A great deal of work goes into scheduling an irrigation controller, the City has audited over 50% of their systems using the catch cup test method to determine the following:

- Microclimate
- Distribution uniformity, (Industry standard 80%)
- Sprinkler precipitation rate
- Plant type, density and root zone depth

This information is used to calculate the weekly water requirements based on millimetres of water per square metre and not the inaccurate method of days and minutes.

Automated Dosing Systems

Fertigation/Dosing is a technique that allows the controlled distribution of fertilisers and wetting agents through the automated irrigation system.

The main benefits of Fertigation/Dosing are:

- Improved nutrient absorption by plants due to the regulated application of fertilisers, wetting agents and water.
- More efficient use of water.
- Reduced use of manpower for fertilising and wetting agent operations.
- Surface not compromised by traditional algaculture methods of application for fertilisers and wetting agents.
- Consistency of fertiliser and wetting agent applications with the absence of nutrient and water losses.

The City installed smart automated dosing systems which integrate with the irrigation central control system to facilitate the application of wetting agents and fertilisers at the following locations:

- Ray Owen Reserve
- Kostera Reserve
- Scott Reserve

Automated dosing system installed at Ray Owen Reserve

Managed Aquifer Recharge

One solution that can contribute to closing the supply demand gap is Managed Aquifer Recharge (MAR).

Existing Managed Aquifer Recharge Project Hartfield Park

MAR describes the process of *"... recharging an aquifer under controlled conditions to store water for later abstraction or to achieve environmental benefits."* DWER who regulate water resources in Western Australia, have undertaken to support MAR as a means of improving groundwater levels, and as an alternate water supply in the Perth-Peel region.

Aquifer Storage and Recovery (ASR) is a technical term used to describe a specific method of MAR, namely the injection and recovery of water from a single bore or well, as shown in *Figure 11*.

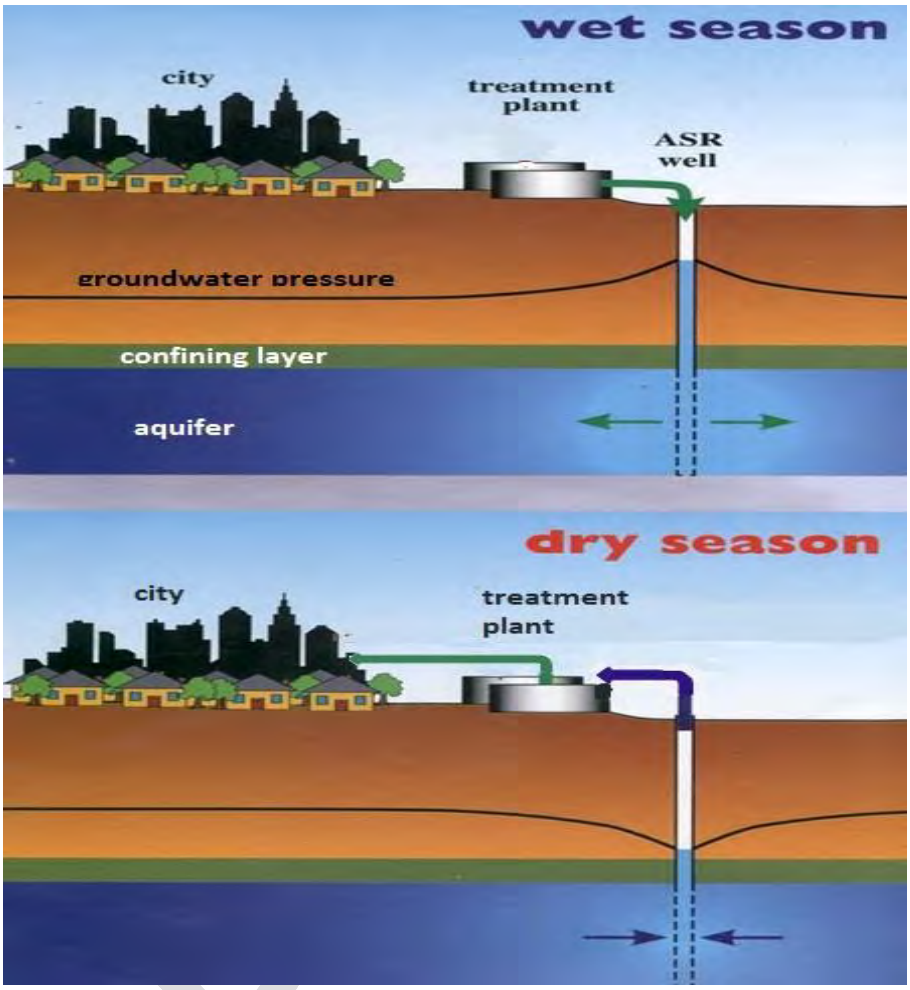


Figure 11: Schematic representation of ASR

The Hartfield Park stormwater harvesting, and MAR project provides a clear template for assessment and implementation of a municipal scale ASR scheme in the Perth region.

Hartfield Park MAR Filter System

Woodlupine Main Drain stormwater extraction point

The current harvesting capacity of the project is 100,000kl annually, with full capacity estimate at 230,000kl annually.

Eco-zoning
Fleming Reserve Upgrade and Eco-zoning Project

Recent upgrades at Fleming Reserve have greatly enhanced the community facilities including the playground with access for people with access requirements, improved picnic and BBQ areas, and extensive improvements to the existing skate park.

Installation of a more efficient irrigation system and the implementation of eco-zoning have also been undertaken. These help to reduce water use, irrigation and mowing costs

Fleming Reserve Post upgrade Improvements (values calculated per annuum)	
Water Savings	11,550kl
Power Savings	$791
Mowing Savings	$6,394
Co-efficiency	80%
Precipitation Rate	10mm per hour

Overwhelming increase in community use and ownership.

Fleming Reserve prior to the development

Fleming Reserve post development

Alternative Water Source for the Darling Scarp

The concept involves evaluating the potential of providing an alternative fit for purpose water source for the irrigation of POS in the hill's environment, where groundwater supplies are scarce.

The project involves the recovery of harvested stored stormwater and piping the water to the hills environment (*Figure12*).

Increasing the capacity of the current annual harvested stormwater from 100,000kl to 230,000kl.

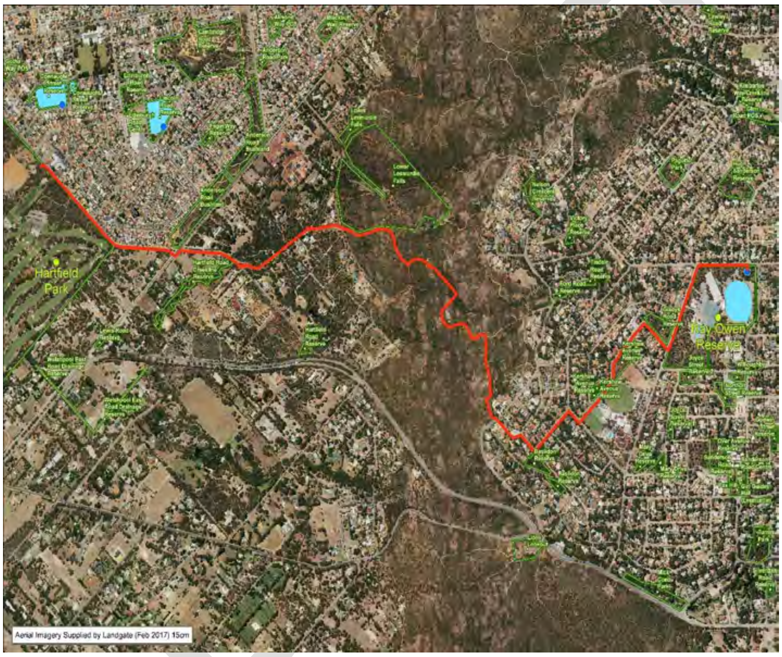


Figure 12: Proposed Pipeline Route

Project Objectives

- Provide an alternative fit for purpose solution for the lack of available water for irrigation in the perth hills environment.
- Increase capacity and efficiency of the current Managed Aquifer Recharge System.
- Ultimately provide a decentralised fit for purpose water service in support of the centralised system.

Proposed Actions

Number	Proposed Actions
We will provide fit for purpose alternative Non-Potable water supply solutions	
1	Increase the capacity of the current annual harvested stored stormwater from 100,000kl to 230,000kl at the Hartfield MAR.
2	Evaluate the potential of providing an alternate fit for purpose water source for the irrigation of parks in the hill's environment, where ground water supplies are scarce.
3	Undertake a full feasibility study and viability assessment for a second MAR in the City.
4	Undertake automated stormwater flow monitoring program targeting the City's main drainage infrastructure for the purpose of identifying potential Non-Potable water sources.
We will continue to improve efficiency of the city's existing irrigation systems	
5	Achieve irrigation system audits on 100% of irrigated City assets.
6	The City will continue to implement the irrigation asset renewal plan, ensuring all irrigation upgrades meet a minimum industry standard of 80% distribution uniformity (DU).
We will continue to implement smart irrigation technology to facilitate efficiency measures	
7	Continue to implement the City's central control system to include all city irrigated assets.
8	Continue to install smart automated dosing systems to facilitate to application of wetting agents.
We will implement Eco-zoning principles on new POS developments and renewal projects	
9	Identify existing parks to be retrofitted to accommodate eco-zoning opportunities through the irrigation asset renewal program.
10	Implement eco-zoning principles on new POS development.

Cost Benefit Analysis

Action	Estimated Cost Per Action	Water Saving's Per Action kl	Money Saved Annually	Operational Cost per kl	Total New Annual Operational Cost	Payback (Years)
Action 1 Full Scheme MAR Hartfield Park	$300,000.00	130,000kl	$286,000.00	$0.30	$39,000.00	1.04
Action 2 Hills Water Supply	$1,500,000.00	50,000kl	$100,000.00	$0.50	$25,000.00	15
Action 3 Second MAR	$1,000,000.00	200,000kl	$440,000.00	$0.30	$60,000.00	2.3
Action 7/8 Implement Irrigation Technology	$100,000.00	50,000kl	$125,000.00	NA	$0	0.8
Action 9/10 Implement Eco-zoning principles	$1,000,000.00	100,000kl	$250,000.00	NA	$0	4
Totals	$3,900,000.00	530,000kl	$1,261,000.00		$ 124,000.00	

Calculations based on current scheme water average cost of $2.50 per kl.
Pay back period Equation = $2.50 – operating cost per kl x Water Savings Per Action kl = Money Saved Annually
Payback Period = Estimated Cost Per Action ÷ Money Saved Annually

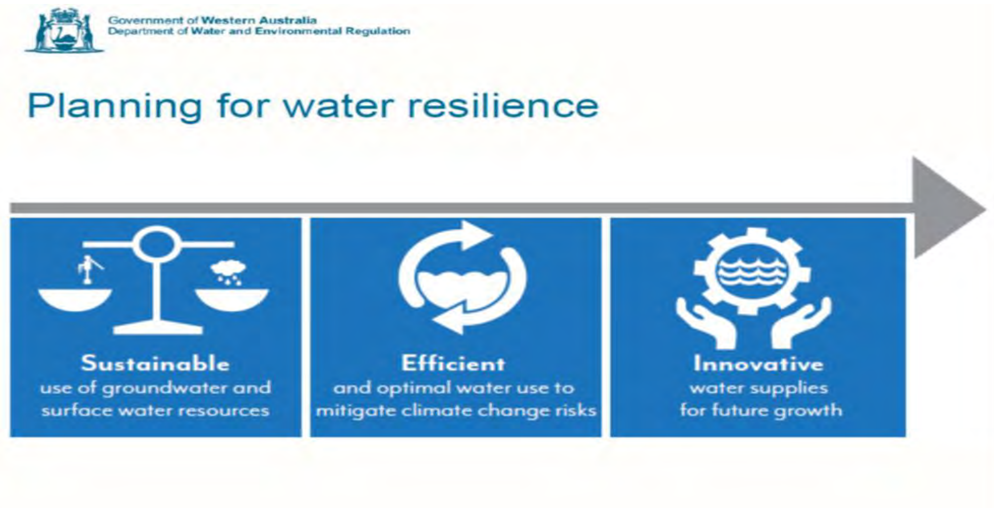
City of Kalamunda

Glossary of Terms/Abbreviations

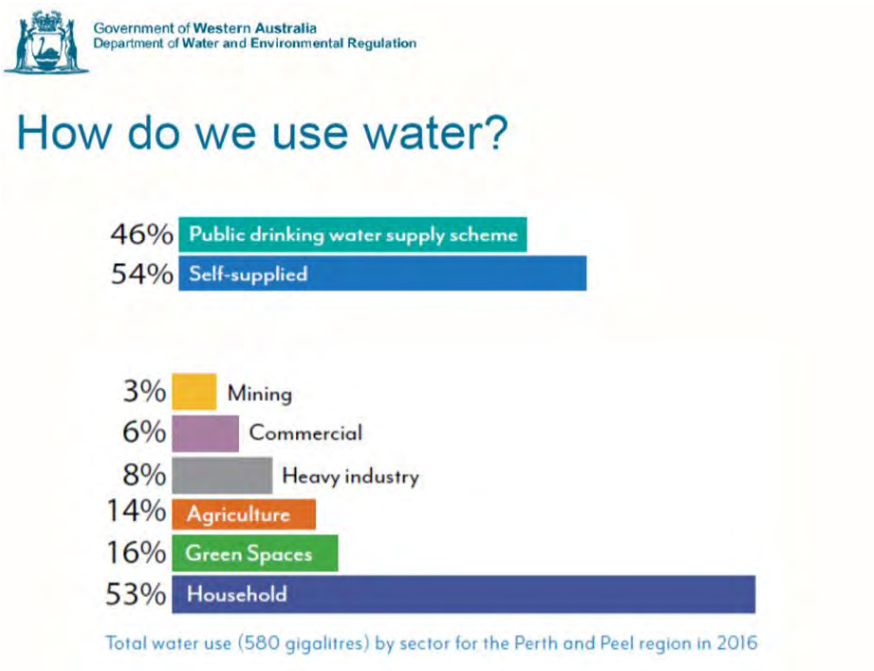
PW	Potable Water	Potable is a Latin word is meaning any drinkable liquid or healthy liquid that human being drink. Potable comes from Latin word Potare.
NPW	Non-Potable Water	Means water that is not for drinking e.g. irrigation water.
kl	Kilolitre	One thousand litres
ML	Megalitre	One million litres
Gl	Gigalitre	One billion litres
MAR	Managed Aquifer Recharge	Managed aquifer recharge describes the process of *"… recharging an aquifer under controlled conditions to store water for later abstraction or to achieve environmental benefits."*
ASR	Aquifer storage and recovery	Is a technical term used to describe a specific method of MAR, namely the injection and recovery of water from a single bore or well
DWER	Department of Water and Environmental Regulations	State Government regulatory and licencing body.
HDZ	Eco-zoning	Is the practice of clustering together plants with similar water requirements in an effort to conserve water.
ADP	Automated Dosing Pump	It is designed to pump a very precise flow rate of a Wetting Agents or fertiliser into the irrigation system.
DU	Distribution Uniformity	Is a measure of how evenly water is applied across a field during irrigation.
POS	Public Open Space	Is defined as an open piece of land both green space or hard space to which there is public access
PSA	Perth Superficial Aquifer	The shallowest aquifer which stretches across the coastal plain. Superficial aquifers are located closer to the surface and often express themselves as wetlands or lakes.
LEEA	Leederville Aquifer	Below the superficial aquifer and is separated by confining layers which minimises water movement. The Leederville aquifer is often several hundred metres thick and in some areas it connects with the surface.

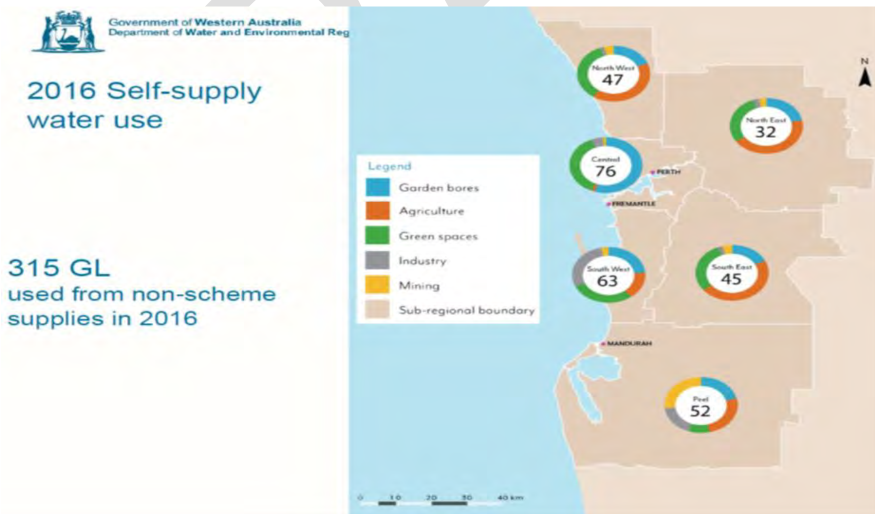
Appendix A

State Government Outlooks

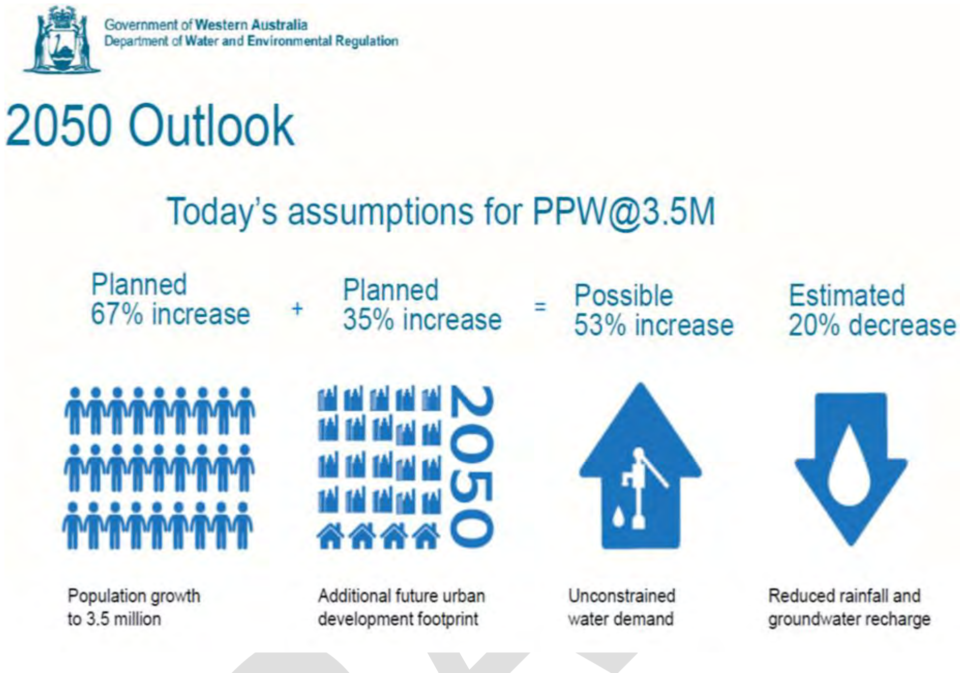


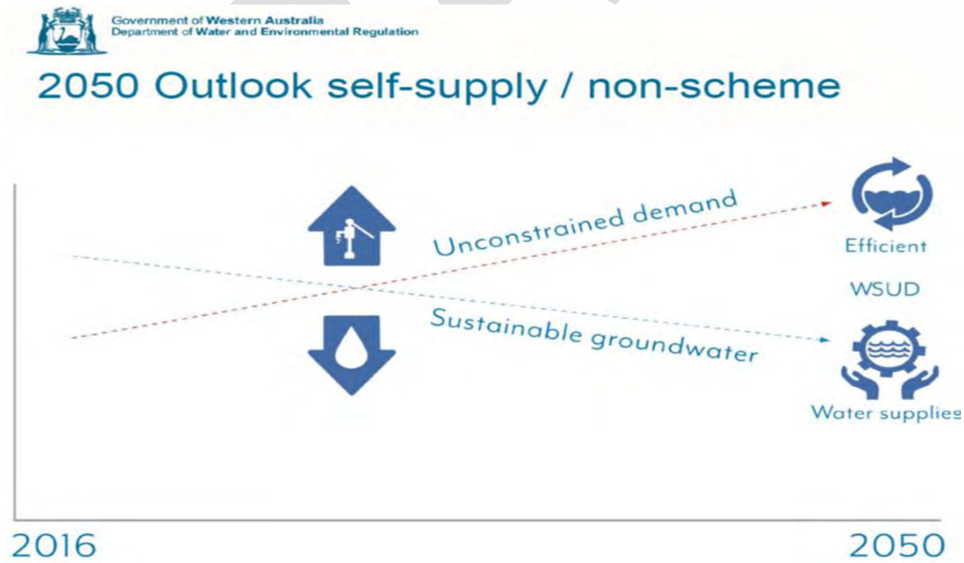
City of Kalamunda

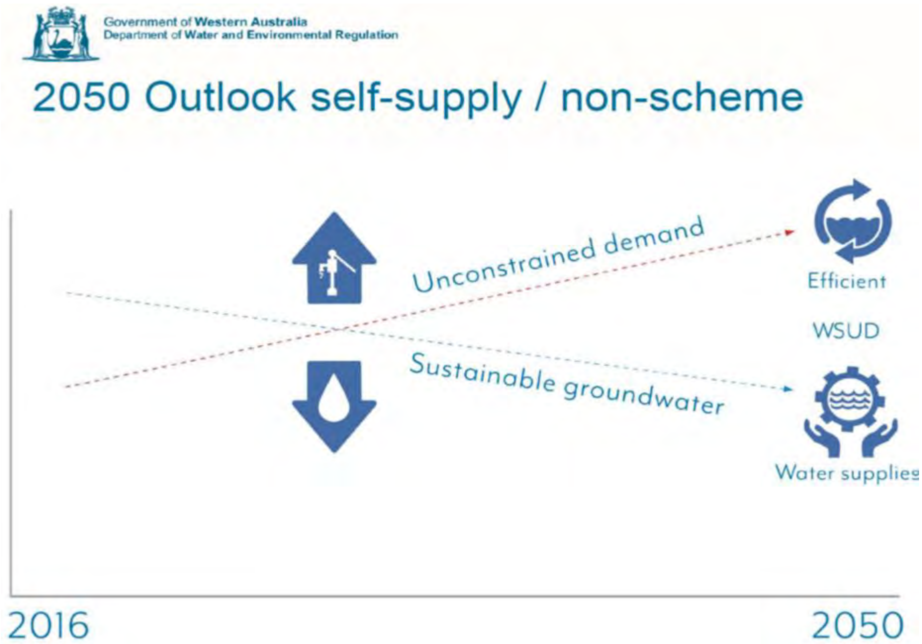




City of Kalamunda

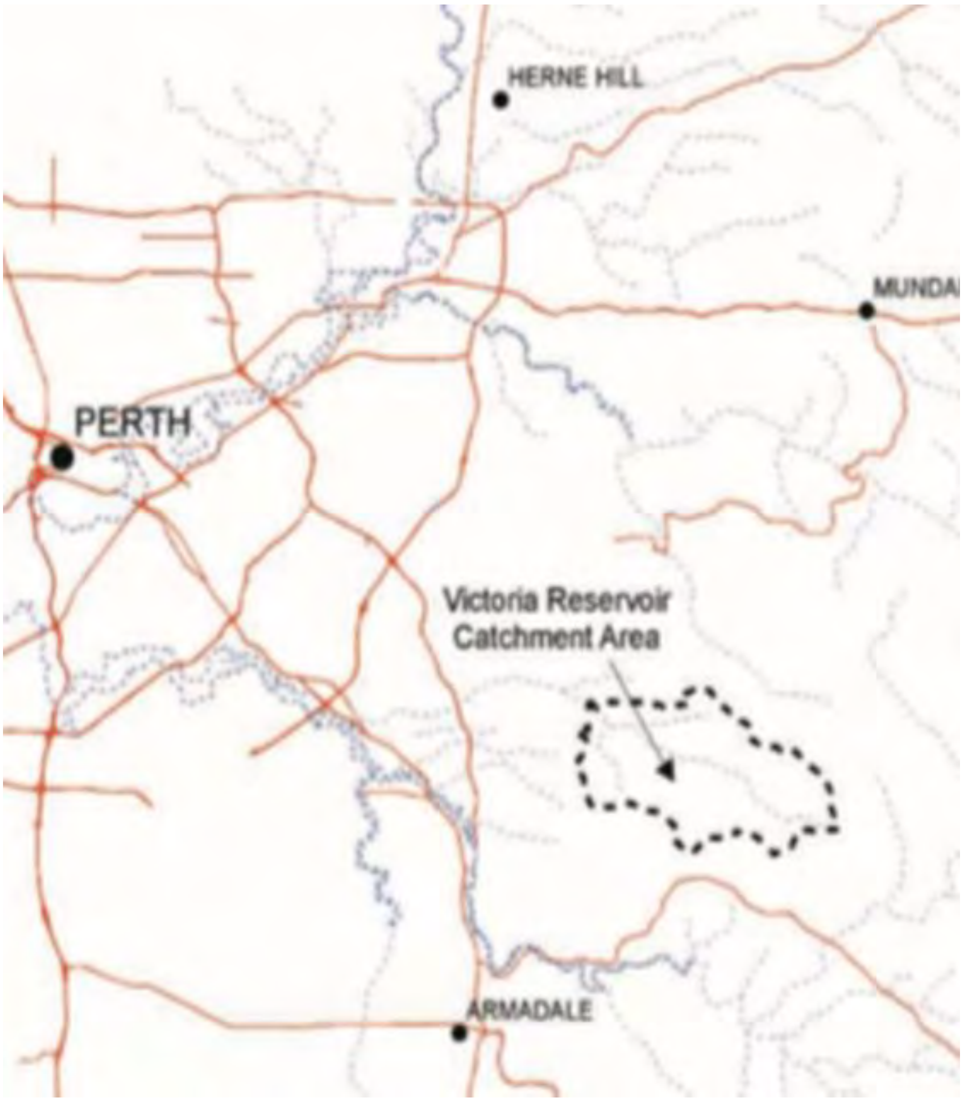





Government of Western Australia
Department of Water and Environmental Regulation
2050 Outlook self-supply / non-scheme
Unconstrained demand
Efficient
WSUD
Sustainable groundwater
Water supplies
2016
2050

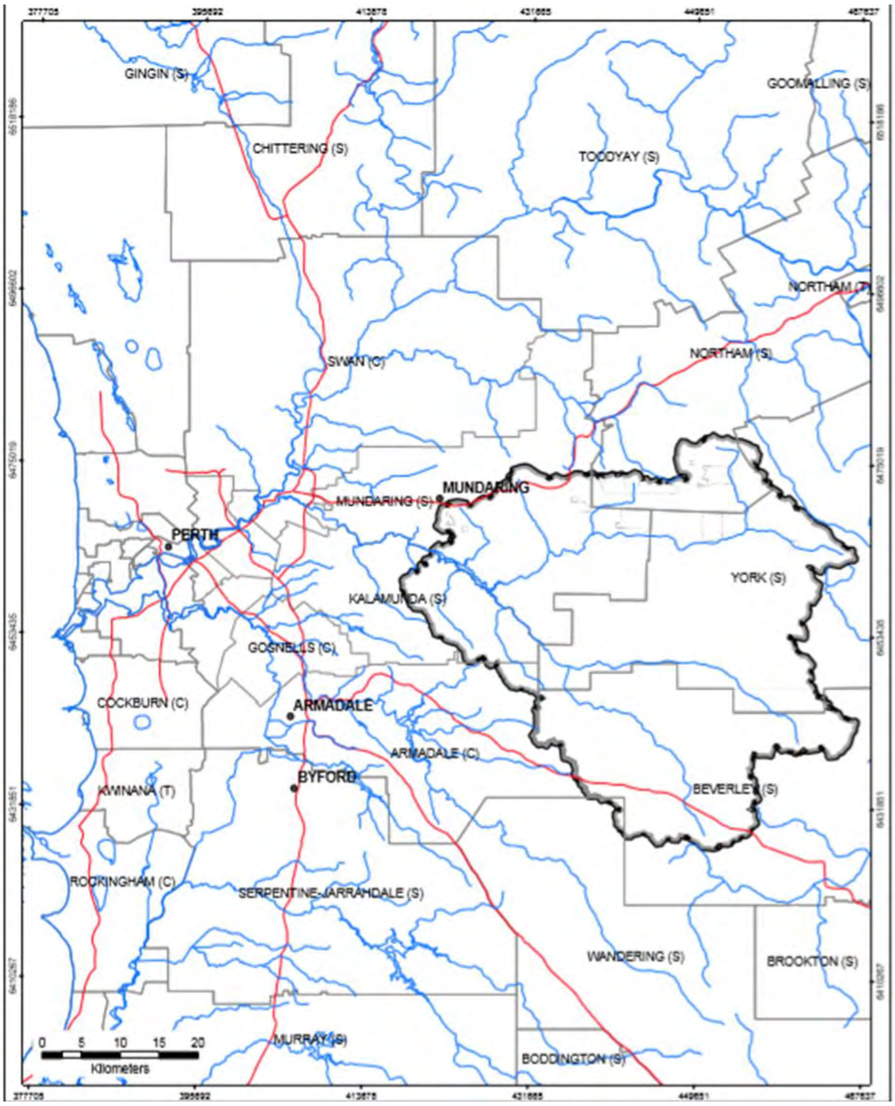
Appendix B

Victoria Dam Catchment Area Map



Appendix C

Mundaring Weir / Helena River Catchment Area Map



Appendix D

Canning Dam Catchment Map