



AN INTEGRATED SUPPLY DEMAND PLANNING (ISDP) MODEL FOR PERTH

Client Report to WA Government

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WATER FOR A HEALTHY COUNTRY

National Research Flagship



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TABLE OF CONTENTS

1.	INTRODUCTION.....	11
1.1	Background to the model	11
1.2	Objectives of this report.....	11
1.3	Scope of the Perth Metropolitan model	12
2.	THE INTEGRATED SUPPLY DEMAND PLANNING (iSDP) BASE MODEL	15
2.1	The Perth iSDP model structure	15
2.2	End Use Data Availability	15
2.3	Choice of June 2000 reference date	16
2.4	Population Estimates.....	16
2.5	Residential Water Consumption	17
2.6	Bores	21
2.7	Rainwater Tanks	22
2.8	Non-Residential Water Demand	23
2.9	Non-Revenue Water.....	23
2.10	Comparison of Demand Predictions based on the iSDP Model with the current Demand Prediction method	24
2.11	Water Restrictions.....	29
2.12	Waterwise Rebates.....	31
3.	NEW WATER EFFICIENCY/DEMAND MANAGEMENT OPTIONS.....	33
3.1	Introduction.....	33
3.2	Residential Options.....	34
3.2.1	Residential indoor (existing households).....	35
3.3	Residential (new households)	36
3.4	Residential other sources	37
3.4.1	Tariff reform	37
3.5	Non Residential Options	38
3.5.1	Non residential (existing properties).....	39
3.5.2	Non residential (new properties).....	41
3.6	Non revenue water (system losses).....	41
3.6.1	Leakage detection and pressure reduction programs	41
3.7	Comparison of Water Efficiency/Demand Management Options	42
4.	MAJOR SUPPLY OPTIONS IN THE MODEL.....	49
4.1	Overview	49
4.2	South West Yarragadee.....	52

4.3	A second desalination plant	52
4.4	Kimberley options.....	53
4.4.1	Ocean transport	53
4.4.2	Canal	53
4.4.3	Piping	54
4.5	Water trading - Harvey	54
4.6	Water trading - Collie	55
4.7	Eglinton groundwater.....	56
4.8	Yanchep groundwater	56
4.9	Gingin groundwater	56
4.10	Gnangara groundwater - pine thinning and removal	56
4.11	Brunswick Dam	57
4.12	Catchment management – Wungong and other catchments	57
4.13	Wastewater reuse – Managed Aquifer Recharge.....	57
4.14	Wastewater reuse – industry	58
5.	SUPPLY AND DEMAND OPTION CASE STUDIES FOR PERTH METROPOLITAN AREA	59
5.1	Summary of Demand and Supply Side Options	59
5.2	Overview of Case Studies	60
5.3	Option Case Studies – Planning for Perth’s Water Future	62
5.3.1	CASE STUDY 1	62
5.3.2	CASE STUDY 2	64
5.3.3	CASE STUDY 3	66
5.3.4	CASE STUDY 4	68
5.4	Summary of Case Studies	71
6.	DATA GAPS AND RESEARCH NEEDS	73
6.1	Data gaps.....	73
6.1.1	Domestic Water Use Study post restrictions.....	73
6.1.2	Sub-division and housing trends	73
6.1.3	Bore numbers and use trends	74
6.1.4	Non-revenue water.....	74
6.1.5	Supply-demand prediction in non-urban areas.....	74
6.1.6	Breaking down per capita consumption figures.....	74
6.2	Research needs.....	74
6.2.1	Impact and cost effectiveness of BASIX, METRIX and RETROFIX	74
6.2.2	Washing machine and dishwasher efficiencies.....	75
6.2.3	Influencing behaviour / adoption	75
6.2.4	Industrial and commercial demand management studies.....	76
6.2.5	Price elasticity of demand for water in its various uses	76
6.2.6	Uncertainty and risk in supply systems.....	76

7.	CONCLUSIONS AND RECOMMENDATIONS.....	79
7.1	Conclusions.....	79
7.2	Recommendations.....	79
8.	REFERENCES.....	81
APPENDIX 1	INTEGRATED RESOURCE PLANNING PRINCIPLES	83
A1.1	Definition and principles.....	83
A1.2	The gap.....	84
A1.3	The options.....	86
A1.4	Selection of options.....	87

LIST OF FIGURES

Figure 1.1	Geographical Area covered by the iSDP Model	13
Figure 2.1	Perth Metropolitan Population Growth rate (ABS 2003; Department of Planning and Infrastructure 2005).....	17
Figure 2.2	Perth Metropolitan Occupancy Ratio (Department of Planning and Infrastructure 2005)	17
Figure 2.3a	A comparison of end uses by non-bore owners and without water restrictions in 2000 as estimated by the Domestic Water Use Study (left) and by the iSDP model (right)	18
Figure 2.3b:	Modelled residential scheme and groundwater use for properties with a garden bore (using baseline end use data for 2004/05).....	19
Figure 2.3c:	Modelled residential water use in 2005 for properties without a bore during the two-day-per-week sprinkler restrictions period (from modeled data for 2004/05).	20
Figure 2.3d:	Modelled residential water use in 2005 for properties without a bore assuming no sprinkler restrictions (from modeled data for 2004/05).	20
Figure 2.4	Distribution of Perth IWSS Water Consumption in 2004/2005.....	23
Figure 2.5.	Modelled non-revenue water for 2004/05	24
Figure 2.6	Baseline demand forecast from the iSDP model compared with the 155 and 170 kL/person/year	25
Figure 2.7	Baseline demand forecast disaggregated to major sectors (residential, non-residential and non-revenue water) with Source Development Plan data overlain for comparison	26
Figure 2.9	Comparison of current and projected baseline demand and baseline system yield assuming no new sources beyond Desalination Plant #1 and Harvey Water Trading	28
Figure 3.1	Ranked Water Efficiency/Demand Management Options	47
Figure 3.2	Supply Curve for Water Efficiency/Demand Management Options	48
Figure 5.1	Demand - Supply Balance for Case Study 1 (demand side options shown in detail)	63
Figure 5.2	Demand - Supply Balance for Case Study 1 (supply side options shown in detail)	63

Figure 5.3	Expenditure profile for Case Study 1 (includes agency, government and customer expenditure)	64
Figure 5.4	Demand / Supply Balance for Case Study 2 (details of demand side options)	65
Figure 5.5	Demand / Supply Balance for Case Study 2 (details of supply side options)	65
Figure 5.6	Expenditure profile for Case Study 2 (includes agency, government and customer expenditure)	66
Figure 5.7	Demand / Supply Balance for Case Study 3 (details of demand side options)	67
Figure 5.8	Demand / Supply Balance for Case Study 3 (details of supply side options)	67
Figure 5.9	Expenditure profile for Case Study 3 (includes agency, government and customer expenditure)	68
Figure 5.10	Demand / Supply Balance for Case Study 4 (details of demand side options)	69
Figure 5.11	Demand / Supply Balance for Case Study 4 (details of supply side options)	70
Figure 5.12	Expenditure profile for Case Study 4 (includes agency, government and customer expenditure)	70
Figure A.1	Supply/Demand deficit.....	84
Figure A.2	Managing the Supply/Demand deficit.....	86
Figure A.3	Data requirements and IRP boundary	87

LIST OF TABLES

Table 2.1	Summary of estimated and actual demand reduction associated with water restrictions.	30
Table 2.2	Estimated water savings from historical records (Water Corporation) and from end use modelling (iSDP model) as a result of two day per week sprinkler restrictions	31
Table 2.3	History of the Rebate Program.....	31
Table 3.1	Options Summary.....	43
Table 4.1	Potential future water sources considered for inclusion in the Source Plan for the IWSS (Water Corporation April 2005)	50
Table 4.2	Allocation to irrigation from surface water resources in the State's southwest (Water Corporation 2005).....	54
Table 5.1	Summary of option packages considered in Case Studies	61

1. INTRODUCTION

1.1 Background to the model

The integrated Supply Demand Planning (iSDP) model described in this report has been developed in response to three main needs:

- The State Water Strategy (Government of WA 2003) requires the government to use the Integrated Resource Planning (IRP) approach within the allocation and licensing process to drive appropriate consideration of, and appropriate investment in, conservation measures;
- Any new water supply from the Kimberley region needs to be placed in context with other supply and demand management options in the South West of the state. These other options were outlined in a report to the Kimberley Panel in 2005 (McFarlane 2005) but the comparison needs to be quantitative using levelised costs to the community for the supply and demand options; and
- The method currently used to estimate future drinking water demands for the Integrated Water Supply Scheme (IWSS) is relatively simple (population growth times per capita consumption) and does not transparently account for factors that may make future consumption patterns different than in the past.

The type of end use model that would meet these three needs was outlined in a report to the Kimberley Expert Panel (McFarlane *et al.* 2005).

The integrated Supply Demand Planning (iSDP) model was recommended in the report because it brought together four key components of the supply / demand balance:

- Current allocation/yield/supply/water availability;
- Projection of baseline water demand requirements (the reference case or “business as usual” water demand);
- Options to increase water availability (supply side options); and
- Options to manage demand (demand side options).

In addition it brings together the costs of the broad spectrum of options considered and the associated benefits using a consistent boundary and assumptions to enable direct comparison.

1.2 Objectives of this report

Section 2 of this report details the iSDP base case and compares the current demand prediction with one based on a more detailed understanding of the factors underpinning demand. Because the base case is based on year 2000 conditions, it also estimates the impact of introducing the two-days-per-week sprinkler restrictions on demand in late 2001 and the rebate scheme that was introduced in February 2003 and revised in June 2005.

A number of realistic demand management options are detailed in Section 3. Some options were not included because they were considered either uncompetitive or there was inadequate information to properly model them.

The major water source options available to the south west are summarised in Section 4. These include the Kimberley options of a canal, pipeline and ocean transport.

The capability of the model is demonstrated in Section 5 through four case studies. These are used for illustrative purposes only and no definitive conclusions can be drawn from them in terms of future supply and demand management options.

In carrying out the modelling a number of data gaps and research needs were identified. These are summarised in Section 6 to guide future work programs, including that carried out by the Water for a Healthy Country Flagship within CSIRO.

Section 7 brings together the conclusions and recommendations in the understanding that this is the first application of a detailed supply and demand planning model produced within a tight timeframe.

The modelling capability will allow water planners to continually refine and compare options as better data become available.

1.3 Scope of the Perth Metropolitan model

The dataset used by the iSDP comes from the billing suburbs within the Perth Metropolitan area extending as far South as Rockingham and as far North as Yanchep (Figure 1.1).

In the near future it is expected that the Mandurah and Pinjarra billing areas will be added and eventually the Goldfields and Agricultural Water Scheme (GAWS). However the data on factors affecting water demand in areas is less well known and there is not the urgency to include them at this early stage of modelling.

The metropolitan model covers about 586,500 domestic services, 54,000 industrial and commercial services and 1,484,300 people as at June 2005. It therefore covers three-quarters of the state's population.

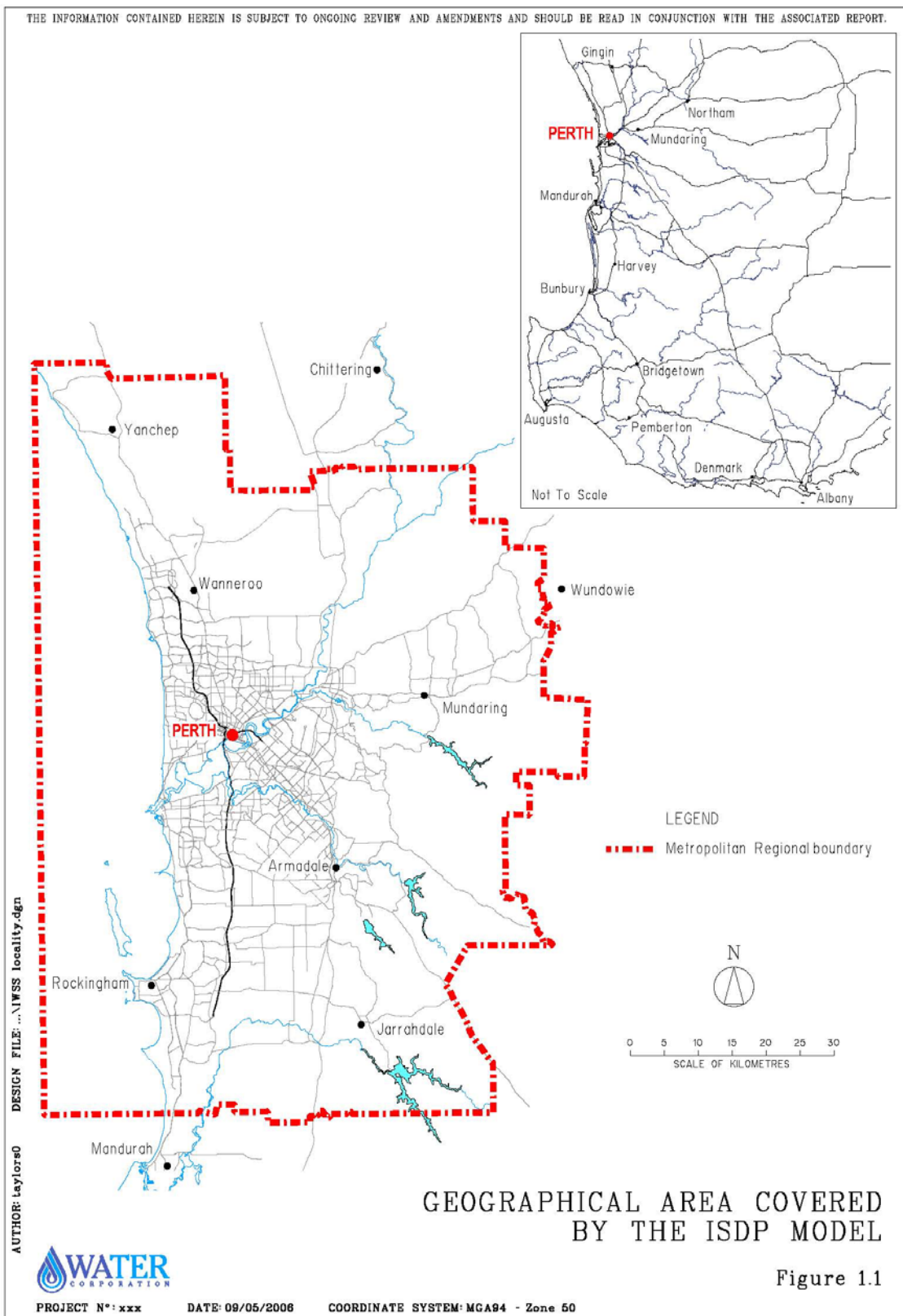


Figure 1.1 Geographical Area covered by the iSDP Model

2. THE INTEGRATED SUPPLY DEMAND PLANNING (iSDP) BASE MODEL

An End Use Model (EUM) was evaluated by the Corporation in 2004 and found to be potentially useful for comparing supply and demand options for the Integrated Water Supply Scheme (IWSS). As part of this project the EUM was re-titled as an integrated Supply Demand Planning (iSDP) model because the new name better encompasses the main application of the model, with end use estimates being a component only. The name change was approved by the model's custodian, the Water Services Association of Australia (WSAA).

This chapter outlines the structure of the iSDP model for the Perth region, how the baseline demand model is configured and how the model was calibrated.

2.1 The Perth iSDP model structure

The Integrated Water Supply System can be split into four demand regions:

- Perth Metropolitan;
- IWSS (South West Region) – including Mandurah and Pinjarra;
- Goldfields and Agricultural Water Scheme (Agricultural Region) [G&AWS (AR)]; and the
- Goldfields and Agricultural Water Scheme (Goldfields Region) [G&AWS (GR)]

The water consumption in the Perth Metropolitan area is significantly larger than the other three regions. End use knowledge for this area is also significantly greater than those for the other three regions. This is due to the fact that there have been two domestic water use studies carried out (Water Authority of WA 1987; Loh and Coughlan 2003) as well as a Domestic Water Use Survey carried out by the Australian Bureau of Statistics (ABS 2003).

Therefore, it is possible to model water consumption based on residential end use for the Perth Metropolitan region. Because 78% of water used in the region is by the residential sector it is important to model residential end use with some accuracy.

The IWSS (SWR) may have similar information to enable a more detailed modeling of end use demands at a later stage. However, due to the lack of information for the G&AWS (AR) and G&AWS (GR), only sectoral demand can be modeled for these regions. The Great Southern Towns Water Scheme (GSTWS) is another supply system that could be modeled at a future time. Finally, the method could be applied to the many disconnected supply systems in rural and regional areas, although the effort would need to justify the expense.

2.2 End Use Data Availability

A domestic water use study (DWUS) for the Perth Metropolitan area was carried out by the Water Corporation between 1998 and 2003 (Loh and Coughlan 2003). The study collected end use and consumption information for around 120 single residential households from November 1998 to June 2000 and for around 120 multi-residential households from September 2000 to November 2001. In addition, end use

(but not consumption) information for 600 single residential households and 173 households was also collected.

End use data collected from the DWUS include the following:

- Ex-house usage:
 - Watering – type of reticulation system installed and frequency of watering; and
 - Swimming pools.
- In-house usage:
 - Washing machines;
 - Showers;
 - Toilets;
 - Taps;
 - Dishwashers;
 - Spas;
 - Evaporative air conditioning systems; and
 - Other water consuming devices.

Similar end use information was collected in the 1980 DWUS study (Water Authority 1985) although the collection methods were different from that of the 1998 – 2000 study (Loh and Coghlan 2003). The early study however provided a good early reference point for the calibration of the iSDP model.

The Australian Bureau of Statistics (ABS) carried a survey in October 2003 on domestic water use for Western Australia (ABS 2004). This report also provided relevant end use information for calibrating the iSDP model.

2.3 Choice of June 2000 reference date

Supply and demand variables are constantly changing so for modelling purposes it is important to designate a reference date from which a “business-as-usual” case can be estimated, with the impacts of all subsequent changes being compared with this case.

The 1998-2000 DWUS was carried in the Perth Metropolitan area just prior to the introduction of two-days-per-week sprinkler restrictions in October 2001. The end use and consumption information from the study could therefore be used to derive a baseline demand scenario for the Perth Metropolitan area in the absence of restrictions. With the detailed end use and service consumption information available for 2000, an accurate calibration of the model could be carried out and therefore June 2000 was chosen as the model’s reference date.

2.4 Population Estimates

The past population for the Perth Metropolitan area was estimated using ABS information (ABS 2003) while future population growth was based on housing growth information from the Department of Planning and Infrastructure (2005) as shown in Figure 2.1. Using these data the metropolitan population is expected to reach 2 million in 2026.

The house occupancy ratio for the Perth Metropolitan area, as estimated by the Department of Planning and Infrastructure (2005) is currently about 2.5 but is predicted to decline to about 2.25 by 2040 (Figure 2.2).

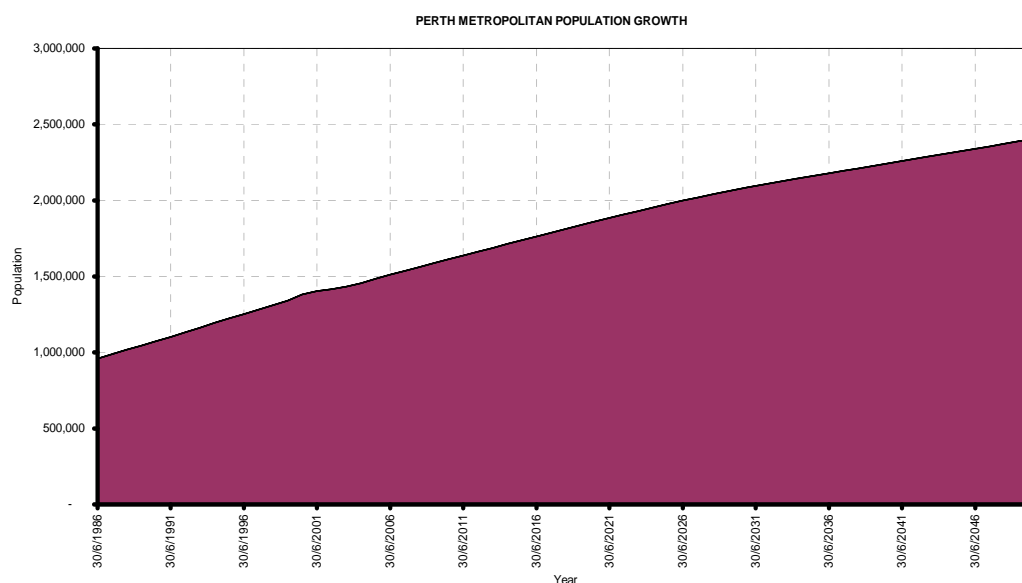


Figure 2.1 Perth Metropolitan Population Growth rate (ABS 2003; Department of Planning and Infrastructure 2005)

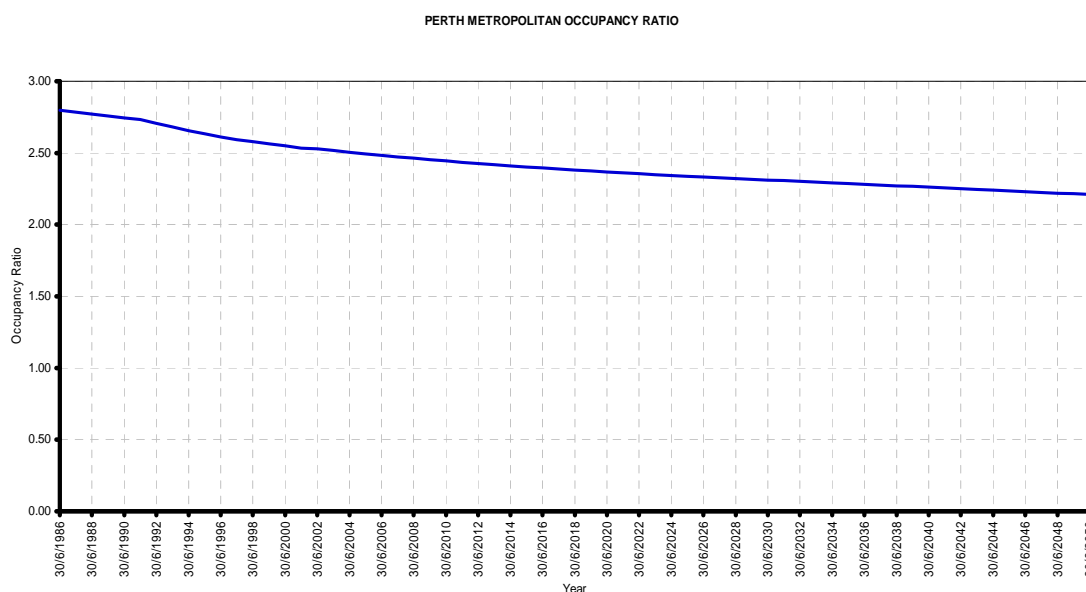


Figure 2.2 Perth Metropolitan Occupancy Ratio (Department of Planning and Infrastructure 2005)

2.5 Residential Water Consumption

The annual residential consumption for the Perth Metropolitan area was estimated from the Grange database (Water Corporation) between 1994/95 and 2004/05.

Information prior to that period was obtained from Annual Reports from the Water Authority of Western Australia between 1985/86 to 1993/94.

Residential water consumption is made up of end use components for both single and multi-residential households. It is important to separate the end uses of different types of residential households because of significant differences in the composition of the end use components. Data from 2000 were used as the calibration point.

Based on the DWUS 1998 – 2000 study, the residential end uses in 2000 were estimated to be as shown in Figure 2.3a. The iSDP model was used to generate the end uses shown in Figure 2.3b.

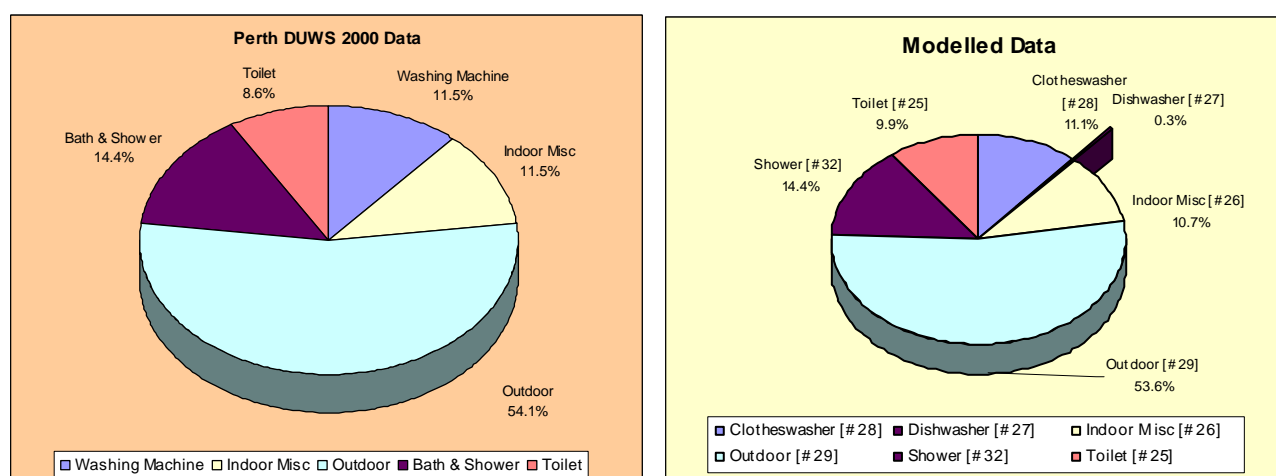


Figure 2.3a A comparison of end uses by non-bore owners and without water restrictions in 2000 as estimated by the Domestic Water Use Study (left) and by the iSDP model (right)

The percentage difference between measured consumption of a sample of homes and modelled consumption for all residential homes are small (maximum difference is 1.3% for toilets) with most differences probably being due to:

- Households picked for the DWUS were older households which may have lower outdoor water use characteristics than ones still establishing lawns and gardens; and
- The average occupancy rate of single residential households in the DWUS survey was 3.35 while the average for the Perth metropolitan area was 2.88 per households.

The iSDP model was also used to estimate end uses of scheme and groundwater for single residential bore-owners (Figure 2.3b) and to estimate end uses of scheme water only under two-day-per-week restrictions for non-bore owners (Figure 2.3c).

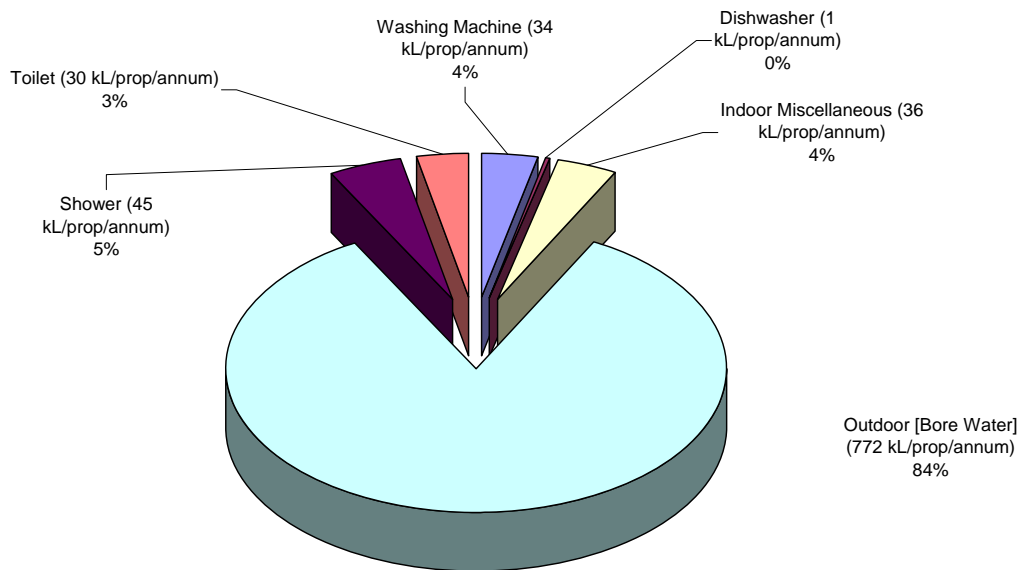


Figure 2.3b: Modelled residential scheme and groundwater use for properties with a garden bore (using baseline end use data for 2004/05)¹.

Figure 2.3b shows the dominant role of groundwater use for those properties with bores. This picture, while developed using baseline demand data, is not expected to vary considerably during periods of restrictions.

For properties without a bore in 2005, the effect of two-days-per week sprinkler restrictions was modeled and found to be significant through a reduction in lawn and gardening water (compare Figures 2.3c and 2.3d). A saving of 87 kL/household/annum in outdoor use has been calculated through the implementation of the two-day-per-week sprinkler ban. Outdoor use drops from 57% of total residential water consumption to only 40% as a result of restrictions. As will be shown later, this drop has resulted in an annual savings of over 48 GL/yr in scheme water use in the IWSS.

¹ As discussed in Section 2.6, estimates of bore water usage in the residential sector varying greatly – a simple assumption has been used in the iSDP model of bore water use being twice the volume of scheme water for lawn and garden watering. The resulting figure is within the range of numbers presented in Section 2.6.

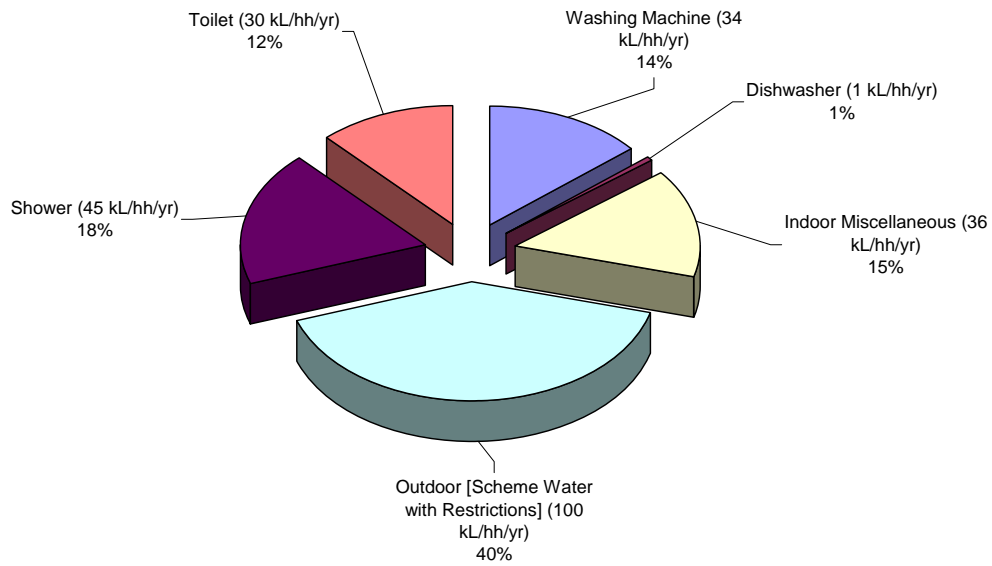


Figure 2.3c: Modelled residential water use in 2005 for properties without a bore during the two-day-per-week sprinkler restrictions period (from modeled data for 2004/05).

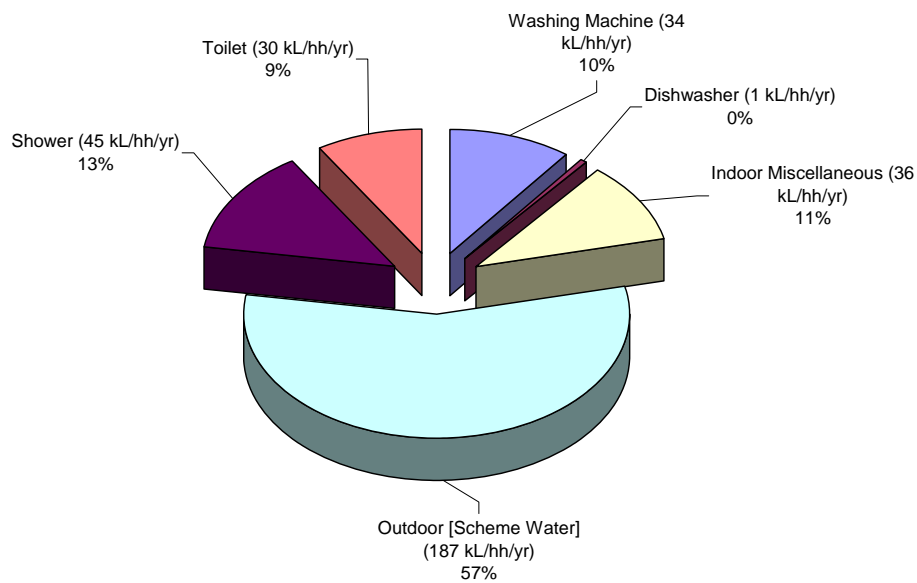


Figure 2.3d: Modelled residential water use in 2005 for properties without a bore assuming no sprinkler restrictions (from modeled data for 2004/05)².

² Figure 2.3d is presenting similar data to Figure 2.3a – the differences in percentages for some end uses (notably outdoor) across the short interval of time covered by these two charts is due to the outdoor component being adjusted in both cases to ensure that the modelled total water demand matches the actual demand for those two years.

2.6 Bores

Data collected from the 1998 – 2000 DWUS indicated that approximately 32% of the single residential households had private bores at that time. The total number of bores in Perth was estimated to be about 135,000 in 2003 (ABS 2004) with about 4,400 bore subsidies being issued each year for urban bores on the Swan Coastal Plain since the rebate scheme was introduced in February 2003. The DoW estimate there are 149,000 urban bores in 2006 using about 119GL/yr (Alex Kern pers. comm.). Some installers of bores have not claimed a rebate so the total number cannot be estimated from subsidies alone.

Based on historical data for households (recorded in the Water Corporation's Grange database), the estimated scheme water reduction that takes place after a bore is installed in a single residential household before water restrictions were introduced in 2001 was 280 kL/annum.

A recent analysis of the reduction of scheme water use after installation of a bore following a subsidy being received has indicated that only about 116 kL/property/yr is saved. This is much less than the 280 kL/property/yr, possibly because:

- People have reduced their garden watering after being on two-days-per-week restrictions and have continued to apply less water even through they have a bore; and
- Most urban blocks are now much smaller, and houses much larger, resulting in a reduced garden area requiring watering.

The amount of groundwater used by the households with a bore is likely to be much more than the reduction in scheme water use for the following reasons:

- Bore owners can irrigate any day of the week but not between 9am and 6 pm. It is likely that most bore owners water between 3 and 7 days a week compared with twice a week for scheme water users under Stage 4 restrictions;
- Often bores produce more pressure than scheme supplies resulting in larger volumes being irrigated per unit time;
- Almost all bore owners use automatic reticulation systems which are known to increase water use;
- Because there are no charges related to the volumes applied (only the small cost of electricity to operate the pump) there is less financial incentive to reduce water use; and
- Many bore owners have larger gardens and grow more water sensitive plants because of their access to their own water supply.

The number of bore subsidies has declined from 5 to 8,000 per annum in the first two years to about 3,000 in the third year. It may be surmised that many owners of large blocks concerned about the impact of a complete sprinkler ban have already installed bores and the market for new bores is concentrating in new urban development areas.

Various estimates have been made of bore water consumption. These range up from 500 (Lieb and Brennan 2006) to 1060 kL/bore /year (Aquaterra 2000). The

Department of Water has adopted 800 kL/yr as an average use, based on their calibration of the PRAMS model amongst other factors (A. Kern pers. comm.).

Groundwater levels under Perth are poorly monitored at present but recent reports by Lindsay (2004) and Smith *et al.* (2005) have shown that levels are in slow decline in many areas and more rapid decline in a few areas.

Smith *et al.* (2005) showed that the ten-year trend in mean freshwater thickness beneath about 14% of the metropolitan area was stable; beneath 41% was falling; and beneath 45% could not be determined due to a lack of groundwater level data. Areas with a rising trend were less than 1% of the study area.

Declining trends in aquifer storage were most evident in the northern coastal strip (especially near the Whitfords, Quinns and Neerabup borefields); central part of Gnangara Mound and in the region of the Gwelup and West Mirrabooka borefields. Storage appears to have been mostly stable around the East Mirrabooka borefield and in the Swan-Canning Estuary environs, including the southern-most part of Gnangara Mound, Cloverdale Mound and northern Jandakot Mound. The pattern of storage change in the central part of Jandakot Mound was less consistent and exhibited both falling and stable trends. Storage in the Serpentine Area has been mostly stable but there is a likelihood of seawater intrusion as a result of storage decline in the Safety Bay Mound and the Stakehill Mound.

Given these findings, it was decided to:

- Keep track of groundwater extraction levels in the iSDP model as this represents a very important complementary resource to scheme water (much as rainwater tanks are in some Australia cities); and
- Estimate the impact of a partial failure of this water source on scheme demand through the iSDP model.

For the impact assessment, suburbs at risk from bore failure were chosen. They represent potential salt water intrusion north and south of Rockingham and the Mosman Peninsula. Potential groundwater pollution was modelled around the recent release of arsenic that was trapped in peaty soils prior to disturbance and oxidation in the Stirling area (Appleyard *et al.* 2004).

Using the Water Corporation Grange database an estimate of bore ownership was obtained for the selected suburbs. It was assumed salt water penetration would be a progressive event occurring over a five years period whereas groundwater contamination from arsenic would occur instantly across the whole suburb.

From the model it was estimated that some 14,000 houses could be affected with a need to increase scheme water supply to those houses by an extra 2.1 GL/annum rising to 5.4 GL/annum after the five year period.

2.7 Rainwater Tanks

The Domestic Water Use Survey (Loh and Coghlan 2003) estimated that 4.6% of the households in Perth Metropolitan had a rainwater tank. Over 8000 subsidies have been offered for rainwater tanks since February 2003 but this represents only 3.5% of

the funds allocated, indicating that many consumers do not believe that they are a cost effective method of saving water. Less than half of the rainwater tank subsidies are being taken up in the Perth metropolitan area, possibly because alternatives to roof runoff are available. Calculations by Loh (2005) have indicated that rainwater tanks are not cost effective for most metropolitan households due to the prolonged dry summers when water demand is highest in Perth.

2.8 Non-Residential Water Demand

Non-residential consumption can be categorized into:

- Services – including commercial, hospitality, institutions, offices etc.
- Industry;
- Mining;
- Irrigation;
- Stock; and
- Parks and gardens.

At this stage, there is no end use information for the non-residential sector. This sector accounts for approximately 22% of the total water consumption in Perth (Figure 2.4). One of the demand management strategies being pursued by the Water Corporation is to target the top 100 non-residential consumers.

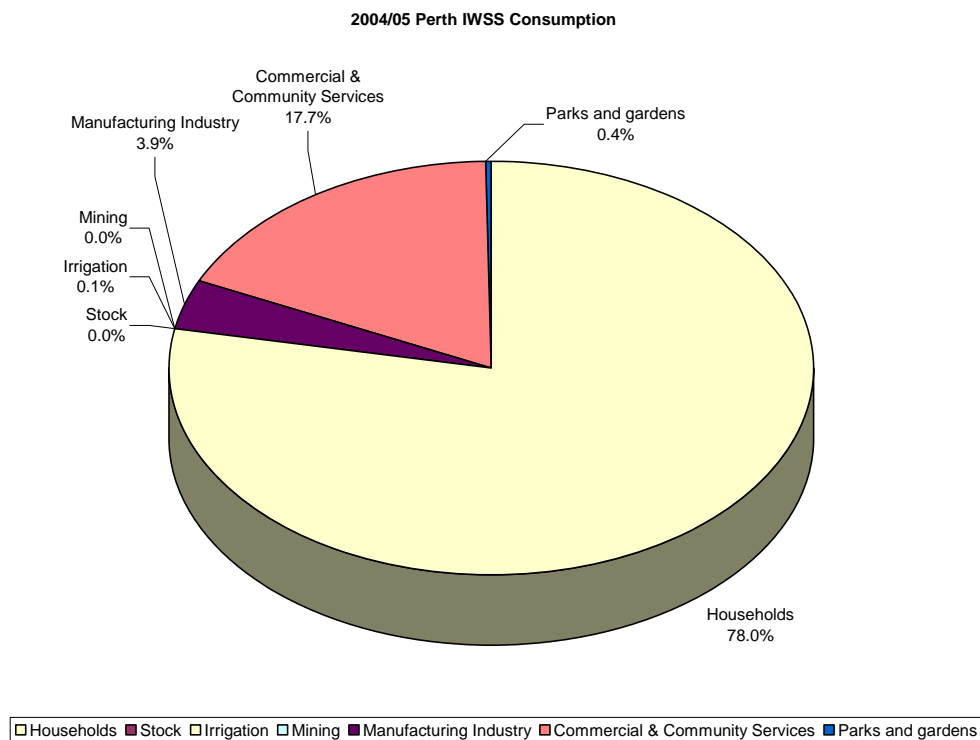


Figure 2.4 Distribution of Perth IWSS Water Consumption in 2004/2005

2.9 Non-Revenue Water

Non-revenue water represented 8.9% of the total water supplied for Perth in 2004/2005 (actual data). This includes leakage, water used by the Water Corporation in its water and wastewater plants, and water provided as a public service (eg firefighting). Until recently, some water used on building sites was not metered. The iSDP model estimated non-revenue water as 8.3% which is considered an adequate calibration given the uncertainty surrounding this volume (Figure 2.5).

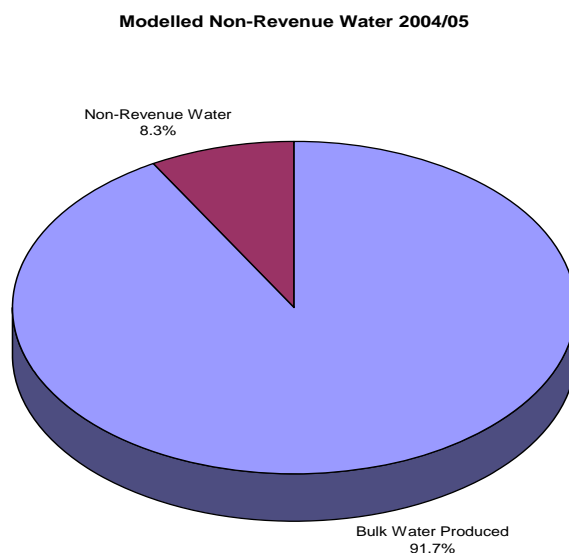


Figure 2.5. Modelled non-revenue water for 2004/05

The proportion of water in the different non-revenue categories within the model is only a guide. Further investigations are needed to define the non-revenue water components of the International Water Association's (IWA) 'best practice' standard water balance. The key components in the IWA approach are:

- Unbilled Metered Consumption
- Unbilled Unmetered Consumption
- Unauthorised Consumption
- Customer Metering Inaccuracies
- Leakage on Transmission and /or Distribution Mains
- Leakage and Overflows at Utility's Storage Tanks
- Leakage on Service Connections up to Point of Customer Metering

More work is also required to calculate leakage indices that can be compared across jurisdictions so that accurate benchmarking can take place.

2.10 Comparison of Demand Predictions based on the iSDP Model with the current Demand Prediction method

Calculation of the baseline demand forecast represents the starting point for assessment of the water supply/demand balance. The purpose of the forecast is to

estimate future water use requirements in the absence of direct intervention by the water utility or government agencies that would alter water use characteristics. In this way the baseline captures the effect of factors such as changing population, shifts in urban development trends and changes in appliance efficiency (eg through new technologies) on demand. Often referred to as ‘Business as Usual’ or ‘Do Nothing’ forecast, the baseline demand forecast defines a reference point for comparison with supply availability. Using this reference, the number and combination of supply-side and demand-side options required to manage the demand- supply balance can begin to be assessed.

Average per capita water demand slowly decreased in the Perth region between the mid-1980’s and 2000 as shown in Figure 2.6.

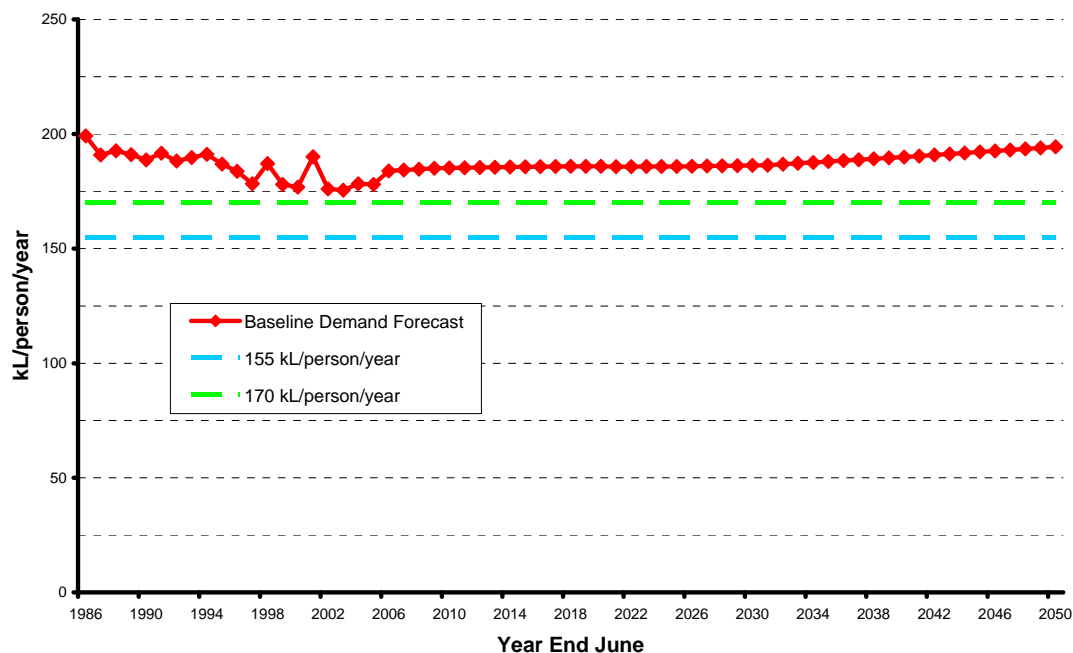


Figure 2.6 Baseline demand forecast from the iSDP model compared with the 155 and 170 kL/person/year

The iSDP Baseline Forecast predicts demand climbing marginally to 188 kL/person/year by 2035 (Figure 2.6). This level of demand is essentially equivalent to the projection adopted by the 2001 Source Development Plan of 185 kL/person /yr (Water Corporation, 2001). Comparatively, this level of demand is 11% higher than the 170 kL/person/year and 21 % higher than the 155 kL/person/year demand management scenarios used in the 2005 Source Development Plan (Water Corporation, 2005). Further analyses, outlined later, explores possible reasons for this slow increase in per capita demand.

When viewed as total demand, it is evident that water use in Perth is projected to increase rapidly into the future (Figure 2.7). Through to 2050, the population of the Perth metropolitan area is expected to grow to approximately 2.4 million (Figure 2.1). So while average per capita unrestricted demand is anticipated to remain fairly constant (Figure 2.6), population growth is a major factor driving up total water requirements for the Perth Metropolitan Area.

The iSDP model provides a framework for exploring the sub components within the demand projection to provide an increased understanding of the drivers of demand. The first step is to investigate which sectors are primarily responsible for the anticipated demand increase.

Figure 2.7 shows demand forecasts for the residential, non-residential and non-revenue water sectors as developed in the iSDP model. Overlain on this Figure are six demand projections based around the Source Development Plan’s 155 (high efficiency) and 170 kL/person/yr (medium efficiency) demand assumptions and three ABS population projections (low, medium and high).

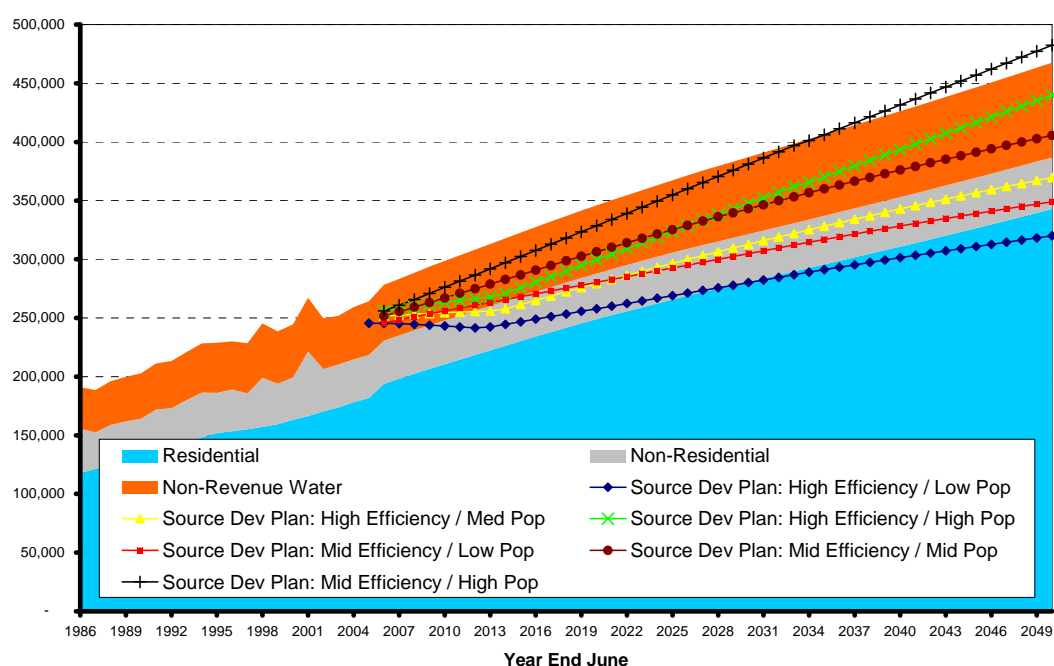


Figure 2.7 Baseline demand forecast disaggregated to major sectors (residential, non-residential and non-revenue water) with Source Development Plan data overlain for comparison

From Figure 2.7, the Baseline demand forecast developed by the iSDP model most closely approximates the medium efficiency/high population growth scenario used in the Source Development Plan (Water Corporation, 2005). Given that the iSDP model uses the mid-range population growth estimate and an unrestricted demand (185 kL/person/yr), its estimate of future demand is greater than the Source Development Plan’s mid-range efficiency (170 kL/person/yr) estimate (Figure 2.6). Importantly, the difference between the mid- and high-range population estimates in approximately 80 GL in 2050 for the medium efficiency assumption.

Figure 2.7 also shows that while non-residential revenue water use (ie commercial and industrial) is projected to increase using iSDP model assumptions, it is the residential sector that has the greatest impact on the overall water use requirements for Perth. Therefore, in seeking to determine the drivers behind the slow increase in per capita water demand estimated by the model in Figure 2.6, it is the residential sector that warrants additional investigation.

Further analyses can be undertaken using the iSDP model to provide an end use breakdown of baseline water demand within the residential sector and identify likely trends for water use at this end use level. Figures 2.3d and 2.8 present an end use breakdown of baseline water demand for the residential sector for 2005 and 2035.

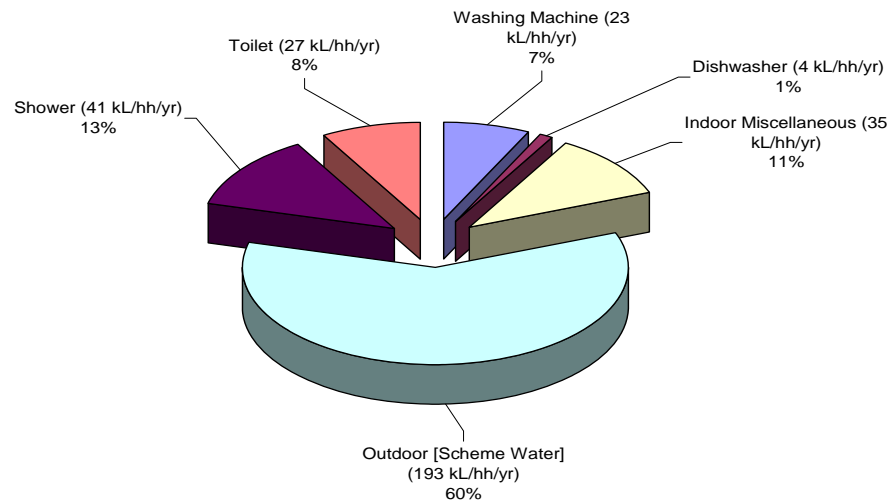


Figure 2.8 An end use breakdown of baseline residential water demand in 2035

A key trend that is evident from these figures is the increasing proportion of outdoor water use in the absence of restrictions. Water use associated with washing machines is estimated to decrease from 8 to 5% by 2035 due to a sustained shift to more efficient machines which are assumed to dominate the market by 2035. Other key indoor residential uses show little proportional change moving forward to 2035.

In developing the model components for each residential end use, information was collected and analysed for a particular sets of appliances and fixtures. In the case of the toilet end use model component, there have been some changes occurring in the market place since this study was commissioned. Caroma have released a 4.5 / 3 litre dual flush toilet and anticipate that sales of this product will soon outpace the 6 / 3 litre dual flush toilet. It is recommended that further analyses be conducted using the iSDP model to assess the sensitivity of the baseline demand forecast to the introduction of more water efficient products such as 4.5 / 3 litre toilet from Caroma.

Whether the five per cent increase predicted in the proportion of water used outdoors actually eventuates by 2035 will depend on factors such as average lot sizes (currently decreasing in new developments) and house sizes (currently increasing) resulting in proportionally smaller garden areas. In addition, some new developments may have community bores, greywater systems or third pipe schemes which would reduce the use of drinking water used on lawns and gardens. However, lower occupancy rates may increase proportional outdoor use per household. The iSDP model can be used to help predict the cumulative or separate impacts of these factors on end uses.

The average yield from existing water sources supplying the Perth metropolitan area was de-rating in 1996 and again in 2004 (Figure 2.9). These de-ratings were due to a step reduction in rainfall and runoff in 1976 and again in 1998. The baseline

projection of yield includes new augmentations³ carried out in response to the poor runoff year in 2001 and the first desalination plant (2007) and Harvey Water trading as part of the baseline yield projection. Issues such as climate change and the potential for further de-rating of the yield are not considered as part of the Baseline – this analysis is conducted during the development of case studies as discussed in later sections of this report.

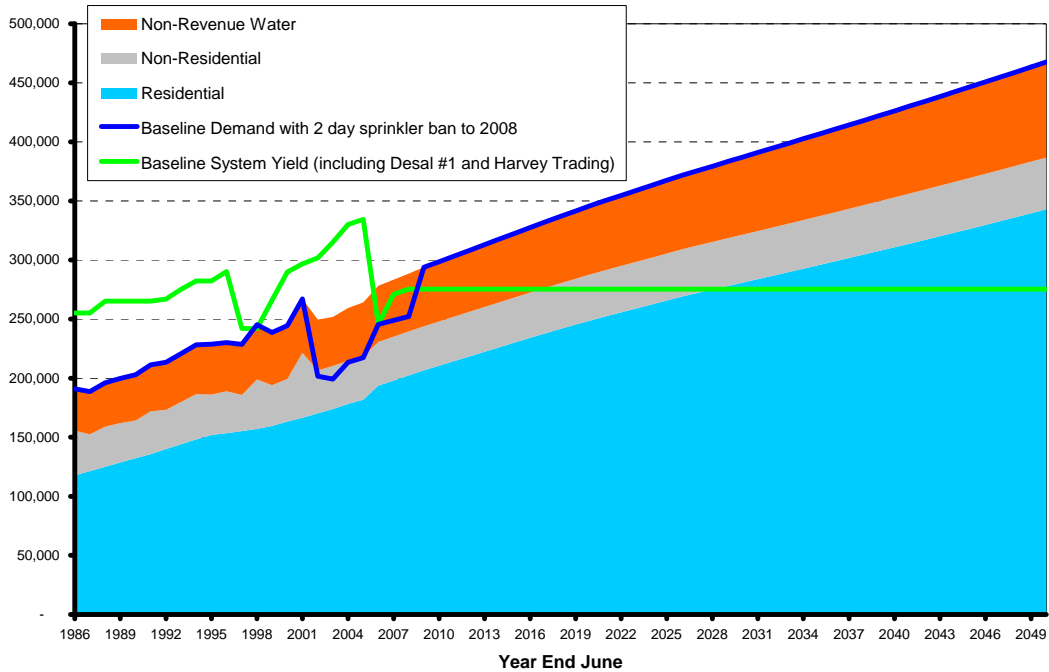


Figure 2.9 Comparison of current and projected baseline demand and baseline system yield assuming no new sources beyond Desalination Plant #1 and Harvey Water Trading

While available supply has been boosted in recent years with new sources coming online, there have also been two de-rating events that have seen a reduction in yield from sources. Water restrictions are assumed to remain in place for a few years, but as soon as they are lifted, demand is projected to outstrip supply. The gap between demand and supply is projected to increase into the future unless additional sources are commissioned. The baseline supply - demand balance shown in Figure 2.9 is based on a number of growth assumptions which are outlined below.

Growth

The role of population growth underpinning the increase in demand was highlighted in earlier sections of the report. A secondary, but compounding issue is the decline in occupancy ratios for Perth. A reduced occupancy ratio indicates that a greater number of dwellings will be required to house an equivalent population. From a water use perspective, this will result in an increase in total water required for an equivalent

³ These included the Samson and Wokalup Dams, three deep Yarragadee bores under Perth, extension of the West Mirrabooka Wellfield and some coastal bores. In some cases these new sources were offset by a failure to use existing wellfields due to environmental constraints. Therefore the mix of sources may change while the system yield may not rise to the extent expected.

population as there are a number of end uses of water that increase as occupancy rates fall; outdoor water use being the major one.

Strong population growth offers opportunities with residential design to significantly enhance the water efficiency of homes. With a large number of dwellings being constructed, there is considerable scope to make an impact on total water demand in the future. While many other areas of Australia are not witnessing such high growth in percentage terms, Perth is an example where incorporating water efficiency in new urban development would have a significant impact on the region's total water use.

2.11 Water Restrictions

Background

A key factor affecting the supply side of the demand - supply balance is the level of water restrictions.

Historically, water restrictions in Perth were triggered by the amount of water in the hill's reservoirs. However in the 1990s the proportion of scheme water supplied from groundwater passed dam sources and from late 2006 desalinated water will supply about 17% of unrestricted demand. The reduced reliance on surface water will continue if the SW Yarragadee aquifer becomes a future water source and runoff into the reservoirs further decrease due to climate change (and is not offset by catchment thinning).

Currently an agreed reduction in groundwater extraction occurs if / when hill's reservoir levels recover. The social and economic impacts of restrictions and the environmental impacts of groundwater extraction, all affect whether restrictions are introduced or relaxed. Therefore there is no longer a simple trigger at which restrictions are imposed or reduced.

In the case of the Perth system, the different restriction levels and estimated savings are listed in Table 2.1.

Table 2.1 Summary of estimated and actual demand reduction associated with water restrictions.

Restriction Level	Sprinkler use allowed	Estimated Demand Reduction (GL)	Actual Demand Reduction (GL)
3	3 times per week	35	Not assessed
4	2 times per week	45	48.3
6	Hand held hoses only	70	Not assessed
7	No outdoor water use	100	Not assessed

Impact of two-days-a-week sprinkler restrictions

Water restrictions limiting sprinkler use to two days per week were introduced in September 2001 to reduce the outside water use of domestic customers. The restrictions apply to the entire IWSS.

Prior to the restrictions being introduced, the Water Corporation estimated that the annual saving would be about 45 GL/annum for the Perth Metropolitan area. There had been no previous experience with two day a week sprinkler restrictions so this amount was not certain.

Using a method adopted by the Water Corporation's Infrastructure Planning Branch, 46 to 51 GL/yr savings were achieved in the first two years, after which the base level was reduced, making the estimated savings during the next two years to be only 38 to 43 GL/yr (Table 2.2). The iSDP model estimates savings to have been between 45.9 and 52.6 GL/yr over the four year period because the comparisons are made with the June 2000 base case with provision for demand growth due to population growth. The iSDP estimates are therefore more indicative of actual savings compared with pre-restriction demand.

There was anecdotal evidence that some people started making permanent changes to their water demand, especially by reconfiguring their gardens and installing bores (demand was reported by irrigation companies to have doubled following the introduction of restrictions and the \$300 / bore subsidy).

Table 2.2 Estimated water savings from historical records (Water Corporation) and from end use modelling (iSDP model) as a result of two day per week sprinkler restrictions

Year	Estimated savings – Water Corporation (GL/annum)	Estimated Savings from iSDP model (GL/annum)	Difference between the methods (GL/annum)
2001/02	46.2	47.9	+1.7
2002/03	51.4	52.6	+1.2
2003/04	37.4	45.9	+8.5
2004/05	38.2	46.9	+8.7
Average of four summers	43.3	48.3	5.0

2.12 Waterwise Rebates

The state government introduced a rebate scheme for products that would reduce scheme water demand in February 2003. Rebates are available for many water saving devices including approved washing machines, showerheads, garden bores, rainwater tanks, tap timers, soil wetting agents, in-flow tap regulators, greywater re-use systems, aerobic treatment units, swimming pool covers, subsurface irrigation pipework, rain sensors and Waterwise garden assessments. Many of the approved items must a specified efficiency rating as classified by the Water Services Association of Australia (WSAA).

The rebates applied to purchases completed after the start dates as shown in Table 2.3.

Table 2.3 History of the Rebate Program

Type of rebate	Start date
Washing machines	11 February 2003 to present
Showerheads	
Garden bores	
Rainwater tanks	
Greywater re-use systems	November 2003 to present
Aerobic treatment units	
Tap timers	11 February 2004 to present
Soil wetting agents (SWA)	
In-flow tap regulators	
Swimming pool covers	1 July 2005 to present
Subsurface irrigation pipe work	
Rain sensors	
Waterwise garden assessments	

Rebate data collected by the Water Corporation indicated that the following subsidies were not very popular:

- Aerobic Treatment Units
- Greywater Re-use Systems
- In-tap flow regulators
- Rain sensors
- Waterwise Garden Assessments

The impact on water consumptions from these rebate scheme were therefore not included in the iSDP model.

The savings for most items have been assessed from reduced scheme water consumption after a rebate had been claimed (DAA 2006). These modelled savings have been used in the iSDP model to estimate the impact of the rebate program on future demand.

3. NEW WATER EFFICIENCY/DEMAND MANAGEMENT OPTIONS

3.1 Introduction

The water efficiency/demand management options identified in this section refer to a suite of options that consider the potential for water savings in a range of sectors (i.e. residential, non residential and non revenue water) and key end uses (e.g. indoor uses such as showers, toilets and washing machines and outdoor uses such as garden watering). In designing such options, a central consideration is that a reduction in water use through water efficiency/demand management does not imply a reduction in the level of service. The options that are reviewed in this section of the report seek an improvement in the efficiency of the use of water while maintaining, or potentially enhancing, the level of service to the customer.

Water efficiency/demand management options can be categorised by the sectors and end uses they are targeting and by the instruments or combination of instruments used in their implementation (e.g. economic, communicative, regulatory). The relative significance of the various end uses of water has already been identified for the Perth Metropolitan area in Section 2. The options identified below take into consideration the key end uses and have been chosen to highlight the range of options available for key end uses and the types of instruments or implementation pathways available. As such, the options rely on a range of stakeholders to enable implementation over a number of years.

The options have been considered both for existing and for new properties. For example, rebates and retrofits which combine economic and communicative instruments are generally used to target existing properties, while regulatory instruments often aim to target new properties and to lock in the savings associated with retrofits and rebates.

The suite of options covered does not consider all end uses or the full conservation potential available. The options highlight typical participation rates that could be achieved through a moderate water efficiency/demand management program over a period of about five years commencing in 2006/07. Where more water savings are required, higher participation rates can be achieved through more aggressive marketing and the provision of higher incentives.

The suite of options developed in this section draws on the options developed for the Water Corporation in 2005 (Turner *et al*, 2005) and are summarised as follows:

- Residential indoor (existing households)
 - Indoor residential retrofit (single residential and multi unit)
 - Indoor residential retrofit with cistern replacement (single households only)
 - Indoor residential retrofit with full toilet replacement (single households only)
- Residential outdoor (existing households)
 - Garden and irrigation tune up (single residential households)

- Residential (new households)
 - WA BASIX (single residential households)
 - Minimum Water Efficiency Performance Standards (MWEPS)
- Residential other sources
 - bore rebates (single residential households)
 - bore failure for single residential properties (NB this option leads to increased demand for scheme water)
- Residential other
 - Tariff reform
- Non residential (existing properties)
 - Top 100 business program
 - Business program (education sector)
 - Business program (hospitality sector)
 - Business program (office sector)
- Non revenue water (system losses)
 - Leakage reduction program
 - Pressure reduction program

3.2 Residential Options

As indicated in Section 2, 78% of current total demand is attributed to the residential sector with single residential households representing the single largest sector in terms of water demand. Unrestricted average demand of a single residential household connected to the IWSS is 333 kL/household/yr with 187 kL/household/yr of this being attributed to outdoor water uses (for those properties not using bores to access groundwater). The proportion of outdoor use varies greatly between households with and without garden bores as outlined in Section 2. Options considered have therefore focussed primarily on single residential households (whilst remaining equitable) and covered both key indoor and outdoor end uses. In some cases, such as washing machines, the rebates in the existing program have already achieved a high uptake and therefore such rebates have not been considered further as an option except in the case of a regulatory instrument (i.e. minimum water efficiency performance standards on new appliances).

3.2.1 Residential indoor (existing households)

The *indoor residential retrofit* program is similar to the program implemented by the Sydney Water Corporation (SWC) on over 300,000 houses to date and which has been evaluated (for single residential households) and found to save on average 21 kL/household/yr⁴. The retrofit involves offering residential customers a reduced cost or free water efficiency assessment by an experienced plumber. During the assessment the plumber may replace inefficient showerheads with AAA rated showerheads, install tap flow regulators on kitchen and bathroom basin taps and check and repair leaks where possible. The plumber would also provide leaflets on water efficiency around the home. Unlike the SWC program, the iSDP modelled option does not include the use of a cistern weight on single flush toilets. Hence the modelled savings of the retrofit program have been reduced compared to those found in Sydney and weighted for occupancy ratio in single residential households and multi units accordingly. Program savings could be increased and the unit costs of the option reduced if a toilet displacement device or cistern weight could be included in the program.

It is assumed that 20% of single residential households and 10% of multi units participate in the program over a 5 year period with estimated savings of 16 and 8 kL/household/annum respectively.

The *indoor residential retrofit program with cistern replacement (single residential households only)* provides opportunities for water efficiency improvements through modifications to the cistern only (i.e. replacing a proportion of large single flush toilets with 6 litre cisterns which do not require the pan to be replaced). A similar program *indoor residential retrofit program with full toilet replacement (single residential households only)* provides opportunities for water savings where single flush toilets can be replaced with the recently released 4.5/3 litre dual flush toilets, thereby providing higher savings potential.

In each case it has been assumed that 10% of single residential households participating in the *indoor residential retrofit program* would take up the offer of either a cistern or toilet replacement respectively. The purpose of modelling these two options separately is to assess the difference between the higher cost (and higher water savings) approach of complete replacement versus the lower cost (and lower water savings) associated with modifications to the cistern. The program has been limited to single households with higher occupancy ratios to maximise savings. Savings of 33 and 41 kL/household/annum have been estimated for single residential households (including the indoor residential retrofit) with cistern and toilet replaced respectively.

3.2.2 Residential outdoor (existing households)

⁴ An evaluation of the Sydney Water Corporation 'Every Drop Counts' program was carried out on 200,000 houses by the Institute for Sustainable Futures in 2003. Results showed on average a 21 ± 2.5 kL/household/yr saving for single residential houses. These savings take into consideration the fact that some houses had minimal fittings modified while others have all fittings modified and is therefore a conservative estimation of the potential savings available (Turner *et al.*, 2005).

Outdoor water use represents a large component of Perth's residential water use profile and with the proliferation of automated watering systems, there is significant scope for professional advice to enable householders to use water more efficiently outdoors without impacting on the amenity of their gardens.

The *garden and irrigation tune-up* (single residential households) aims to help householders to understand how to reduce outdoor water demand yet still maintain an aesthetically pleasing lawn and garden. Similar to the indoor retrofit programs, householders would be offered a visit by an experienced assessor at a reduced or zero cost. The assessor would complete an inspection of the lawn and garden with the householder and advise on the maintenance and use of the watering system in place, the seasonal watering regime of the plants in the garden, the use of mulch and discuss and provide leaflets on other water saving tips. The specialist would also provide (where appropriate) tap timers and other water saving devices and vouchers to the householder to a specified value (i.e. a \$50 voucher). To maintain savings, the program would need to provide additional vouchers and advice after the initial visit. An additional cost of a \$25 voucher every two years has been incorporated in the costing to assist in maintaining savings. Similar programs have been estimated to save approximately 20% of outdoor demand. In Perth this could provide a saving of approximately 77 kL/household/annum. Participation has been assumed to be 10,000 households per year over the next 5 years (approximately 17% of those single residential households connected to the IWSS).

This option would take advantage of and extend existing foundation work already in place in Perth (e.g. the *Garden Centre Program* and *Garden Irrigators Program*). The option has assumed that the tune up is restricted to customers without bores or rainwater tanks to ensure savings are being made to the IWSS. If deemed necessary the *single residential garden and irrigation tune up* could be extended to those households using bores to enable the yield of the aquifer to be 'shared' by additional users thereby enabling greater savings of potable water.

3.3 Residential (new households)

Similar to BASIX in NSW, the WA BASIX option is assumed to be a regulatory tool for new residential properties (that can be extended to major residential renovations) addressing the water efficiency of indoor and outdoor water demand. In this option all new Single Residential households will be required to attain at least a 25% improvement in water efficiency compared to an average household without bore or rainwater tank connection. Savings are assumed to be obtained through the installation of water efficient indoor fixtures and fittings such as showerheads, toilets, tap regulators and the use of drought-tolerant plants in the garden. Additional savings associated with the installation of a bore could be considered depending on the location of the property and the ability of the groundwater system to sustainably provide groundwater.

Minimum Water Efficiency Performance Standards (MWEPS) are a proposed regulatory framework setting minimum standards for the water efficiency of appliances at the national level. Regulatory options such as MWEPS are generally the most comprehensive, far reaching and cost effective means of securing appliance water efficiency. Although such standards can be imposed on a range of products such

as showerheads, toilets, taps, evaporative air conditioners and outdoor equipment, this option has been modelled for washing machines in isolation commencing from 2008. This is to minimise the potential for double counting of savings with other rebate programs. It has been assumed that the only washing machines in the marketplace beyond 2008 will be either 4A or 5A rated. Such a performance standard is currently being investigated by representatives of the Australian government previously involved in the voluntary water efficiency labelling scheme.

The option has been designed to cover all machine sales – that is, for the new and existing market. A critical assumption to this option is the projected rate of change to market penetration for 4A and 5A machines that is already occurring. The greater the rate of ‘natural’ adoption of these high efficiency machines by consumers, the less impact MWEPS will have. Indeed the current modelling used in the iSDP shows that the baseline for non water efficient machines essentially decreases to zero (in terms of market penetration) by 2030. As such, the water efficiency gains made by this regulatory initiative are only temporary (i.e. to 2030). Hence this option is effectively saving no water after 2030 according to the recent preliminary iSDP modelling. The baseline changes to the washing machine market have an important bearing on the effectiveness over time of this option as well as the baseline demand forecast. Hence further stock modelling using up to date sales data and sensitivity analysis of key assumptions will be required to refine this particular option. Notwithstanding this, this option still provides significant water savings at a low unit cost and should be taken forward for consideration at a national level.

3.4 Residential other sources

The *Single Residential bore rebate* aims to extend the existing *Bore Rebate Program* (currently a \$300 rebate per household connecting to a bore). It assumes that 20% of all bores installed can be linked to at least two households thus increasing the overall savings and reducing the costs for each bore installed. However, due to the high proportion of existing bores already in place even before the original *Bore Rebate Program*, this option also takes into consideration an underlying rate of purchasing bores (free riders) that detracts from the option savings. Assuming the bores are located in an area that does not cause detrimental effects to the local aquifers, savings of about 270 kL/hh/yr have been assumed (which may be optimistically high – DAA 2006).

Considering there are already a large proportion of bores in the Perth Metropolitan area and the effects of climate change and abstraction are unclear, a *Single Residential bore failure* option was modelled to estimate the effects of the loss of scheme water savings over time. As discussed in Section 2, it was estimated that some 14,000 houses could be affected with a need to increase scheme water supply to those houses by an extra 2.1 GL/annum rising to 5.4 GL/annum after the five year period.

3.4.1 Tariff reform

At present around 50% of the water bill paid by the average Perth consumer’s water bill is made up fixed charges, which is used to recover the revenue deficit associated with discounts on variable charges. Since the variable charge paid by the average

consumer is lower than the long run marginal cost, there is scope for reducing demand and improving efficiency of resource allocation by raising variable charges.

Brennan (2006) found that the potential for tariff reform to provide water savings from the residential demand sector could be around 9 percent per annum. Her model accounted for differences in water consumption and prices paid across the population according to household size and outdoor garden characteristics, increasing water prices from current levels to a flat rate of \$1.20 / kL (approximately the long run marginal cost). Her model assumes a price elasticity of -0.04 for indoor use and -0.30 for outdoor use (Table 3.1). She also found that associated with increased variable charges would be a reduction in fixed charges of around \$100 per household, and this would reduce overall water bills for those consumers with relatively low water use.

Table 3.1 Impact on household water demand of a price increase to \$1.20 / kL flat rate

Base case (no restrictions)	Base case demand (kL)	Demand after price increase (kL)	Change (kL)	Net change per household (%)
Indoor demand	138.30	134.14	-4.16	-3
Outdoor demand	178.97	155.98	-22.99	-13
Total demand	317.27	290.12	-27.15	-9

Brennan’s model was used to determine price response assumptions for the iSDP case study on tariff reform in iSDP, and the percentage change per household data shown in Table 3.1 was used to represent the case where there were no outdoor water restrictions. However, for the case study where tariff reform is used in combination with two-days-per-week sprinkler restrictions, assumptions had to be adjusted to account for the fact that the price impact on demand will be reduced as a result of restrictions. This is because water restrictions can override the consumers’ preferences for water consumption in some cases, and the net impact on demand is the combination of demand response to price changes and quantity restrictions on outdoor use (Table 3.2). In developing these assumptions, it was assumed that two-days-per-week sprinkler restrictions were assumed to reduce outdoor water use by about 20 kL per capita, with proportionately greater impacts for automatic reticulation systems.

Table 3.2 Impact on household water demand of a price increase to \$1.20 /kL flat rate under 2 days-per-week sprinkler restrictions

With restrictions	Base case demand (kL)	Demand after price increase (kL)	Change (kL)	Net change per household (%)
Indoor demand	138.30	134.14	-4.16	-3
Outdoor demand	151.37	139.43	-11.93	-8
Total demand	289.66	273.57	-16.09	-6

3.5 Non Residential Options

As indicated in Section 2, the current non residential demand represents 22% of total demand from the IWSS. This represents consumption by over 50,000 commercial, industrial and institutional customers. A preliminary assessment of customers in the customer water meter database was carried out to help design effective water

efficiency/demand management options for this sector. As found in many utility customer databases which were not designed for such purposes, the user classifications proved difficult to interpret and additional investigation of the database will be required to understand the conservation potential available and refine the options. The options presented here provide an indication of the kinds of options that could be implemented in Perth. The options concentrate on the top non residential water users and customer types that have properties with similar end uses thus making implementation of a program easier than non homogeneous customer types.

3.5.1 Non residential (existing properties)

Top 100 business program

Preliminary investigations indicate that the top 100 water using customers have a total current demand of over 17,000 ML/yr (173 ML/property/annum) representing nearly 40% of non residential demand. As such these customers represent a significant opportunity in terms of obtaining large water savings from a small number of customers.

This option would aim to extend the *Waterwise Business Program* currently being implemented by the Water Corporation. The program would involve a team of water conservation specialists engaging with large water using customers and identifying both structural and management modifications that can achieve specified and agreed targets following audits. As an incentive the costs of the audits and specialist advice would be provided free or at low cost to the customer. Water efficiency plans would then be developed with timelines for actions and significant economic incentives used to assist in structural modifications required, thereby minimising customer issues associated with payback periods. These incentives could be provided through a range of mechanisms including revolving loan funds where appropriate. In addition, the water specialists would maintain contact with the customers and provide ongoing advice including advice on measurement of savings attributable to the program. Measurement of savings could form a key performance indicator for any funds provided.

As a small number of these properties have already received some advice under the current *Waterwise Business Program* (although without major financial incentives to assist in structural modifications), the participation rate has been assumed to be 80% and potential savings for this program assumed to be 15%. This is a conservative estimate compared to typical large user non residential programs.

Business program (education sector)

From customer records, properties in the education sector currently use approximately 3,240 ML/a. Excluding the education sector customers in the top 100 users (using 660 ML/a), over 2,500 ML/a is used in this sector, providing significant conservation potential.

The ***business program (education sector)*** is similar to the ***top 100 business program*** in that it offers audits and subsequent retrofits of fixtures and fittings (e.g. toilets and showers) and advice on management practices (e.g. use and maintenance of indoor and outdoor water using equipment). It would also require plans to be developed and savings to be assessed on a regular basis. The program would aim to build on the relationships already developed with schools taking part in the ***Waterwise Schools Program*** that has been running since 1995, which has focused on student awareness of water efficiency rather than structural changes within the schools themselves (Turner *et al.* 2005: p26).

It has been assumed that 30% of schools would participate in the program over a three year period and save approximately 15% of their water demand. As for the ***top 100 business program***, these are relatively conservative savings compared to other areas that have implemented similar programs.

Business program (hospitality sector)

Recent records of the properties in the hospitality sector indicate that this sector uses approximately 2,860 ML/a. Excluding the properties already accounted for in the top 100 users (currently using 485 ML/a), approximately 2,400 ML/a is used in this sector, again providing significant conservation potential.

The ***business program (hospitality sector)*** would be similar to the other business programs described. Audits would be offered followed by retrofits of fixtures and fittings (e.g. toilets, showers), modifying equipment such as in-house laundry services (e.g. adding appropriate reuse units that enable particular rinse water to be recycled) and providing advice on management practices (e.g. outdoor watering and room, kitchen and laundry practices). As part of the program plans would need to be developed and assessed on a regular basis and the savings measured. Significant savings can be made in hotels and other motels and serviced apartments within the hospitality sector (e.g. Sydney Water, not dated)⁵.

Similar to the ***business program (schools sector)*** it has been assumed that 30% of the hospitality sector would participate in the program over a three year period and save approximately 15%. Again, these savings are considered relatively conservative compared to other areas that have implemented similar programs.

Business program (office sector)

⁵http://www.sydneywater.com.au/Publications/_download.cfm?DownloadFile=FactSheets/SavingWaterHotels.pdf

Recent total consumption in the office sector has been approximately 9,500 ML/a, representing over 20% of the demand in the non residential sector. Removing those properties already accounted for in the top 100 customers, leaves a demand of approximately 5,920 ML/a. This sector provides significant opportunities for conservation potential and implementation of a program that targets a specific customer type.

The *business program (office sector)* would again be similar to the other business programs described. Audits would be offered followed by retrofits of fixtures and fittings (e.g. toilets, showers, waterless urinals), modification of management practices of equipment such as cooling towers (e.g. Sydney Water, not dated)⁶ and provide general advice on management practices (e.g. outdoor watering, maintenance practices, ongoing detection of leaks). As with the other business programs, plans would need to be developed and assessed on a regular basis and the savings measured.

Similar to the other *business programs (schools sector)* and (*hospitality sector*) it has been assumed that 30% of the sector would participate in the program over a three year period and save approximately 15% of their water demand. Again, these savings are considered relatively conservative compared to other areas that have implemented similar programs.

3.5.2 Non residential (new properties)

An option for new non residential properties has not been modelled at this time as further analysis is required. As in the residential sector, a **WA BASIX** style program (e.g. *non residential development consent conditions*) could be rolled out which requires all new non residential properties to be made water efficient at the time of construction (i.e. using a regulatory instrument). Such a program could capture all new non residential properties and those being refurbished. Water savings of at least 25% could be assumed. The program could also potentially be linked to a similar energy reduction target depending on the regulatory authority administering the program. Considering the anticipated growth in the Perth metropolitan area, such a program could provide significant water conservation potential opportunities and should be investigated further.

3.6 Non revenue water (system losses)

3.6.1 Leakage detection and pressure reduction programs

Options associated with non revenue water have not been modelled at this time as further analysis is required with respect to the Water Corporation's IWA/WSAA leakage reporting figures, current annual real losses (CARL) and unavoidable annual real losses (UARL); refer to Section 2.9.

Significant water savings can often be made in non revenue water through *leakage detection and pressure reduction programs*. No specific leakage reduction program

⁶http://www.sydneywater.com.au/Publications/_download.cfm?DownloadFile=FactSheets/SavingWaterBestPractiveGuidelinesCoolingTowers.pdf

is currently in place in the Perth region and leakage reduction is carried out on a reactive basis. In addition, pressure reduction valves are currently located in the system for operational purposes but not specifically to reduce pressure. There has been significant research and major advances internationally in leakage reduction and pressure management since the late 1990s. Hence there is significant scope for both *leakage detection and pressure reduction programs* in the complex IWSS system and these should be investigated further.

3.7 Comparison of Water Efficiency/Demand Management Options

Table 3.1 summarises each of the options modelled in the iSDP model in terms of costs, savings, participation rate assumptions and risks associated with double counting of savings. The costs shown are total resource costs (i.e. the combined costs of government, the water utility and the customer). These total cost have been used to estimate the unit cost of each option for ranking the options in Figure 3.1.

Table 3.1 Options Summary

Option	PV Unit Cost (\$/kL)	Total PV Cost (\$ M)	Water Saved in 2010 ML/a	Water Saved in 2030 ML/a	Notes (participation rates/potential for double counting of savings)
Residential Indoor (existing households)					
Indoor residential retrofit (single residential & multi unit)	\$0.90	\$17.6 M	1,320	1,650	Option assumes approximately 22,000 household per annum are retrofitted. The duration of the option is 5 years.
Indoor residential retrofit with cistern replacement (single residential households only)	\$0.83	\$16.3 M	1,330	1,660	Option assumes approximately 18,000 single residential households are retrofitted per annum with 10% households able to have the cistern replaced in addition. The duration of the option is 5 years.
Indoor residential retrofit with full toilet replacement (single residential households only)	\$0.90	\$18.6 M	1,510	1,880	Option assumes approximately 18,000 single residential households are retrofitted per annum with 10% households able to have the cistern replaced in addition. The duration of the option is 5 years.
Residential Outdoor (existing households)					
Garden and irrigation tune up (single residential households)	\$0.38	\$20.5 M	2,470	3,090	Option assumes approximately 10,000 single residential households per annum have a garden tune-up that optimises their auto-retic systems. The duration of the option is 5 years.
Residential (new households)					
WA BASIX (single residential households)	n/a	n/a	2,020	21,160	Option assumes all new single residential properties have to comply with a WA BASIX scheme that sees high efficiency indoor appliances and a 25 % reduction in outdoor water requirements through water conservation initiatives at the design stage.
MWEPS	\$0.61	\$11.3 M	770	526	This option assumes the Minimum Water Efficiency Performance Standards are mandated in 2009 for clothes

Option	PV Unit Cost (\$/kL)	Total PV Cost (\$ M)	Water Saved in 2010 ML/a	Water Saved in 2030 ML/a	Notes (participation rates/potential for double counting of savings)
					washing machines. The savings decrease over time because there is an assumption built into the baseline for this component of demand that the clothes washing machine market will be dominated by high efficiency machines without the need for regulation in 30 or so years.
Residential other sources					
Bore rebates (single residential households)	\$1.27	\$243.4 M	5,220	13,050	Assumes 5,000 households per year install a bore (this excludes those who were already intending to install a bore) - either individual or shared. The duration of the option is 10 years.
Bore failure	n/a	n/a	[Additional water consumed in 2010]	[Additional water consumed in 2030]	Assumes bore failures in 4 high risk suburbs
Residential (other)					
Tariff reform	n/a	n/a	28,000	30,000	This option will potentially overlap with many of the other options listed. It is quite difficult to accurately separate the impact of a tariff reform option from other water efficiency measures.
Non residential (existing properties)					
Top 100 business program	\$0.41	\$10.5	2080	2080	Option assumes that 80 of the top 100 water using businesses will invest to utilise water more efficiency.
Business program (education sector)	\$1.55	\$2.4M	120	120	This option excludes any educational sector customers in the top 100 water users so there is no doubling counting between those two options
Business program (hospitality sector)	\$1.63	\$2.4M	110	110	This option excludes any hospitality sector customers in the

Option	PV Unit Cost (\$/kL)	Total PV Cost (\$ M)	Water Saved in 2010 ML/a	Water Saved in 2030 ML/a	Notes (participation rates/potential for double counting of savings)
					top 100 water users so there is no double counting between those two options
Business program (office sector)	\$1.04	\$3.6M	270	270	This option excludes any office sector customers in the top 100 water users so there is no double counting between those two options
Non residential (new properties)					
Non residential development consent conditions	n/a	n/a	n/a	n/a	Not modelled at this time
Non revenue water (system losses)					
Leakage detection program	n/a	n/a	n/a	n/a	Not modelled at this time
Pressure reduction program	n/a	n/a	n/a	n/a	Not modelled at this time

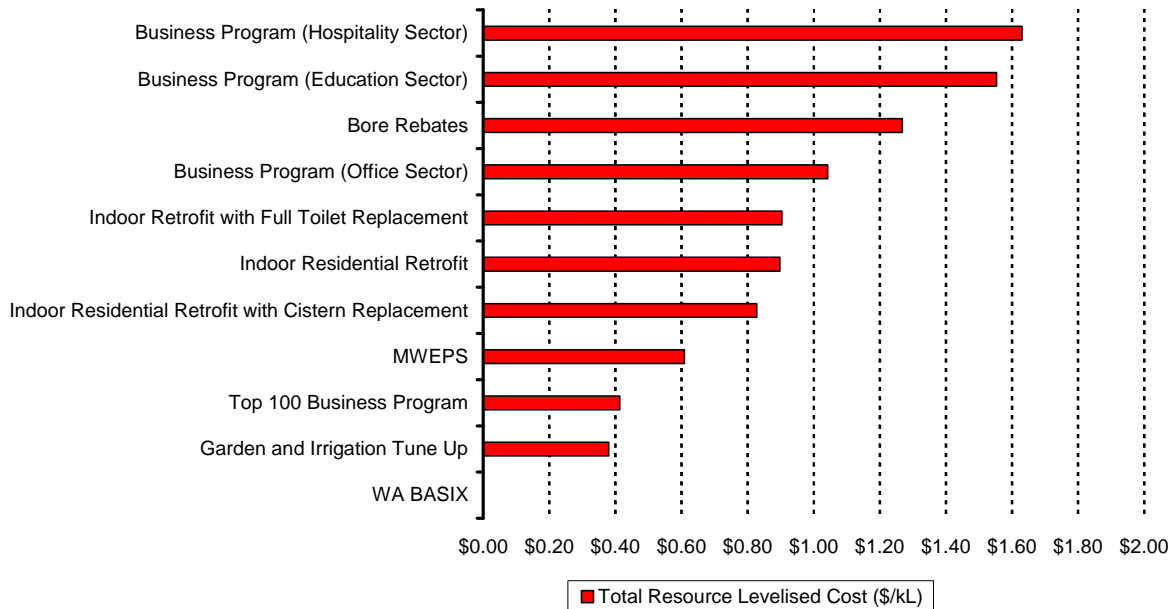


Figure 3.1 Ranked Water Efficiency/Demand Management Options

Figure 3.1 shows that the majority of the demand management options considered as part of this project are very cost effective from the perspective of reduction in scheme water demand when all costs are considered and assuming the levels of adoption mentioned in the sections above.

Three key options stand out from this listing.

- Top 100 Business Customers – targeting high water using business (primarily industrial) customers may be a highly cost-effective measure to reduce water demand. While other non-residential initiatives are considered, a strategy to address the highest water users first has met with much success elsewhere (eg Sydney’s EDC Business Program) and would appear to have significant potential in the context of Perth.
- Garden Tune Up – the results suggest that improving the efficiency of garden irrigation is one of the more cost-effective measures. The option was not considered in the Case Study section of this report due to overlap issues with permanent three-days-per-week sprinkler bans.
- Toilet retrofits – the options included in this report address cistern and whole toilet retrofits in concert with a more traditional retrofit program (showerhead replacement and leak repair etc). The results suggest that both the options considered are relatively cost-effective and highlights the potential value in revisiting some of the regulatory issues already mentioned regarding cistern replacement/modification in particular.

Using the Total Resource Levelised cost data from Figure 3.1, combined with data on the expected volume of water saved in 2030, it is possible to create a supply curve for demand management options (see Figure 3.2).

Eight demand management options are less than the estimated long run marginal cost (LRMC) of water supply (about \$1.20 / kL) when total resource costs are taken into account (ie customer, utility and government). Bore rebates (\$1.28/kL) exceed the LRMC may be cost effective for the utility and government, but the cost for each bore owner can be significant.

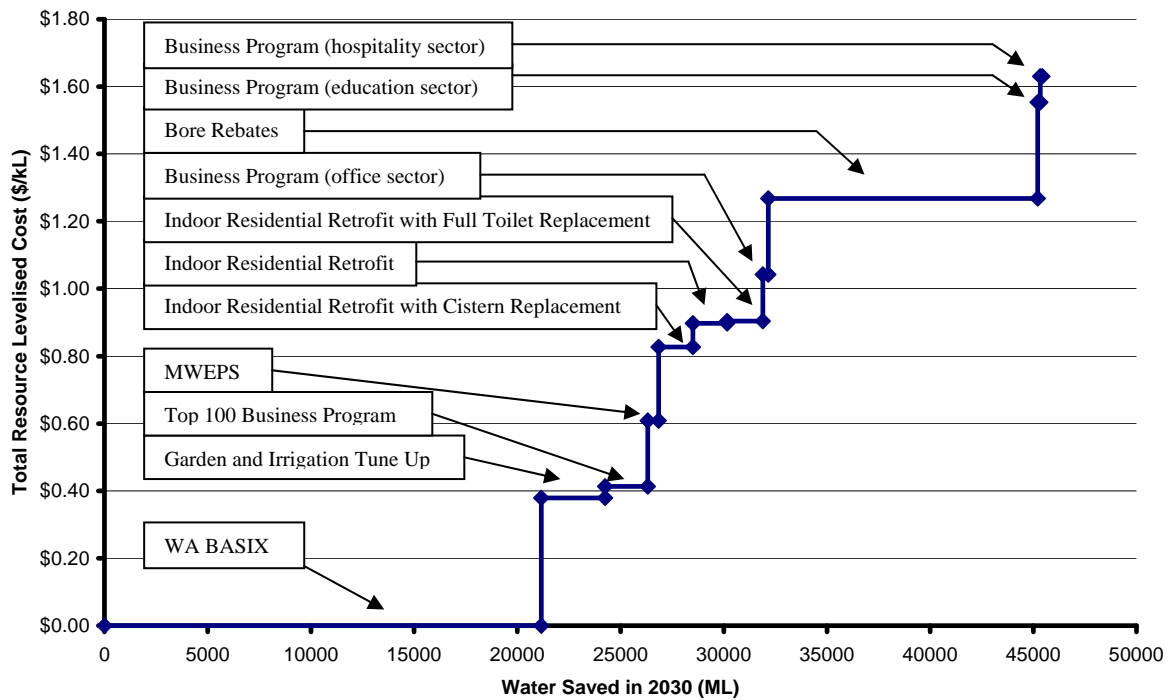


Figure 3.2 Supply Curve for Water Efficiency/Demand Management Options

4. MAJOR SUPPLY OPTIONS IN THE MODEL

4.1 Overview

This section provides background to the water sources that are evaluated in the iSDP model. Much of the material has been sourced from the IWSS Source Development Plan 2005-2050, produced by the Water Corporation in April 2005 (Table 4.1). Work has continued with further assessment and consideration of several of these source options. Water from the Kimberley is now included in the iSDP model as three options that have been developed by the current Kimberley Water Study. The latest information is included in the commentary for the selected sources. However, there are source options identified in Table 4.1 that still require considerable further work before they can be included in the iSDP model.

New sources in Table 4.1 that are not included in the iSDP model are:

- Seawater Desalination No1. – nearing completion;
- Groundwater options for Karnup/Dandalup– no definitive cost estimates and low level of confidence for development;
- Wellington Dam pumpback – now considering Wellington as a strategic source with greater development potential than a relatively small pumpback. There is currently no urgency for a pumpback for drought relief. The pumpback may be incompatible with a longer term development option and should not be considered in isolation. The most appropriate mechanism for future development of Wellington as a major water source is yet to be defined. Water quality issues remain a key factor to be resolved;
- Cloud Seeding – insufficient information available to quantify costs and benefits; and
- Drainage water and stormwater - insufficient information available to quantify costs and benefits.

Table 4.1 Potential future water sources considered for inclusion in the Source Plan for the IWSS (Water Corporation April 2005)

	Level of confidence	Source		Estimated yield (GL)		Indicative capital ^{1,2} cost (\$M at 2004/5)	Estimated operating ³ cost (c/kL at 2004/5)
				30 yr	8 yr		
SEAWATER DESALINATION	VERY HIGH	Seawater Desalination No 1		45		376 ⁴	40-44 ⁵
	HIGH	Seawater Desalination No 2	With station	power	45	514 ^{6,7}	36 ⁵
			Without station	power		424 ^{6,7}	56 ⁵
GROUNDWATER	HIGH	South West Yarragadee groundwater		45		383*	22
	MEDIUM	Eglinton groundwater		17	15	54 ⁸	23
	MEDIUM	Yanchep groundwater		11	9	33 ⁸	23
	LOW	Gingin groundwater		30	20?	439 ⁹	28 ⁹
	LOW	Karnup/Dandalup groundwater		up to 22	?		
	LOW	Gnangara groundwater – in Conjunction with land use changes (over 20 years)		20	15		20
SURFACE WATER	HIGH	Water trading – Stage 1: piping of Waroona & Harvey Irrigation Districts		18	17	134*	5 - 13
	MEDIUM	Water trading – Stage 2: piping of Collie Irrigation District		19	16	253*	26
	MEDIUM LOW	Wellington Dam		15 Up to 45	12 Up to 45	87* 3rd party funding*	35 60 (subject to verification)
		• Pumpback					
		• Desalination					
	MEDIUM	Catchment management - Wungong trial		6	5	R&D	25 NPV
LOW	Additional water trading – Change to land use or on farm practices to reduce irrigation water needs.		To be determined.		*		

	Level of confidence	Source	Estimated yield (GL)		Indicative capital ^{1,2} cost (\$M at 2004/5)	Estimated operating ³ cost (c/kL at 2004/5)
			30 yr	8 yr		
	LOW	Catchment management – other catchments	34	31	*	22 NPV
	LOW	Brunswick River	30 ¹⁰	25	275 ^{10,9}	12
	VERY LOW	Water from the Kimberley	300		11,000 ¹¹	35 ^{11,12}
	VERY LOW	Cloud seeding	Technical viability, yield benefit and cost subject to further investigation.			
WASTEWATER REUSE	LOW	Aquifer storage & recovery	20+ GL and growing		Subject to ongoing analysis.	
		Alternative supply to industry	25GL via KWRP & KWRP-type expansion			
RECYCLING	LOW	Drainage water and storm water	Technical viability, yield benefit and cost subject to further investigation			

- 1 The capital cost associated with source development is assumed to be the same regardless of yield reduction due to climate.
- 2 Unless otherwise stated, indicative cost estimates derived by escalation of planning estimates using Producer Price Index (Non-Residential Building Construction Index 4113 under General Construction Industry (a) Group and class indexes No 16). Corporate overheads have been applied to escalated cost estimates. Cost estimates for options with medium, low or very low levels of confidence will be reviewed as additional information becomes available and the source development concepts are defined with a greater degree of certainty.
- 3 Includes source operation costs only unless stated otherwise.
- 4 \$376M cost quoted for Desalination Plant No 1 is based on successful bid and expressed in \$2004/05. When costs are escalated for construction over the period 2004/5-2006/7, this equates to \$387M (in outturn \$). An additional \$24M (in \$2004/05) will be invested in bulk water transfer infrastructure to provide operational flexibility and to cater for integration of future sources into the IWSS.
- 5 Includes bulk water transfer operating costs.
- 6 Based on medium cost estimate.
- 7 Plus costs associated with bulk water transfer (ie. integration of product water into the IWSS).
- 8 Integration of these sources into the IWSS may also require provision of the north west corridor trunk main at an estimated capital cost of ~\$65M.
- 9 Capital and operating cost estimates include provision for delivery of water to Mount Yokine Reservoir. No allowance has been made for provision of peaking and bulkwater transfer from Mount Yokine Reservoir into the IWSS.
- 10 Capital cost estimate assumes availability of bulk water transfer trunk main to Harvey. The cost for this trunk main is included in the estimate for the South West Yarragadee groundwater scheme.
- 11 Based on a conceptual scheme entailing three 1840 km pipelines from a dam on the Fitzroy River (GHD, September 2004). Does not include water treatment. Alternative development strategies may be possible.

12 Based on operating cost of \$105M for supply of 300 GL of water (GHD, September 2004).

* Integration of southern sources into the IWSS will necessitate upgrades to associated bulk water transfer infrastructure.

4.2 South West Yarragadee

The South West Yarragadee groundwater resource is the most significant underdeveloped water resource in the south west of the State. This resource has been the subject of detailed investigation since early 2003.

Investigation and regulatory approval processes associated with the Water Corporation's proposal to abstract 45 GL/yr from the South West Yarragadee aquifer are ongoing. Findings to date show that a significant volume of high quality groundwater is held within the aquifer and the options of using this water for regional needs as well as, or instead of, the IWSS, are being assessed at present.

In 2004 the region used 64GL/yr of its 112 GL/yr entitlement. Growth in the next 30 years is expected to increase regional use to 159 GL/yr. The relative timing of the regional and scheme developments is likely to affect the viability of the SW Yarragadee source relative to other sources.

Construction of the scheme would take at least two summers. Whilst supply to the IWSS is the primary driver for development of the South West Yarragadee groundwater resource, this option also provides an opportunity to secure reliability of supply for a number of south-west towns.

4.3 A second desalination plant

First desalination plant

In July 2004, the Government announced that the State's next major water source will be a desalination plant to be built at Kwinana. When complete in late 2006, the plant will contribute 45 GL of water to the IWSS (about 17% of current demand) and increase scheme reliability. The plant will be powered by renewable energy from a major wind farm to be developed near Cervantes 245 km north of Perth.

An additional plant

The Water Corporation estimates that a major new water source will be needed by November 2009. While the extraction of water from the South West Yarragadee is the preferred option for this water source, approval for this project is not expected until late 2006.

As a contingency to the South West Yarragadee aquifer, the Water Corporation is proposing to seek environmental approvals for a possible second desalination plant south of Perth.

Planning for this is underway and the Water Corporation has identified three sites for the proposed plant. The preferred site is at Port Kennedy and two others are in East Rockingham.

If the proposed second plant goes ahead, it will deliver 45GL of water per year from the end of 2009.

4.4 Kimberley options

4.4.1 Ocean transport

Two ocean transport options were considered by the Kimberley Expert Panel (Department of Premier and Cabinet 2006):

- specially-designed water super tankers, and
- towing water bags.

Small tankering systems and water bags are already used to deliver water to some Greek Islands and to take water from Turkey to Cyprus.

Tankers of 500,000 tonnes dead-weight would load and unload at a single-point mooring system requiring a 25-30 m water depth. At least four ships would be required to deliver 50GL a year from the Kimberley to Perth (the minimum volume being considered) with fourteen needed for 200GL/yr (Department of Premier and Cabinet 2006).

Water bag options are more varied and untested in terms of their size, design, bag composition and towing mechanisms. The largest bags currently in use are around 25,000 tonnes, 20 times smaller than those proposed for the Kimberley route. They also require a mooring system with 25-30m depth. A bag containing 0.5GL would be about 700 metres long and 160 metres wide with a freeboard to 0.8m and a draft of 25m (Department of Premier and Cabinet 2006).

4.4.2 Canal

The canal being modelled would take water from aquifers under the Fitzroy River and deliver it to the Water Corporation's Integrated Water Supply Scheme. A coastal route would run for 3,700 kilometres carrying up to 200 gegalitres of water a year to Perth and communities along the way. It would require eight pump stations with 127 km of rising main giving a total lift of 450 to 500 m (Department of Premier and Cabinet 2006). A shorter inland route was also considered but this required 570 km of rising main and a total lift of 890m. As the inland route was much more expensive, it is not considered further in this report.

The canal would be of compacted earth construction and generally follow the contours of the land along its route. The bottom of the canal would be lined with a duplex geo-membrane liner topped with concrete, to reduce seepage and minimise friction, and remain open to reduce costs and allow access for maintenance (Department of Premier and Cabinet 2006).

There would be sufficient crossings for people, wildlife and stock. Cross drainage from flooding and natural water courses is a major issue even in the desert.

Structures such as siphons would be required to channel surface waters away so that the canal water is not contaminated.

The canal would require pumping stations along the route. These would be powered from the Dampier–Bunbury natural gas pipeline.

A canal may be more efficient because of the friction that pipelines produce and the pumping that is required to move water through them.

4.4.3 Piping

The Expert Panel evaluated two concepts for this method of delivering water.

- The Watering Australia Foundation concept, which is to collect water from the Fitzroy River and pipe it along a mostly-inland route to Kalgoorlie. There it would be introduced into the existing Goldfields and Agricultural Water Scheme pipeline for pumping back to Perth, a combined distance of about 2,400 km.
- Taking water from the Fitzroy River and following a more direct route over 1,900 km to Perth.

The Fitzroy River is seen as the preferred Kimberley source as it is both closer to Perth and has large and dependable supplies of high quality water in most years. However the best site for a dam has tourism and cultural values and therefore a dam on the Margaret River was considered with water releases allowing water to be taken off at Willare throughout the year with modest off-stream storages.

The Kimberley pipelines would consist of one or two 1.8 metres diameter pipes (for 100 and 200 GL/yr respectively) with four pump stations. An alternative is to build two 1.6m diameter pipes to match demand as it grows which would require seven pump stations to overcome the increased friction from smaller pipes (Department of Premier and Cabinet 2006).

4.5 Water trading - Harvey

Over 153 GL of surface water in the Harvey Water irrigation area is currently allocated to irrigation in the Waroona, Harvey and Collie Irrigation areas (Table 4.2). By irrigation standards, the reliability of supply is high for the Waroona and Collie areas. Demand for Collie water is usually low because of its high salinity which can damage irrigated soils and kill salt sensitive pasture species.

Water law reform over recent years has made the trading of water entitlements possible in Western Australia, and the Corporation has successfully completed trades with Harvey Water for 3 GL in 2003/04, 6 GL in 2004/05 and 10 GL in 2005/06.

In addition, temporary and permanent trades occur between irrigators. June 2005 trading prices were⁷:

Permanent Sales:	Collie	\$34.75 / ML or 3.5 cents / kL
Temporary Sales:	Waroona	\$22.83 / ML or 2.3 cents / kL
	Harvey	\$22.88 / ML or 2.3 cents / kL
	Collie	\$ 5.00 / ML or 0.5 cents / kL

The low price for temporary trading of Collie water is due to the poor quality mentioned previously.

Table 4.2 Allocation to irrigation from surface water resources in the State's southwest (Water Corporation 2005)

⁷ <http://www.harveywater.com.au/didyou/February%202005.pdf>

Surface water system	Mean annual flow ¹	Annual allocation to irrigation industry ¹	Reliability
Harvey, Stirling and Logue	96 GL	68 GL	63%
Samson, Waroona and Drakes	29 GL	17.3 GL	80%
Wellington	126 GL	68 GL	85%

¹ Based on the streamflow record for the period from 1975.

Trading water into the IWSS can be of two types, efficiency savings made in the supply system by the Harvey Water Cooperative and reductions in on-farm use by improved efficiencies or land use changes to low or no irrigation water use systems.

The irrigation industry has the potential to realise significant water savings by replacing unlined irrigation channels with piped distribution networks. Savings realised in this manner are largely independent of climate. Water trading therefore represents a prospective source option, especially in light of the current uncertainty regarding future climate and streamflow.

Full piping of the Harvey and Waroona Irrigation areas would make an estimated 18 GL share of the resource available for trading. Water Corporation considers that a permanent 18 GL trade (yielding 17 GL under an 8-year climate and streamflow regime) could be completed within four years, commencing 2004/05.

In addition to these trading opportunities, there is potential for significant volumes of water to be made available due to reduced water use from land use changes or changes to on-farm practices to improve water use efficiency within current irrigation areas. However not all of the water in the irrigation area is of potable quality. ACIL Tasman (2004) estimated that after the planned trades, only 4 GL of potable quality water will be available under an irrigation allocation. The potential for on-farm water savings is being assessed as part of a CSIRO Water for a Healthy Country Flagship project due to report in 2007.

4.6 Water trading - Collie

Water trading opportunities also exist in the Collie Irrigation area. An estimated 16 GL of water⁸ could be made available via efficiency savings in this area (under the 8 year climate and streamflow regime). However, the issues associated with such a trade are complex, being dependent amongst other things on improved water quality in Wellington Dam. This trading opportunity is therefore less certain than that for the Harvey/Waroona areas, and would require substantial time to resolve.

While sufficient information is available to include this supply concept in the iSDP model it is likely to be included in a larger development project for Wellington Dam as discussed in Section 4.1.

⁸ The amount could be as high as 22 GL/yr according to ACIL Tasman (2004).

4.7 Eglinton groundwater

The Eglinton groundwater scheme is located within a proposed urban area in the North West urban corridor and the final location of bores is unable to be made without a detailed structure plan.

A regulatory review of abstraction from the Leederville Aquifer in the Eglinton area is currently underway and hence the yield of this scheme is uncertain at the present time.

4.8 Yanchep groundwater

The Yanchep groundwater scheme is also located within a proposed urban area and cannot be implemented ahead of land development.

As for the Eglinton groundwater scheme, the Department of Water's current review of statutory water level criteria and the sustainable groundwater abstraction amounts from the Gngangara Mound is likely to have implications for the proposed Yanchep groundwater scheme.

The Yanchep groundwater scheme is unlikely to be required before 2025.

4.9 Gingin groundwater

The Gingin groundwater proposal is a significant scheme with an expected annual yield of up to 30 GL. The Gingin groundwater system is, however, physically complex and competition for the resource is relatively high. Despite water being reserved for public water supplies, it is anticipated that it would take between five and ten years to secure access to this groundwater resource.

The shift to a drying climate that has been brought into focus since the 2001/2002 drought means that this source may not be as prospective as previously thought. However additional recharge under cleared agricultural land in the Perth Basin is resulting in groundwater levels rising despite the drying trend.

4.10 Gngangara groundwater - pine thinning and removal

The proposed harvesting of pine plantations on the Gngangara Mound has the potential to make available up to 20 GL/yr of additional groundwater from this resource. However, the realisation of additional source yield to the IWSS from the Gngangara mound is dependent on external factors, including:

- the schedule for harvesting of pines;
- the Department of Water's approach to re-allocation of groundwater made available by the harvesting of pines; and
- post-harvest management of the land in a manner that is consistent with the long-term preservation of the increased yield from the harvesting of pines.

In light of declining water levels on the Gngangara Mound, the Department of Water and the EPA may take a cautious approach to the re-allocation of water arising from changes in land use. It is anticipated that any yield benefits arising from changing land use on the Gngangara Mound would be realised gradually from approximately 2020, although the harvest program

may be accelerated to take advantage of high market prices for Laminate Veneer Lumber and the impact of the European Wood Borer.

4.11 Brunswick Dam

A storage dam on the Brunswick River has the potential to supply up to 30 GL a year to the IWSS. A smaller pipehead dam would be able to supply lesser amounts but may prove more environmentally acceptable given the discharge of the flow into the Leschenault Estuary, a significant environmental asset in the south west of the state.

While it is a highly prospective water source, it is anticipated that up to five years would be required to complete regulatory approval processes.

4.12 Catchment management – Wungong and other catchments

Catchment management represents a low cost source option aimed at increasing runoff to existing dams by an additional 40 GL through enhanced catchment management, notably thinning young jarrah and marri trees to enable the remaining trees to grow to their full potential.

Realisation of these volumes of water is contingent upon demonstrating the environmental, social and financial feasibility of thinning in a research trial in the Wungong Dam catchment.

The Wungong catchment trial commenced in 2005/06 and is predicted to deliver 4 to 6 GL/yr of water to the IWSS within approximately 5 years of commencing the trial. The Water Corporation is investing in comprehensive environmental monitoring and analyses as part of the Wungong catchment trial. The outcomes of this analysis will be used to guide the extension of the catchment management program into other public drinking water supply catchments. A research project under the Premiers Water Foundation may also enable the Wungong results to be progressively extended to other catchments.

4.13 Wastewater reuse – Managed Aquifer Recharge

Annual inflows to the metropolitan wastewater treatment plants currently total approximately 100 GL, and are projected to grow to 160 GL by 2025, and exceed 200 GL by 2040. There is a state government commitment to achieve 20% reuse of wastewater by 2012.

Treated wastewater from the Beenyup wastewater treatment plant (WWTP) and the proposed Alkimos WWTP, is a significant resource which could be used (with appropriate pre-treatment) to supplement recharge to groundwater resources, thus maintaining groundwater levels in environmentally-sensitive locations and offsetting reductions in sustainable yields from the Gngangara Mound to the IWSS.

Inflows to the Beenyup WWTP currently total around 35 GL/yr. An estimated 60 GL/yr of treated wastewater will be available from the Beenyup and Alkimos WWTPs by 2025, and 80 GL/yr by 2050. Based on a 75% recovery rate from tertiary treatment processes, current wastewater volumes from the Beenyup WWTP represent a minimum yield benefit to the IWSS of 25 GL/year.

Advice has been received from the Environmental Protection Authority and the Health Department on environmental and public health considerations associated with aquifer

replenishment. As a result, work may commence soon on injection trials in the Beenyup WWTP. In the meantime, the impact of adding treated wastewater via galleries to the Spearwood Dunes / Tamala Limestone is being assessed at the CSIRO Floreat site under a Premiers Water Foundation grant.

4.14 Wastewater reuse – industry

Recycling of treated wastewater for industrial use through the Kwinana Water Reclamation Project (KWRP) reduces the demand for both scheme and groundwater resources in the Kwinana industrial area and provides a water source of high quality for industry expansion (eg HI-Smelt).

The Woodman Point wastewater treatment plant currently receives inflows of approximately 40 GL per annum. At an estimated 60% reclamation rate, this equates to a 25 GL non-potable supply and inflow volumes are projected to double by 2040.

The KWRP1 plant currently supplies 5.5 GL/yr and there are plans to develop another desalination plant to increase capacity if there is sufficient uptake by industry. For the iSDP model, it has been assumed that KWRP1 would offset 2.9 GL/yr of scheme water usage.

5. SUPPLY AND DEMAND OPTION CASE STUDIES FOR PERTH METROPOLITAN AREA

5.1 Summary of Demand and Supply Side Options

In considering case studies to illustrate the capability of the iSDP model it was decided to limit them to realistic options for which good supporting data were available.

As a result of the poor runoff in 2001 and historically low reservoir levels, two-days-per-week sprinkler restrictions have been used to manage demand since that time. However with a 45 GL/yr desalination plant commencing in late 2006 it was assumed for a number of the Case Studies that three-days-per-week sprinkler restrictions would be introduced as a permanent measure.

Water efficiency programs with a high likelihood of success in the both the residential and non-residential sectors were also considered likely future options. Some sections of the community would like all future imbalances to be met by water conservation and reuse options so it is important to assess the feasibility of this option.

The impact of moving to marginal cost pricing while reducing the fixed cost of water is also a feasible demand management measure that is worth evaluating.

From a supply viewpoint, the first desalination plant and trading with Harvey Water are major initiatives that will lift supply over the June 2000 base case. Later supply options include the SW Yarragadee (to be decided in late 2006), thinning of the jarrah forest in the Wungong Catchment (commenced in 2006) and extension to other catchments if successful, the Eglinton and Yanchep wellfields and Gingin groundwater after 2030. Water trading with the Collie Irrigation District can also be considered over a long time period.

Comparison of the cost-effectiveness of the available demand and supply side options can be undertaken using supply curves. Figure 5.1 presents a broad selection of options analysed over the period 2005 to 2030. These are included on the basis of levelised costs and do not take account of social or environmental impacts, or the practicality of supplying water into different parts of the water supply treatment.

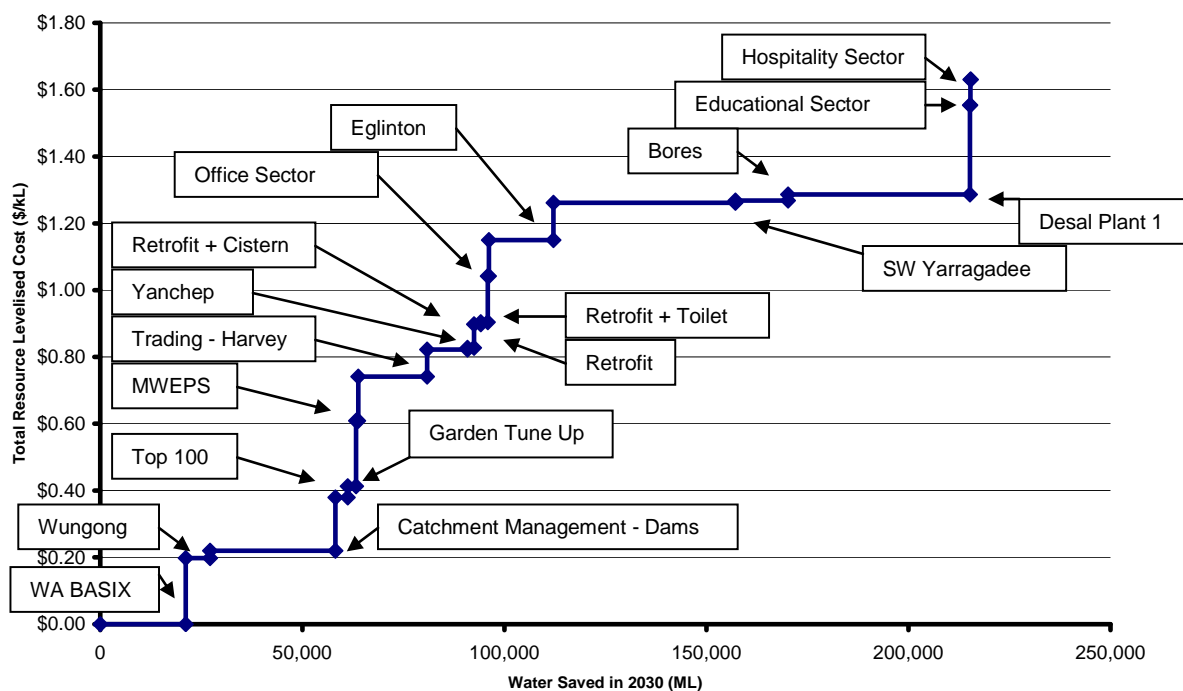


Figure 5.1: Supply Curve for demand and supply options created within the iSDP model

5.2 Overview of Case Studies

Four case studies were chosen to highlight the range of demand - supply balance scenarios that can be investigated by the iSDP model. Each case study uses the baseline demand supply balance discussed in Section 2 as a starting point for the investigation of a range of new options. The impact of these options is assessed in terms of their impact on the demand - supply balance in the short, medium and long term.

Table 5.1 summarises the options that have been included in the four Case Studies.

Table 5.1 Summary of option packages considered in Case Studies

Case Study	Options			
	Water restrictions (permanent)	Water savings through efficiency	Supply augmentation	Pricing reform
1	Yes (Stage 3 ⁹)	Yes	No new supplies	No Change
2	Yes (Stage 3)	Yes	Yes (low cost & staged)	No Change
3	No	Yes	Yes (low cost & staged)	No Change
4	No	No	Yes	Marginal cost pricing

Case Study 1 looks at the ability to maintain the supply-demand balance through permanent Stage 3 water restrictions and increased water efficiencies alone. This option roughly equates to the “environmental” social cohort identified by Nancarrow *et al.* (1996) in a study of community attitudes towards water. This represents an attitude that no new supplies should be developed while there are feasible options for better water conservation and reuse.

Case Study 2 allows cost-efficient supply options to be included to meet the supply - demand gap and is closest to the current government policy, assuming that the current two-days-per-week sprinkler restrictions are relaxed to become permanent three-days-per-week.

Case Study 3 attempts to meet the supply – demand gap without permanent water restrictions or changes to the current tariff arrangements whereby fixed charges remain relatively high. However low cost supply augmentation measures are allowed.

Case Study 4 allows tariffs to reflect the marginal cost of water supply in the absence of restrictions or water efficiency measures. This option almost equates to the “self-interest” social cohort defined by Nancarrow *et al.* (1996) in their study of community attitudes towards water. Water supply is controlled through pricing signals rather than through mandated efficiency savings and sprinkler restrictions.

It must be emphasised that the four case studies are used for illustrative purposes only and other combinations of supply and demand can be simulated using the iSDP model. These are not recommended policy settings by the authors of this report.

⁹ Stage 3 restrictions allow irrigating using scheme water on only 3 nominated days of the week

5.3 Option Case Studies – Planning for Perth’s Water Future

5.3.1 CASE STUDY 1

Case Study 1 focuses on the potential for demand reduction measures and recently agreed supply augmentation measures to reduce the demand - supply deficit.

The package of options that are modelled are:

- Three-days-per-week sprinkler restrictions are in place permanently;
- Subsidies continue to be offered to encourage people to meet their lawn and garden watering needs through garden bores;
- Non-residential efficiency program target the top 100 businesses as well as the Office, Hospitality and Education sectors;
- Retrofits and rebate programs are offered to residential customers;
- New residential customers have to comply with the BASIX program; and
- Water trading and the first desalination plant are successful in augmenting supplies.

The demand side options that are most effective are the three-days-per-week-sprinkler restrictions, bore subsidies (in the short term) and residential efficiency measures (in the medium and long term (Figure 5.1). The Figure shows that the demand – supply balance could be met until 2028 using these measures, which is counter to the Source Development Plan which requires the SW Yarragadee or Desal Plant #2 to keep the balance until 2017. The key difference for Case Study 1 is the assumption that sprinkler bans become a permanent demand reduction measure and that savings from the option are maintained on a per property basis. The model also does not assume any more de-rating of existing water sources as a result of climate change.

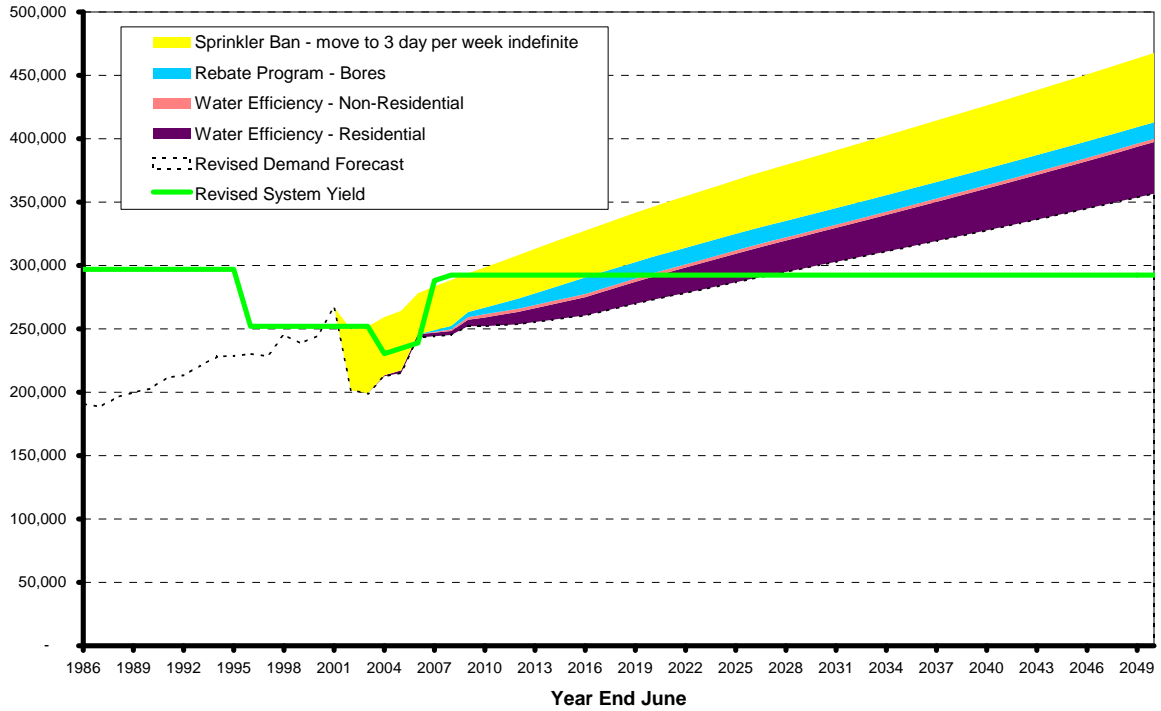


Figure 5.1 Demand - Supply Balance for Case Study 1 (demand side options shown in detail)

Most of the increase in supply is provided by the 45 GL/yr desalination plant which will be commissioned in late 2006 (Figure 5.2). Water trading has been important for meeting the short term demand – supply gap since 2004.

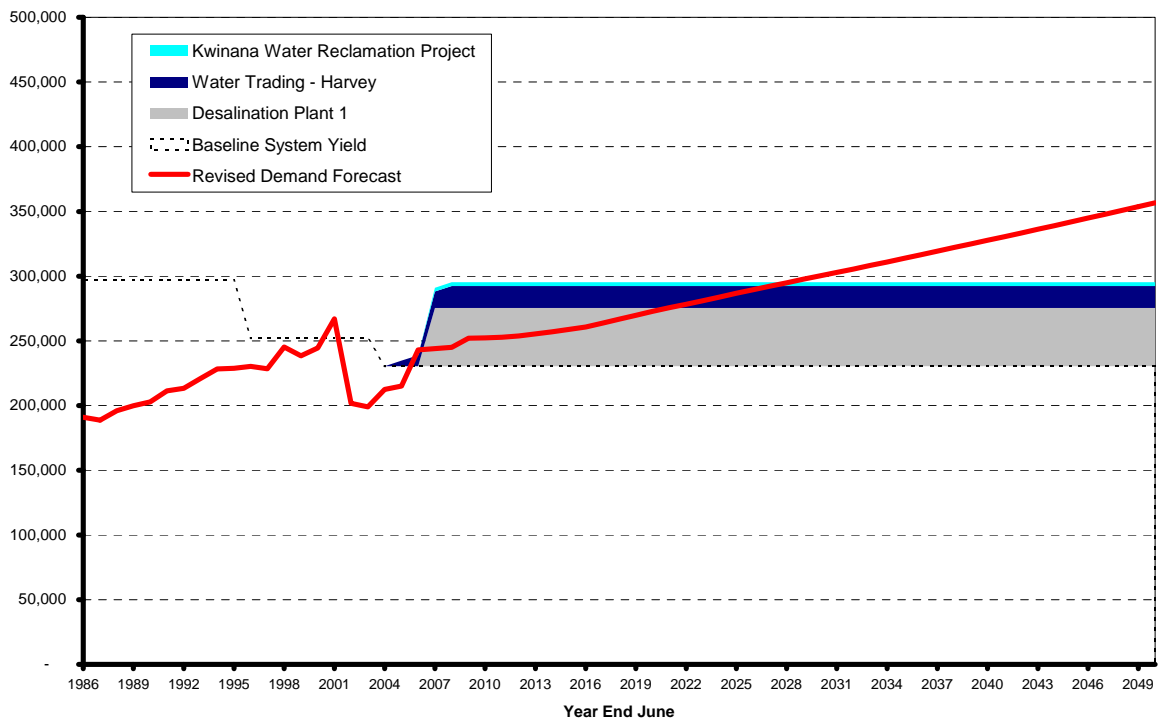


Figure 5.2 Demand - Supply Balance for Case Study 1 (supply side options shown in detail)

The package of options represented by Case Study 1 includes large capital expenditure components (essentially spent at the time of writing) as well as requiring ongoing investment into the future (see Figure 5.3).

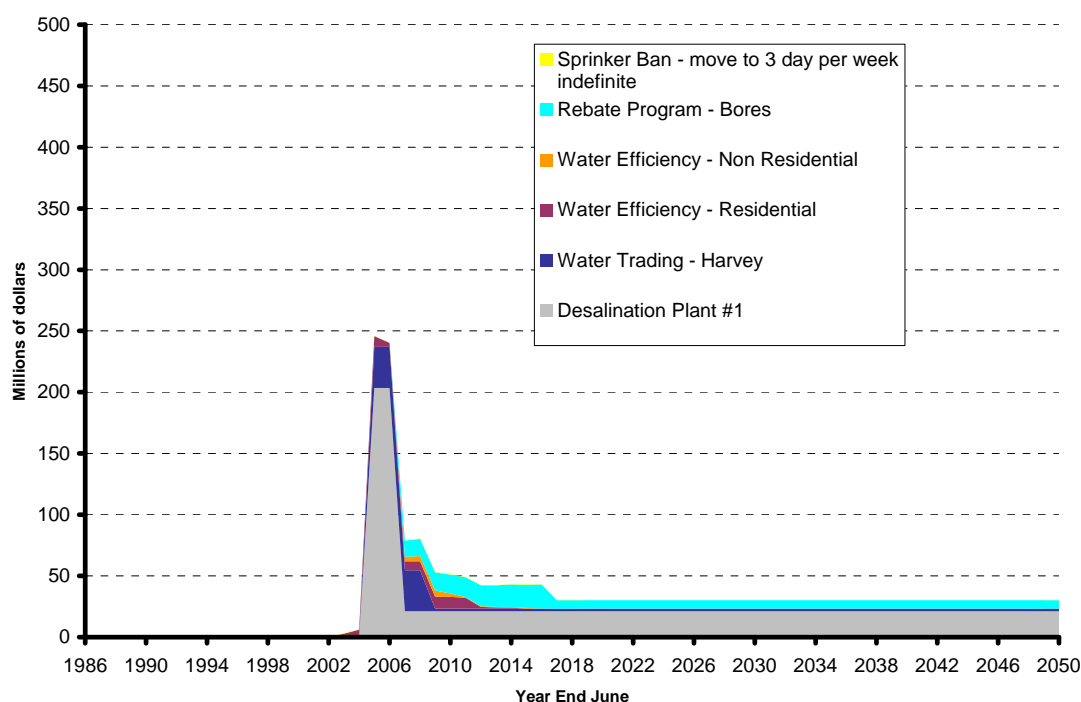


Figure 5.3 Expenditure profile for Case Study 1 (includes agency, government and customer expenditure¹⁰)

The profile in Figure 5.3 shows that expenditure on water efficiency measures is concentrated in the period through to 2016. Beyond this point, water savings through efficiency are driven by regulatory measures such as minimum performance standards and a permanent sprinkler ban. Three components of this Case Study require on-going investment – operating costs for the desalination plant; management of Harvey Water trading scheme and the rebate program for private bores.

5.3.2 CASE STUDY 2

The package of options that are modelled are the same as that for Case Study 1 but including staged, low cost supply side augmentation in the form of the SW Yarragadee, thinning of the jarrah forest in the Wungong Catchment and the Eglinton Wellfield (Figures 5.4, 5.5).

¹⁰ Includes ‘direct’ costs associated with the implementation of an option – externalities are not accounted for however. Applies to all cost data presented in this report.

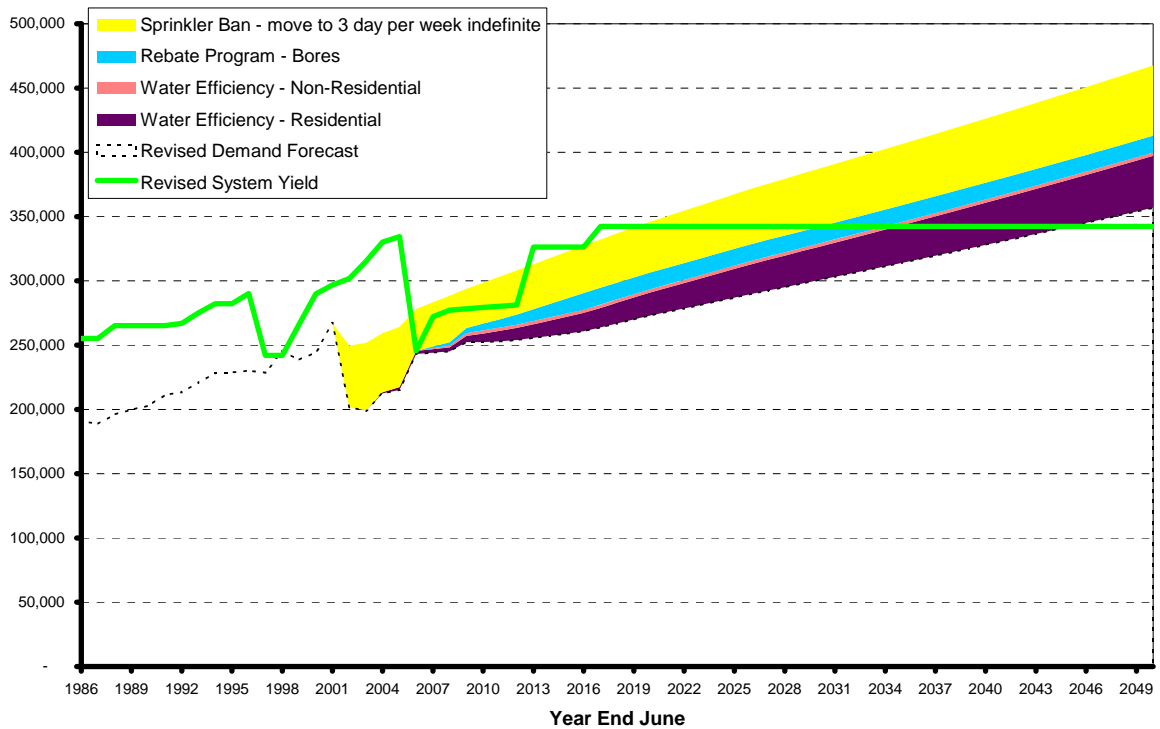


Figure 5.4 Demand / Supply Balance for Case Study 2 (details of demand side options)

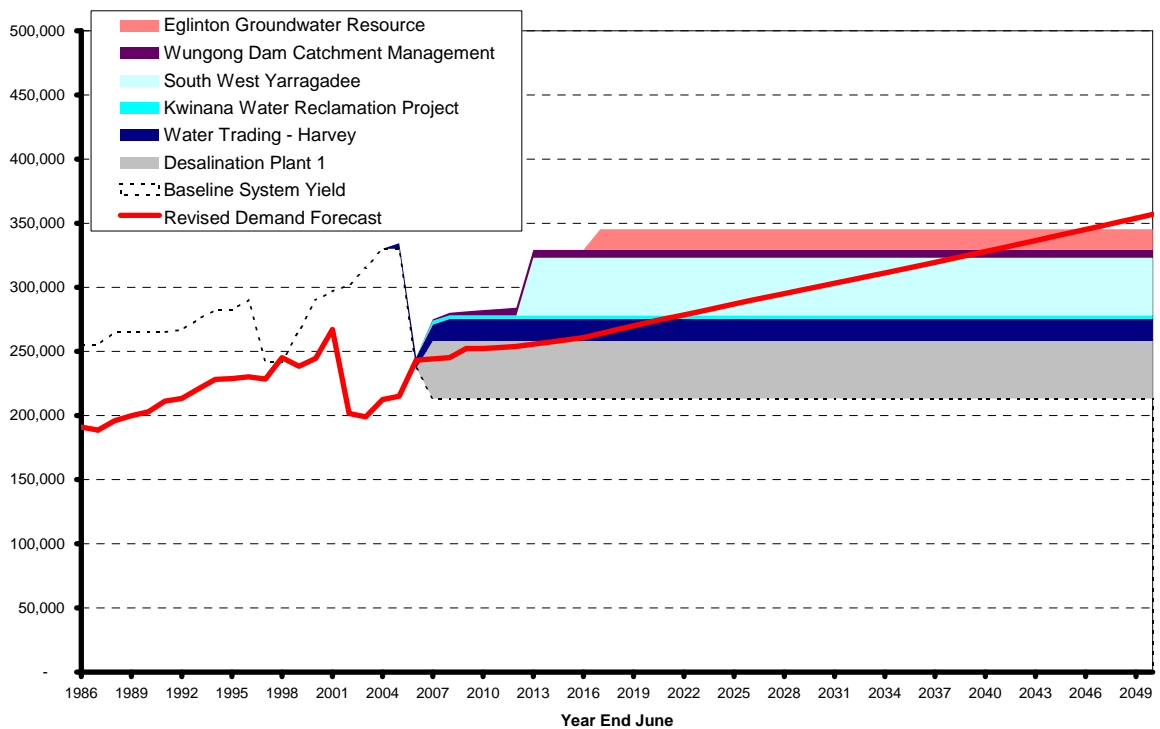


Figure 5.5 Demand / Supply Balance for Case Study 2 (details of supply side options)

With the addition of these three new sources, the demand supply balance is notionally maintained through the duration of the scenario. Importantly, the timing for the introduction of the new sources shown in Figure 5.5 is conservative. Given the assumptions regarding

water efficiency, there would appear to be scope to delay introduction of the South West Yarragadee and the Eglinton Wellfield.

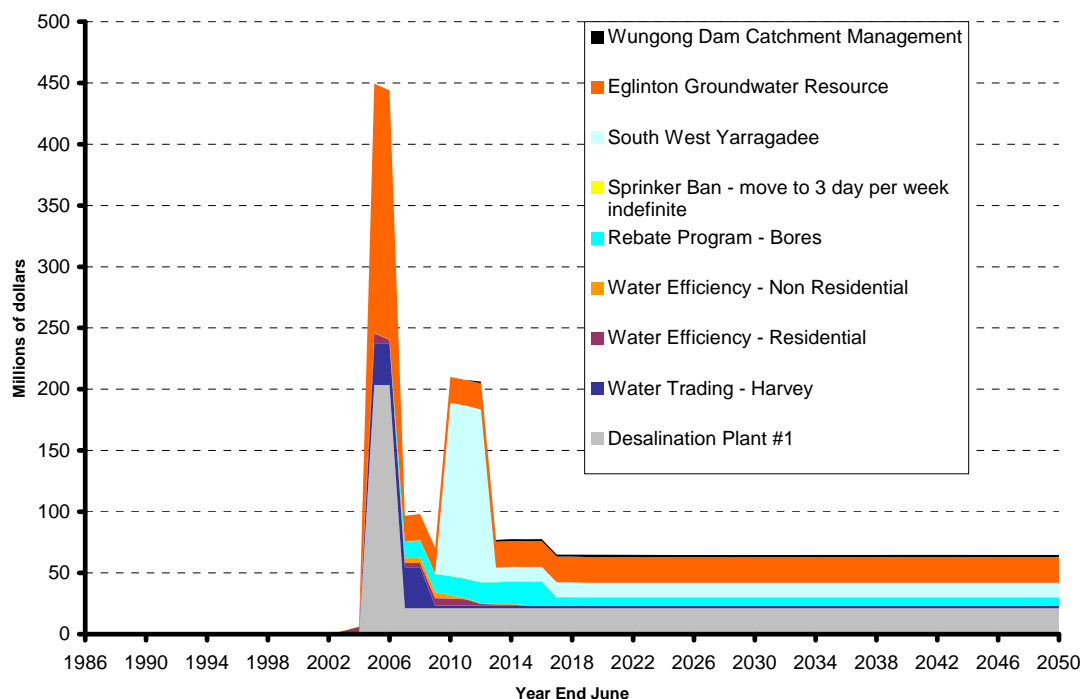


Figure 5.6 Expenditure profile for Case Study 2 (includes agency, government and customer expenditure)

The expenditure profile for this Case Study (Figure 5.6) highlights the considerable capital expenditure required to bring on-line the South West Yarragadee and Eglinton groundwater resources. As mentioned in Section 4, some sources may need to be introduced earlier despite their higher cost due to land planning requirements.

All of this expenditure is currently presented in this Case Study as occurring in the next decade. The potential to delay introduction of these two particular options would more evenly distribute expenditure over a longer period – thereby reducing some of the expenditure peaks evident from Figure 5.6. The key to this potential to delay some supply-side options is the effectiveness of the water efficiency measures.

5.3.3 CASE STUDY 3

This case study relaxes all sprinkler restrictions, resulting in water demand increasing as the population increases in Perth (Figure 5.7). However three additional water supplies are able to be added – extension of the Wungong thinning to other hill’s catchments, and the Yanchep and Gingin groundwater resources (Figure 5.8).

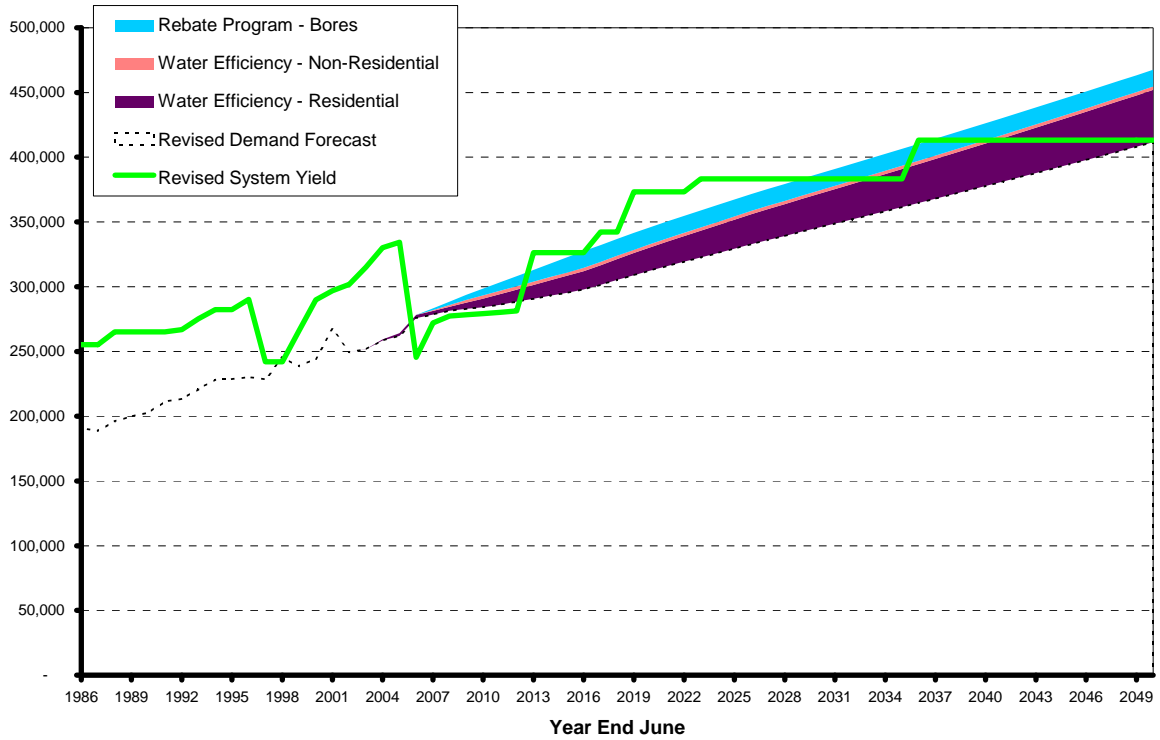


Figure 5.7 Demand / Supply Balance for Case Study 3 (details of demand side options)

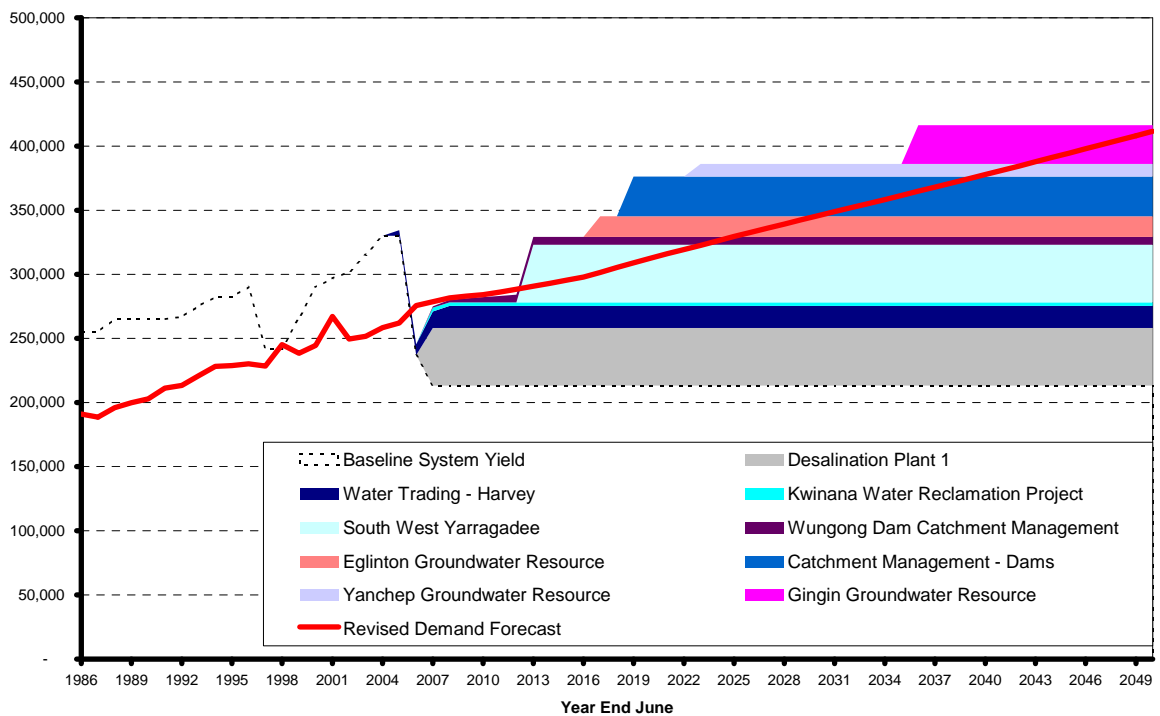


Figure 5.8 Demand / Supply Balance for Case Study 3 (details of supply side options).

These additional water sources are able to meet the increased demand until 2049 under the assumptions used. All new sources will be needed up to twelve year earlier (eg SW

Yarragadee) as a result of the increased demand under unrestricted consumption. These case studies highlight the importance of sprinkler restrictions in closing the supply-demand gap.

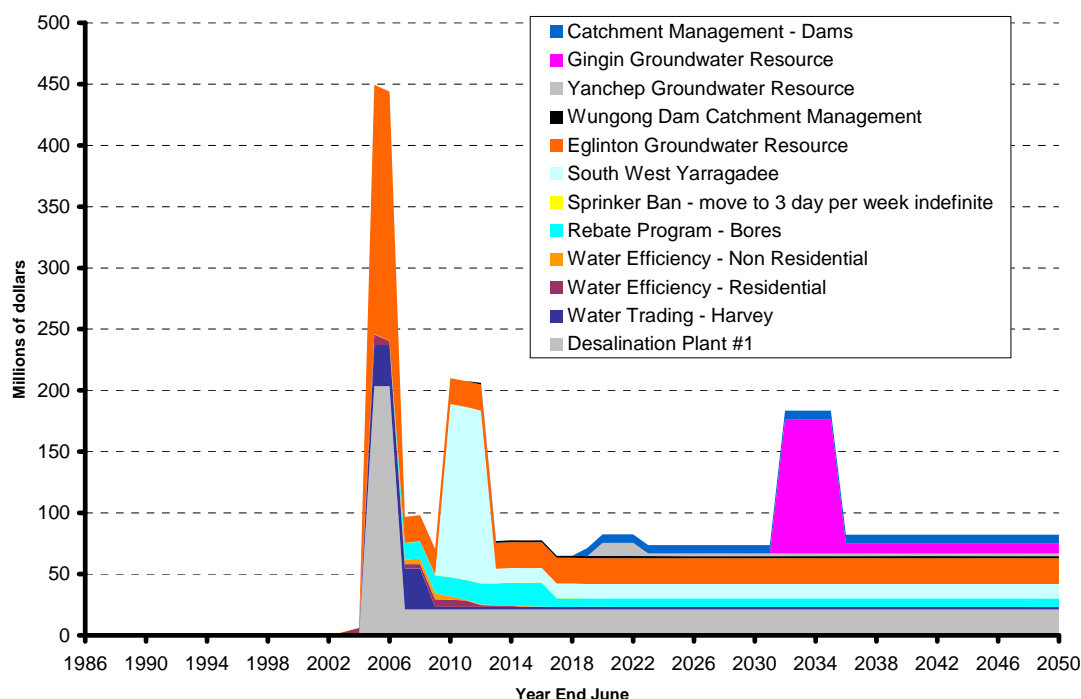


Figure 5.9 Expenditure profile for Case Study 3 (includes agency, government and customer expenditure)

The additional supply-side options included in Case Study 3 add a significant capital expenditure peak at around 2035 associated with the development of the Gingin groundwater resource. The demand/supply balance charts (Figures 5.7 and 5.8) suggest that there is scope to delay the Yanchep and Catchment Management – Dams options. This would have only a minor affect on the expenditure profile associated with this Case Study.

5.3.4 CASE STUDY 4

This case study relaxes all restrictions and the emphasis on water conservation and uses marginal cost pricing to ensure that new water sources are brought on in a timely manner (Figure 5.10). While economically efficient, any change in tariff structures will have income distributional impacts that will need to be considered. Brennan (2006) has suggested that the current tariff structure actually favours larger water users who tend to be wealthier (e.g. they are more likely to have automatic reticulation). However, another determinant of high water consumption that is not related to wealth is the number of occupants, and tariff reform would adversely affect large families and possibly tenants. Policies to alleviate hardship on those groups with high non-discretionary water use might be necessary when introducing the tariff reforms modelled here. The costs of such policies were not considered in this exercise.

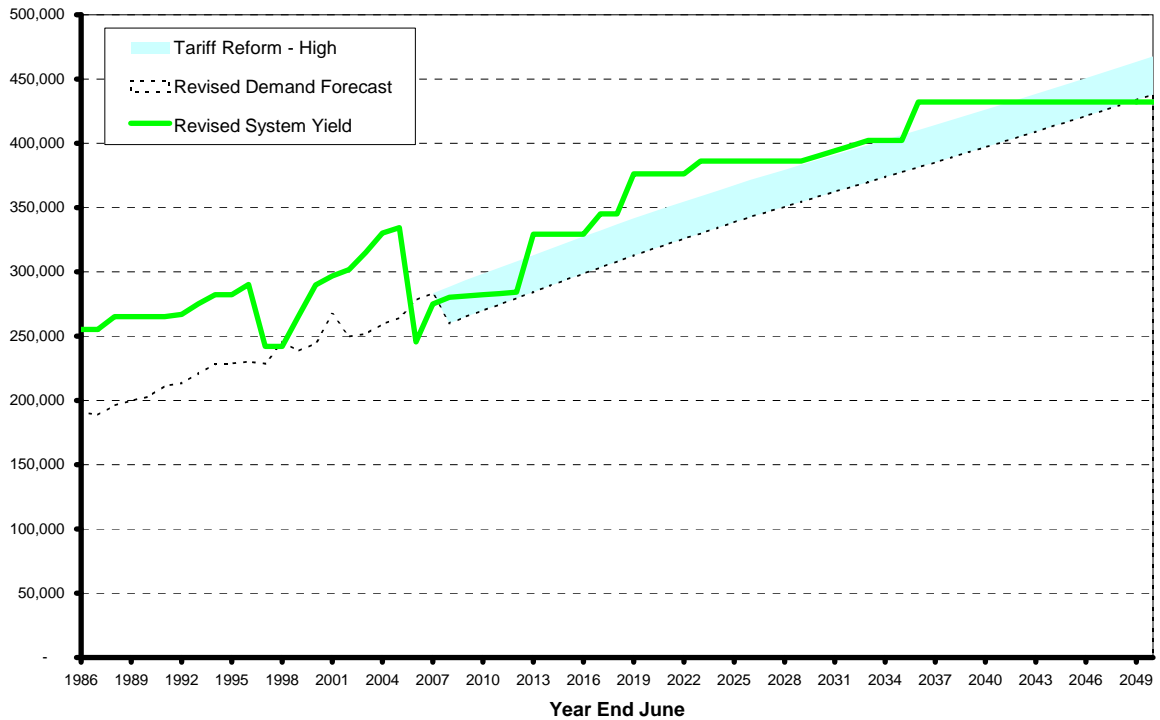


Figure 5.10 Demand / Supply Balance for Case Study 4 (details of demand side options)

Marginal cost pricing and rebalancing the fixed charge for water is estimated to reduce demand by about 21 GL/yr by 2040 which will require additional water sources be brought on about four years earlier than in Case Study 3 and up to 16 years earlier than in Case Study 2 because there are no efficiency changes assumed to occur. Demand under this scenario would grow to about 440 GL/yr by 2050, as against 415 GL/yr under Case Study 3 and only 355 GL/yr in Case Study 2 and 1.

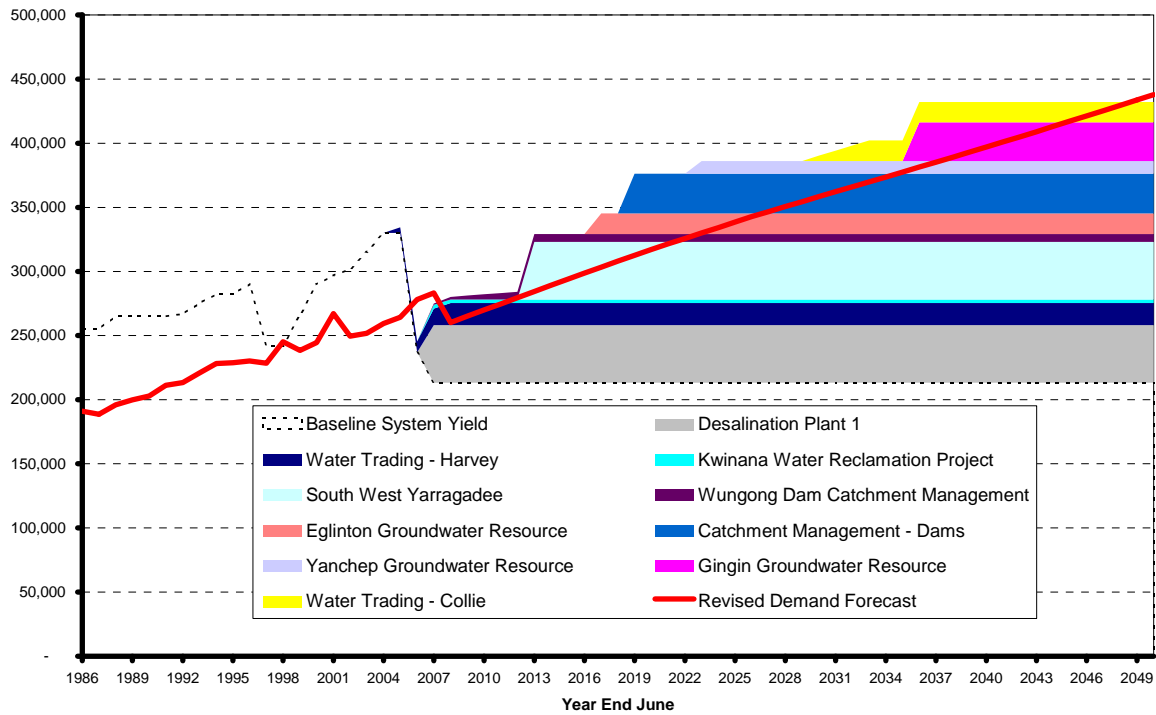


Figure 5.11 Demand / Supply Balance for Case Study 4 (details of supply side options)

The expenditure required for this Case Study is the greatest of the four investigated by this report. Figure 5.12 presents a profile of expenditure for Case Study 4.

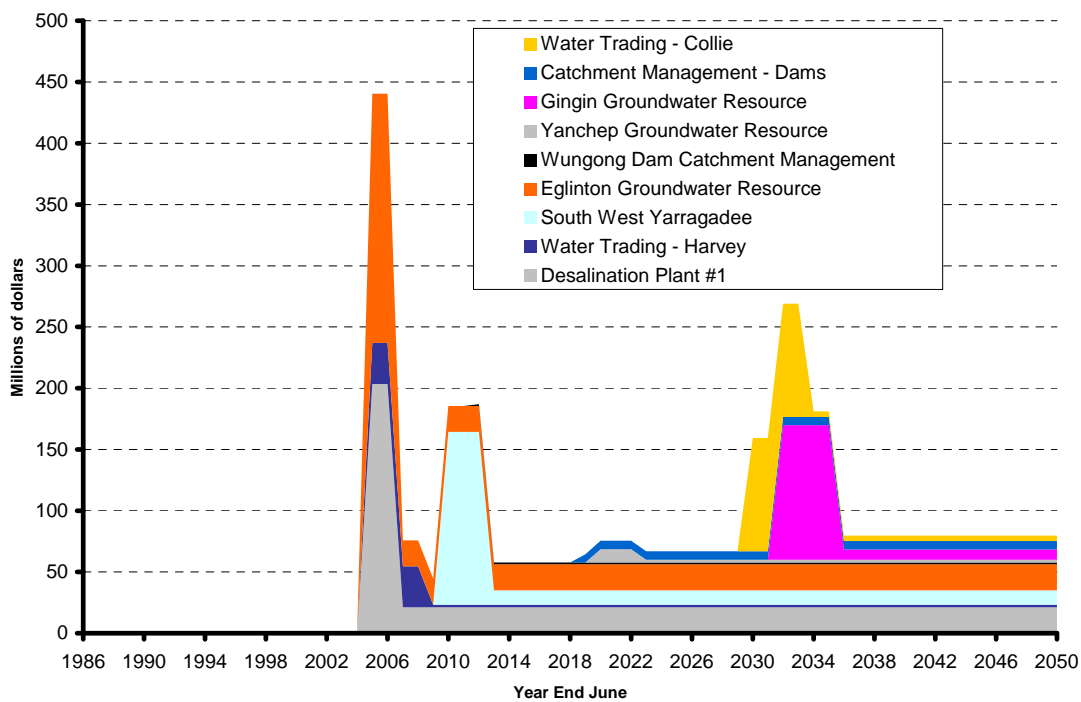


Figure 5.12 Expenditure profile for Case Study 4 (includes agency, government and customer expenditure)

Considerable expenditure is required around the period 2030 to 2035 with an overlap between developing the Gingin resource and establishing water trading in the Collie Irrigation area. Given the projected demand/supply balance at that point, there would appear to be some scope to delay the Collie Water Trading option which would reduce the peak in expenditure evident in Figure 5.12.

Annual on-going costs (primarily operating expenditure) are approximately \$75 million beyond 2040 – this compares with on-going expenditure estimates for Case Study 1 of around \$25 million.

5.4 Summary of Case Studies

The four case studies presented above provide several perspectives on the combination of options that could be considered in managing the demand/supply balance for the Perth Metro region. They range from a high reliance on active intervention to target water efficiency through to a high reliance on source development.

It is evident from the case studies that the water efficiency measures considered have the potential to manage the demand/supply balance in the short term (through the next decade or so). Importantly, the assumptions behind the savings from each of the demand side options are considered conservative and by no means have maximum savings been attributed to any of the residential end uses or non-residential sectors. There remains conservation potential across many of the major residential end uses. There are, however, a number of risks or uncertainties that would affect the demand / supply balance – these have been summarised at the end of this section of the report.

In the medium to long term, a number of additional sources are required for the Case Studies to ensure supply availability can match the increasing demand – driven primarily by growth in the residential sector. There appears from the Case Studies to be some scope for delaying the implementation of some of the source development options – again these issues of timing will be impacted by the risks and uncertainties highlighted below.

Reliance on pricing reform by itself to manage demand would appear to require the greatest level of capital and operating expenditure for source development. Clearly there is potential for significant feedback with such an arrangement as pricing reform would potentially be accelerated under a high capital and operating expenditure scenario – potentially realising greater demand savings than assumed in Case Study 4.

Finally, the role of permanent outdoor restrictions, through the permanent adoption of a three-days-per-week sprinkler ban, has a significant impact on the timing of source development initiatives. The capacity for the community to accept restrictions on such a basis needs to be assessed due to the potential impact this option would have on expenditure requirements.

Key Risks

- One of the key options included in this package is the permanent three-days-per-week sprinkler restriction. No studies have been done to evaluate the acceptability of this option from the perspective of the community.

- With increased levels of water efficiency through demand management, the capacity for water restrictions to continue to be as effective as they have in the past at reducing water use will diminish. This process is known as demand hardening. The effectiveness of water restrictions represents a key input to the modelling of yield from water supplies. In this way, demand hardening will result in a lowering of yield estimates as restrictions become less effective. The scope of this reduction in yield will depend on the package of demand management measures that are implemented and the range of water sources (and their reliability) that are accessible. The iSDP model is not designed to assess such impacts – this work needs to be undertaken using other modelling frameworks.
- The sustainability of installing additional bores in a drying climate may be called into question and it is doubtful they could continue to be used in a wasteful manner.
- The current water supply system has been de-rated twice in ten years due on the most part to a drying climate. Uncertainty regarding the trends in climate patterns cannot rule out further de-rating of yield from the water sources.
- Population growth projections – while the iSDP model utilises medium level population numbers, there is considerable uncertainty regarding the accuracy of the projection, particularly over the long time period covered by the Case Studies. Data from the Source Development Plan (Water Corporation, 2005) suggest that in 2050, the difference between the medium and high population forecasts results in a 70 GL differential for total water demand.

In summary, the case studies have highlighted the following aspects:

- Growth in residential demand is the main contributor to overall demand and factors that mainly influence it in the short to medium are sprinkler restrictions and tariffs, and in the medium to long term are water conservation measures and mandated water efficient products.
- Perth has a number of water supply options that can meet restricted or unrestricted demand and it will be possible to bring these on in an orderly manner if there is a willingness to pay for these more expensive options and the planning and regulatory approvals are able to be obtained in time.
- The iSDP model can look at combinations of both demand and supply side options to close the supply-demand gap with different degrees of risk. These options can be compared on a least cost basis allowing others factors (environmental, social, feasibility, equity, timeliness) to be considered in the order of implementation.
- The sensitivity of the supply and demand estimates to underlying assumptions can be tested and refined as additional data and research gaps are filled (see Section 6).

6. DATA GAPS AND RESEARCH NEEDS

6.1 Data gaps

Areas with inadequate data have become evident in building the iSDP model and these are listed here in order of importance. “Data gaps” are areas that can be filled relatively easily given the availability of resources. A distinction is made between them and research needs, for which a more considered program is required and the results will be less easy to predict in advance. However there is often a gradation between the two.

6.1.1 Domestic Water Use Study post restrictions

Perth is unique in Australia in having the only two detailed studies of in-house water use, although Melbourne is currently undertaking a similar study. Water restrictions on outdoor sprinkler use were introduced in Perth three years after the last DWUS (Loh and Coghlan 2000). Having been in place for five years and with no expectations of an imminent reprieve, people will almost certainly have altered their water use patterns. This has been evidenced by an average 48.3 GL/yr being saved since September 2002.

Whether the saving is temporary or more permanent (eg paving areas that were previously irrigated) is unclear. While it is expected that the savings have come almost exclusively from reduced outdoor use, the \$28M spent on almost 249,000 subsidies for water saving devices until June 2006 should have reduced indoor water use by almost 2 GL/yr. It is important to be able to predict the size of any water rebound that may occur if restrictions were relaxed to either a three-days-per-week or to daytime sprinkler bans only.

Therefore it is important to repeat the DWUS, perhaps taking advantage of the research findings coming from a Smart Water Fund project being carried out in Melbourne.

In carrying out the measurements of domestic water use, much more attention needs to be taken of outdoor water use this time. It seems likely that most discretionary demand is in the outdoor sector and information on irrigation efficiencies is poorly known. The relative ease with which 48.3 GL savings was made following the imposition of restrictions, and the public support for their continuation, may indicate that there was considerable scope for efficiencies prior to 2001. The remaining opportunity for savings, and the ability to maintain water use efficiencies in the absence of restrictions, is not well known.

6.1.2 Sub-division and housing trends

Trends in urban block size and housing types (cluster developments etc), as well as occupancy rates, have resulted in in-built mechanisms to both save and use water. The decrease in garden size is probably resulting in major savings in new developments given that about half of scheme water use is outside in unrestricted supply periods. However there is a trend for houses with dark coloured roofs, an absence of eaves and evaporative air conditioners, all of which can increase water consumption. Better survey data needs to be collated so that future demands can be predicted with more accuracy.

6.1.3 Bore numbers and use trends

Ownership of a domestic bore is a major determinant of scheme water use in Perth but there are poor data on numbers on a spatial basis. In addition, the amount of water used by bores is poorly known with estimates ranging from 500 to over 800 ML/yr. It is important to know usage so that impacts on long term availability of this resource can be better made through groundwater models such as PRAMS. The impact of bore failure on scheme consumption is also poorly known, although there have been instances of this occurring (eg City of Stirling arsenic incident; saltwater intrusion at Belmont Racecourse).

6.1.4 Non-revenue water

There is a need to better delineate the contribution of different proportions of non-revenue water – leakage, Water Corporation use, non-commercial use (fire fighting etc). Some “use” may also be the result of metering errors. The development of robust leakage indices that allow a good comparison between water service providers is needed for assessing the cost-effectiveness of intervention programs.

6.1.5 Supply-demand prediction in non-urban areas

Data on metropolitan Perth may not be suitable for estimating future demand and supply options in rural and regional areas. Of particular need are the Mandurah - Pinjarra part of the IWSS (which has the fastest population growth in Australia), the Great Southern Towns Water Scheme and the Goldfields and Agricultural Water Scheme.

Mining and agricultural areas that are not part of a reticulated scheme have their own set of supply and demand circumstances. Where warranted, more data on future demands and supply options need to be collected.

6.1.6 Breaking down per capita consumption figures

Currently the target for water efficiency is 155 kL/person/year but this includes residential, institutional, industrial and commercial consumption. The target could be met by an economic downturn, or be exceeded despite a successful residential campaign if water use by the commercial sector increased. An estimate of actual residential per capita consumption equivalent to the 155 L/person/day target is 105 kL/person/day but this figure needs to be accurately assessed and monitored over time.

6.2 Research needs

6.2.1 Impact and cost effectiveness of *BASIX*, *METRIX* and *RETROFIX*

Western Australia is adapting a suite of sustainability indices first applied in Sydney. These include:

- WA-BASIX – for new urban developments;
- METRIX – for sub-division and suburban planning; and
- RETROFIX – for current residential housing.

There is a need to research the cost effectiveness of the options contained in these three sustainability measures to meet the required demand reductions under Perth conditions.

For example, estimates of the ability of rainwater tanks in a Mediterranean climate to reduce scheme water consumption vary widely according to whether the person doing the calculations is a tank enthusiast or a sceptic. Also the impact of preventing roof runoff from recharging the Superficial Aquifer, which is used for watering about a third of the lawns and gardens in Perth, is not taken into account in these estimates. Finally, the savings that come from tanks is much greater if they are plumbed into households for non-potable purposes (toilet flushing, clothes washing) but this can result in increased power consumption to run low efficiency pumps (eg SE Queensland study) and therefore the wider implication of mandating such measures may be counter productive if only a partial analysis is carried out.

6.2.2 *Washing machine and dishwasher efficiencies*

Estimating the water saved using more efficient washing machines and dishwashers requires knowledge of the water used per cycle, the number of cycles used per wash and how the machine is used in practice (eg size of wash loads, whether efficiency modes are used if they are installed). To ignore consumer use of machines may overestimate the savings that could result. The water savings that come from subsidised devices has been determined by comparing equivalent households which have and haven't received a subsidy since February 2003. The savings will become easier to calculate as the database increases, especially for subsidised products that were introduced only recently, considering that water meters are only read at six monthly intervals in Perth.

6.2.3 *Influencing behaviour / adoption*

A project is about to commence with the University of Western Australia (UWA) to build on the end use modelling approach used in this project.

Although End Use Modelling may facilitate a more technocratic approach to demand projections (e.g. modelling inventories of white goods by efficiency class, or the garden water use by projected housing developments) it should be recognised that the behavioural component of water demand is still fundamental: adoption of new technologies, choices of housing infrastructure etc are determined by individuals in response to incentives, whether market or policy based. Even where mandated change may seem to negate choice (e.g. compulsory restrictions) evaluating the impact of those restrictions on consumer welfare (i.e. the costs of implementing the policy) still need to be evaluated within the context restrictions to choice.

The UWA study will explore methodologies to generate behaviourally-based projections of water demand by end use, which can be integrated into the iSDP model for Perth urban water demand. It will have an explicit focus on outdoor water use, as this is the area where there is greatest discretionary demand, and hence greater responsiveness to changes in policy. This will then allow projections of demand to be made under a number of exogenously driven scenarios (e.g. population growth) and at the same time explore implications of policy-driven change, that will almost certainly be required if the supply-demand balance is to be achieved.

Analyses of the determinants of the demand for water are typically constrained by data availability. In particular, there is a lack of variability in the price paid for water across geographical regions and time. Furthermore, the use of a block tariff structure means that the marginal price of water (which is the relevant economic signal for consumption) is difficult to estimate at the aggregate level. However, responses to the use of water to changing prices may be identified by estimating the marginal value of water in different uses. This could be

undertaken by estimating household production models, which account for how water (and other purchased goods) is used to satisfy fundamental desires of the household. Thus, the responsiveness of demand to price can be determined in part by the degree of substitution that can be used in the production of fundamental goods. Substituting water with other inputs in the generation of basic goods (such as a garden) would be an example of this process.

The project will generate models of household water demand by end use, by explicitly considering the value of water within household production models. These models will then be used to generate projections of water demand under alternative scenarios, both in terms of population growth and climate change, but also in response to alternative policy interventions. Given that the household models will include different household composition, capital endowments, income etc as arguments, a natural outcome of the model will be heterogeneous estimates of the impact of such policy on households, and thus provide insights into the distributional impacts of alternative policies.

6.2.4 Industrial and commercial demand management studies

The Domestic Water Use studies carried out in Perth have provided an excellent insight into how water is used within households. Understanding water demand by industrial and commercial users is much less advanced. There is a need to categorise the demand into those which may respond best to demand management options and test the efficiency of methods – subsidies, tariff changes, technology improvements, feedback, education, reuse etc.

6.2.5 Price elasticity of demand for water in its various uses

Analysis of the impact of price policy on water demand requires an understanding of the nature of demand for water, by households and by industries. Whilst there is large volume of literature on this subject which supported the elasticity assumption of -0.30 for outdoor water use for households used in the Case Study 4 analysis, the relationship between price and the adoption of water using appliances requires further research. Consumer response to prices can take a number of forms, including a change in habits that can reduce water use given current technology, and a change in technology which can reduce water use yet supply the same level of benefit to the consumer.

Examples of the former include taking shorter showers, paying more attention to irrigation scheduling, reusing laundry water. Consumers might exhibit these behavioural changes at a result of price increases or other motivations, such as increased environmental awareness as a result of advertising. Whilst these changes in consumer behaviour could be incorporated in the model by changing parameter assumptions, more research is needed in order to determine the extent of such changes.

Examples of the latter include adoption of more efficient washing machines, redesign of gardens, changes to irrigation technology, some of which are explicitly treated in the iSDP Model and others which have the potential to be incorporated. More research is needed in order to be able to represent the influence of price changes on rates of adoption. The work on adoption rates discussed in Section 6.2.3 will go some way towards addressing this data gap.

6.2.6 Uncertainty and risk in supply systems

Climate change has required water sources to be de-rated already, and competition from other users and regulatory requirements have resulted in other sources having associated

uncertainties and risks. These need to be handled in a systematic way to avoid some sources being rated too lowly and others being counted as being too certain with a consequent inability to supply water when required. Exogenous factors such as a failure of domestic bores to provide garden watering is another example which needs to be considered when assessing future demand.

A further consideration is the potential impact on water supply yield from demand hardening through increases in the efficiency of water use. Tools such as CSIRO's HydroPlanner software allow demand and supply models to be dynamically connected facilitating investigation of complex interactions such as those listed here. Work to connect an iSDP equivalent with the REALM model has already been undertaken in Melbourne. A similar approach for the Perth IWSS would enable some of these risks to be assessed and prioritised as their significance, while having been highlighted, is at this point unclear.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Before building the iSDP model the state had two domestic water use surveys conducted about 15 years apart (the last one being before two-days-per-week sprinkler restrictions had been introduced) and a 20 year record of scheme water consumption to use as a basis for estimating how its scheme water was being used.

The iSDP model has integrated these data sets into a powerful tool that can be used to predict where water is currently being used by user groups, and where it may be used in future under different social, economic and regulatory environments. The model can also be used to assess the efficacy of demand management programs and rank supply and demand management options on a least cost basis.

As such the model is a powerful integrating tool for other (partial) analyses of water demand and supply options. It also summarises a large body of local and national research knowledge and clearly identifies data sources and assumptions.

The method used is consistent with that already in use in Sydney and Melbourne, and under development or consideration in Adelaide, Brisbane and Canberra.

The ability of the model to evaluate policy options has been shown in four indicative case studies. These studies are for illustrative purposes only, and should not be used to question current policy settings. A decision between supply and demand options also requires knowledge of social, environmental, feasibility, timing and equity consequences of each option. The iSDP model can be used as an integrating method to display the results of more specific analyses if required.

7.2 Recommendations

The iSDP model needs to be continually updated and refined to take account of changing circumstances, especially information of the efficacy of demand management options, the relative cost of supply options and alternative ways to meet water demand (reuse, self supply etc).

Immediate applications of the iSDP model include:

- Further assessment of the cost effectiveness of demand management options for the Integrated Water Supply Scheme;
- An assessment of the impact of three-days-per-week sprinkler restrictions on household water demand and use patterns;
- Setting of realistic target water consumptions for consumer groups. For example, the 155 kL/person/yr target set in the State Water Strategy (Government of Western Australia 2003) for the Integrated Water Supply Scheme needs to be broken up into specific targets for residential, commercial and industrial consumers based on a knowledge of the feasibility of making savings in each sector;
- As an integrating tool for a revised version of Perth's Water Future (Water Authority of Western Australia 1995) or the proposed Perth-Peel Regional Water Plan;

- Expansion of the iSDP model to the IWSS – SW region, the IWSS - Goldfields and Agricultural Scheme and the Great Southern Water Scheme so that demand projections can be improved, and supply demand options evaluated; and
- Further analyses be conducted using the iSDP model to assess the sensitivity of the baseline demand forecast to the introduction of more water efficient products such as 4.5 / 3 litre toilet from Caroma.

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APPENDIX 1 INTEGRATED RESOURCE PLANNING PRINCIPLES¹¹

A1.1 Definition and principles

Integrated Resource Planning (IRP) for water can be defined as the integration of demand management and water supply augmentation options to address a supply/demand deficit through a timely, cost-effective, environmentally sound and socially acceptable program of initiatives. The following principles are represented in this definition:

- A megalitre (ML) of water provided through a new source is equivalent to a ML of water saved through more efficient use. The focus shifts to provision of service rather than provision of a volume of water;
- The potential deficit between projected available supply and projected demand must be addressed over the short (5 years), medium (5 to 15 years) and long term (15+ years) – therefore data on water saved or supplied by an option must include a time dimension;
- Implementation costs for options must consider all contributors (water utilities, state and local government agencies, community groups and individual customers) – this is referred to as total resource cost or cost to the community; and
- Environmental and social impact data for options need to be included in the decision making process – these parameters and datasets can be monetised where appropriate cost data is available. Alternatively, environmental and social criteria can be considered as distinct components in the assessment of the sustainability of options.

Two other points are worth clarifying in the context of this definition:

- Impact on peak demand, or impact on sewage flows, can be captured as an output from the IRP process – however the water supply/demand deficit is typically considered first on the basis of monthly or annual average; and
- Short term climate variability is not considered in medium to long term IRP¹². Climate change however, where sufficiently understood, can be incorporated into the supply/demand deficit through projected impact on yield (reduction in inflows with drier climate for example) and projected impact on demand (increased outdoor water use with drier climate for example).

These principles are not location specific and as such are widely transferable – this is evident from a number of examples within the Australian and international water industry. Equally,

¹¹ Adapted from McFarlane, D.J., Inman, M., White, S., Loh, M., Turner, A. and English, L. (2005). Integrated Resource Planning for the Integrated Water Supply Scheme. Client Report to W.A. Government. CSIRO: Water for a Healthy Country National Research Flagship Canberra, 39pp.

¹² Short term climate variability is an important consideration in ensuring that the starting point for projections of future water use is adjusted to average climate conditions (to reflect the fact that out-year forecasts are also considered as being on the basis of average climate conditions).

these principles, while presented here in the context of water, have been applied to other resources such as energy – consider a kWh provided through a new source as equivalent to a kWh of energy saved through demand management (Swisher *et al.*, 1997, Tellus Institute, 2000).

The key steps and information/data needs for IRP are detailed in the following sections.

A1.2 The gap

The first consideration in IRP is to forecast future requirements for water and estimate the future availability of water supplies. The objective of this step is to quantify the supply/demand deficit (or indeed surplus) in the short, medium and long term (Figure 3.1).

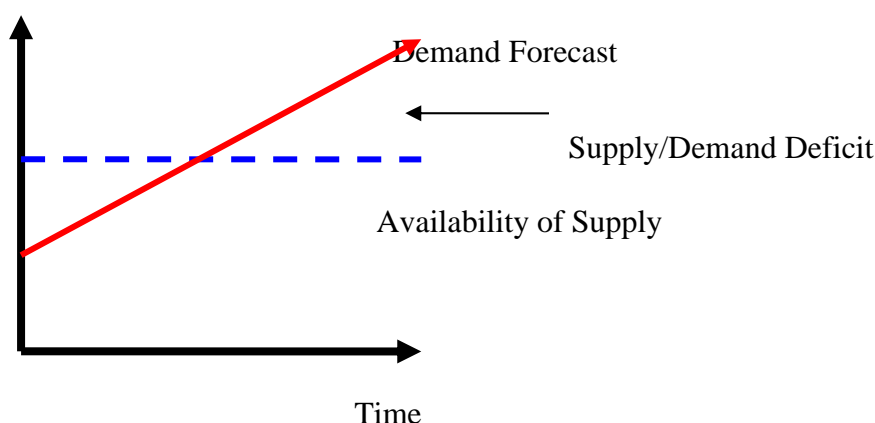


Figure A.1 Supply/Demand deficit

Importantly, the demand forecast and availability of supply projection needs to be undertaken in the context of a ‘Business as Usual¹³’ approach. In this context, changes in demand and availability of supply that occur without active intervention (by government agencies and water utilities for example) should be incorporated into the Business as Usual datasets. The often quoted example is the changeover from single flush to dual flush toilets in Australia. As older single flush toilets are replaced, the only choice (effectively) for consumers is to purchase a dual flush toilet. This change increases the efficiency of use, reducing the demand for water – and yet is not generally considered as an active intervention.

The key information/data needs can be divided between determining availability of supplies and forecasting demand.

- Availability of Supply

This component is also referred to as allocation or yield. For major water storages (surface and subterranean), specialised modelling tools are typically utilised to determine allocation / yield. If an established program of environmental flows was in operation for surface water storages for example, then this data should be reflected in the yield / allocation component. If long term climate change impacts were projected to reduce (or indeed increase) the yield over

¹³ Often shortened to BAU or alternatively referred to as ‘Base Case’ or ‘Do Nothing’ or ‘Reference Case’

time then, again, this data should be reflected in the yield / allocation component. So the availability of supply under ‘Business as Usual’ may not necessarily remain constant over the planning period. A report by WSAA entitled “Framework for Urban Water Resource Planning” (Erlanger and Neal, 2005) discusses the tension between levels of service and supply yield, factors affecting yield and the uncertainty around calculating yield.

Key Dataset

1/ ‘Business as Usual’ supply availability curve at the appropriate time step

All of this information is then provided to the IRP process as a referenced data set.

- Demand Forecast

Methodologies for the projection of future water requirements have become more sophisticated in recent years. Historically, projections of demand have been based on Equivalent Tenement (ET) where all future growth (residential and non-residential) is converted to ET’s and an average demand per ET is then used to determine total demand. This approach, while generating a demand forecast, is not considered robust enough in the context of IRP.

Demand should be disaggregated to at least the key ‘sectors’ (agricultural, residential, commercial, industrial, institutional and non-revenue water for example – depending on the context) and growth projected for these same sectors. An assumption that all future growth can be represented as an ET does not respect the changes that are occurring throughout major urban areas as the density of development increases and in many cases, industrial companies are moving out – these changes highlight the need for a sector based approach to be the starting point for demand forecasts. Within the sector based approach a change in population, households (both single residential and multi residential dwellings), lot size and number of non residential properties are considered important factors that need to be taken into consideration.

An ‘end use’ approach should also be undertaken to further disaggregate the residential sector. This is of key importance to determine the relative contribution of indoor and outdoor demand as well as the major appliances/fixtures within a house (typically toilets, clothes washers and showers). This end use approach is necessary, for example, to quantify the impact of replacement of single flush toilets with dual flush.

Demand forecasts may also need to be developed for existing alternative water sources that are not provided by the municipal authority or water utility where such sources are in use. Rainwater tanks are an example, as is use of private groundwater bores. This data is not used directly in determining supply/demand deficit but rather to provide a complete picture of total water use requirements for a region.

Key Datasets

1/ ‘Business as Usual’ demand forecasts for major sectors with the residential sector further disaggregated where feasible into indoor demand associated with major appliances/fixtures and outdoor demand (i.e. an end use approach);

2/ Demand forecasts for existing alternative water sources (other than those operated by municipal or water utility) where such sources are in use [for use in association with total water use requirements rather than comparison with availability of existing (bulk) supplies];

3/ Demand forecasts for alternative water sources supplied by the water utility (e.g. major reticulated reuse scheme) where such sources are in use (again, to give a total water use perspective for the region).

All of this information is then provided to the IRP process as a referenced data set.

A1.3 The options

Options to reduce the supply/demand deficit cover a very broad spectrum of projects, initiatives and ideas. Reducing the supply/demand deficit can be achieved either by increasing supply or reducing demand through efficiency improvements or substitution with alternative water sources (Figure 3.2). Options could include supply augmentation through bulk infrastructure (desalination plants, inter-catchment transfers, catchment management initiatives); demand management through (distribution leakage repairs, water use audits for industrial/commercial properties, retrofitting of residential fixtures, pricing and performance standards for appliances); alternative water sources (third pipe recycled water systems for residential customers, rainwater tanks for toilet flushing plus outdoor usage, bores) and provision of recycled water to industrial customers).

The alternative water sources category covers sources that are both centralised (e.g. recycled water for industrial customers) and decentralised (e.g. rainwater tanks and private bores). These options can be considered as either demand or supply side measures. Ultimately, this will be determined by what key questions are being addressed through the IRP process. For example, if the planning objective is to manage the supply/demand deficit from the context of existing water sources then a recycling option will reduce demand from these existing storages. Conversely, if the planning objective is to manage total water use then recycling is considered as an offset - providing an additional water supply.

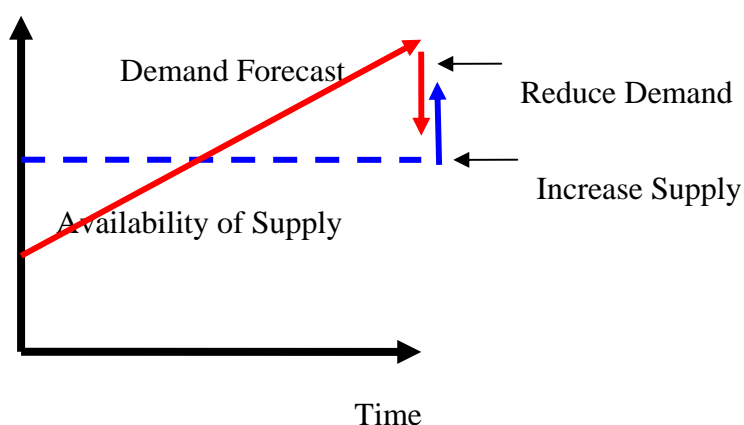


Figure A.2 Managing the Supply/Demand deficit

Given this range of options, a consistent approach to managing data and information needs is necessary to ensure that each option is adequately described and can be compared with all other options. At this point of data collation, there also needs to be a clear understanding of

the boundary for the IRP process. For example, what is the limit of analysis to be undertaken? Are costs simply limited to those incurred to establish and maintain the option? Should indirect costs and benefits generated by an option be considered?

This boundary can also be considered in terms of the data requirements to undertake the planning process. In this way, as more data becomes available, the boundary for IRP may extend – however, any such change must be consistent across all options under consideration.

Figure 3.3 demonstrates the link between the boundary for consideration and the required data from an economic perspective.

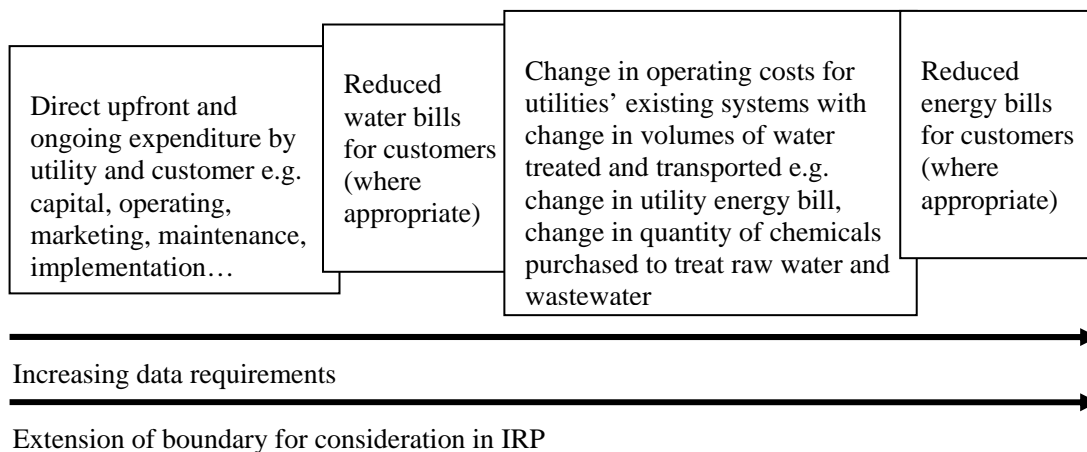


Figure A.3 Data requirements and IRP boundary

By extending the boundary for consideration within IRP, additional and valuable perspectives can be added to the decision making process. The issue of consistency is paramount however – on a first pass through each option, only data associated with direct upfront and on-going costs should be collected. A second, subsequent pass through each option could then extend the boundary of the IRP process to incorporate data on indirect system and customer costs and benefits. It would be inappropriate, however, to incorporate indirect system costs and benefits data for only a subset of the options under consideration.

The same concept holds for environmental and social datasets. With appropriate data, the impact of demand and supply options could be measured in terms of pollution of aquatic environments or the volume of biosolids trucked to agricultural regions for land application. Clearly, additional data will provide a fuller perspective of the relative merits of each option – the primary limitation is, of course, data availability.

A1.4 Selection of options

With an extensive range of potential options available to IRP decision makers, ranging from demand management to alternative sources and supply, there needs to be a clear rationale for choosing particular options or packages of options over another.

The principles of IRP include the need to address economic, environmental and social criteria as part of the decision making process. This can be achieved in several ways. For example, methods can be used which attempt to quantify the indirect costs and benefits, that is, the

externalities. For some costs this is more straightforward than others. For example, greenhouse gas emissions can be estimated, and a monetary value based on existing markets, such as the European Trading Scheme, can be applied. Other criteria can be quantified using survey methods or deliberative valuation processes. Alternatively, option screening can be undertaken using multi-criteria assessment methods. Importantly, in some of the most recent examples of IRP in Australia, the full range of sustainability criteria have not been combined into a single parameter. Instead, options have been ranked on economic criteria, and then the additional criteria applied to screen or filter options.

Typically in the assessment process, the whole cost of an option is measured in terms of present value \$/ML or c/kL, known as the levelised or unit cost. This metric compares the total cost to all contributors (government, community and customer) with the volume of water saved (or supplied) by the option. This calculation uses a discount rate not only for the costs but also for the 'service' provided by the volume of water, which, for two identically costed options, will favour that which supplies or saves the 'service' provided by the water earliest. Hence the levelised or unit cost calculation enables the costs, savings/supply of water and time dimension to be taken into consideration in one metric and all options can be compared on an economic criteria by using a straight-forward ranking process of unit cost (Fane *et al.*, 2003).

To further explore the sustainability assessment methods, assume a metric had been developed for river health, such as incidence of algal blooms. The two criteria (the whole of society unit cost, \$/ML, and river health) do not necessarily need to be amalgamated through a weighting process. Indeed, application of weighting procedures can simply introduce yet more assumptions to the decision making process. Instead, options can be ranked separately for \$/ML and river health. Once this has been done it then becomes apparent that options which have low \$/ML as well as high river health would be flagged as favourable (in this simplistic example of only two criteria). The last step is to review the timeliness of the most sustainable options in the context of changes to the supply/demand deficit over time.

The specific measures or criteria that are used in IRP for decision making will vary from location to location. Some examples are provided in Section 5 of this Report. The key point to make though is that IRP should cover the three tenets of sustainability – economy, society and environment. The level of detail to which each is addressed will be a function of the available data – again, this is addressed further in Section 5.

An additional set of criteria that has been utilised relates to risk and uncertainty. This might be as simple as an index of outcome certainty for each option – or be more complex such as results from a detailed risk assessment procedure.

The final package of options recommended through an IRP process must address the supply/demand deficit over the full planning horizon and should clearly demonstrate favourable outcomes across the range of criteria considered in the decision making process. The decision making process should, as far as possible, use participatory methods to develop the criteria, their weighting and associated values and engage relevant stakeholders such as the utility, government, regulator and citizens during the process.