Stirling Alliance

Stirling City Centre environmental and water investigation

Integrated water management strategy

November 2013

Executive summary

As the Stirling City Centre develops, the demand for water (drinking, non-drinking and irrigation) will also increase.

The Stirling Alliance has prepared a comprehensive draft Performance Framework to guide the planning of the Stirling City Centre. The desire to maximise water reuse and reduce overall water consumption as well as the targets provided in the performance framework underpin the preparation of this Integrated Water Management Strategy.

The study area has been separated into a residential zone and a distributed services zone. The distributed services zone encompasses the vacant government land, the existing retail areas, the Osborne Park industrial area and the proposed mixed use areas north of Mitchell Freeway. The residential zone consists predominately of residential lots that will be redeveloped over time. As the distributed services zone consists of vacant land and increased redevelopment, it has been considered that only this zone will be suitable for a distributed non drinking water scheme.

The estimated ultimate daily water demands for the study area are summarised in Table 1 and further described in Section 4. Scenario 1 assumes a waterwise approach (ie more efficient appliances, fixtures and irrigation methods) and Scenario 2 assumes the water demands adopt a conventional approach.

Table 1 Daily water demands

		Scenario 1 Waterwise demand		Scenario 2 Conventional demand	
		Summer	**Winter**	**Summer**	**Winter**
Dwellings (L/dwelling/day)	DW	118	118	164	164
	NDW	93	93	148	148
	Irrigation	52		80	
	Total	**263**	**211**	**392**	**312**
Non-residential ($L/m^2/day$)	DW	1.46	1.46	2.26	2.26
	NDW	0.79	0.79	1.22	1.22
	Irrigation	0.32		0.49	
	Total	**2.57**	**2.25**	**3.98**	**3.49**
POS irrigation (kL/ha/day)		23.6	-	26.5	-

DW – drinking water NDW – non drinking water

In assessing the available alternative water sources to meet the expected growth in non-drinking water demands for the Stirling City Centre, four options were considered:

- Rainwater;
- Greywater;
- Stormwater; and
- Recycled wastewater.

For each water source and the expected demands, a simple water balance model was prepared to determine the viability of each source from a quantity perspective. The modelling highlighted that there are two potentially viable sources, groundwater and recycled wastewater. While groundwater is viable from a modelling perspective, the availability of groundwater within the study area is limited and as such recycled wastewater is considered the preferred alternative water source.

The preferred integrated water concept for the Stirling City Centre is to implement a recycled water scheme where wastewater generated within the development is collected, treated and then returned for non-drinking use via a third pipe scheme (Section 5). Further assessment of the supply and demand of the recycled wastewater determined that there is an excess of recycled wastewater and therefore disposal options need to be assessed. The preferred disposal option for the excess water is to inject to the superficial aquifer (Section 5.3.2).

The implementation of the preferred integrated water concept for the distributed services zone will need to be undertaken in stages and as part of an integrated approach to servicing as further planning and design for the Stirling City Centre unfolds. After the structure planning is finalised and adopted, the broad next steps and decisions required to further develop and design the integrated water solution include:

1. Understand the timing of the development or identify appropriate triggers for the commencement of the integrated water solution for the distributed services zone.
2. Confirm a preferred proponent/service provider to deliver the solution.
3. Seek preliminary approval for the concept.
4. Undertake the preliminary engineering design.
5. Develop a business case in conjunction with the preferred service provider.
6. Seek final approval of the detailed design and/construction of the scheme.

The design and construction of the integrated water solution for the distributed services zone is not dependent on the commencement of redevelopment in the Stirling City Centre, although there are substantial cost savings by constructing the non drinking water reticulation with the construction of the new roads. A potential trigger for the implementation of the integrated water concept would be to sewer the currently unsewered areas of the Osborne Park Industrial Area.

The following are the immediate recommendations for the Stirling City Centre integrated water concept for the distributed services zone:

- Adopt an integrated water concept utilising recycled wastewater as the preferred non drinking water source for the distributed services zone.
- Revise the district water management strategy to include the preferred integrated water management outcomes.
- Investigate the options for sewering Osborne Park industrial area as a trigger to implementing the integrated water solution as well as for providing improved groundwater and surface water quality (particularly with respect to enterococci).
- Develop a staging strategy for the development of the Stirling City Centre which will incorporate the required staging and construction of the necessary infrastructure including the recycled water network and recycled water plant.

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1. Introduction

1.1 Project summary

The Stirling City Centre Alliance (the Alliance) commissioned GHD to undertake an environmental and water management investigation for the redevelopment of Stirling City Centre (study area) as shown on Figure 1. The site encompasses the area bound by Karrinyup Road in the north; Telford Crescent in the east, across the Mitchell Freeway to King Edward Road, Pearson Street in the south and Thor Street in the west. The site currently contains retail, residential and industrial areas.

The Stirling City Centre aims to be a sustainable 21st century city – a place for everyone. It will be a hub for a diverse and prosperous community offering wellbeing for all[1]. A draft District Structure Plan (DSP) has been prepared outlining how the Stirling City Centre will meet its vision.

One of the key features of the Stirling City Centre vision is the transformation of the existing Osborne Park Main Drain into an urban stream. The urban stream will enter the Stirling City Centre from the north, passing under the Mitchell Freeway and then leave the development area to the south discharging into Herdsman Lake. Whilst the entry and exit locations of the urban stream are fixed, there is some flexibility in the alignment which the stream takes between these two points. Additionally, the Stirling City Centre redevelopment will involve the extension of Stephenson Avenue across Scarborough Beach Road to Cecil Avenue. This new road will pass through the middle of the proposed city centre and its proposed alignment is parallel to the urban stream.

Currently the population of the study area is approximately 3,800 with the aim of ultimately increasing this to approximately 19,500[2]. This increased density will be realised through creating new dwellings and increasing the existing densities as currently described in the draft DSP.

An increase in population will have an impact on the current infrastructure including traditional water and wastewater services. This report investigates possible integrated water management scenarios which may be implemented within the study area.

1.2 Stirling City Centre Performance Framework

The Stirling Alliance has prepared a comprehensive draft Performance Framework to guide the planning of the Stirling City Centre.

The framework defines the objectives, Key Result Areas (KRAs) and Key Performance Indicators (KPIs) for each of the Areas of Strategic Focus. A number of targets are defined for the KRAs/KPIs. The Performance Framework establishes aspirational, agreed, minimum and current targets.

The Environmental Health Area of Strategic Focus has the following objectives:

- Restore and enhance the level of biodiversity;
- Reduce pollution to healthy levels;
- Reduce energy and water consumption;
- Maximise water reuse;

[1] *Stirling's City Centre Alliance Performance Framework November 2010*
[2] Based on the Stirling Alliance Yield Analysis 5 September 2013

- Maximise renewable energy production; and
- Reduce waste.

The desire to maximise water reuse and reduce overall water consumption as well as the targets provided in the performance framework inform the preparation of this Integrated Water Management Strategy.

1.3 Purpose of this report

The objective of this integrated water management strategy is to establish a preferred approach to management of the water cycle based on the Stirling City Centre project objectives and targets as outlined in the Stirling City Centre Alliance Performance Framework (November 2010).

A groundwater and surface water model has been prepared separately for the area. The results of this model have informed the investigation of available integrated water management options which will in turn inform the future development scenario analysis and the urban stream concept.

1.4 Scope and limitations

The purpose of this task is to provide the Alliance and stakeholders in the development project with information regarding:

- Feasible and sustainable options that provide for the water and wastewater needs of the Stirling City Centre, including fit-for-purpose water supply. These options will aim to achieve the objectives and criteria contained in the Stirling City Centre District Water Management Strategy (Essential Environmental Services 2010) including creation of an urban living stream environment.
- Risks and uncertainties associated with each option.
- What further hydrological / hydrogeological assessment and modelling work is required to enable detail design of integrated water management systems and processes for the development (as a whole and within each precinct).

The report from this work will inform both the local water management strategies for each development precinct and the Environmental Master Strategy being prepared for the study area.

This report: has been prepared by GHD for Stirling Alliance and *may only be used and relied on by Stirling Alliance for the purpose agreed between GHD and the Stirling Alliance as set out in section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than Stirling Alliance arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 3, 5 and Appendix A of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

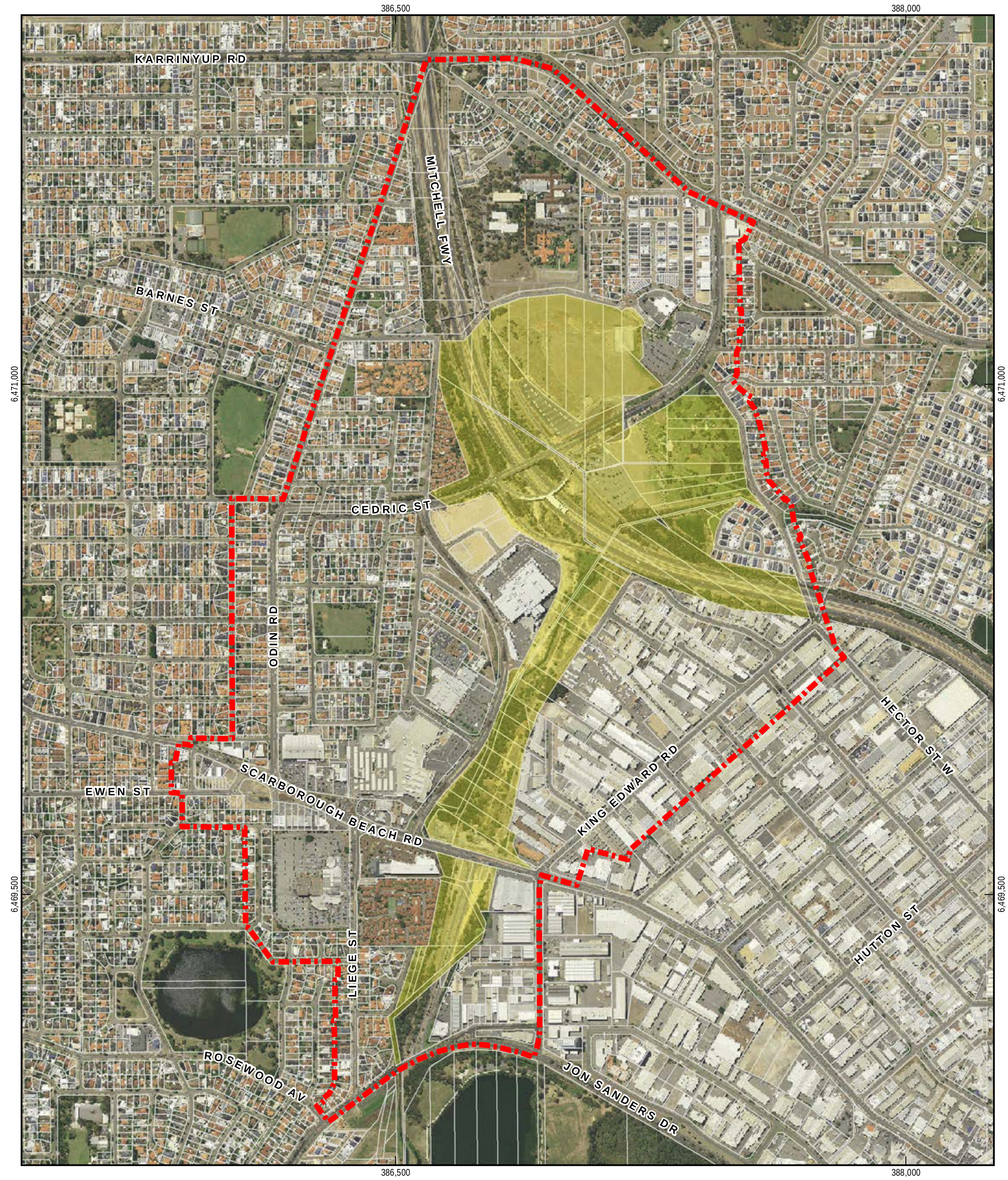
GHD has prepared this report on the basis of information provided by Stirling Alliance and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Assumptions

Several key assumptions have been adopted during the preparation of this report. These assumptions include but are not limited to the following:

- The draft Stirling City Centre district structure plan.
- The current recorded water demands and the unit water demand estimates as outlined in the Water Corporation's H2Options.
- The preferred infrastructure solution as outlined in the Utilities Report.
- Stirling City Centre - Yield Comparison - Vacant Govt Land (updated 5 Sept 2013) (Stirling Alliance).

Further details of each of these assumptions are provided in the following sections.



LEGEND

Cadastre

Structure Plan Area

Study Area

1:15,000 (at A4)

0 75 150 300 450 600

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

GHD

Stirling city centre alliance

SLIP ENABLER

Stirling City Centre Alliance
Water and Environmental Investigation

Job Number 61-26652
Revision 0
Date 02 Apr 2013

Site Locality and Study Area

Figure 1

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Data source: GHD: Study Area - 20110314; Stirling City Centre Alliance: Cadastre - 20110210, Structure Plan Area - 20110210; Landgate: Road Names - 20110421, Metro Central 2012 Aerial - 20130402. Created by: aosbaldeston, erice, erice

2. Site summary

2.1 Site description

The Stirling City Centre aims to be a sustainable 21st century city – a place for everyone. It will be a hub for a diverse and prosperous community offering wellbeing for all[3]. A draft district structure plan has been prepared outlining how the Stirling City Centre will meet its vision.

The site is located on approximately 215 ha of land, 8 km north of the Perth Central Business District (CBD). The land is used for residential, retail and industrial purposes. In the past, the area contained a mixture of residential areas, native bushland and the Osborne Park Market Gardens (EES 2010).

There is an existing stormwater drain passing through the study area, Osborne Park Branch Drain, which is currently owned and maintained by the Water Corporation. The area surrounding the drain is vegetated with regrowth.

2.2 Previous work

Previous studies have been undertaken to assess the viability of various water source options for the Stirling City Centre study area, specifically the following three reports:

- Stirling City Centre District Water Management Strategy (Essential Environmental Services, 2010)
- Stirling City Centre Green Infrastructure Study (Parsons Brinckerhoff, 2010); and
- Stirling City Centre C^{CAP} Precinct Sustainability Analysis Report (Kinesis, 2012).

A brief summary of the reports listed above and their findings is provided in the following sections.

2.2.1 Stirling City Centre District Water Management Strategy

The Stirling City Centre District Water Management Strategy (DWMS) (Essential Environmental Services, 2010) broadly outlined potential water source options for the Stirling City Centre as well as documenting issues associated with groundwater within the region.

Part of the Stirling City Centre (north east) falls under the Gwelup Underground Water Pollution Control Area. This area is classified as a Priority 3 (P3) area and as such land use and development needs to consistent with the relevant Department of Water's Water Quality Protection Notes. Currently the Department of Health (DoH) does not support wastewater reuse in P3 areas as this is seen as a potential groundwater contamination risk. This affects the potential viability of recycled wastewater as a water source option in the North eastern part of the Stirling City Centre.

There is also the potential for contamination of groundwater from the areas described below. Contamination risk is dependent on the direction of groundwater flow and as such this might impact the viability and availability of groundwater as a water source option.

- former Hertha Rd landfill (hydrocarbons, zinc, arsenic and copper in soils);
- East Roselea (acid, sulphur, heavy metals, nutrients); and
- Osborne Park Industrial area (which is largely unsewered).

[3] *Stirling's City Centre Alliance Performance Framework November 2010*

Water source options suggested within the DWMS include the capture of rainwater and stormwater as well as the reuse of wastewater through the following mechanisms:

- Rainwater tanks to augment water supply in domestic and commercial areas, preferentially plumbed into toilets and washing machines;
- Rainwater tanks to provide water supply for public ablutions facilities in community spaces;
- Stormwater harvesting for reuse in commercial areas and public open spaces;
- Stormwater harvesting and managed aquifer recharge for reuse in a non-drinking reticulated network or for irrigation;
- Greywater reuse systems at precinct, grouped dwelling/apartment and individual lot scale; and
- Wastewater reuse possibly sourced from the existing sewer system via sewer mining or potentially from a decentralised treatment plant located within the City area. The recycled wastewater could be used to supply non-drinking water demands through a reticulated system utilising aquifer storage and recovery or an alternative method of capture.

In addition to these ideas, the DWMS suggests that consideration should be given to rooftop raingardens, green walls and community gardens, small scale aquifer storage and recovery as well as decentralised wastewater systems and reuse.

2.2.2 Stirling City Centre Green Infrastructure Study

The Stirling City Centre Green Infrastructure Study (Parsons Brinckerhoff, 2010) provided two broad conceptual water source objectives:

1. Best available technology option with the goal to use 50% less scheme water; and
2. Global best practise methods and technologies – with the goal to use zero net scheme water.

The study aims to meet these goals through the use of decentralised water systems. Key solutions and water source options suggested are as listed, these sources were suggested to be used in combination with no one option chosen or recommended:

- Water harvesting – both rainwater and stormwater;
- Re-use of grey water in buildings prior to treatment;
- District level water treatment of wastewater using 'living' streams such as wetland and reed beds;
- Stormwater capture for non-drinking water usage and to recharge groundwater and wetlands or urban stream;
- Maximise building water reuse prior to disposal;
- On-site rainwater capture, treatment and use in drinking and hot water applications;
- On-site capture of all bathroom hot water sources as grey-water and treatment to a standard for ruse in toilet flushing, washing machines and garden irrigation;
- Application of very low water use toilets and 'insinkerators' and collection black-water and organic household waste through a vacuum transfer system to centralised treatment facility;
- Resupply of centrally treated water back to environmental flows;

- On site rainwater capture, treatment and use in drinking and hot water applications; and
- Close loop water system using natural systems.

This study was high level and conceptual in nature and noted that further investigation would be required to assess how to effectively implement the suggested alternative water source options.

2.2.3 Stirling City Centre C^CAP Precinct Sustainability Analysis report

The Stirling City Centre C^CAP Precinct Sustainability Analysis Report was prepared by Kinesis in 2012. The report undertook a sustainability analysis for the proposed Stirling City Centre to determine the preferred green infrastructure scenario.

Kinesis suggested the use of recycled water for toilet flushing, laundry and irrigation of open space and playing fields. It was estimated that a storage tank of 450 m^3, equivalent to 8 hours of recycled water storage would be needed for this water source to service the ultimate development.

A workshop was undertaken with the Stirling Alliance and key stakeholders and the key outcomes of the workshops were:

- Environmental importance of maintaining high groundwater levels; and
- Community importance of keeping water in the stream.

Whilst the use of rainwater and stormwater as water sources was suggested and assessed within the Kinesis study, it was determined that the preferred use for this water was to recharge the groundwater in the area rather than as a non-drinking source in line with the key outcomes of the workshop.

It was agreed at the workshop that a recycled water system should be configured to overflow to sewer. However, if treated to appropriate standards to ensure that environmental systems were not adversely affected, it was noted that an opportunity exists to utilise overflow from the recycled water tank (in addition to rainwater and stormwater) for groundwater recharge or discharge to stream.

2.3 Utilities infrastructure assessment

A separate Utilities Infrastructure Strategy is being undertaken by GHD in parallel with this integrated water management strategy.

The utilities strategy is reviewing the current servicing arrangement for the study area including, water, wastewater, energy, waste and telecommunications and has determined the capacity of the existing services to accommodate for future growth. In addition to investigating traditional approaches for upgrading services, an alternative servicing strategy which incorporates ‘best available technology’ has been developed.

3. Non drinking water sources

The available water sources that could be feasibly considered for the Stirling City Centre are:

- Scheme water from the Integrated Water Supply Scheme (IWSS) operated by the Water Corporation;
- Rainwater from rooftop runoff stored in tanks situated on lots;
- Stormwater from hard surfaces runoff stored in tanks situated in one or more locations in the development (either inclusive or exclusive of rooftop runoff);
- Surface water from the proposed urban stream;
- Groundwater abstracted from one or more locations in the structure plan area;
- Greywater extracted from the plumbing system of buildings, specifically from bath, shower, washing machine, and laundry trough (some systems are also approved to use water from kitchen sink); and
- Recycled wastewater extracted from the sewerage collection system and treated in accordance with the Australian Guidelines for Water Recycling in a manner acceptable to the Department of Health.

Outlined below is a brief description of the available non drinking water sources for the site, followed by a summary in Section 3.6. It has been assumed that scheme water is the preferred source for the provision of drinking water.

3.1 Rainwater

Collection and reuse of rainwater at a lot scale within rainwater tank systems can be constrained by storage requirements within a high density urban development. There are also opportunities for small scale rainwater storage and distribution systems to be used for multi-residential dwellings which may be developed as part of the residential zone. The use of this water is generally limited to in-house fit-for-purpose demand (ie toilets and washing machines) because rainfall does not occur during the irrigation season and tank sizes to retain sufficient water for year round irrigation demands are likely to be excessive.

The viability of rainwater tanks for the Stirling City Centre area will be dependent on the availability of sufficient roof area but the viability is also limited by variable rainfall patterns.

If rainwater tanks were to be mandated, the implementation mechanisms would need to be determined.

3.2 Stormwater

Harvesting of stormwater from drainage infrastructure is similarly constrained by storage requirements and again its use may be limited by the seasonality of irrigation demands.

3.2.1 Managed aquifer recharge

There is scope to investigate the potential for stormwater harvesting for Aquifer Storage and Recovery (also known as Managed Aquifer Recharge, MAR). This involves infiltration or injection of treated stormwater into a suitable groundwater aquifer to be later re-abstracted and used locally or distributed to the wider development area for use as a year round fit-for-purpose water source. Storage and treatment requirements for this type of scheme can vary significantly according to the quality and suitability of the receiving aquifer as well as the quality and availability of stormwater for harvesting. This process is regulated in Western Australia under the Department of Water's *Operational policy 1.01 - Managed aquifer recharge in Western Australia* (DoW, 2011). Under this policy, changes in land use that result in additional runoff and would typically increase the groundwater recharge are not considered MAR. In order to gain additional abstractable water it would be necessary to demonstrate that an excess exists and cannot be infiltrated at source.

It is expected that there will be a slight increase in runoff from the development in the ultimate scenario which will need to be managed. The possible options for capturing this stormwater are though:

- Storage areas (eg lined basins or tanks) during the winter months for reuse in the summer months;
- Infiltration of the additional runoff at source; or
- Discharge into the urban stream.

The viability of each of these management options for stormwater is assessed from a quantity perspective as part of the IWM modelling described below. If stormwater harvesting were to be viable from a quantity perspective, the implementation and construction of storage areas would likely be expensive.

3.2.2 Surface Water

The primary surface water body within the study area is the Osborne Park Branch Drain and provides an opportunity as a water source.

The *Draft Stirling City Centre modelling report* (GHD October 2013) assessed the predicted streamflow within the Osborne Park Branch Drain for the existing and future development as well as the existing climate, the future dry, future median and future wet climate scenarios. In the future wet climate, the streamflow volumes leaving the structure plan area are reduced by 7%, 19% for the future median climate and 35% for the future dry climate from the existing development and climate. While in the modelled future scenarios the stream does not dry out, the variability in flow and the uncertainty in the availability of the water does not make water from the stream a viable alternative water source.

The surface water monitoring program indicated that there are elevated concentrations of enterococci within the Osborne Park Branch Drain which further confirms that the water within the drain is not a suitable alternative water source. Enterococci are currently considered the most suitable faecal indicator bacteria for classification of the potential microbial risk of a water body. The enterococci ranged from 23 CFU/100 mL (SW3, 9 July 2012) to 690 CFU/100 mL (SW3, 18 January 2012) for all quarterly sampling events. 13 out of 15 samples exceeded the ANZECC (2000) Recreational Purpose Guidelines median criteria for primary contact of 35 CFU/100 mL. Sources of microbial contamination may include septic tanks, animal faeces from public open space areas with high dog or waterbird usage and animals living in the vicinity. The Osborne Park Light Industrial area is largely unsewered and has been identified as a potential source of surface water contamination to the Osborne Park Branch Drain through direct discharge of pollutants to stormwater systems, including microbial sources (EES 2010).

3.3 Hydrogeology

The following section provides a basic summary of the hydrogeological information for the site based on information from existing reports, publically available sources as well as the results from the groundwater and surface water monitoring being undertaken at the site.

3.3.1 Groundwater

The site is situated above the superficial aquifer and a groundwater and surface water monitoring program has been undertaken by GHD from October 2010 to May 2013. The GHD field investigations indicate that the observed groundwater level ranges between approximately 11.5 mAHD (S7-A and S7-B, groundwater mound in central area of former landfill), to approximately 7 mAHD (S6-A and S6-B at southern boundary of site) (Appendix B). The depth to groundwater varies across the site and is generally reflective of the site elevation. At sites S4-A and S4-C the observed depth to groundwater was less than 1 m, whereas the greatest depth to groundwater was over 8 m at site S4-D.

The monitoring program also collected groundwater and surface water quality samples ranging from metals, inorganics to microbial. The key contaminates of concern within the groundwater were identified as:

- Nitrogen (nitrate, ammonia)
- Metals (in particular boron and zinc [other metals are elevated but show either no distinct spatial or temporal relationship and/or are indicative of background elevated concentrations]).
- Hydrocarbons (BTEX, TPH and PAHs)

These contaminates of concern were detected (in varying concentrations) across the monitoring site and the groundwater quality should be further assessed further prior to any use as a non drinking water source, particularly for internal purposes.

3.3.2 Drinking water

The site is located in a Public Drinking Water Source Area (PDWSA) with the north-east part of the site classified as ‘Protection Area Priority 3’ as part of the Gwelup drinking water source (DoW Groundwater Atlas). The production bores to which this PDWSA relates are located to the north and are up hydraulic gradient from the site.

Priority 3 areas are declared over land where water supply sources need to coexist with other land uses such as residential, commercial and light industrial developments have been defined to limit the risk of pollution to the water source. Protection of Priority 3 areas is achieved through management guidelines rather than restrictions on land use.

Irrigation using wastewater (ie disposal of wastewater to land) is compatible with conditions within a Priority 3 area (Department of Environment 2004).

3.3.3 Groundwater availability

The site is located above the City of Perth subarea of the Perth Superficial Swan aquifer as well as the Perth North confined subarea of both the Perth Leederville and Yarragadee North aquifers. The currently availability of groundwater within these aquifers is shown in Table 2 below.

Table 2 Groundwater availability

Sub area	Aquifer	Allocation Limit (kL)	Licenced Allocation (kL)	Total Allocated, Committed and Requested (kL)	Committed and Additional Allocations (%)
City of Stirling	Superficial	7,203,500	7,761,860	6,848,610	95%
Perth North Confined	Leederville	1,364,220	1,364,220	1,364,220	100%
	Yarragadee North	247,000	80,000	80,100	32%

Source: Department of Water January 2013

The Leederville Aquifer is not considered viable based on the current groundwater allocations. While the Yarragadee aquifer has available allocation, little is known about the quality of the groundwater. Considering the depth to the Yarragadee Aquifer, the construction of a production bore(s) is likely to be expensive and as such, the Yarragadee Aquifer is not considered a viable source. The Superficial Aquifer has some available allocation however this may become further limited in the future.

3.4 Wastewater

There is an existing wastewater network throughout the site and this provides an opportunity for onsite wastewater harvesting for treatment and local distribution. In order to reuse wastewater for non-drinking purposes, treatment, storage and distribution infrastructure will be required. Additionally the construction of new lots and roads within the distributed zone and providing sewerage to the unsewered areas of Osborne Park also provide an opportunity to harvest and treat wastewater as an alternative water source.

Additionally, if several lots were to be redeveloped by one developer within the residential zone, there is the opportunity to investigate a small package wastewater treatment plant and reuse the recycled wastewater within the lot. Prior to the this occurring, investigations into the available supply and the required demand, the required quality, governance and operational arrangements as well as necessary approvals would be required to be undertaken by the developer.

3.5 Greywater

At the household scale, treated greywater is suitable for garden irrigation or infiltration in accordance with the Code of Practice for the Reuse of Greywater in Western Australia. Greywater can typically only be stored for up to 24 hours after which time there are significant impacts to water quality and subsequent risks to public health.

If greywater were to be used for domestic irrigation, the supply would be greater than the demand during the winter months. Alternative uses or disposal to the wastewater network would be required due to the reasons as described above.

Individuals may choose to install a greywater system for household irrigation and they will be responsible for adhering to the Code of Practice for Greywater Reuse in Western Australia. In this case the responsibility and costs for operation and maintenance are with the householder.

3.6 Review of water sources

Outlined in Table 3 below is a summary of the available water sources for the Stirling City Centre. For each of the available water sources, a summary of the advantages and disadvantages has been discussed. The advantages and disadvantages have been prepared using the objectives and views from the previous reports (Section 2.2) as well as the views and objectives of the Stirling Alliance.

While a high level assessment of reliability of the source is provided in Table 3, a more detailed assessment of the viability of the source to supply the required water demands is discussed in Section 4.

Table 3 Non drinking water source summary

Water source	Potential uses	Application scale	Advantages	Disadvantages
Drinking water	• All water demands	• Structure plan	• Reliable source of water • No additional treatment required	• Will not meet any of the objectives in the Stirling Alliance's Performance Framework • Existing infrastructure is unlikely to be sufficient for the future water demand and upgrades will be required
Rainwater	• Irrigation • Internal non drinking water uses	• On lot • Multi-lot residential developments	• Reduces water demand from the drinking water system • No treatment requirements • Will aid in meeting some objectives in the Stirling Alliance's Performance Framework	• Unreliable water source • Individual owners (or developers) will be required to install a rainwater tank at their own cost
Stormwater harvesting	• Irrigation • Internal non drinking water uses	• On lot • Precinct / catchment	• Reduces water demand from the drinking water system • Will aid in meeting some objectives in the Stirling Alliance's Performance Framework	• Potential long term impacts on groundwater levels as reduced natural recharge may result in exposure of peat and potential ASS. • Strong desire from the Stirling Alliance to infiltrate stormwater runoff and rainwater at source (or as close to source as possible) to maximise opportunities for water quality treatment. • Potential impacts on the available water inflow to the urban stream • Treatment will be required for internal non drinking water use • Unreliable water source • Large storages are required to harvest runoff

Water source	Potential uses	Application scale	Advantages	Disadvantages
Groundwater	• Irrigation • Internal non drinking water uses	• Structure plan	• Reduces water demand from the drinking water system • Treatment of groundwater may be avoidable for irrigation purposes • Will aid in meeting some objectives in the Stirling Alliance's Performance Framework	• Potential contamination • Potential long term impacts on groundwater levels resulting in exposure of peat and potential ASS. • Treatment of groundwater will be required for internal non drinking water use. • Groundwater availability
Greywater	• Irrigation • Internal non drinking water uses	• On lot • Multi-lot residential developments	• Reduces demand from the drinking water system • Will aid in meeting some objectives in the Stirling Alliance's Performance Framework	• Individual owners will be required to install and maintain systems at their own cost. The performance of the system is therefore unreliable. • Excess water may exist during winter months when irrigation is not required and discharge options are necessary
Recycled wastewater	• Irrigation • Internal non drinking water uses	• Structure plan • Multi-lot residential developments	• Reduces demand from the drinking water system • Reliable water source • Excess discharge can be directed into the aquifer to increase groundwater levels or the urban stream (subject to water quality and approval). • Potential to defer or avoid upgrades to the existing sewer network • Will aid in meeting most objectives in the Stirling Alliance's Performance Framework	• Additional infrastructure required for treatment and conveyance. • Infrastructure will need to be staged as development occurs. • Multi-lot developers will need to undertake the necessary investigations to determine the viability, approval process and governance framework required to implement a small scale wastewater recycling scheme.

4. Integrated water management options

4.1 Water demands

This section aims to provide a summary of calculations undertaken to estimate the current and future water demands within the Stirling City Centre study area. These calculations have been made for residential, commercial/light industrial areas and public open space (POS). In addition calculations were made to determine future drinking and non drinking water demands.

4.1.1 Current water demands

Outlined below is a summary of the Stirling City Centre study area current water demands; estimated from Water Corporation data. A detailed description of how the current water demand was calculated is provided within Appendix A.

Currently the Stirling City Centre study area is home to **3,800 people** (Stirling City Centre Alliance, 2011) living in **1,427 dwellings** using **301,141 kL** of water per year (see Appendix A for more details). This is equivalent to approximately:

- 211 kL/dwelling/year
- 79.25 kL/person/year

The current water consumption per dwelling type is presented in Table 4.

Table 4 Current residential water consumption

Dwelling type	% of current total housing	Current water use/dwelling	Current dwelling numbers	Current water consumption (kL/year)
Common - residential	7%	170.25	94	16,003
Duplex unit	20%	199.41	289	57,629
Flats	1%	73.09	18	1,316
Home unit	7%	174.23	96	16,726
Home units	1%	181.06	14	2,535
House	43%	258.92	607	15,7163
Quadruplex unit	1%	113.12	21	2,375
Town house	1%	155.86	12	1,870
Triplex unit	18%	165.12	255	42,105
Villa house	1%	162.80	21	3,419
TOTAL			1,427	301,414

The current commercial water usage within the study area is shown in Table 5.

Table 5 Current commercial water usage

	Water usage kL/year	Water usage kL/m2 GFA*
Office business	20,540	1.34
Retail	180,656	1.06
Health, education & community welfare	54,715	4.49
Irrigation - common	20,335	N/A
TOTAL	276,246	1.40

*gross floor area

A drinking water POS demand of 237 kL/year was identified from the information supplied by the Water Corporation. It has been assumed that this drinking water demand was for all toilets, taps and drinking fountains located within the Stirling City Centre study area parks and open space.

4.1.2 Projected water demands

The project water demands have been calculated based on the Stirling City Centre - Yield Comparison - Vacant Government Land (updated 5 Sept 2013) prepared by the Stirling Alliance. The adopted parameters are as provided in Table 6 and have been based on information provided by the Stirling Alliance and the assumptions contained within the draft Stirling City Centre structure plan (Stirling City Centre Alliance, 2011):

Table 6 Land use areas

		Existing	Ultimate
Residential	dwellings	1,427	10,780
	population	3,500	19,400
Non-residential (1)	m2	178,348	888,723
POS irrigation (2)	ha		17.3

1) includes office, health/welfare/community, retail, and entertainment/recreation/culture land uses

2) includes open space and road verges

The water usage estimates were undertaken using a combination of current water use data, the Water Corporation water demand calculator and current industry knowledge (in respect of irrigation of public open space). Two demand scenarios were developed to provide a potential range of consumption figures for infrastructure sizing and water source requirements.

- Scenario 1 – Waterwise
  - Assume all internal fixtures and fittings are waterwise and the landscaped areas consist of waterwise plants
- Scenario 2 – Conventional
  - Assume all internal fixtures and fittings are conventional and the landscaped areas consist of European plants

The demands adopted for “conventional” are similar to the measured data for existing residential multi unit dwellings. The demand for conventional commercial development has been based on existing unit consumption figures. The following sections outline the range of estimated demands with further detail provided in Appendix A.

Outlined in Table 7 and Table 8 below are the unit rates adopted for each demand scenario.

Table 7 Scenario 1 Waterwise - Water demand unit rates (kL per annum)

	In-building		Ex-building	Totals		
	A	B	C	A	B+C	A+B+C
	DW	NDW	Irrigation	DW	NDW	DW+NDW
Residential (per dwelling)	43	34	11.3	43	45.3	88.3
Office (per m^2)	0.48	0.28	0.04	0.48	0.32	0.8
Health / Welfare / Community (per m^2)	0.48	0.24	0.08	0.48	0.32	0.8
Retail (per m^2)	0.60	0.30	0.10	0.60	0.40	1.0
Entertainment / recreation (per m^2)	0.60	0.30	0.10	0.60	0.40	1.0
POS and verge irrigation (per ha)	-	-	5,000		5,000	5,000

DW – drinking water NDW – drinking water

Table 8 Scenario 2 Conventional - Water demand unit rates (kL per annum)

	In-building		Ex-building	Totals		
	A	B	C	A	B+C	A+B+C
	DW	NDW	Irrigation	DW	NDW	DW+NDW
Residential (per dwelling)	60	54	17	60	71	131
Office (per m^2)	0.80	0.47	0.07	0.80	0.54	1.34
Health / Welfare / Community (per m^2)	2.69	1.35	0.45	2.69	1.80	4.49
Retail (per m^2)	0.64	0.32	0.11	0.64	0.42	1.06
Entertainment / recreation (per m^2)	0.64	0.32	0.11	0.64	0.42	1.06
POS irrigation (per ha)	-	-	7,500		7,500	7,500
Verge irrigation (per ha)			5,000		5,000	5,000

DW – drinking water NDW – drinking water

Based on the unit demands provided above, the demands for the distributed zone, the residential zone and the total ultimate development have been calculated for Scenario 1 – Waterwise and Scenario 2 – Conventional. The estimated demands are provided in Table 9 and Table 10. As shown in the tables below, the estimated total water demand for the waterwise scenario is 1.957 ML/year which is approximately 33% lower than the conventional water demand estimate of 2,932 ML/year.

With the adoption of a non drinking water source for all NDW demands, the drinking water demands can be reduced by approximately 47% for the conventional scenario and 46% for the waterwise scenario (assuming POS and verges would be supplied by groundwater in a business as usual scenario).

Table 9 Scenario 1 Waterwise water demand (kL/year)

Land use			DW	NDW	Irrigation	Total	% total
Dwellings	No.	10,780	463,540	366,520	122,170	952,230	49%
Office	m^2 GFA	525,766	252,368	147,215	21,031	420,613	21%
Health	m^2 GFA	52,305	25,107	12,553	4,184	41,844	2%
Retail	m^2 GFA	440,504	264,302	132,151	44,050	440,504	23%
Entertainment	m^2 GFA	15,019	9,011	4,506	1,502	15,019	1%
POS	ha	4.35	-	-	21,750	21,750	1%
Verges	ha	12.96	-	-	64,800	64,800	3%
Total			**1,014,328**	**662,945**	**279,487**	**1,956,760**	**100%**

DW – drinking water NDW – drinking water

Table 10 Scenario 2 Conventional water demand (kL/year)

Land use			DW	NDW	Irrigation	Total	% total
Dwellings	No.	10,780	646,800	582,120	183,260	1,412,180	48%
Office	m^2 GFA	525,766	422,716	246,584	35,226	704,527	24%
Health	m^2 GFA	52,305	140,910	70,455	23,485	234,851	8%
Retail	m^2 GFA	440,504	280,161	140,080	46,693	466,934	16%
Entertainment	m^2 GFA	15,019	9,552	4,776	1,592	15,920	1%
POS	ha	4.35	-	-	32,625	32,625	1%
Verges	ha	12.96	-	-	64,800	64,800	1%
Total			**1,500,139**	**1,044,016**	**387,682**	**2,931,836**	**100%**

DW – drinking water NDW – drinking water

4.2 Drinking and non-drinking water uses

The use of scheme water for all uses save irrigation of public open space and school ovals represents a Business as Usual approach to water servicing at Stirling City Centre. Under all of the scenarios outlined below, it has been assumed that drinking water (DW) from the scheme will be required for all uses excluding:

- Private and public irrigation;
- Toilet flushing; and
- Cold water inlet of washing machines.

For these uses, a suitably treated non-drinking water (NDW) product could be used. It is possible that in future, further uses could be considered for an NDW product, e.g. hot water. It is also possible in future that drinking quality water could be produced from recycled wastewater, however it not considered further at this stage.

These possibilities are canvassed in the following sections.

4.3 Water cycle model

4.3.1 Model description

A daily time step stock and flow model with a duration of one year was constructed to facilitate the simulation of water supply and demand for various potential NDW sources. The model includes all the sources mentioned above (save for greywater), and these sources serve the demands set out above. Sources can be "switched on" one by one or in combination.

A graphic that summarises the model is provided as Figure 2. The variables in boxes are "stocks" and have storage capacities associated with them. The model calculates vertical fluxes only and so water "accumulates" in groundwater and urban stream storages. Groundwater depths have been assumed to be constant at 27 m across the site at the commencement of the simulation. The vertical fluxes in groundwater are to be used for comparison purposes between options only and are not a definitive representation of the potential changes in groundwater levels.

The objective of the water cycle model is to determine which water sources are viable from a quantity perspective. The preferred alternative water source will be then be further considered in the detailed groundwater and surface water model being prepared for the Stirling City Centre area.

4.3.2 Demands

The model has assumed the waterwise scenario and also assumes the daily demands are constant save for irrigation, which has been simplistically modelled as a daily constant between October and April (inclusive), i.e. for 212 days per year. The adopted daily demands are summarised in Table 11 below.

Table 11 Daily water demands

		Scenario 1 Waterwise demand		Scenario 2 Conventional demand	
		Summer	**Winter**	**Summer**	**Winter**
Dwellings (L/dwelling/day)	DW	118	118	164	164
	NDW	93	93	148	148
	Irrigation	52		80	
	Total	**263**	**211**	**392**	**312**
Non-residential (L/m^2/day)	DW	1.46	1.46	2.26	2.26
	NDW	0.79	0.79	1.22	1.22
	Irrigation	0.32		0.49	
	Total	**2.57**	**2.25**	**3.98**	**3.49**
POS irrigation (kL/ha/day)		23.6	-	26.5	-

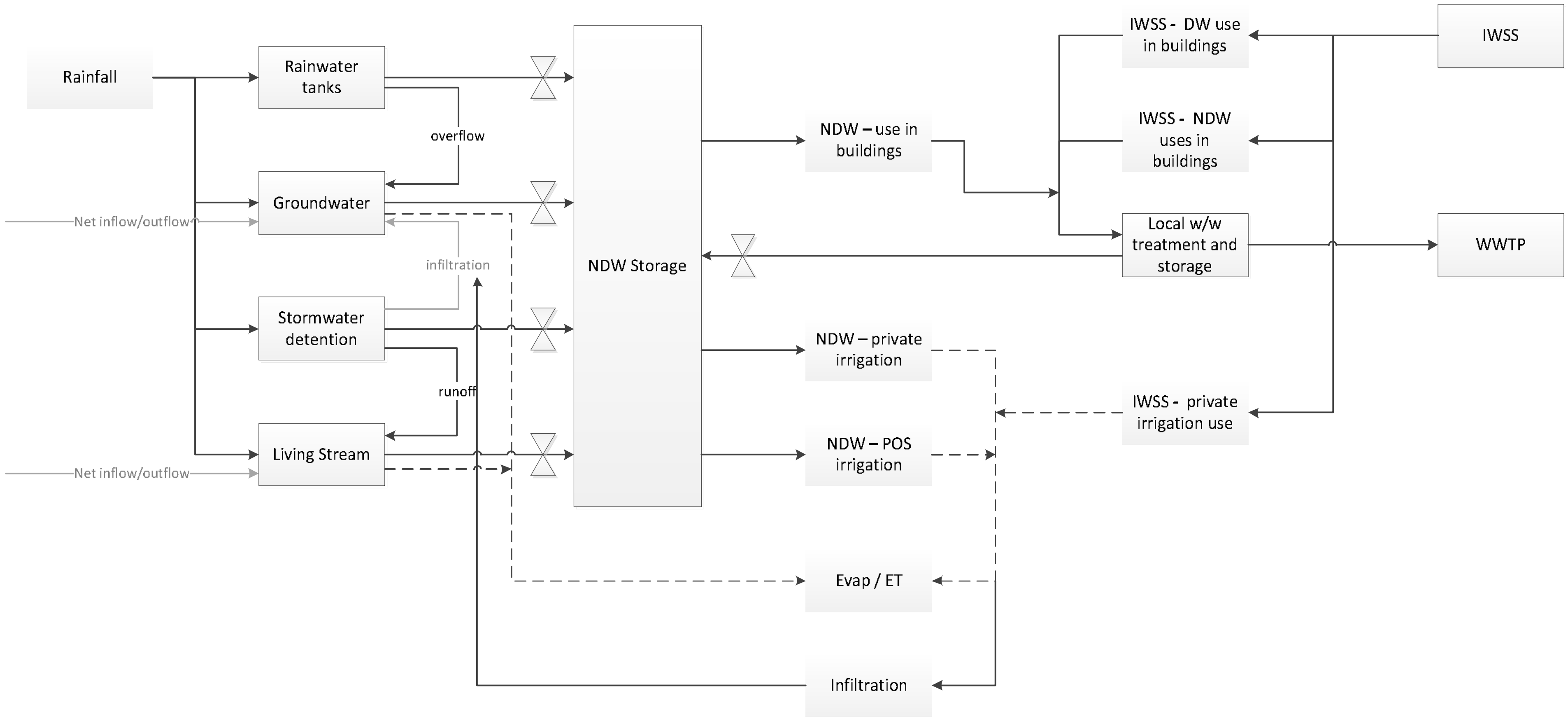


Figure 2 IWM model

4.3.3 Rainfall

For the purposes of the IWM modelling, the future rainfall was modelled as follows:

1. The observed daily rainfall data for Perth from the years 1961-1990 was modified in accordance with a method derived by the Department of Water using internationally accepted future climate scenarios. (Further detail on this process will be outlined in the surface water and groundwater modelling report). This process yields wet, medium and dry simulated daily rainfall and pan evaporation for the 30 year period.
2. A single year of modified data was selected to represent each of these wet, medium and dry scenarios, and these have been used as model inputs.

Figures depicting the modified data sets and the selected years are set out in Figure 4 on the following page. The simulated cumulative daily rainfall is summarised in Figure 3 below and the medium year dataset was used to undertake the IWM scenario modelling as described in Section 4.4

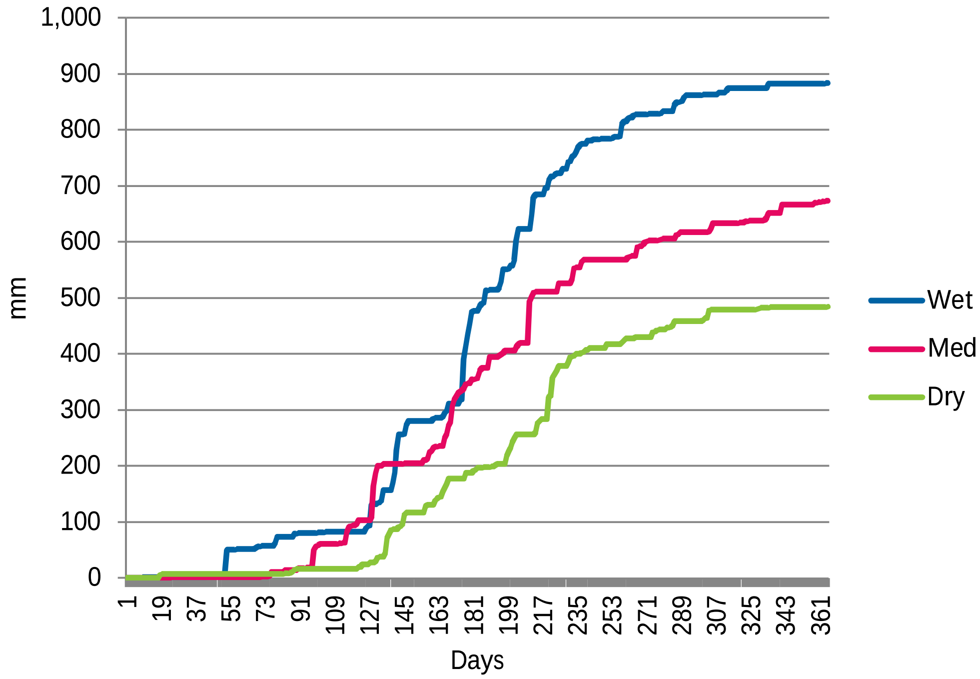


Figure 3 Daily cumulative rainfall

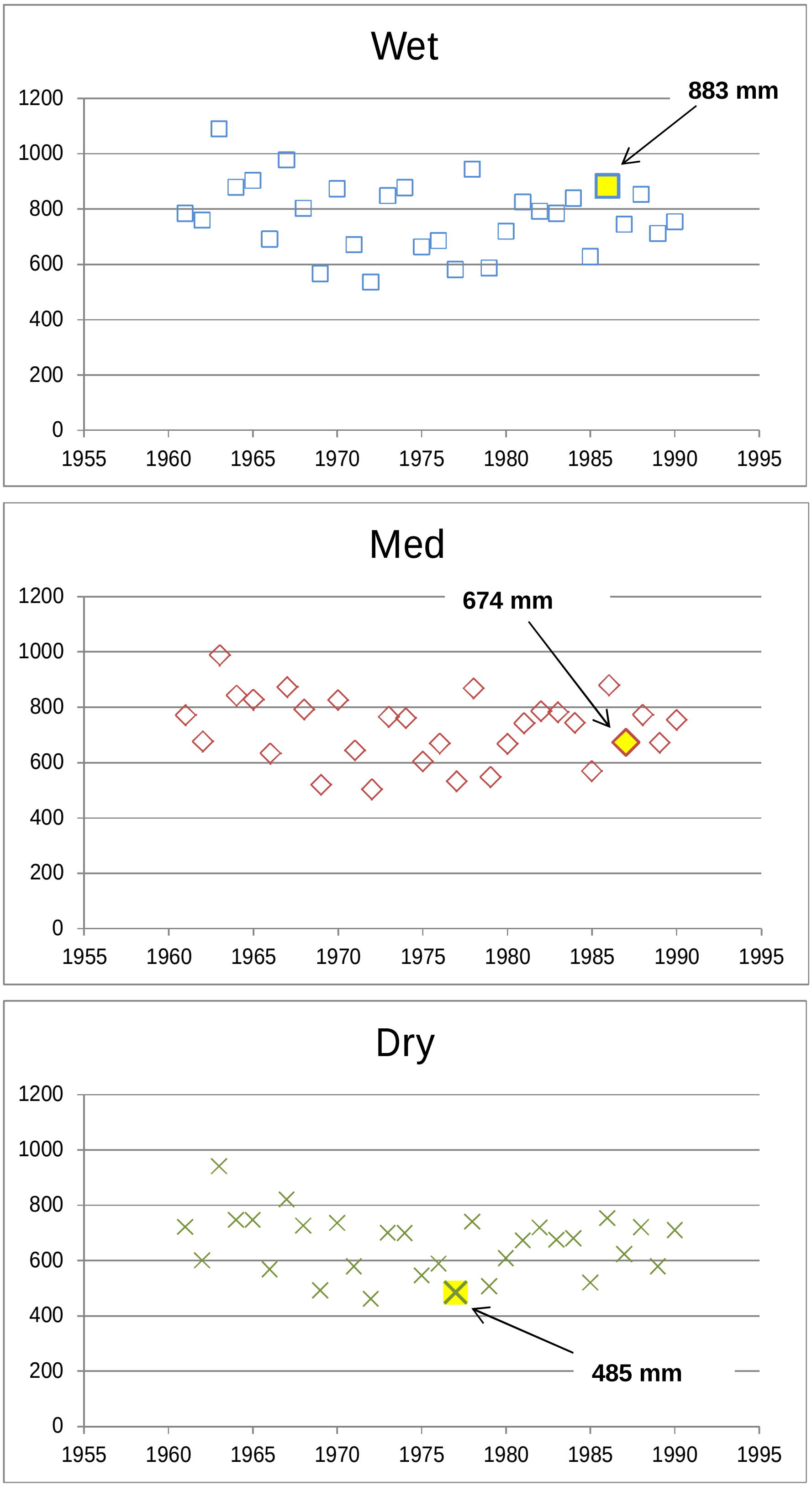


Figure 4 Rainfall data

4.4 Integrated water management scenarios

In this first phase of modelling, each of the available sources described in Section 3 above has been modelled as an independent non-drinking water (NDW) source, and compared with Business as Usual supply. In all of the following scenarios, the medium rainfall dataset has been used, and waterwise demand assumed.

4.4.1 Scenario 1 – business as usual

This scenario simulates a conventional water cycle in which all uses (with the exception of POS irrigation) are serviced by the integrated water scheme supply. Wastewater from in-building uses is exported in the normal manner through the Water Corporation sewerage network. POS irrigation is sourced directly from groundwater.

Rainfall (medium future in this scenario) is distributed in accordance with surface area between:

- Stormwater – that which falls on impermeable surfaces (assumed to be 15% of the site area) less losses (10%). Stormwater is detained (stored) and is discharged to the urban stream over a 7 day period.
- Surface water – that which falls directly on the urban stream. Losses from evaporation from the free water surface are based on daily pan data associated with the rainfall data.
- Groundwater – that which falls elsewhere on the site and recharges the superficial aquifer (a recharge ratio of 50% was assumed[4]).

Groundwater accumulates throughout the year, as does the water in the urban stream. It has been assumed that 30% of water used for irrigation recharges groundwater[5], with the balance lost to evapotranspiration.

This business as usual run establishes the base case for the analysis. Time series plots of key variables are shown in Figure 5 below.

Groundwater depths accumulate throughout the year (in the absence of lateral flows). The sourcing of POS irrigation reduces groundwater levels by around 50 mm. Stream water depths (again in the absence of lateral flows) initially drop in the summer period before rising to a level of approximately 5 m, mainly though stormwater discharges.

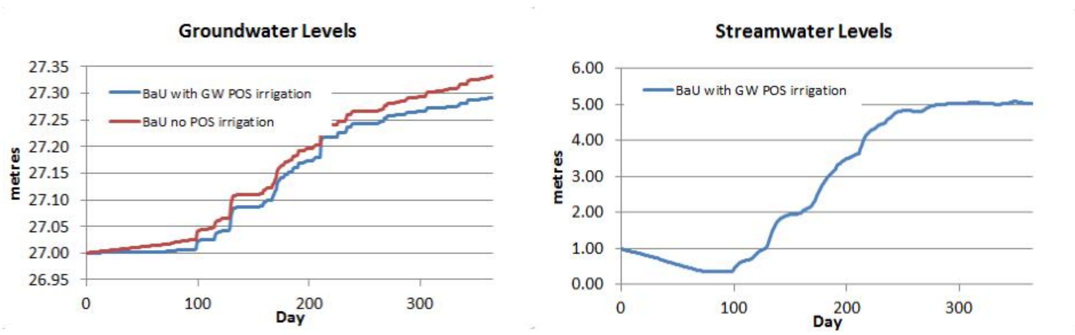


Figure 5 Scenario 1 groundwater and streamwater levels

4 Department of Water (2009)

5 Department of Water (2009)

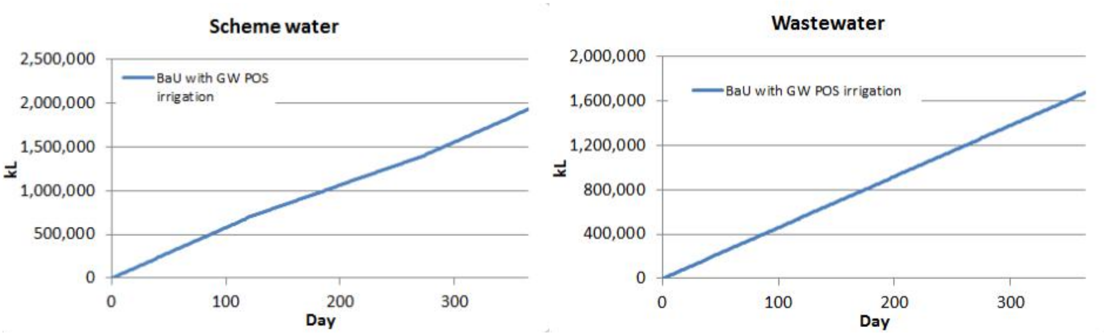


Figure 6 Scenario 1 cumulative scheme water usage and wastewater flows

In this scenario, scheme water is used for both in-building and private irrigation. Annual supply is approximately 1.8 GL, with some 1.7 GL being exported as wastewater.

4.4.2 Scenario 2 – recycled wastewater as an NDW source

In this scenario, wastewater is treated at a local recycled water facility. Following treatment, water is pumped into a dedicated NDW attenuating storage, from where it is supplied via a dedicated reticulation network (third pipe) to service NDW demands, including both private and public irrigation. At times when supply cannot meet demand, scheme water is substituted. For present purposes the recycled water recovery has been assumed to be 90%.

Under this scenario scheme water supplies are accordingly reduced, as is the quantity of wastewater exported from the site area. Rainfall is treated as per Scenario 1.

As shown in Figure 7, the groundwater depths are somewhat higher than the base case as irrigation has been sourced from recycled wastewater (RWW). Stream levels remain unchanged from the base case.

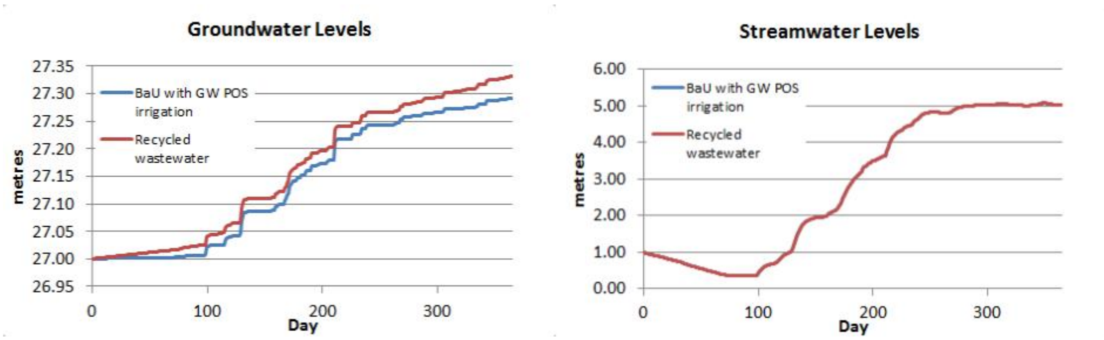


Figure 7 Scenario 2 groundwater and streamwater levels

Scenario 2 has a major impact on scheme water supply, reducing it by 50% (Figure 8). Flows to the sewer are nearly eliminated during the summer period, as the NDW demand closely matches RWW supply. In the winter time irrigation is negligible, and hence NDW demand is reduced, so sewer flows increase. The net annual effect is to reduce the sewer load by 65%.

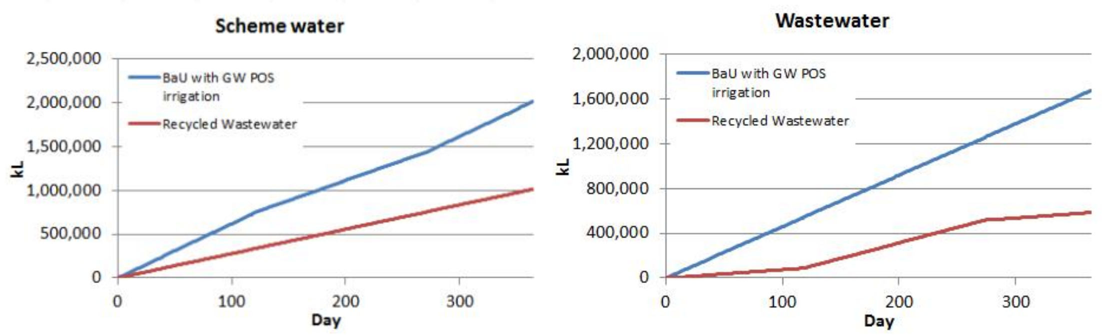


Figure 8 Scenario 2 cumulative scheme water usage and wastewater flows

4.4.3 Scenario 3 – groundwater as an NDW source

In this scenario, NDW sources are met from groundwater. Groundwater is treated (if necessary) and pumped into a dedicated NDW attenuating storage, from where it is supplied via a dedicated reticulation network (third pipe) to service NDW demands, including both private and public irrigation. As in Scenario 2, scheme supplies are accordingly reduced, as is the quantity of wastewater exported from the site area.

Rainfall is treated as per Scenario 1, and groundwater is depleted by the diversion of water for NDW purposes, much of which is used for in-building uses and therefore exported via the wastewater system.

In Scenario 2, groundwater levels drop by 0.45 m (Figure 9). Stream flows are unaffected in this scenario.

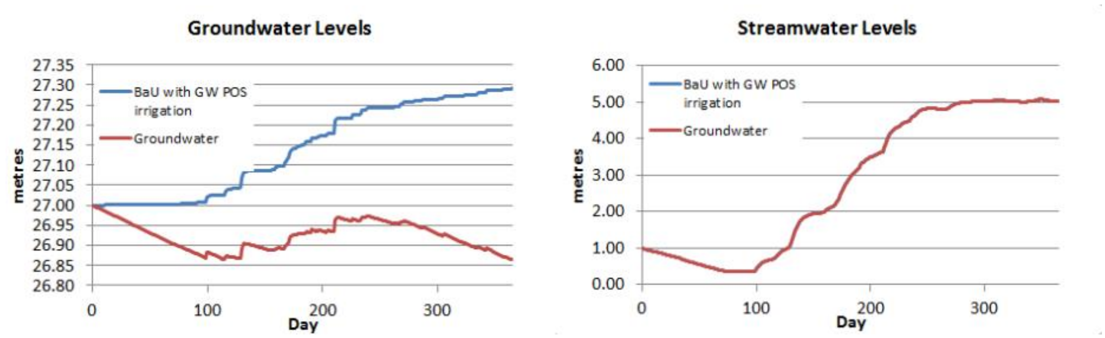


Figure 9 Scenario 3 cumulative scheme water usage and wastewater flows

The reduction of scheme water is the same as in the case of the RWW run. However flows to wastewater are the same as the base case (Figure 10).

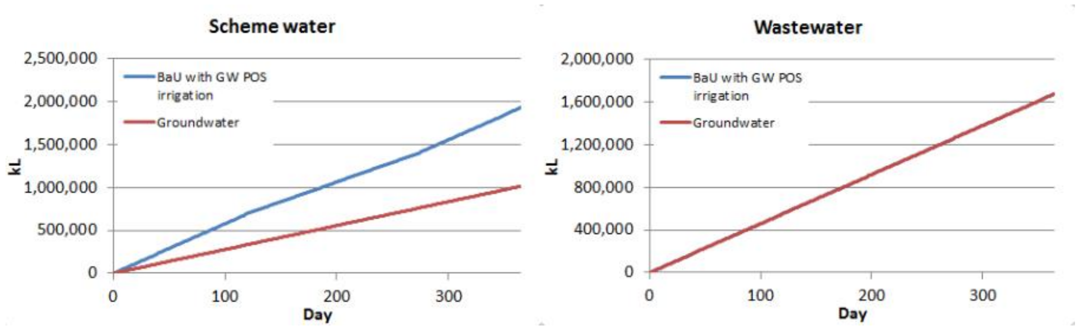


Figure 10 Scenario 3 cumulative scheme water usage and wastewater flows

4.4.4 Scenario 4 – rainwater as an NDW source

In this scenario, rainwater tanks are associated with all dwelling units. For each dwelling it has been assumed that the rainwater catchment is 100 m^2 and the tank capacity is 2 kL. (Given the high rise nature of the development it is questionable whether either of these assumptions could be achieved).

Rainfall in this scenario is distributed also to rainwater tanks, then pumped to a dedicated NDW attenuating storage, from where it is supplied via a dedicated reticulation network (third pipe) to service NDW demands, including both private and public irrigation. Rainwater overflows are assumed to be infiltrated on site to groundwater.

Again groundwater is depleted by the diversion of water from rainfall to NDW uses, although not to the extent of Scenario 3 (Figure 11). Stream flows are again unaffected.

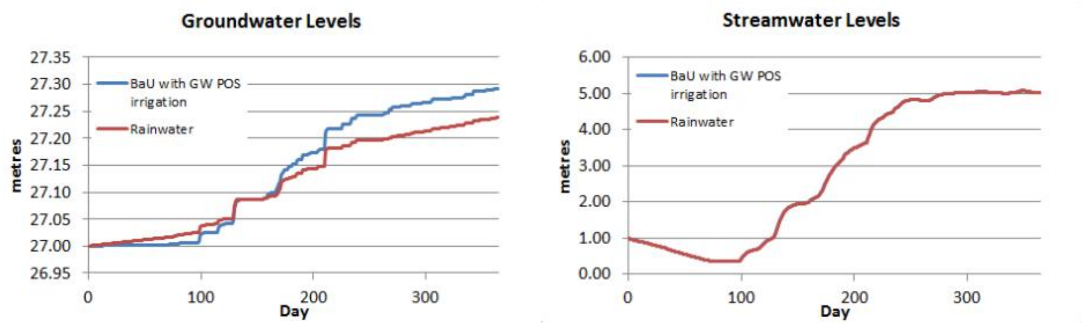


Figure 11 Scenario 4 cumulative scheme water usage and wastewater flows

As in Scenario 3 scheme water is substituted when rainfall is not available. Scheme supplies are reduced, but only in the winter time, as rainfall is insufficient to supply NDW in the summer. That proportion which services in-building uses is exported from the site via wastewater. The quantity of wastewater exported from the site area is therefore unchanged.

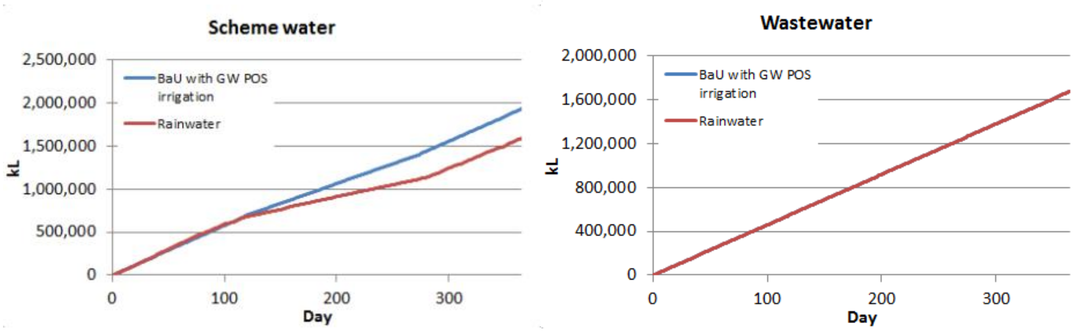


Figure 12 Scenario 4 cumulative scheme water usage and wastewater flows

4.4.5 Scenario 5 – stormwater as an NDW source

In this scenario, the stormwater detention arrangements are modified from previous scenarios. Rather than being discharged to the urban stream, stormwater is stored and pumped to the NDW attenuating storage, from where it is supplied via a dedicated reticulation network (third pipe) to service NDW demands, including both private and public irrigation. The stormwater storage capacity has been assumed to be tankage equivalent to 50% of the stormwater catchment area, 1 m deep.

As shown in Figure 13, groundwater depths are somewhat higher than the base case as irrigation has been sourced from stormwater rather than groundwater. Stream levels drop to zero by year end, as water is diverted from the stormwater collection system.

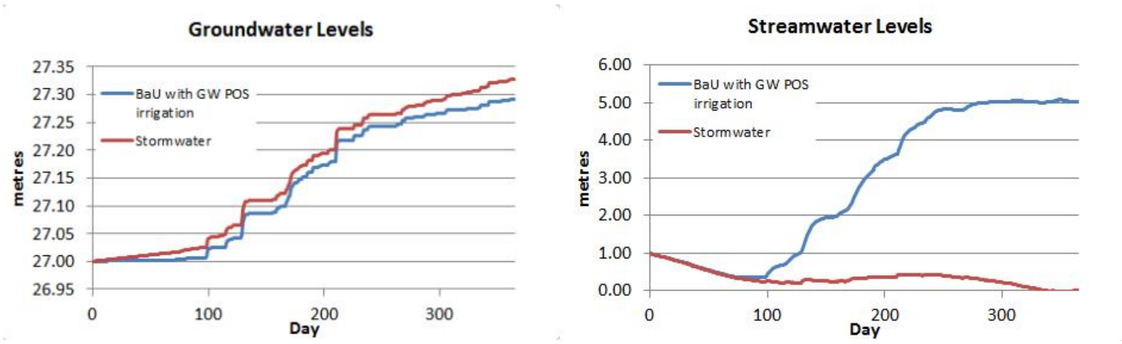


Figure 13 Scenario 5 cumulative scheme water usage and wastewater flows

As in Scenarios 2 and 3, scheme water is substituted when stormwater is not available. Scheme supplies are reduced only marginally, and (as the case for rainwater tanks) only in the winter (Figure 14). The difference in this and the rainwater scenarios is the catchment area. The assumed rainwater collection catchment is 140 ha compared with a stormwater catchment of only 32 ha (15% of the project area of 214 ha). The quantity of wastewater exported from the site area is unaffected.

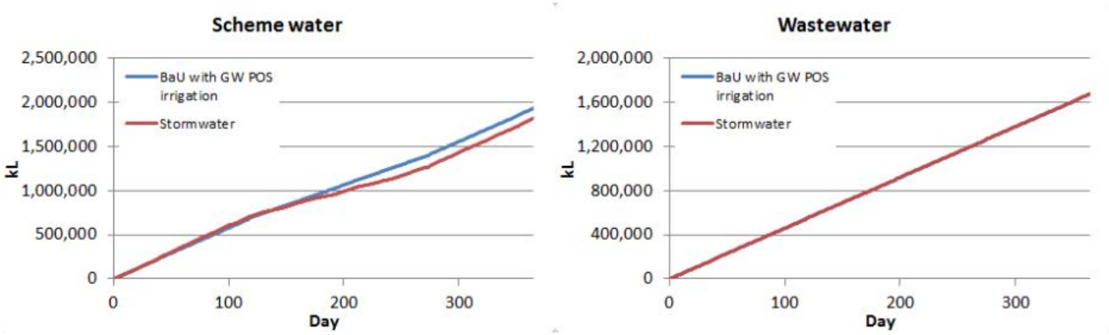


Figure 14 Scenario 5 cumulative scheme water usage and wastewater flows

4.4.6 Scenario 6 – urban stream water as an NDW source

In this scenario, NDW sources are met from the urban stream, which is recharged through stormwater. Water is treated (if necessary) and pumped into a dedicated NDW attenuating storage, from where it is supplied via a dedicated reticulation network (third pipe) to service NDW demands, including both private and public irrigation.

The surface area and average depth of the urban stream have been estimated from the Water Corporation sections for the Osborne Park Main Drain. Water levels are only available for 10 year ARI event and 100 year ARI event. The average depth in the 10 year ARI event is 1.35 m. It has been assumed that in a normal year, the average water depth in the drain is 2 m. It is assumed to be 50% of this capacity at the commencement of the simulation.

Groundwater depths are somewhat higher than the base case as irrigation has been sourced from stream water rather than groundwater (Figure 15). In this scenario, stream water levels are significantly impacted as water is withdrawn to supply NDW.

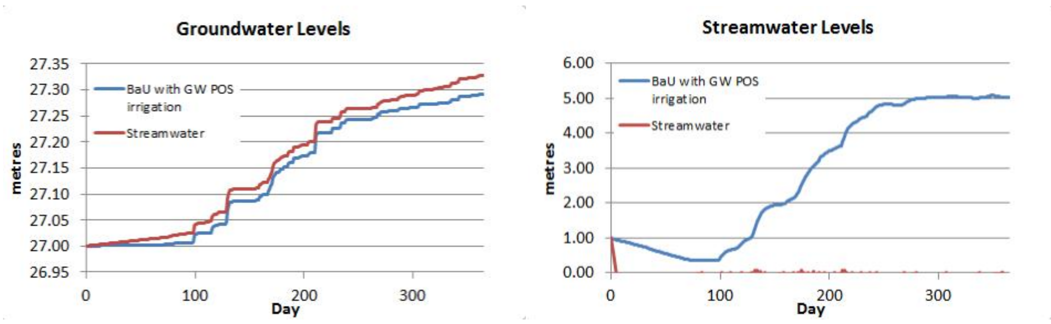


Figure 15 Scenario 6 cumulative scheme water usage and wastewater flows

As in previous scenarios, scheme water is substituted when stormwater is not available. Scheme supplies are reduced only marginally, and (as the case for rainwater and stormwater) only in the winter (Figure 16). The quantity of wastewater exported from the site area is unaffected.

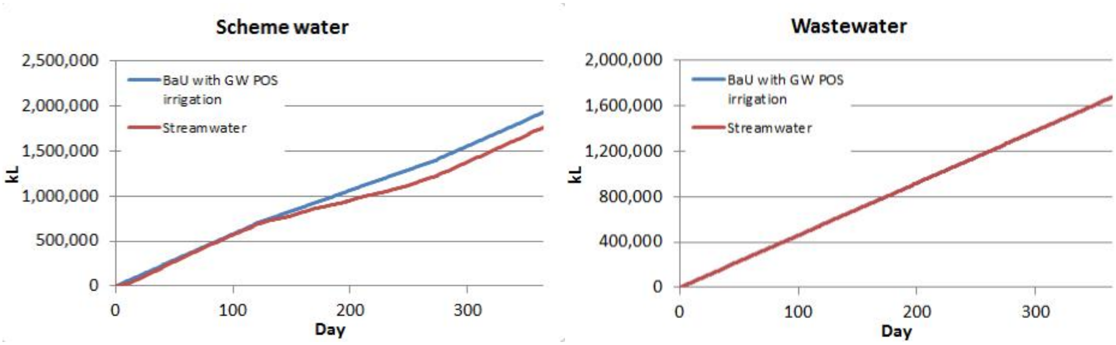


Figure 16 Scenario 6 cumulative scheme water usage and wastewater flows

4.4.7 Summary of NDW source modelling

By observation, it can be seen from the above sections that the only sources capable of independently supplying NDW are recycled wastewater and groundwater.

However groundwater availability is limited in the superficial aquifer in the area. Some 1.8 GL/yr would be required, and only 0.36 GL/yr is available (see Table 2 above). This leaves recycled wastewater (RWW) as the only source that can provide sufficient water independently for NDW uses and reduce wastewater flows. This latter point is important as it reduces pressure on upgrades to the wastewater network.

In the above modelling RWW is just sufficient to supply NDW uses in the peak summer period, including public and private irrigation. Further details of using RWW (or treated wastewater) as the preferred non drinking water source are outlined in Section 5.

5. Preferred option

5.1 Viable options

As observed from the integrated water cycle modelling (Section 4), there are two viable water sources for non-drinking water; groundwater or recycled wastewater.

The availability of groundwater from the Superficial Aquifer is currently limited and it is likely that it will be further limited in the future. The modelling of groundwater as a non drinking water source (Section 4.4.3) also indicated that there would be a reduction in groundwater levels over time due to the ongoing abstraction. While the reduction in groundwater levels has not be modelled further as part of the detailed groundwater and surface water modelling (undertaken separately for the Stirling City Centre), the expected lowering of groundwater levels has the potential to impact on acid sulfate soils within the study area.

Recycled wastewater also has additional significant advantages over groundwater including:

- **Availability**: The supply of recycled wastewater does not diminish over time and does not vary significantly throughout the year. Recycled wastewater is a more robust and climate resilient water source than groundwater, rainwater/stormwater.
- **Flexibility**: If there is a problem with the recycled wastewater supply, the treatment process will have flexibility to accommodate a supply 'top up' of groundwater.
- **Infrastructure**: By treating and using the wastewater generated within the Stirling City Centre, there are options to defer the upgrades of significant regional wastewater infrastructure (eg trunk mains and wastewater treatment plants). This can provide significant cost reductions in the required headworks for developers.

Based on availability and potential impacts to the environment from the drop in groundwater levels, recycled wastewater is preferred. Further details of the preferred non drinking water option using recycled wastewater as its source is outlined in the following sections.

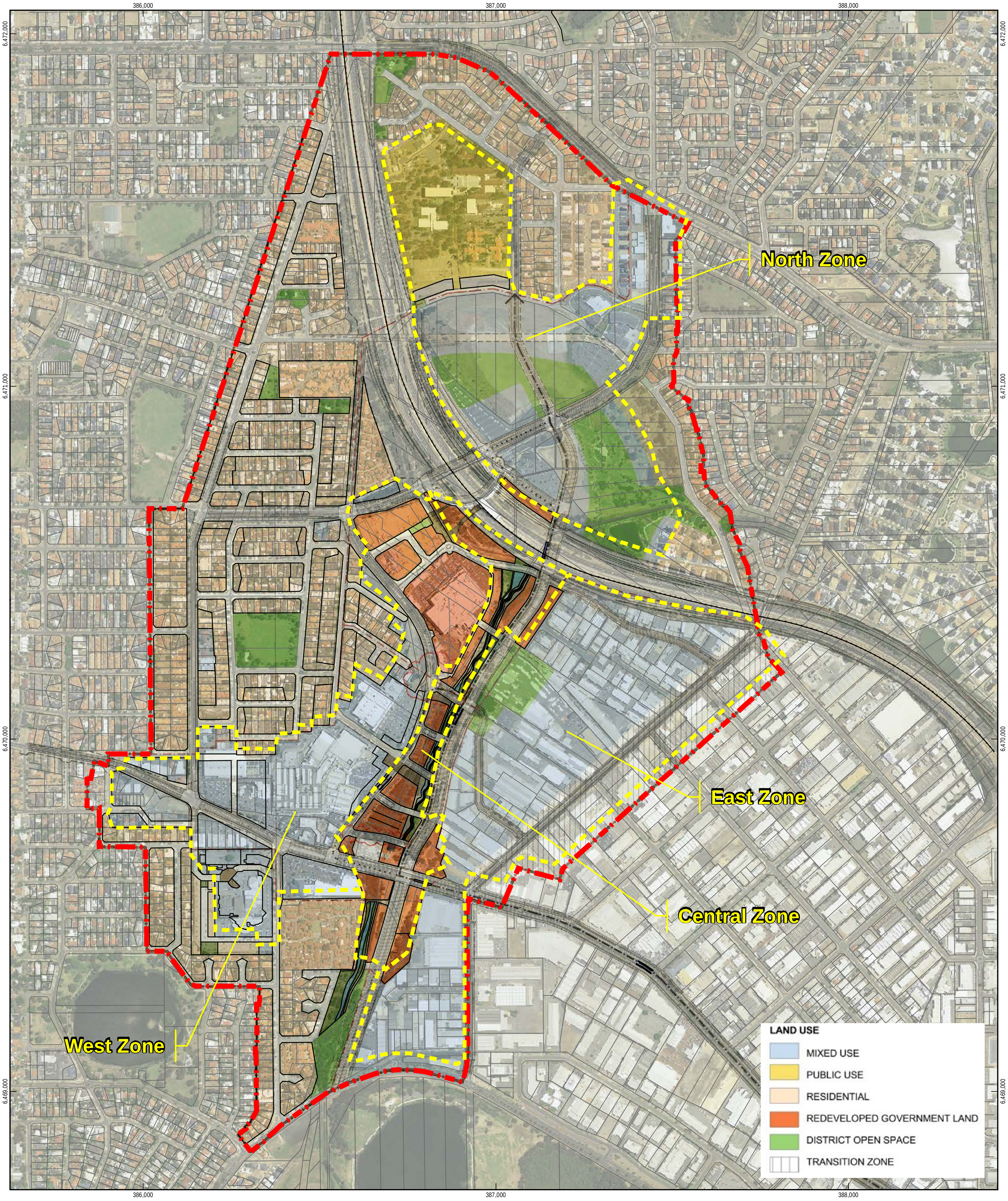
5.2 Zoning

The utilities strategy has identified that the residential areas of the structure plan area are not suited to a distributed alternative servicing strategy due to the uncertain timing and ad-hoc growth expected in these areas. As such the structure plan area has been separated into the following two zones (shown on Figure 17):

- Residential zone
- Distributed services zone.

The distributed services zone encompasses the vacant government land, the existing retail areas, the Osborne Park industrial area and the proposed mixed use areas north of Mitchell Freeway. It has nominally been broken into sub-zones (Central, Eastern, Western and Northern) representing potential staging of the rollout of distributed services.

The distributed services zone will see large increases in density, both from residential, commercial and retail land uses as well as the construction of additional roads which makes it more suitable to an alternative servicing strategy than the residential zone. While an alternative servicing strategy has not been prepared for the residential zone, there are still opportunities for alternative water options which can be led by developers (see Section 3).



LEGEND

- Structure Plan Area
- Zone Boundaries
- Cadastre

1: 10,000 (at A3)

0 50 100 200 300 400 500
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

Western Australian Planning Commission
Stirling City Environ & Water Management Plan

Job Number	61-26652
Revision	0
Date	12 Nov 2013

Distributed Service Zone

Figure 17

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239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: Landgate: Metro Central 2013 Mosaic - 20130925, Cadastre - 20130826; GHD: Super Lots - 20130925, Structure Plan Area - 20110210; WAPC: Composite Plan for Stirling City Centre - Scenario 1 - 20130830 Created by: bflorczak

The calculated water demands for these zones are set out below in Table 12 and Table 13.

Table 12 Zoned water demands – waterwise consumption

Land use	DW	NDW	Irrigation	Total	% total
Distributed services zone					
Sub Total	808,484	511,665	208,679	1,528,828	78%
Residential zone					
Sub Total	205,844	151,279	70,808	427,931	22%
Total Ultimate development					
Total	**1,014,328**	**662,945**	**279,487**	**1,956,760**	**100%**

Table 13 Zoned water demands – conventional consumption

Land use	DW	NDW	Irrigation	Total	% total
Distributed services zone					
Sub Total	1,135,435	769,150	277,870	2,182,455	74%
Residential zone					
Sub Total	364,704	274,866	109,812	749,382	26%
Total Ultimate development					
Total	**1,500,139**	**1,044,016**	**387,682**	**2,931,836**	**100%**

5.3 Description

The preferred integrated water management option for the Stirling City Centre is a treated wastewater recycling scheme for the distributed services zone. For the residential zone, a normal servicing strategy will be implemented; however alternative servicing at the lot scale (or multi lots) can be implemented by developers. In simple terms the proposed scheme for the distributed zone can be described as:

- Wastewater collected from residential and commercial properties located within the distributed services zone and treated at a purpose built recycled water treatment plant within or adjacent to the Stirling City Centre.
- Recycled water is delivered via a third pipe to non-drinking users for uses including:
  - residential in-house non-drinking uses (toilet flushing and cold washing machine tap)
  - commercial toilet flushing
  - ‘new’ POS irrigation (POS that doesn’t currently exist and is established within Stirling City Centre); and
  - road verge irrigation for areas established within Stirling City Centre.

– New POS irrigation and verge irrigation will be sourced from recycled water created within Stirling City Centre while the existing POS irrigation source will remain local groundwater using current groundwater licences.

The proposed best available technology servicing concept (for water only) prepared for the Stirling City Centre Utilities Infrastructure Strategy is depicted in Figure 18.

It is proposed that the residential zone continues with traditional servicing due to the cost of retrofitting a third pipe scheme and the ad-hoc nature that the redevelopment will occur. While a third pipe will not be constructed, this will not preclude developers from considering alternative servicing strategies within the lot itself, however this will need to be led by individual developers or landowners.

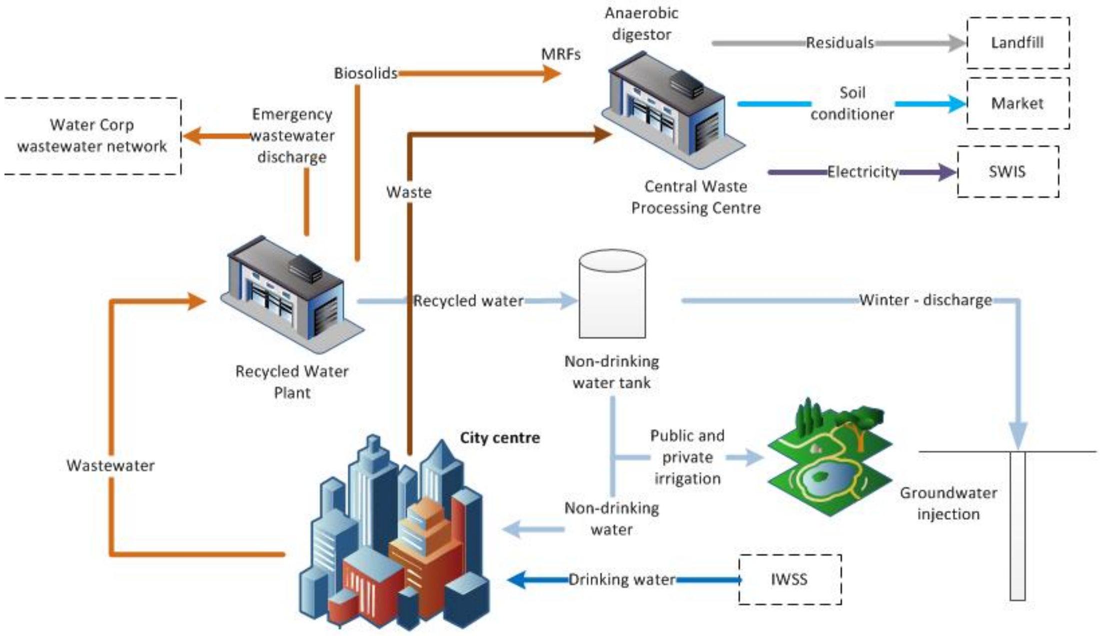

Figure 18 Best available water technology servicing concept

5.3.1 Monthly water demands

A further assessment of the water demand and available wastewater supply to determine if there is any excess water or water shortfall has been undertaken for the preferred recycled wastewater option (distributed services zone only). The outcome of this assessment is outlined in Table 14 and graphically in Figure 19. It has been assumed that 90% of the in-building water supply will be disposed to sewer, therefore available for use as recycled wastewater. The additional assumptions adopted in determining the monthly demands are documented further in the Utilities Strategy.

Table 14 Monthly water demands for the distributed services zone

Month	DEMAND				SUPPLY*					Excess for Disposal	
	Non Irr	Irr	Total		Res	Non res	Total	To sewer			
	ML/d	ML/d	ML/d	ML	ML/d	ML/d	ML/d	ML/d	ML	ML/d	ML
Jan	1.46	1.33	2.80	87	1.48	2.20	3.68	3.31	103	0.52	16
Feb	1.46	1.29	2.75	77	1.48	2.20	3.68	3.31	93	0.56	16
Mar	1.46	0.86	2.32	72	1.48	2.20	3.68	3.31	103	1.00	31
Apr	1.46	0.40	1.86	56	1.48	2.20	3.68	3.31	99	1.45	44
May	1.46	0.00	1.46	45	1.48	2.20	3.68	3.31	103	1.85	57
Jun	1.46	0.00	1.46	44	1.48	2.20	3.68	3.31	99	1.85	56
Jul	1.46	0.00	1.46	45	1.48	2.20	3.68	3.31	103	1.85	57
Aug	1.46	0.00	1.46	45	1.48	2.20	3.68	3.31	103	1.85	57
Sept	1.46	0.00	1.46	44	1.48	2.20	3.68	3.31	99	1.85	56
Oct	1.46	0.44	1.90	59	1.48	2.20	3.68	3.31	103	1.42	44
Nov	1.46	0.67	2.13	64	1.48	2.20	3.68	3.31	99	1.18	35
Dec	1.46	1.19	2.66	82	1.48	2.20	3.68	3.31	103	0.66	20

Irr – irrigation Res – residential

* Stirling City Centre distributed services area only

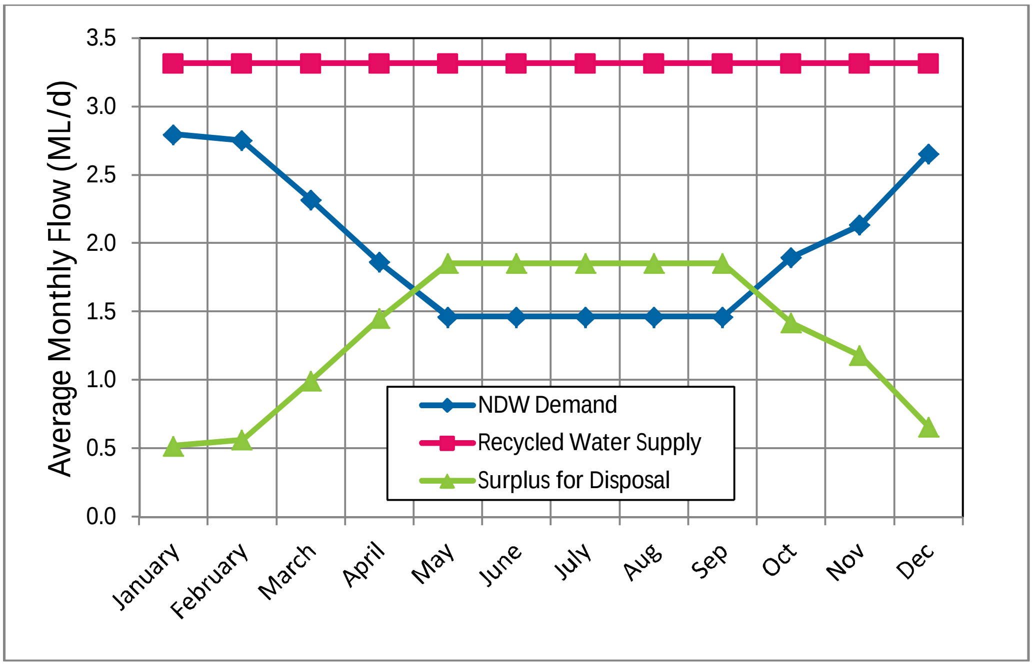

Figure 19 Monthly water balance

The monthly water balance highlights that is the requirement for disposal of excess recycled wastewater all year round as the supply is greater than the demand. On an annual basis, approximately 0.5 GL of recycled wastewater must be disposed. Accordingly, appropriate disposal options for the excess recycled wastewater have been explored.

5.3.2 Disposal options

The available options for the disposal of the excess recycled wastewater include:

- Return to sewer
- Direct discharge to the urban stream
- Direct discharge to Herdsman Lake
- Injection into the superficial aquifer
- Injection into the Leederville (or Yarragadee) aquifer

The excess wastewater can be returned to the sewer to be further treated and disposed of at the Subiaco Wastewater Treatment Plant (WWTP) or the Beenyup WWTP (depending on point of return to the sewer). Through the implementation of a recycled water scheme there is the ability to defer upgrades of the wastewater distribution mains as well as at the wastewater treatment plants themselves. If the excess wastewater from the distributed services zone of the Stirling City Centre was returned to the sewer, the benefits achieved from a recycled water network would not be fully realised. As such, the return to sewer disposal option is not preferred, leaving local environmental discharge as the preferred approach.

The water quality of the discharge volume is an important consideration. While the recycled water to be distributed for use will be disinfected for public health reasons, it is preferable to avoid this this treatment for environmental discharge. This limits the opportunity for discharge to surface water bodies where human contact is a potential risk.

Accordingly the direct discharge to either the urban stream or Herdsman Lake options are not preferred. Directly discharging the excess recycled wastewater to the proposed urban stream will result in the need to increase its hydraulic capacity to accommodate the flow. This would be difficult to achieve in an already space constrained environment. Discharging to Herdsman Lake will result in additional infrastructure that can be avoided through other disposal options.

Injecting the recycled wastewater excess to the deeper Leederville or Yarragadee Aquifers is a more expensive option that injecting the excess to the Superficial Aquifer. Injection to the shallower aquifer will raise groundwater levels at a local scale and therefore assist in keeping the peat soils wet. There is the potential that the recycled wastewater injected into the superficial aquifer may travel to the urban stream and / or increase groundwater levels at a local scale. To overcome this, careful consideration of the injection bores with respect to the proximity to the urban stream and to groundwater elevations is required.

As such, the preferred option for disposal is injection into the superficial aquifer. Some preliminary work has been undertaken to site the proposed injection bores (Figure 20) and these locations and the monthly excess wastewater has been incorporated into the groundwater and surface water model being prepared for the Stirling City Centre. The injection bore locations modelled are indicative only and as land use planning continues, an assessment of the most beneficial location, number and spacing of bores is recommended. The bores will need to be located within the vicinity of the final wastewater treatment plant location.

The modelling of the bore locations indicates that for the future minimum groundwater levels there is an increase of 0.75 m at the point of injection and an increase of 0.25 m within the vicinity of the stream (Appendix C – Figure 20). This translates to a depth to groundwater of approximately 4 m at the point of injection and 2 m to groundwater just west of the stream

(Appendix C – Figure 21). For the future maximum groundwater levels, there is an increase of 0.25 m near the point of injection and a small increase of 0.05 m south and east of the bore locations. The depth to groundwater at the point of injection will be approximately 3 m rising to a depth of 1 m to maximum future groundwater east of the stream (Appendix C – Figure 22).

These initial modelling results are subject to confirmation after the final bore location is determined. As the depth to the maximum groundwater levels in the future conditions (as a result of the injection of treated wastewater) is less than 2 m, further assessment will be required to site the bores to minimise impact on future development.

5.4 Required infrastructure

The infrastructure requirements for the preferred integrated water management option for the distributed services zone are described within the final Stirling City Centre Utilities Infrastructure Strategy (October 2013). The report sets out the treatment plant specifications, the land requirements as well as the servicing corridors necessary to implement the preferred scheme.

5.5 Regulatory issues

Prior to implementation of an integrated water management scheme for the distributed services zone, there are several regulatory issues and policies that need to be addressed. The final Stirling City Centre Utilities Infrastructure Strategy (October 2013) outlines the regulatory issues for the required services and those specific to an integrated water concept are summarised below. There will potential be additional regulatory requirements should a developer or landowner wish to implement an alternative water strategy within their lot which are not described here.

5.5.1 Economic Regulation Authority

The Economic Regulation Authority (ERA) is the independent economic regulator for Western Australia. The ERA was established under section 4 of the Economic Regulation Authority Act 2003.

The ERA licenses providers of gas, electricity and water services. Under the Water Services Licensing Act 1995, the ERA issues water service licences to entities supplying drinking water, non-drinking water, sewerage and drainage services in Western Australia that are not exempt from the requirement to hold a licence. The ERA is also responsible for the approval of Customer Service Charters and the review and development of customer protection provisions contained within the licence.

The preferred service provider of the integrated water concept described in this report would require a licence under the Water Services Licensing Act 1995 as non-drinking water services will be provided customers.

The Department of Water (DoW) and Department of Health (DoH) will be consulted by the ERA in considering a licence, and will a have direct regulatory role in some cases.

- The DoW is responsible for protecting and managing the State's water resources, including management of the licensing system for water source allocation.
- The DoH regulates health standards for water supplied by the service providers and the service provider and/or proponent will need to demonstrate the relevant health standards will be achieved.

5.5.2 Department of Water

The Department of Water (DoW) is responsible for all aspects of the water in Western Australia.

The current approvals necessary for developing an integrated water scheme are managed through the *Draft approval framework for the use of non-drinking water in Western Australia* (DoW, 2010). DoW is the lead agency for coordinating cross-agency approvals for non-drinking water schemes in Western Australia through this framework. Under the current framework all agencies including DoH, ERA and Department of Environment and Regulation (DER) have an opportunity to comment on the proposed scheme. All proposals submitted for approval under the approval framework will have to demonstrate compliance with relevant legislation, guidelines and requirements of each agency (eg demonstration that appropriate treatment and disinfection of recycled wastewater has been adopted for use within the house).

Managed aquifer recharge is considered under the *Draft approval framework for the use of non-drinking water in Western Australia* (DoW, 2010) however is outlined further in DoW's Operational policy 1.01 Managed aquifer recharge in Western Australia (DoW 2011).

As the Stirling City Centre is developed, it is recommended that the approval and legislative requirements for the use of non-drinking water are regularly reviewed to ensure that any designs and documentation are prepared in accordance with the current approval framework.

5.6 Implementation

The integrated water concept for the distributed services zone is one part of a broader best available technology solution proposed by the Stirling City Centre Utilities Infrastructure Strategy (October 2013). When assessed in conjunction with the other required services (ie wastewater, energy and waste), there is a benefit for one integrated utility providing an integrated service. The Utilities Infrastructure Strategy canvasses several options but suggests that a local government owned utility is a logical way of implementing an integrated servicing solution, which will need to be integrated with, and facilitated by the local planning scheme and associated developer contribution scheme. It is envisaged that a private sector partner would design, build and operate the facilities as an integrated service contract, offering the additional benefit of risk mitigation and private sector investment.

The implementation of the preferred integrated water concept for the distributed services zone will need to be undertaken in stages and as part of an integrated approach to servicing as further planning and design for the Stirling City Centre unfolds. A revision to the existing draft district water management strategy to include the preferred integrated water management outcomes is required prior to the finalisation and adoption of the Stirling City Centre structure plan. The revised district water management strategy will provide the framework and statutory requirement for the implementation of the concept as development proceeds.

After the structure planning is finalised and adopted, the broad next steps and decisions required to further develop and design the integrated water solution include:

1. Determine the timing of the development and identify appropriate triggers for the commencement of the integrated water solution for the distributed services zone.
2. Confirm a preferred proponent/service provider to deliver the solution.
3. Seek preliminary approval for the concept.
4. Undertake the preliminary engineering design.
5. Develop a business case in conjunction with the preferred service provider.
6. Seek final approval of the detailed design and/construction of the scheme.

The design and construction of the integrated water solution for the distributed services zone is not dependent on the commencement of redevelopment in the Stirling City Centre, although there are substantial cost savings possible by constructing the non drinking water reticulation at the same time as new roads are constructed. A potential trigger for the implementation of the integrated water concept would be to sewer the currently unsewered areas of the Osborne Park Industrial Area.

As indicated in Section 3.3.1, the observed surface water quality within the Osborne Park Branch Drain has a high concentration of enterococci, an indicator of human faeces. The source of this is likely to be the septic tanks or other primary wastewater treatment facilities located at the unsewered properties within the Osborne Park industrial area. The construction of sewers within Osborne Park industrial area will provide:

- Improved groundwater and surface water quality, particularly enterococci concentrations;
- An initial baseflow for the recycled water plant, therefore creating opportunities to development the recycled water network.

It is recommended that the potential for sewering Osborne Park industrial area is further investigated.

5.7 Recommendations

The following are the immediate recommendations for the Stirling City Centre integrated water concept for the distributed services zone:

- Adopt an integrated water concept utilising recycled wastewater as the preferred non drinking water source for the distributed services zone;
- Identify and document lot-based non-drinking water strategies for inclusion in design guidelines for the residential zones;
- Revise the district water management strategy to include the preferred integrated water management outcomes;
- Investigate the options for sewering Osborne Park industrial area as a trigger to implementing the integrated water solution as well as for providing improved groundwater and surface water quality (particularly with respect to enterococci);
- Develop a staging strategy for the development of the Stirling City Centre which will incorporate the required staging and construction of the necessary infrastructure including the recycled water network and recycled water plant.

6. References

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North Metro Conservation Group (2007) *Draft Herdsman Lake Integrated Catchment Management Plan*.

Parsons Brinckerhoff (November 2010). *Stirling City Centre Green infrastructure study*. Prepared for the Stirling City Centre Alliance.

Stirling City Centre Alliance (February 2011) *Draft Stirling City Centre Structure Plan*.

Appendices

Appendix A – Water demand calculations

Current water usage calculations

Five years of water consumption data (2008 – 2012) for the Stirling City Centre was supplied by the Water Corporation as a summary of all the accounts located within the study area. Each account was organised into four land use classes:

- Commercial
- Other
- Residential
- Vacant Land

Each of these land use classes were then further classified into 52 land use codes ranging from Aged Home to Workshop.

For the water usage calculations only three of the land use classes were assessed, commercial, other and residential. Vacant land water usage was not considered to be relevant for future planning.

Residential

Each residential account was not necessarily for a single dwelling as sometimes more than one dwelling share the same water account. The land use codes which stated residential units rather than residential unit and high water using accounts were assessed separately to see how many dwellings may be using the accounts. This was determined to be **1,427 dwellings** and **1,276 accounts**.

The water usage within the study area was estimated using the average of the 5 years' worth of data provided by the Water Corporation. It was estimated that the Stirling City Centre study area currently used on average **301,141 kL/year.**

The current population was assumed to be **3,800 people** (Stirling City Centre Alliance, 2011) which translates into a per dwelling consumption of **211 kL/year** and a per person consumption of **79.2 kL/year.**

Commercial

The commercial water usage was estimated from a combination of 'Commercial' and 'Other' category land uses. The relevant land use codes were separated into three general categories as shown in Table 15.

Current commercial water usage within the study area was estimated to be **255,911 kL/year**. Current gross floor area (GFA) information was used to then determine category specific water usage (Table 16).

Commercial areas were also estimated to have an irrigation component of **20,335 kL/year**. This was determined from accounts with land use code 'Common non-res' within the 'Other' land use class.

Table 15 Commercial categories and their land use codes

Health, education, & community welfare	Office business	Retail
Day care centre	Bank	Commercial centre
Hostel	Office	Factory
Medical centre/clinic	Offices	Factory unit
Surgery	Centre	Fast food outlet
Aged care		Office, factory
		Office, shop
		Office, showroom
		Office, warehouse
		Office, workshop
		Office, yard
		Restaurant
		Sale yard
		Service station
		Shop
		Shopping centre
		Shops
		Showroom
		Showroom, factory
		Showroom, warehouse
		Showroom, workshop
		Showrooms
		Warehouse
		Workshop

Table 16 Current commercial category water usage

Commercial category	Gross floor area (m2)	Water usage (kL/year)	Water usage (kL/m2 GFA)
Office business	15,273	20,540	1.34
Health, education, & community welfare	12,174	54,715	4.49
Retail (including entertainment)	169,773	180,656	1.06

POS

The current POS irrigation water demand could not be estimated from the Water Corporation data, however within the data, drinking usage for land use class ‘reserve’ was noted. Based on the five year average, reserve drinking water usage was estimated to be **237 kL/year**. This was demand was assumed to be for toilets, taps and drinking fountains located within the parks and open spaces.

Future water demand calculations

The water usage calculations were undertaken using a combination of current water use data extrapolation, water demand calculator and current industry knowledge (irrigation) as outlined in Section 4.1.

Calculated residential water demand

Future residential water demand was estimated using the following four different usage options:

- Waterwise calculator – waterwise house and garden
- Waterwise calculator – waterwise house and European garden.

Water demand details from the waterwise calculator are shown in Table 17. Each dwelling was assumed to have an average 1.8 residents.

Table 17 Waterwise calculator demands (per dwelling)

Waterwise calculator water consumption	Waterwise house/garden (kL/year)	Conventional house/European garden (kL/ year)
Drinking water in-house	43	60
Non-drinking water in-house	34	54
Irrigation	11.33	17
Total water demand	**88.33**	**131**

The following assumptions were adopted to estimate the potential future residential water demands:

- Population – 19,404 people
- Dwelling yield – 10,780

Water Calculator

- 10% of houses had a pool
- 4% of houses had a spa
- All pools and spas had covers
- Spray irrigation was assumed for both lawn and garden
- 15% of the total residential area is irrigated gardens

Commercial

Two commercial water usage options were considered; waterwise or conventional. The conventional water scenario adopted the current unit water rates whereas the waterwise scenario adopted the unit rates provided in Water Corporation's water supply calculator. The difference in unit rates is provided in Table 18, along with the breakdown of drinking water, non drinking water and irrigation water usage.

Table 18 Commercial unit demands (kL/m^2 GFA)

	Conventional scenario				Waterwise scenario			
	DW	**NDW**	**Irrigation**	**Total**	**DW**	**NDW**	**Irr**	**Total**
Office business	0.80	0.47	0.07	1.34	0.48	0.28	0.04	0.80
Retail	0.64	0.32	0.11	1.06	0.60	0.30	0.10	1.0
Entertainment / recreation	0.64	0.32	0.11	1.06	0.60	0.30	0.10	1.0
Health / community	2.69	1.35	0.45	4.49	0.48	0.28	0.04	0.80

DW – Drinking water   NDW – non drinking water

Irrigation and POS demand

Future road verge and POS areas were provided by the City of Stirling[6]. Irrigation rates were assumed to be consistent with the generally accepted industry standards.

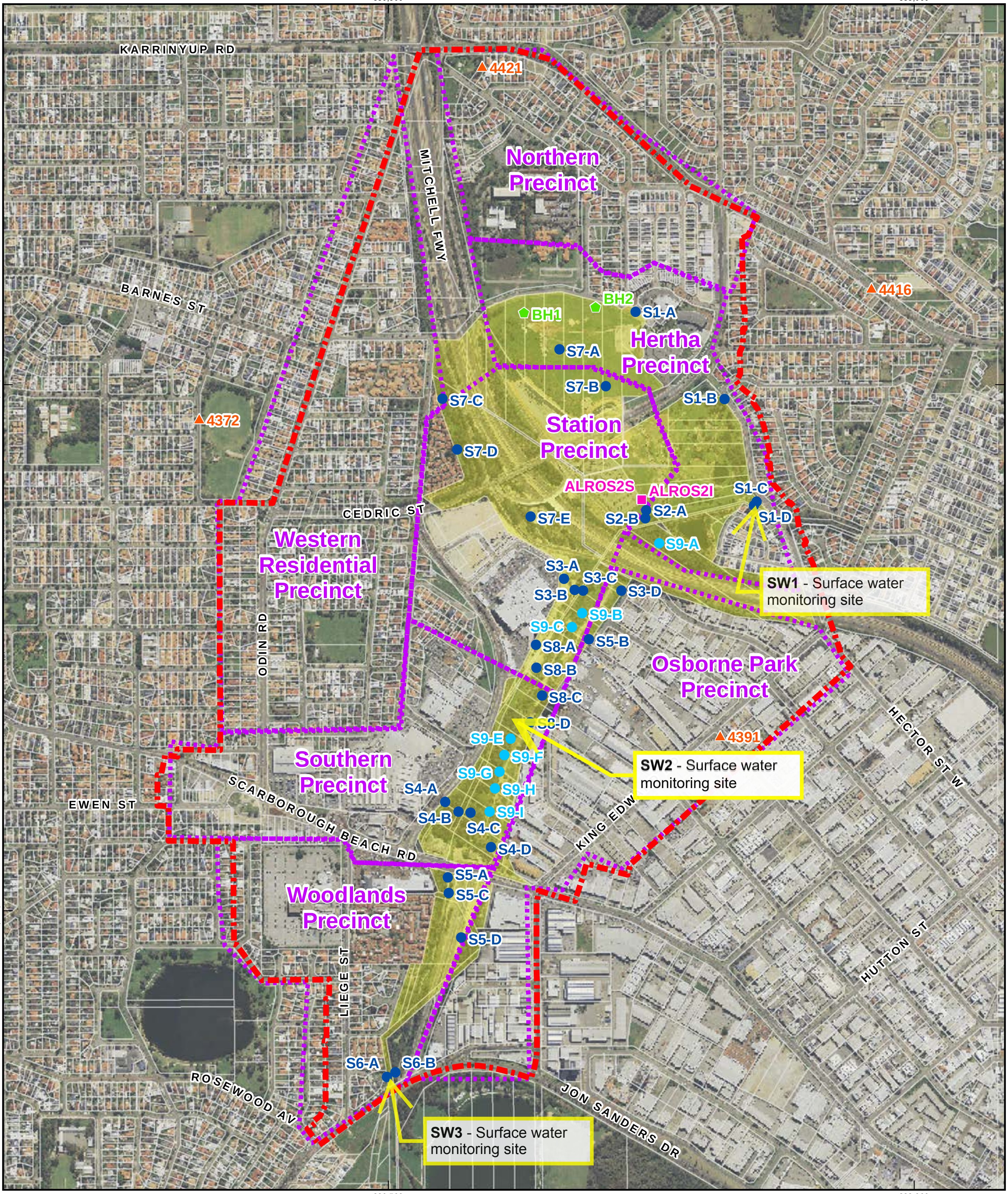
POS drinking water demands were estimated from the Water Corporation consumption data. These water demands were assumed to be for taps, toilets and drinking fountains. It was assumed that this drinking water demand would remain constant in the future

Water demands for the ultimate development were estimated as follows:

- Road Verge area of 86.4 ha – 15% of this area to be irrigated at 5,000 kL/ha/year
- POS area of 14.5 ha – 30% of this area to be irrigated at 7,500 kL/ha/year for the conventional scenario and 5,000 kL/ha/year for the waterwise scenario

[6] Pers. Comm. Stephen Kovacs, City of Stirling, 6 November 2012

Appendix B – Groundwater monitoring locations



LEGEND

Monitoring Well

- GHD (50mm groundwater well) - New
- GHD (soil bore only) - New
- Department of Water (WIN) - Existing
- SMEC - Existing
- Other - Existing
- Cadastre
- Structure Plan Area
- Precinct
- Study Area

1:15,000 (at A4)

0 75 150 300 450 600

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

CLIENTS | PEOPLE | PERFORMANCE

Stirling City Centre Alliance
Water and Environmental Investigation

Sampling Locations

Job Number	61-26652
Revision	0
Date	01 Dec 2011

Figure 2

N:\AU\Perth\Projects\61\26652\GIS\Maps\MXD\6126652_W002_SamplingLoc_Fig03_Rev0.mxd GHD House, 239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com **W** www.ghd.com

Data source: GHD: Monitoring Well - 20111130, Precinct - 20100810; Study Area - 20110314; Stirling City Centre Alliance: Cadastre - 20110210, Structure Plan Area - 20110210; Landgate: Metro West 2011 Aerial - 20111130.
Created by: aosbaldeston, lhyoong

Appendix C – Modelling results of injection bores

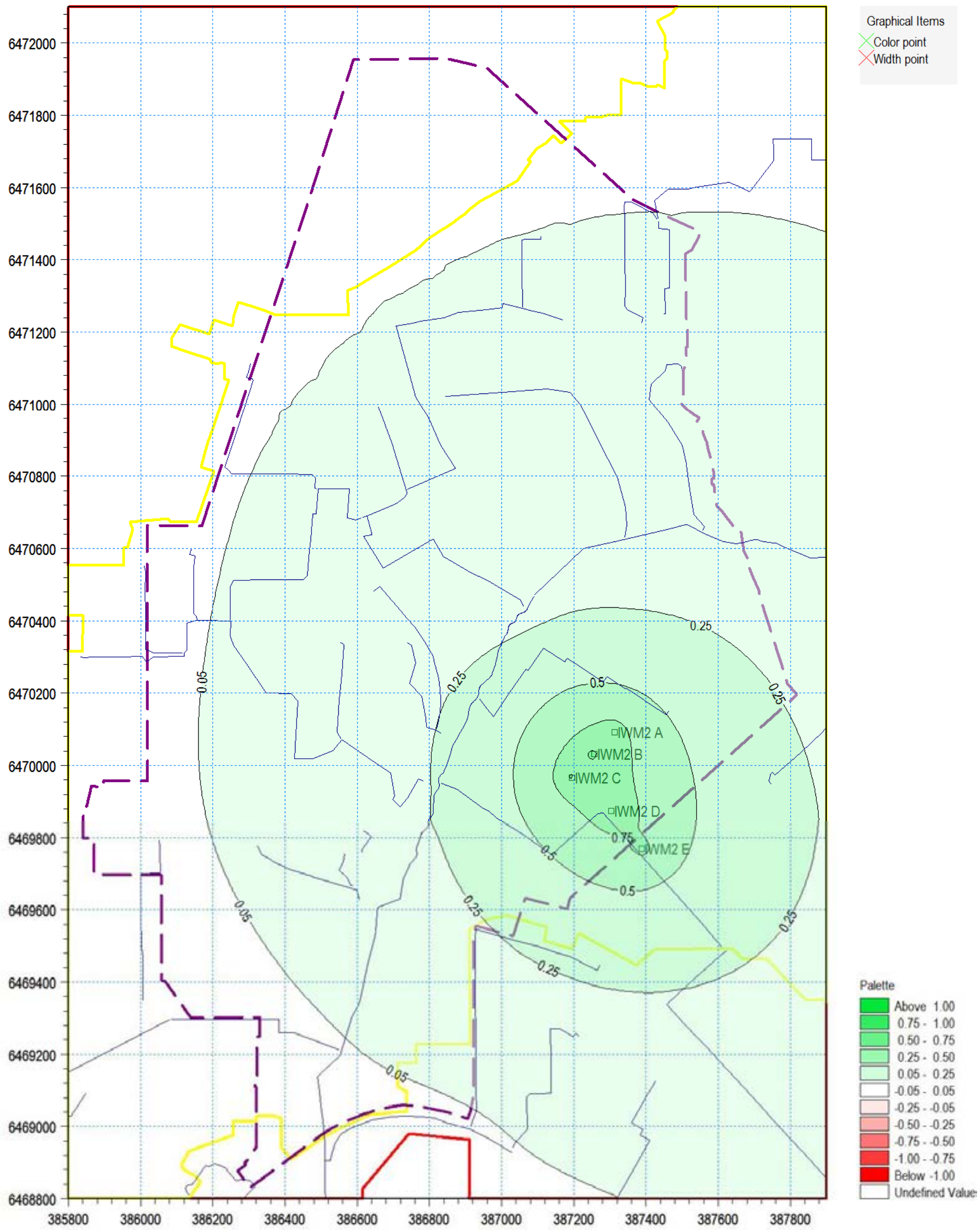


Figure 20 Changes in minimum water levels with injection of excess recycled wastewater

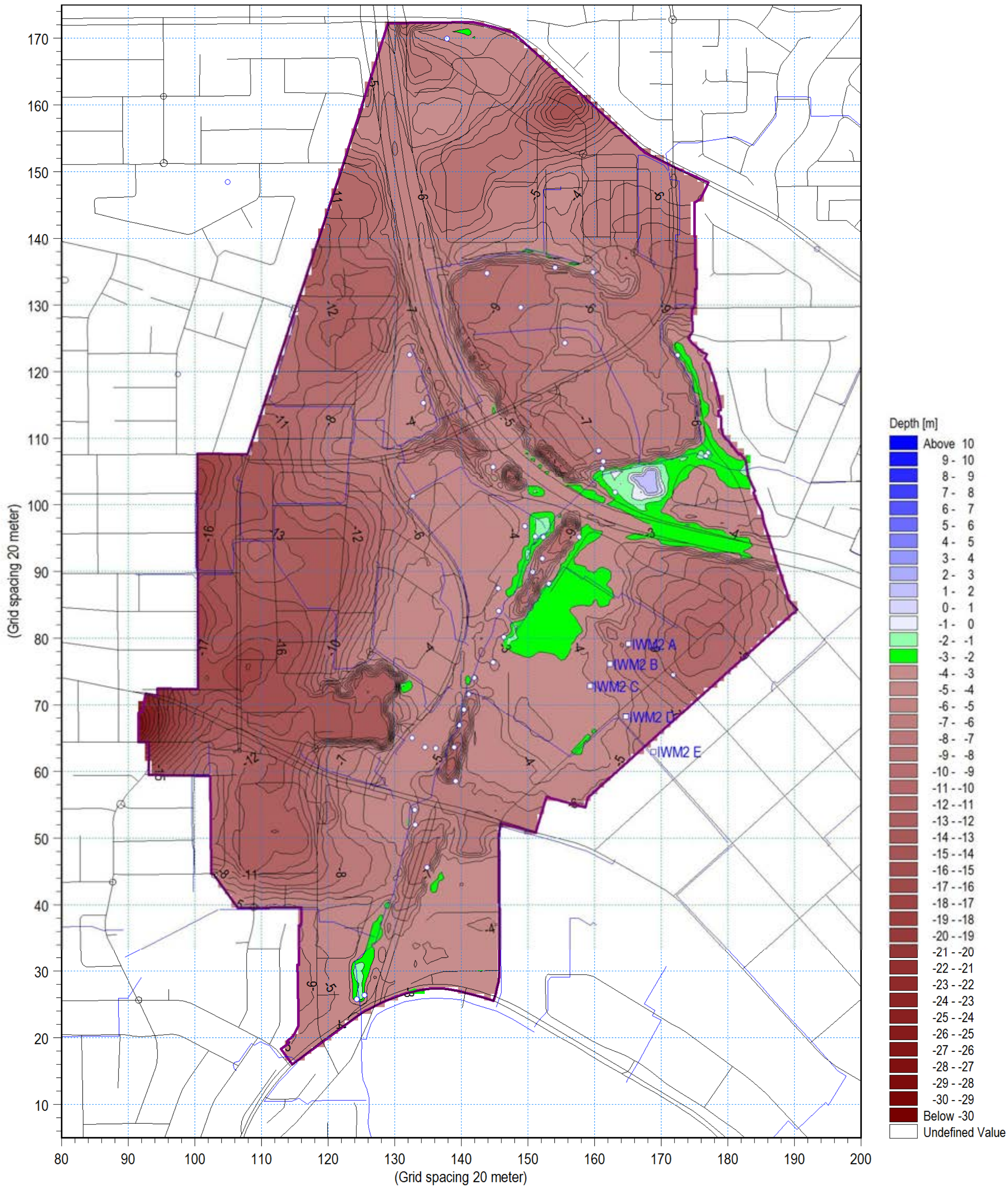


Figure 21 Depth to future minimum groundwater levels with injection of excess recycled wastewater

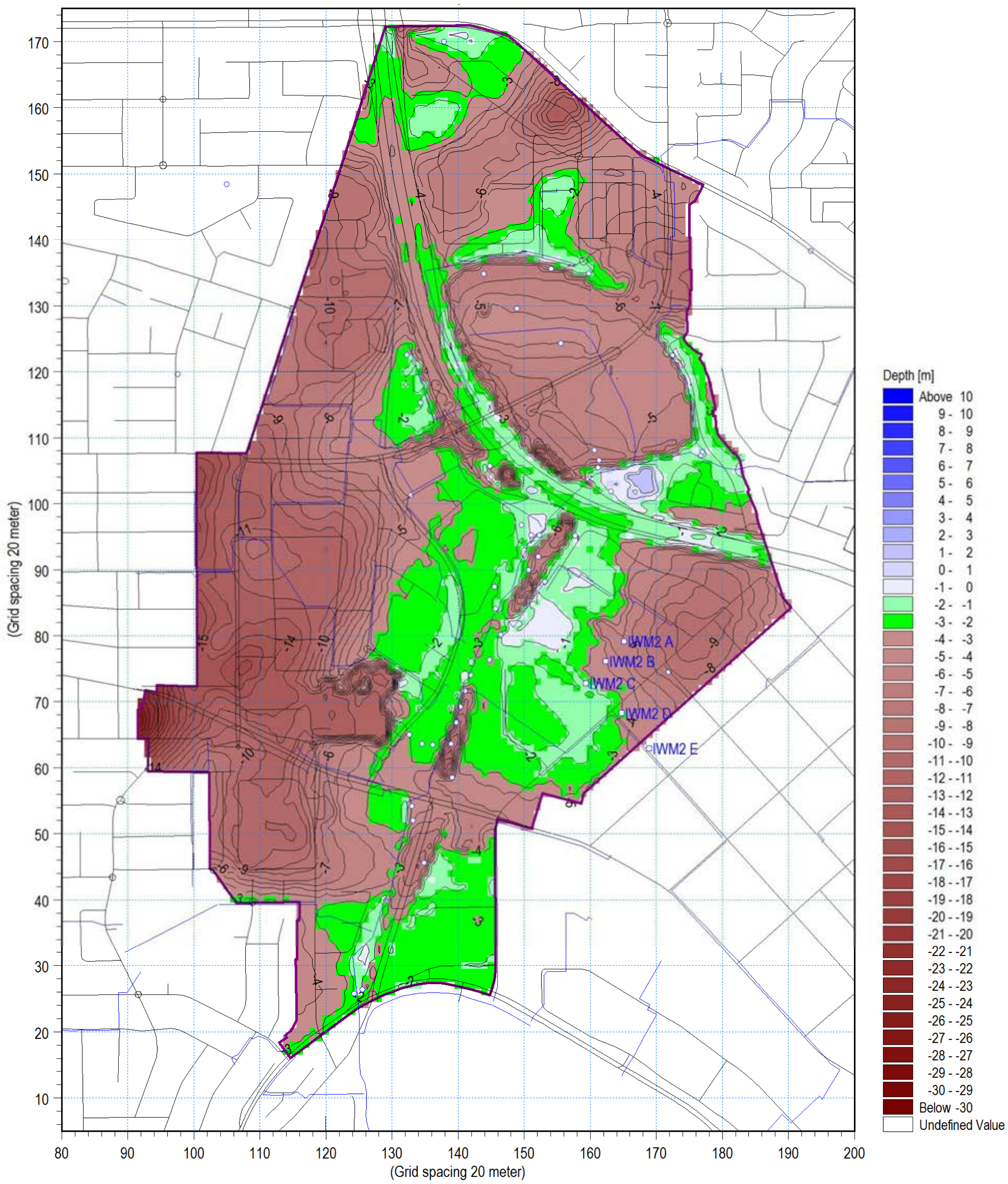


Figure 22 Depth to future maximum groundwater levels with injection of excess recycled wastewater

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