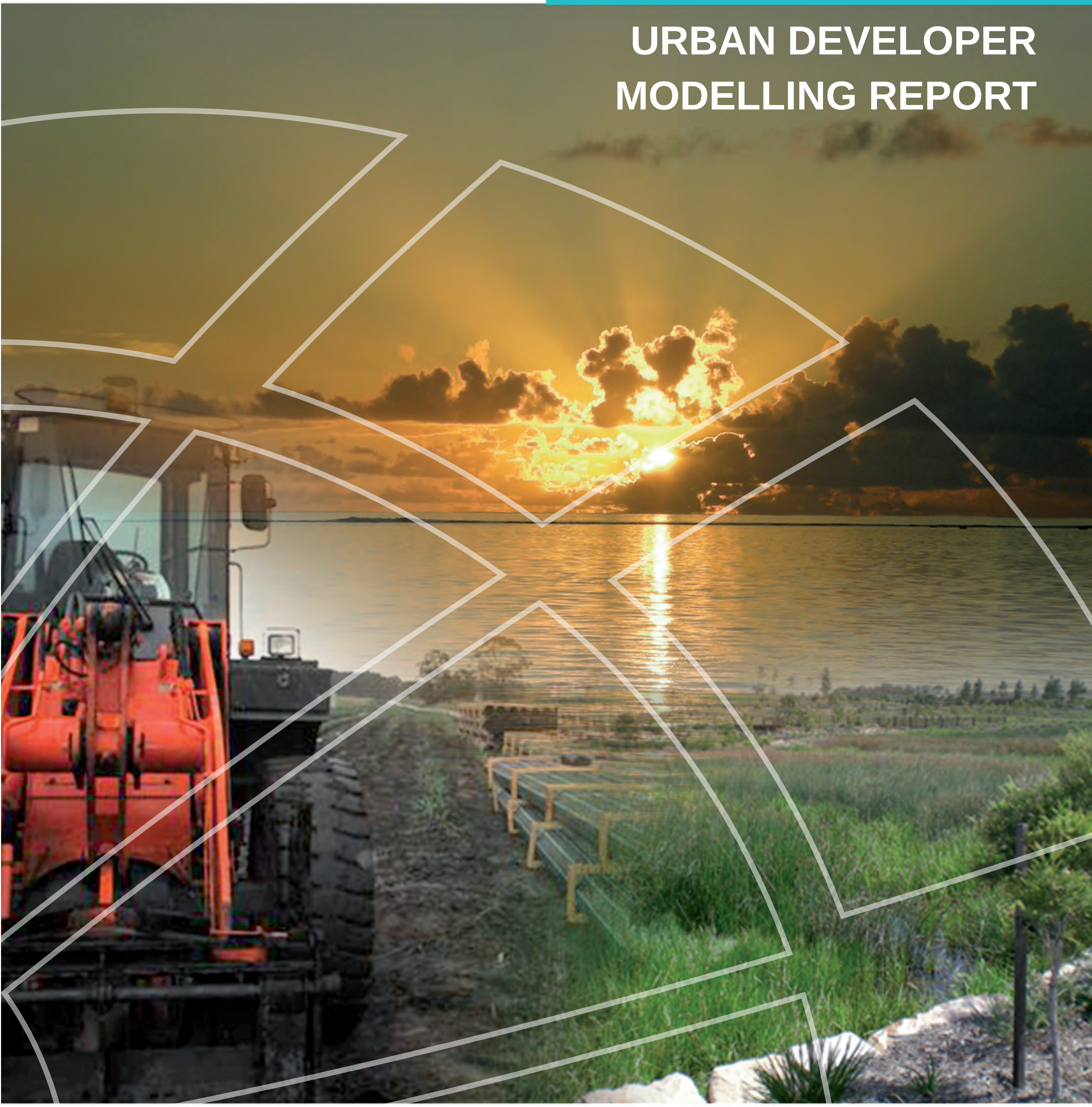
APPENDIX A:

URBAN DEVELOPER MODELLING REPORT



Caboolture Identified Growth Area Urban Developer Modelling

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Title :	Caboolture Identified Growth Area Urban Developer Modelling
Author :	Nigel Hardie
Synopsis :	This report presents the methodology and results of Urban Developer modelling for the CIGA, as part of the sub-regional total water cycle management planning process.

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1 INTRODUCTION

The Caboolture Identified Growth Area (GIGA) is a 4,160 hectare area 7 km west of the Queensland town of Caboolture. The area is the site of a proposed residential development catering for a potential population of 52,500 people by 2031. Of the many elements of infrastructure required to support this population, the water supply system is one of the most critical.

As with all residential developments, CIGA will have a variety of water supply demands varying from potable household use to public space irrigation. To meet these demands, there are a number of potential water supply options available. Finding the most efficient combination of supply sources to satisfy these demands will be a critical step to designing the water supply system.

The aim of this investigation is to model the effects of different urban water supply options to meet the future development needs using the eWater CRC Urban Developer modelling framework.

2 URBAN DEVELOPER MODELLING APPROACH

Urban Developer has been created by eWater CRC as a conceptual design tool for the modelling of multiple scenarios of water supply against demands. The software stochastically simulates the behaviour of a supply-demand network using an adaptive time-step approach. This method allows the model to simulate the catchment with sub-minute time-steps during periods of change (e.g. during rainfall) and adapt to longer time-steps during periods of stability (e.g. dry conditions). Using this technique enables the model to produce high resolution results in an efficient manner. For this investigation the time-steps were 30 seconds during rainfall, 6 minutes during transitions from wet to dry, and 2 hours during dry periods.

Models are constructed using a combination of nodes and linkages that simulate the behaviour of the system. Metrological data is entered in 6 minute time-steps over the duration of the modelling period to simulate the environmental conditions. A layout of the Urban Developer model is presented in Figure 2-1.

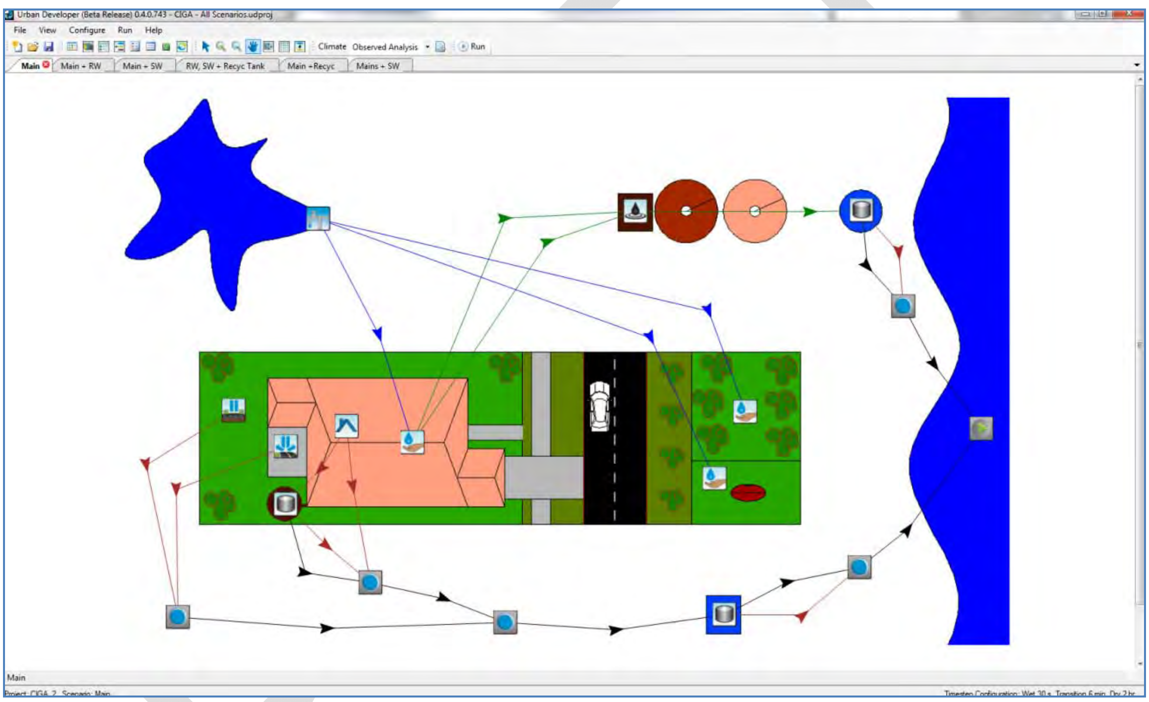

Figure 2-1 Urban Developer Model Layout

2.1 Source Nodes

The approach taken for this investigation has been to model the water supply-demand system at a representative household level. The sizes of the elements in this system have been scaled from the land usage proportions estimated for the CIGA development. Additional area proportion information has been sourced from the Water By Design MUSIC Modelling Guidelines (2010). Table 2-1 presents the land usage and population assumptions.

Table 2-1 Land Usage and Population Assumptions

Parameter	Value	Reference
Assumed CIGA area	4160 ha	(MBRC, 2011)
Assumed public open space for CIGA	194.25 ha	(Unitywater, 2010)
Assumed public sporting field area for CIGA	115.50 ha	
Assumed CIGA population	52500	
Assumed people per household	2.8	Based on a 15 dwellings/ha residential density (Water By Design, 2010)
Assumed residential density	15 dwellings/ha	
Assumed roof area per household	215 m2	
% Road reserve (road + verge) per residential Area	25.0%	
% Roof area per residential area	32.5%	
% Ground level per residential area	42.5%	

Table 2-2 Residential Area Breakdown and Fraction of Imperviousness

Parameter	Value	Fraction of Imperviousness
Roof Area	215 m^2	100%
Allotment Ground Level Area	281.2 m^2	20%
Road Reserve Area	165.4 m^2	60%
Public Space Area	103.6 m^2	20%
Sporting Field Area	61.6 m^2	20%

2.2 Demand Nodes

Urban developer uses demand nodes to simulate the water supply needs within the system. For this investigation the demands have been distributed between household indoor, household outdoor and public space/sports field irrigation. The demands of commercial, agriculture and industry were not included due to the highly variable nature of their requirements.

Data from the recent Urban Water Security Research Alliance study of household water use (Beal, Stewart, & Huang, 2010) has been used to simulate the household indoor demands. The household outdoor demands have been based on the Unitywater estimation of an average usage of 25 L/person/day. With an average household occupation of 2.8 people, this equates to a daily average demand of 70 L/household/day. A summary of the indoor and outdoor household demands is presented in Table 2-3.

Table 2-3 Household Water Demands

Demand	Demand Volume (L/house/day)	% Total Indoor Demand
Tap	209.0	54%
Toilet	65.8	17%
Laundry	85.1	22%
Leaks	27.1	7%
Total Household Indoor Demand	**387.0**	
Household Garden Average Irrigation Demand	70.0	
Total Household Demand	**457.0**	

Urban Developer has the ability to vary the irrigation demand throughout the year in order to reflect the seasonal changes in water usage. The default variation within Urban Developer has been applied to the produce the monthly outdoor demand variation. The resultant outdoor demand variation is shown in Figure 2-2.

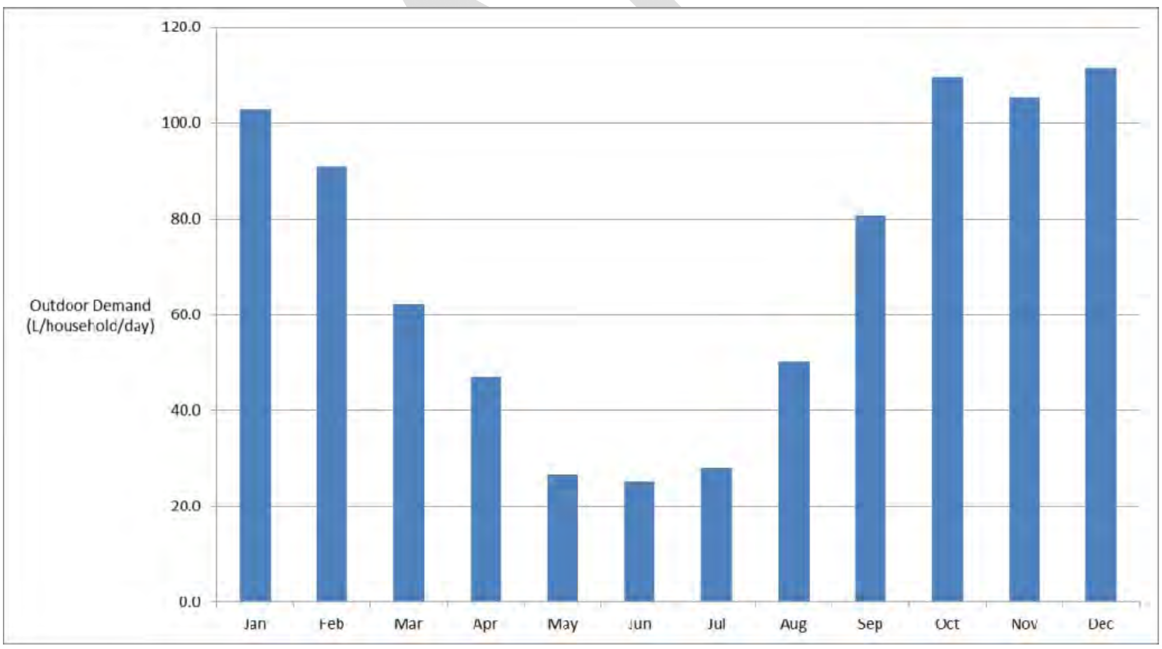

Figure 2-2 Annual Household Outdoor Water Demand Variation

Public space and sporting field irrigation also contribute to the total demand on the water supply system. These demands have been calculated based on the irrigation rate provided by Water By Design (2010). A summary of the demands is presented in Table 2-4 and Table 2-5.

Table 2-4 Sports Field Irrigation Demands

Irrigation Rate	730 mm/yr
Irrigation Area	61.60 m^2
Daily Average Irrigation Demand Volume	45 kL/yr

Table 2-5 Public Open Space Irrigation Demands

Irrigation Rate	548 mm/yr
Irrigation Area	103.6 m^2
Daily Average Irrigation Demand Volume	156 kL/yr

The Urban Developer default seasonal demand variation was also applied to the sports field and public space irrigation demand.

2.3 Supply Nodes

Supply nodes simulate water supply from sources such as water treatments plants. For this model only a mains water supply has been used to simulate the supply of potable water to the system.

2.4 Tank Nodes

Tank nodes can be used to model a static supply of water (e.g. a finite reservoir) or a storage tank that receives inflow from another part of the system (e.g. a rainwater tank receiving run-off from a roof during rainfall events).

For this simulation a 5kL household rainwater tank was included in the network. As per the Queensland Development Codes 4.2 and 4.3 (Queensland Government, 2010), the lessor of 50% or 100m^2 of the roof area for a new residential house is to be connected to a rainwater tank. For the 215m^2 tank used in this simulation, this equated to 100m^2 of area.

Other tanks used in the model included a wastewater storage tank and a stormwater harvesting tank. The wastewater tank was continually filled by the effluent from the wastewater treatment node in order to simulate the storage of treated effluent for potential re-use. A stormwater harvesting tank was connected to the stormwater system in order to provide an additional supply source.

2.5 Receiving Nodes

The model incorporated a receiving node to simulate the total system flow (treated wastewater and stormwater) to the receiving environment.

2.6 Metrological Data

Urban Developer uses rainfall, temperature and evaporation data in 6 minutes time-steps to conduct its simulation. The climate period chosen for this investigation was from the 1st of January 1980 to the

31st of December 1989. According to Water By Design (2010), this period provides a good representation of the typical climatic conditions for this region.

Metrological data was obtained from the Bureau of Metrology for the Dayboro Post Office weather station (station No. 40063) located approximately 9km to the south of the CIGA boundary. This station is the nearest to the CIGA site which records 6 minute time-step metrological data. The Dayboro Post Office station has a mean annual rainfall of 1242 mm. As a comparison, the Wamuran weather station (station No. 40343), which is 2km to the north of the CIGA boundary, has a mean annual rainfall of 1271mm.

In order to simulate the potential impacts of climate change, a secondary set of metrological data was generated based on the predictions for 2030, outlined in the CSIRO (2007) report "*Climate change in Australia: Technical Report 2007*". The report estimates that by 2030 the South East Queensland region will experience:-

- A reduction in mean annual rainfall of 3%, with spring and winter rainfall expected to decrease by 5%;
- An annual average temperature rise of 0.9°C with little variation between the seasons; and
- An annual potential evaporation increase of between 3-4%, with upper estimates of a 6% increase during autumn and winter.

2.7 Modelling Scenarios

Urban Developer allows multiple scenarios to be investigated by altering the linkages between nodes and changing the demand priorities of each supply. Each water demand may have up to four supply priorities. For example, a household toilet demand could be given a first priority of rainwater tank supply and a second priority given to mains water; in this scenario if the rainwater tank were to empty, mains water would be used to meet the demand.

A summary of the scenarios investigated is presented in Table 2-6. The supply priorities used in each scenario are presented in Table 2-7 to Table 2-14.

Table 2-6 Modelling Scenarios

Scenario	Description
#1	• Mains supply for all demands.
#2	• Mains supply + 5kL rainwater tank for household toilet, laundry and garden. • Mains supply for sports field and public space irrigation
#3	• Mains supply + 10kL stormwater harvesting tank for household toilet and garden. • 10kL Stormwater harvesting tank for sports field and public space irrigation
#4	• Mains supply + 10kL stormwater harvesting tank for household toilet and garden + 5kL rainwater tank for household laundry. • 10kL Stormwater harvesting tank for sports field and public space irrigation
#5	• Mains supply + 5kL rainwater tank for household toilet, laundry and garden. • 10kL Stormwater harvesting tank for sports field and public space irrigation
#6	• Mains supply + 5kL stormwater harvesting tank for household toilet and garden. • 5kL Stormwater harvesting tank for sports field and public space irrigation

#7	• Mains supply + 5kL stormwater harvesting tank for household toilet and garden + 5kL rainwater tank for household laundry. • 5kL Stormwater harvesting tank for sports field and public space irrigation
#8	• Mains supply + 5kL rainwater tank for household toilet, laundry and garden. • 5kL Stormwater harvesting tank for sports field and public space irrigation
#9	• Mains supply + recycled water for household toilet and garden. • Recycled water for sports field and public space irrigation
#10	• Mains supply + recycled water for household toilet and garden + 5kL rainwater tank for laundry. • Recycled water for sports field and public space irrigation
#11	• Mains supply + 5kL rainwater tank for household toilet, laundry and garden. • Recycled water for sports field and public space irrigation

Table 2-7 Scenario #1 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Mains	
Household Laundry	Mains	
Household Leaks	Mains	
Garden Irrigation	Mains	
Sports Field Irrigation	Mains	
Public Space Irrigation	Mains	

Table 2-8 Scenario #2 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Rainwater Tank	Mains
Household Laundry	Rainwater Tank	Mains
Household Leaks	Mains	
Garden Irrigation	Rainwater Tank	Mains
Sports Field Irrigation	Mains	
Public Space Irrigation	Mains	

Table 2-9 Scenario #3 and #6 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Stormwater Harvesting	Mains
Household Laundry	Mains	
Household Leaks	Mains	
Garden Irrigation	Stormwater Harvesting	Mains
Sports Field Irrigation	Stormwater Harvesting	Mains
Public Space Irrigation	Stormwater Harvesting	Mains

Table 2-10 Scenario #4 and #7 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Stormwater Harvesting	Mains
Household Laundry	Rainwater Tank	Mains
Household Leaks	Mains	
Garden Irrigation	Stormwater Harvesting	Mains
Sports Field Irrigation	Stormwater Harvesting	Mains
Public Space Irrigation	Stormwater Harvesting	Mains

Table 2-11 Scenario #5 and #8 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Rainwater Tank	Mains
Household Laundry	Rainwater Tank	Mains
Household Leaks	Mains	
Garden Irrigation	Rainwater Tank	Mains
Sports Field Irrigation	Stormwater Harvesting	Mains
Public Space Irrigation	Stormwater Harvesting	Mains

Table 2-12 Scenario #9 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Recycled Water	Mains
Household Laundry	Mains	
Household Leaks	Mains	
Garden Irrigation	Recycled Water	Mains
Sports Field Irrigation	Recycled Water	Mains
Public Space Irrigation	Recycled Water	Mains

Table 2-13 Scenario #10 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Recycled Water	Mains
Household Laundry	Rainwater Tank	Mains
Household Leaks	Mains	
Garden Irrigation	Recycled Water	Mains
Sports Field Irrigation	Recycled Water	Mains
Public Space Irrigation	Recycled Water	Mains

Table 2-14 Scenario #11 – Supply Priorities

	Supply Priority	
Demand	**First**	**Second**
Household Tap	Mains	
Household Toilet	Rainwater Tank	Mains
Household Laundry	Rainwater Tank	Mains
Household Leaks	Mains	
Garden Irrigation	Rainwater Tank	Mains
Sports Field Irrigation	Recycled Water	Mains
Public Space Irrigation	Recycled Water	Mains

3 RESULTS

The results from modelling each of the 11 scenarios, with both historical and predicted climate change metrological data, are presented in Table 3-1, Table 3-2, Figure 3-1 and Figure 3-2.

Table 3-1 Results – Supply Volume Per Household Per Year

	Supply Volume (kL/household/year)							
	Historic Meteorological Data				Climate Change Meteorological Data			
Scenario	Mains	RWT*	SW*	RW*	Mains	RWT*	SW*	RW*
#1	268.16	0.00	0.00	0.00	268.16	0.00	0.00	0.00
#2	211.43	56.73	0.00	0.00	212.29	55.86	0.00	0.00
#3	130.94	0.00	137.41	0.00	131.39	0.00	136.76	0.00
#4	100.82	30.12	137.22	0.00	101.39	30.00	136.76	0.00
#5	114.14	56.73	97.29	0.00	115.22	55.86	97.07	0.00
#6	152.93	0.00	115.22	0.00	153.75	0.00	114.40	0.00
#7	122.82	30.12	112.22	0.00	123.75	30.00	114.40	0.00
#8	124.98	56.73	87.45	0.00	125.30	55.86	87.01	0.00
#9	117.34	0.00	0.00	150.82	117.34	0.00	0.00	150.82
#10	87.22	30.12	0.00	150.82	87.33	30.00	0.00	150.82
#11	110.18	56.73	0.00	101.25	111.04	55.86	0.00	101.25

*RWT=Rainwater Tank, SW=Stormwater Harvesting, RW=Recycled Water

Table 3-2 Results – % Reduction in Mains Supply Volume Per Household Per Year

	% Reduction in Mains Supply	
Scenario	Historic Meteorological Data	Climate Change Meteorological Data
#2	21.2%	20.8%
#3	51.2%	51.0%
#4	62.4%	62.2%
#5	57.4%	57.0%
#6	43.0%	42.7%
#7	54.2%	53.9%
#8	53.4%	53.3%
#9	56.2%	56.2%
#10	67.5%	67.4%
#11	58.9%	58.6%

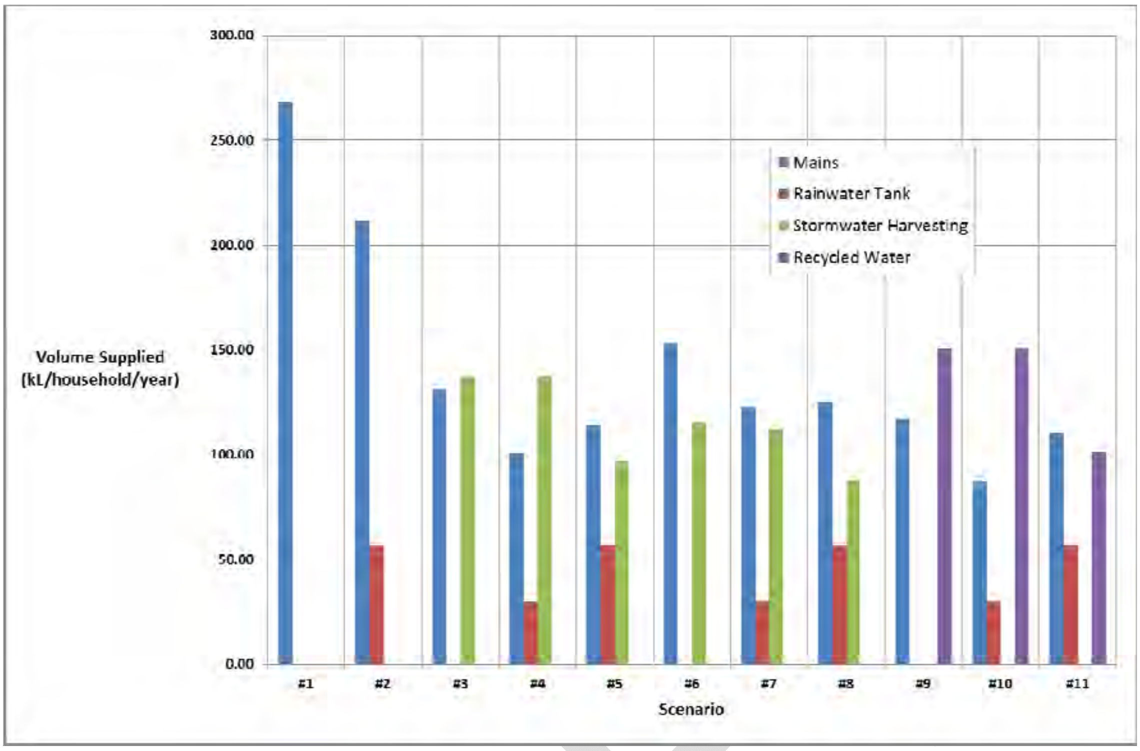

Figure 3-1 Annual Household Water Consumption

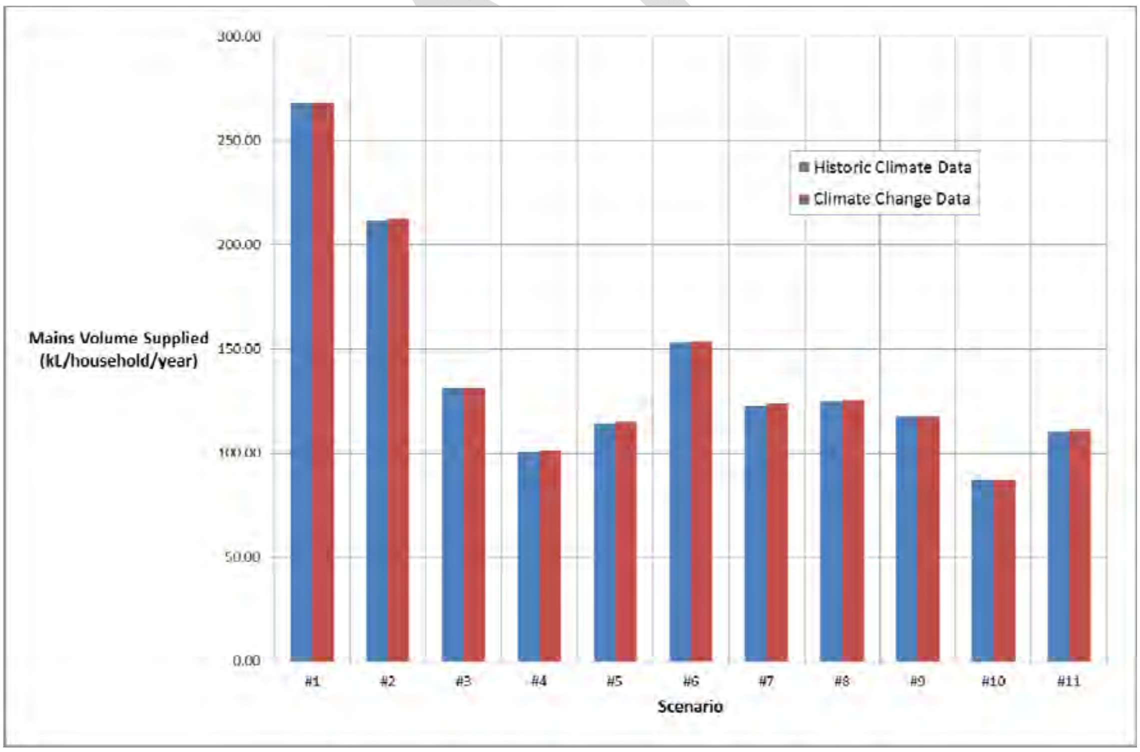

Figure 3-2 Annual Household Mains Water Consumption with Climate Change

From the results the following observations can be made:

- The total annual water consumption from the household and public space irrigation was 268.16 kL.
- The least amount of mains water consumed occurs in scenario #10, where mains are supplemented by recycled water for the toilet and garden, and a rainwater tank is used for the laundry. Public open space irrigation uses recycled water as a priority. In this scenario mains water consumption reduced by 67.5% per year.
- The climate change metrological data had an impact only on the scenarios that relied upon rainfall for the alternative water supply i.e. rainwater tanks and stormwater harvesting. This was due to the annual reduction in rainfall from climate change.
- The larger infrastructure schemes (stormwater harvesting and recycled water) produce the largest reductions in mains water use (more than 40%).
- Doubling the size of the stormwater harvesting tank from 5kL (scenarios #6, #7 and #8) to 10kL (scenarios #3, #4 and #5) only resulted in an extra 8.2% reduction in mains supply.

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