SimulAIt Water Forecasting & Barwon Model Configuration

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Authors

Dr Don Perugini

Dr Michelle Perugini

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Acknowledgements

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Table of Contents

1. Introduction

The Victorian Essential Services Commission (ESC) requires water demand forecasting to inform its water pricing review. Of particular interest is analysing the expected bounce-back in water demand as restrictions are eased across Victoria. ESC requires a water forecasting tool that incorporates a wide range of factors that impact on water demand, including population trends, product penetration, and consumer behavioural characteristics, in order to better forecast future water demand and bounce-back. This model could provide insight into the factors that contribute to bounce-back and/or future demand, and facilitate social, economic and environmental assessment.

Intelligent Software Development (ISD) has water demand forecasting and demand management micro-simulation software SimulAIt (Simulait) which has been successfully applied in the water industry to assist with strategy and policy, including business case development, demand management and water conservation, pricing, trading, and informing incentive and behaviour change programs. The multi-purpose forecasting platform has a demonstrated accuracy of greater than 95%, and has been able to assist decision makers to gain greater insight into complex socio-economic systems.

ISD was commissioned by the ESC to configure a validated water forecasting model for the Barwon region, and to provide both training and access to ISD's SimulAIt Online (SOL) water forecasting tool which can be configured and applied to any region across Victoria. This report provides an overview of the methodology and validation results of the Barwon model. Further detail regarding the components of the SimulAIt water model can be found in the SOL Water reference manual.

2. Methodology: SimulAIt Water Demand Forecasting Platform

2.1. Complexity of Water Demand Forecasting

There are various factors that impact on water demand, which include:

- *Population trends and dynamics*: Water demand is dependent on population growth, consumer demographic type, and household structure and size, which change over time. Additionally, household allotment and garden size is a significant factor on water demand, which are becoming smaller.
- *Products or appliances used*: The type and efficiency (consumption of water, energy and carbon) of water related appliances used by consumers' impacts on water demand. Appliances are becoming more efficient, and the penetration of these efficient appliances into households is increasing over time.
- *Consumer behaviour*: How consumers use appliances, e.g. frequency and duration of use, is a significant factor on water demand. Different consumer types may behave differently with regard to using appliances, and the usage may be based on per household (e.g. washing machine usage) or per person (e.g. showering). Behaviour may be dependent on seasonal

factors (e.g. weather and garden watering), demographic types (e.g. infants and bath usage), and influences (refer dot point below).

- *Behaviour change & maintenance from influences (strategies and policies)*: Exposure to influences, e.g. strategies and policies, may impact on consumers and result in behaviour change. Additionally, consumers that persist with changed behaviour over a period of time may become accustomed to the behaviour, and thus permanently maintain the behaviour. Various influence types may impact on consumer behaviour, which include water conservation (restrictions, rebates, retrofit programs), water price (discretionary and non-discretionary usage), and marketing and media exposure regarding the water situation (e.g. drought & water supply levels). Different consumers may respond differently to these influences, e.g. higher water prices may impact less on higher income consumers. Understanding and modelling the range of *possible and rational* behaviours associated with appliance usage, and casual relationships that drive and influence different types of behaviour for different consumers, is vital in better capturing consumer behaviour, behaviour change, and thus water demand.

ISD's SimulAIt water forecasting platform considers these complex and wide range of factors to assist with, and simplify, water demand forecasting. Particularly in recent years given the drought and complex schedule of restrictions and water conservation programs, which has significantly affected natural historical water demand characteristics, SimulAIt provides a practical approach to assess future demand and bounce-back since the model has little reliance on historical demand data.

2.2. SimulAIt Micro-Simulation Platform Overview

SimulAIt micro-simulation is based on a variety of technologies, including agent-based modelling, micro-economics, and cognitive reasoning. The general theory behind SimulAIt and agent-based modelling can be described using ant behaviour as an example. Ants exhibit what appears to be efficient, coordinated and adaptable behaviour when collecting food to feed the colony. It would appear as though there were a central manager coordinating this complex task, however, this is not the case. The complex behaviour of the ants is driven by each individual ant following three simple rules: i) when you see food pick it up; ii) then release a chemical trail for others to follow; and iii) follow any chemical trails you come across. Ants' individual behaviour for collecting food therefore results in *emergent behaviour* of the colony.

Not dissimilar to ants, consumers can also be considered as rule based, although the rules that describe consumers are unsurprisingly more complex. For example, if the weather is hot, most consumers will respond by turning on their air-conditioner, or go somewhere cool like the beach. These rules are largely driven by a consumer's demographic characteristics, situation, and preferences. Mass-consumer behaviour can thus be described by the emergent behaviour of millions of individual consumers making different decisions in response to different cues.

Agent-based modelling is a type of micro-simulation that provides a practical approach to model consumers. Agents are software components within a simulation environment that can represent consumers and their prescribed rules to mimic the decisions and behaviours of different consumers. Many agents can then be used to simulate millions of consumers in order to predict (emergent) mass-consumer behaviour.

With agent-based modelling SimulAIt uses a bottom up approach to developing models - starting with consumers (refer Figure 1). SimulAIt allows implementation of rules that describe consumer behaviour: e.g. how they make decisions in different circumstances given different choices; how they interact or are exposed to communications; and how they respond to different strategies including policies, marketing, pricing, and competition. Different types of qualitative and quantitative data can be utilised to define the rules. This includes market research and social data, demand and sales data, economic data, environmental and policy data, and more importantly expertise and domain knowledge about consumers.

SimulAIt comprises a human cognition reasoning engine and dynamic multi-dimensional database that enables the easy translation of complex and dynamic human decision making and system behaviour from the real world into the SimulAIt agents. Once the high-level behaviours have been defined, SimulAIt's integrated Census data and population dynamics allow the rules and behaviours to be extrapolated across varying population sizes – where individual agents are created and represented by different consumers. SimulAIt can then simulate millions of individual consumers and their behaviours, and provide forecasts of different regions and over various timeframes. More importantly, SimulAIt allows *what-if* scenarios by testing a broad range of different strategies, assumptions and parameters, to assess the impact on consumer behaviour and to assist in optimising strategies to influence consumer behaviour and ultimately future demand.

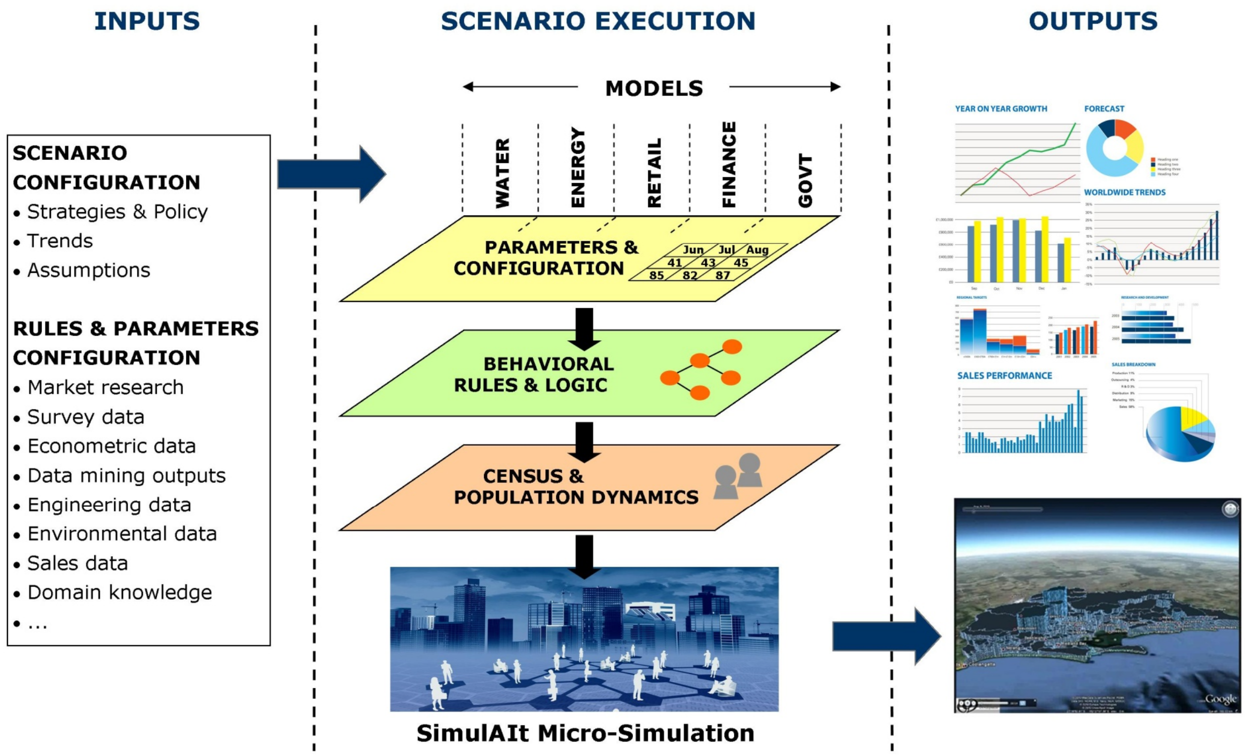

Figure 1. Overview of the SimulAIt micro-simulation platform. Various data sources (e.g. market research, etc.) are used to create the parameters and behaviour logic layers, which extrapolated over in-built Census data creates a micro-simulation of mass-consumers. Scenarios can be configured by changing or updating parameters (e.g. strategies, assumptions) to run what-if scenarios. Forecast results can be in a range of formats over different regions, times (past and future) and products.

2.3. SimulAIt Water Model Overview

ISD's SimulAIt platform comprises a comprehensive water forecasting model, developed over many years based on various sources of research on consumer behaviour and attitudes regarding water usage. In this project, the SimulAIt water forecasting model was configured to create a dynamic micro-simulation of over 100,000 households in the Barwon region; at postcode level of detail. For each postcode region considered, a bottom-up approach was used where a detailed model of individual households was constructed.

The model details each area within individual households (eg. toilet, laundry), the composition of water related products and water use behaviours, outdoor water usage and behaviours, and the change in product composition and consumer behaviours over time in response to influences, e.g. restrictions and price increases. The model was built up to include all households within a postcode, and subsequently all postcodes within the region to simulate and predict behavioural outcomes in the Barwon region as a whole. The configured model can then be used to (retrospectively or prospectively) predict consumer behaviour resulting from a range of consumer factors (e.g. population and product trends) and influences (e.g. restrictions and prices).

The SimulAIt simulation results output a large quantity of data, describing water, carbon and energy use behaviours within; each region (Postcode), each area of the household (e.g. kitchen, laundry, etc.), and each sub-area of the household (e.g. shower, bath, taps), over the months simulated.

To follow we provide further detail regarding the SimulAIt water forecasting model's approach (high-level conceptual model).

2.4. The SimulAIt Water Behavioural Model

The high-level SimulAIt water conceptual model is shown in Figure 2. Software agents in the micro-simulation comprise a representation of appliances/products and their usage characteristics to describe the water consumption profiles of households. The model takes into account the behaviours that drive the decision for usage and the decision for change (of products used) which ultimately influence overall water consumption. Additionally, the SimulAIt water model considers influences that may be used to drive behaviour change and alter consumer decisions for usage and product acquisition to modulate water consumption.

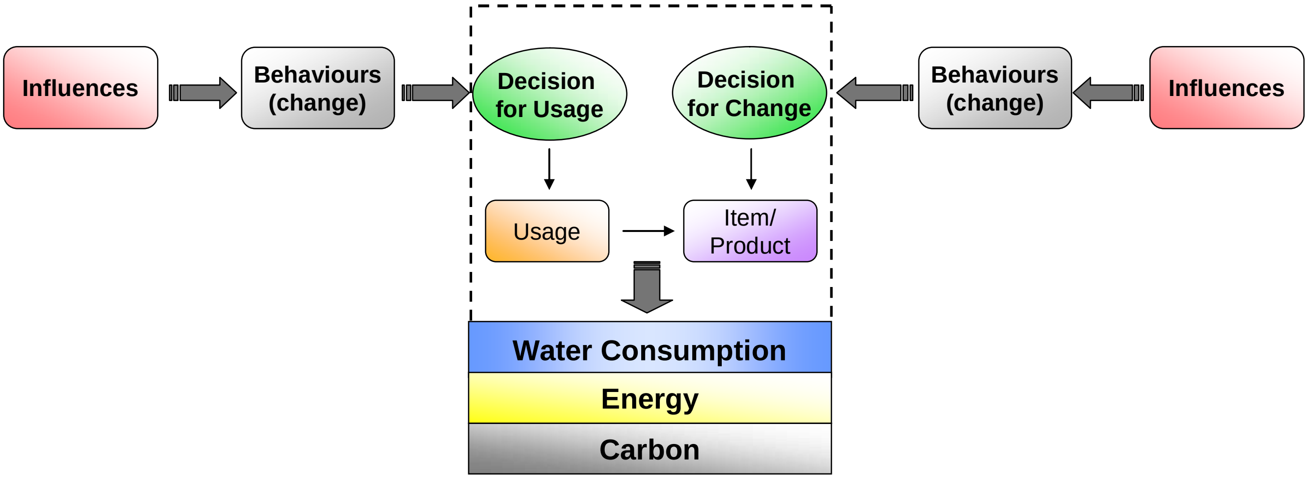

Figure 2 The SimulAIt behavioural model.

The SimulAIt behavioural model is run over time to assess the effects of various influences on decisions for change and decisions for usage on water consumption. SimulAIt takes into account the many influences that contribute to the overall situation including population dynamics and social influences (see Section 2.4.1), physical and environmental surroundings (eg. weather), economic and political influences (eg. water restrictions, water prices, and uptake trends from rebates and retrofit programs), and the composition of the items and products (eg. type of washing machine). In this way, water consumption can be modelled over time and effects of different policies and social trends can be assessed, as well as allowing likely effectiveness of existing and new demand management programs and policies to be quantified.

2.4.1. Influence-Behaviour Change Model

The influence-behavioural change model (Figure 3) in SimulAIt describes how social (including economic) influences may alter behaviours, decisions for change and ultimately water consumption (see Figure 2).

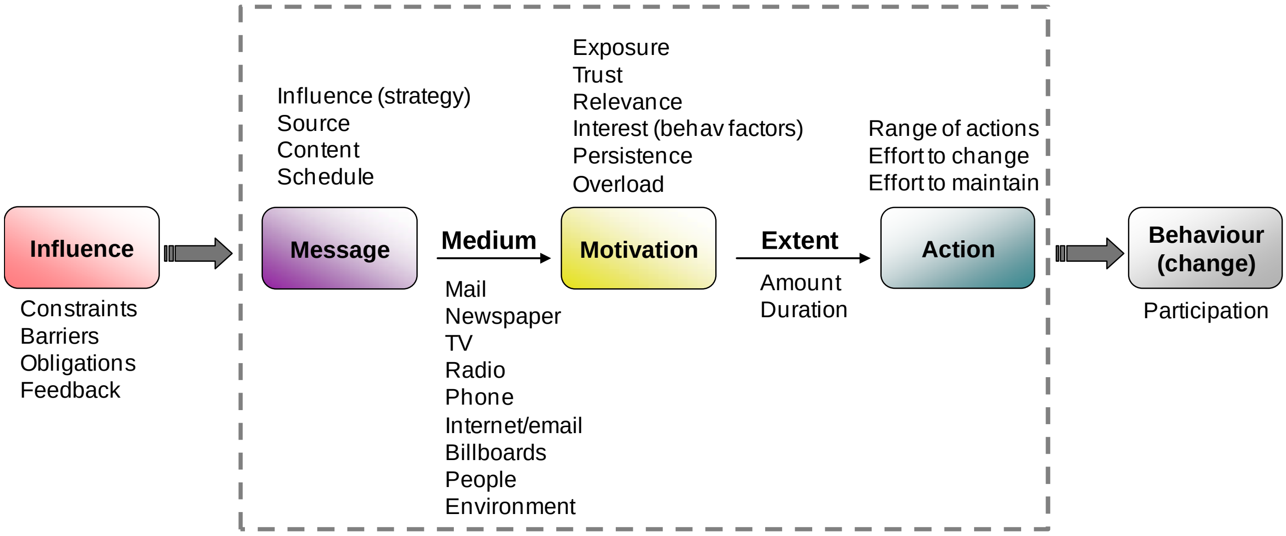

Figure 3. High level model of the relationship between influences and behaviour change.

Influences are defined by four categories in the model:

- Constraints (restrictions): Behavioural change forced upon residents (no legal choice).
- Barriers (financial and other measures): Financial measures including prices, rebates and taxes (if applicable). The financial measures provide a barrier (when a choice is available) for water use and product acquisition behaviour.
- Obligation (severity of the situation and/or communications): Behavioural change resulting from (personal and social) obligation to reduce water consumption in response to the severity of the environmental situation (e.g. current water levels or restriction levels).
- Feedback (monitoring): Enables residents to obtain feedback from their behaviours, such as monthly statements, to assist in controlling their behaviours.

How influences ultimately result in behaviour change depends on messages received, as well as motivation and actions of individuals. The influence-behaviour change model describes the exposure of individuals to influences communicated (*messages*) through various *mediums* including; radio, television, newspaper, phone, internet, billboards, or other people. Different individuals have different levels of exposure to particular mediums, and individuals that are exposed to messages of influence may become motivated to change their behaviour.

The *motivation* of an individual to change behaviour is dependent on both the message and the individual, which is defined by the influence type, trust in the source of the message, message content, schedule of communication (e.g. frequency of communication), relevance of the message to the individual (e.g. garden restrictions have less relevance to those without a garden), and the level of interest (concern) that an individual may vest in the message.

Individuals that are motivated to change their behaviour *may* translate this into *action*. The *action* (behaviour change) of an individual is determined by the causal relationship between possible behaviours and motivation. The *extent* to which behaviour changes (amount and persistence) is largely dependent on the level of motivation, the level of inconvenience for a particular behaviour change and any constraints preventing a choice (eg. water restrictions).

Persistence describes how long an individual retains a particular behaviour and relates to the reversion/bounce-back in behaviour when influences are reduced. Persistence may be influenced by; the extent to which an individual is inconvenienced with its current behaviour, the duration that an individual has endured a particular behaviour (ie. becomes accustomed to a behaviour resulting in reduced inconvenience), and the level of influence still bearing on that behaviour.

3. Configuration of a validated residential model for Barwon

3.1. Barwon Scenario

ISD's validation process involves forecasting forward from the past given the actual strategies/policies implemented over that time, and comparing the results with the actual historical water demand, where the actual water demand is minimally used (if at all) as an input to the model. Actual historical results are only used where required for calibration of uncertain data or assumptions in the model by comparing with simulation results at discrete points/events in time. In this particular validation, only the demand in the year 2005-2006 was used to calibrate the level garden water usage (i.e. size of garden and lawn areas that are watered).

The Barwon validation consists of the aggregation of four separate scenarios comprising different regions each with differing levels of restrictions. The scenarios include: Barwon region; the Apollo Bay, Skenes Creek, Marengo regions; the Colac region; and the Fairhaven, Aireys Inlet and Lorne regions.

3.2. Validation Results

The validation results are shown in Figure 4 and Table 1. The results show that during a high level of restrictions in the Barwon region (2008 to 2010), the accuracy of the simulated forecast is lower than for other years. Possible reasons for this include:

- *Less efficient appliances in the home*: The scenario assumptions regarding the uptake/trends of efficient appliances in the home could be overestimated, and thus a higher level of inefficient appliances would increase the overall demand. The forecasts in Figure 4 and Table 1 are produced from a scenario with greater inefficient appliances in the Barwon region (and currently not other regions) compared with that seen in Melbourne (refer section 5). A higher level of inefficient appliances is consistent with previous projects in regions outside metropolitan/city areas in Victoria, however the level of inefficient appliances actually used could still be greater than the assumptions in the scenario. Monthly historical demand data could be used to validate and/or calibrate this component of the scenario.
- *Non-compliance*: The SimulAIt model does not consider/model non-compliance. Higher actual demand could be a result of non-compliance by residents in the Barwon region that were completely restricted from watering their lawn and garden. The high level of accuracy in 2010-11 when restrictions were eased in the Barwon region, supports the case that the

lower accuracy with high restrictions may be due to non-compliance. Monthly historical demand data could be used to verify whether non-compliance is indeed a factor, since greater water demand will be observed over the summer months.

- *Missing customers not on restrictions*: Table 1 shows the actual number of residential customers, and the simulated number of residential customers. There is a reasonable discrepancy between the actual and simulated numbers (over 10,000, or approximately 10%). It is commonly observed that the household numbers in the Census data are lower than actual customer numbers (hence the larger jump in simulated customer numbers in 06-07 reflects SimulAIt's calibration to take this into account), and it is unlikely that SimulAIt's population trends will match exactly to the actual customer numbers, however this discrepancy could indicate that some regions or customers which were considered in the actual demand were not included in the scenario and thus forecast results. If so, these customers may not have been subjected to restrictions, as with the Fairhaven, Aireys Inlet and Lorne regions, likely resulting in a higher overall demand during 2008 - 2010. Note that the discrepancy in customer numbers could also be due to the reduction in the population in the Barwon region during the winter/autumn period, when the Census was taken.
- *Lower level of communications and customer impact*: Finally, another reason for the lower accuracy between 2008 and 2010 could be due to a lower level of communications and community impact in the Barwon region (compared with that seen elsewhere in Victoria) from water shortages and drought, and thus assumptions used in the scenario may have been overestimated. Monthly historical demand data could be used to validate and/or calibrate this component of the scenario.

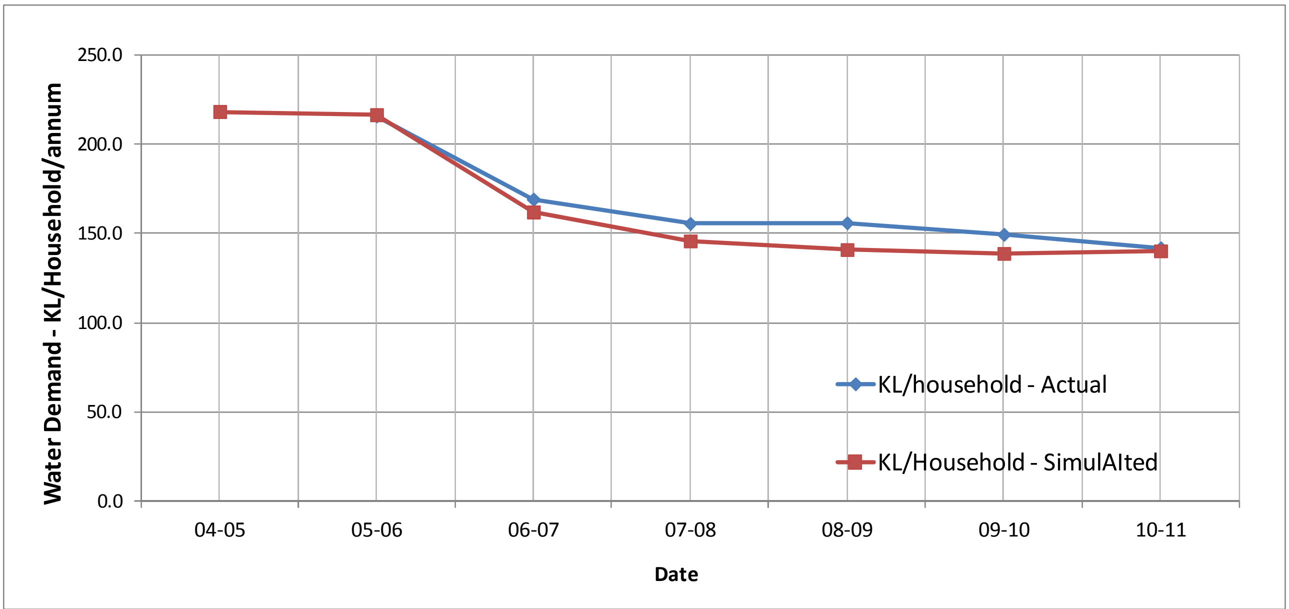

Figure 4. Barwon validation – comparison of simulated (historical forecasted) demand with actual demand.

Table 1. Validation results comparing actual and simulated demand from July 2005 to June 2011, and comparison of actual and simulated number or residential customers (households).

Validation		05-06	06-07	07-08	08-09	09-10	10-11
Demand comparison	KL/household - Actual	215.8	169.1	155.6	155.9	149.4	142.0
	KL/Household - SimulAIted	216.5	162.0	145.7	140.9	138.8	140.2
	Accuracy	**99.7**	**95.8**	**93.7**	**90.4**	**92.9**	**98.8**
Households comparison	Actual number of residential customers	115,090	117,044	119,731	121,813	123,866	126,011
	SimulAIted number of residential customers	93,660	106,788	108,057	109,329	110,520	111,721

4. Demand Forecasts

The validated Barwon demand model was used to forecast and compare different scenarios and levels of permanent *behaviour maintenance* from 2006-2018 (refer Figure 5 and Table 2). Permanent behaviour maintenance refers to the level of behaviour change that consumers persist with permanently as influences ease (e.g. restrictions, drought conditions and associated communications), due to consumers becoming accustomed to their changed behaviours which they have persisted with over a period of time[1]. The greater the level and duration of behaviour change by consumers, whether voluntary or enforced through policy, the greater the level of behaviour maintenance.

Figure 5 shows the forecasts comparing the baseline scenario with a standard[2] level of behaviour maintenance, with scenarios comprising a 33% increase and decrease in behaviour maintenance. Additionally, the 'no influences' scenario represents the water demand that would likely have been seen if no restrictions or other influences were implemented in the past. The no influence scenario shows the natural gradual decline in water demand from population changes and uptake of efficient

1 Permanent behaviour maintenance is in addition to temporary behaviour maintenance which is the lag time for consumers to gradually revert back to their desired behaviour.
2 Standard behaviour maintenance in the model is where for every 18 months that a customer persists with a given behaviour, there is a10% reduction in the effort to maintain that behaviour.

appliances. The no influences scenario represents the 'theoretical maximum' bounce-back in demand if consumers reverted back to their previous water usage behaviours. Therefore, the difference between the no influences scenario and the other scenarios represents the reduction in water demand from permanent behaviour maintenance/change. Also shown in Figure 5 is Barwon's forecast demand, both from their submission in December 2011 and their revised numbers in February 2012.

The scenario forecasts show that water demand is expected to increase from a minimum of approximately 140 KL/household/annum during level 4 restrictions to between 160 to 170 KL/household/annum in 2013-14 as restrictions completely ease to permanent water saving rules (PWSR) in March 2011. The bounce-back is expected to be less than the pre-drought demand level of approximately 215 KL/household/annum.

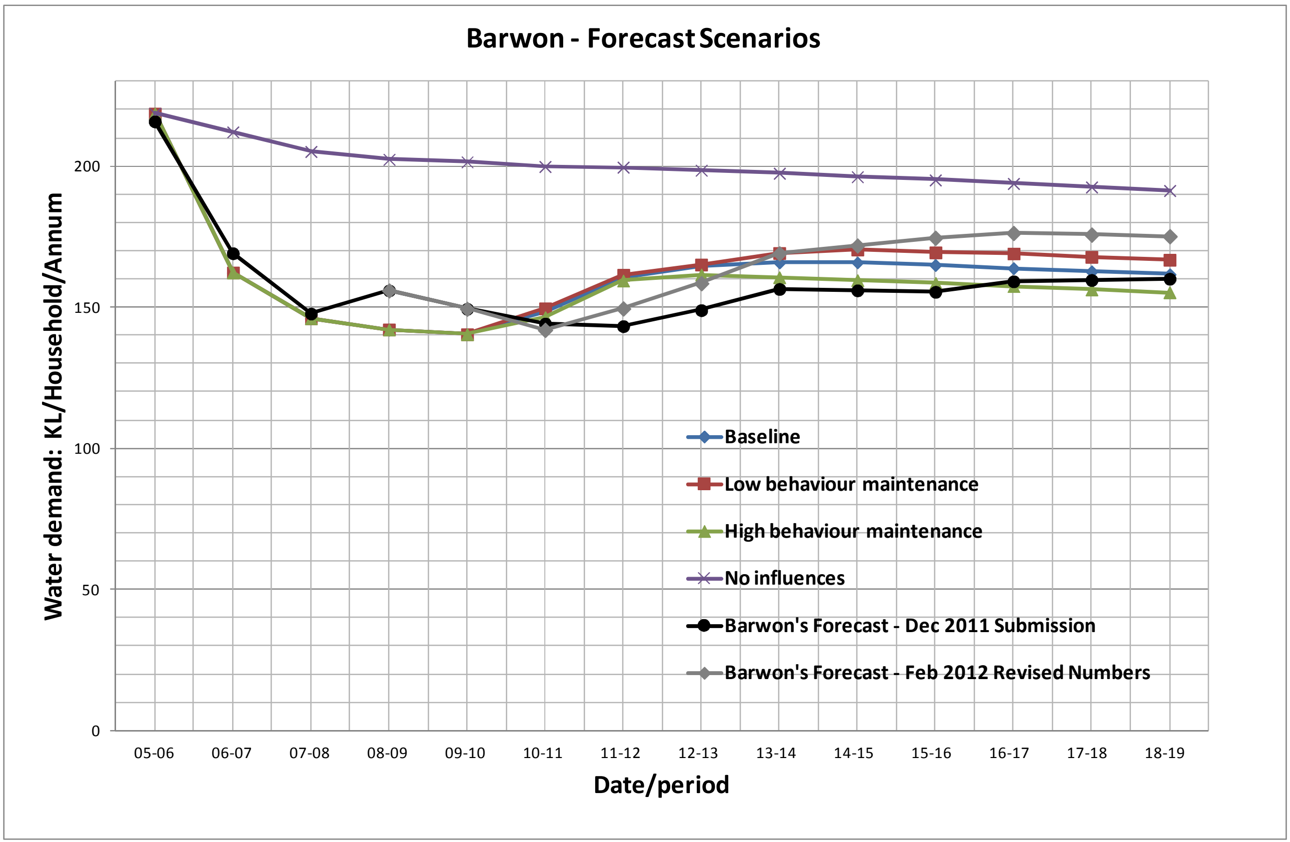

Figure 5. Comparison of baseline scenario with varying permanent behaviour maintenance – KL/Household/Annum.

The no influences scenario shows that the theoretical maximum bounce-back in water demand during 2013-14 is below 200 KL/household/annum where there are no influences affecting behaviour change. The difference in demand between the theoretical maximum bounce-back (no influences scenario) and the predicted bounce-back (in baseline, low and high behaviour maintenance scenarios) is due to behaviour change/maintenance from past influences affecting pre-drought behaviours, which is approximately 25 KL/household/annum from 2013-14. Behaviour change includes consumers using less water on their gardens and lawns, reducing their garden or lawn areas, and maintaining other water conserving behaviour both outdoors and indoors. The gradual decline in water demand up to 2019 for all scenarios is due to population changes and uptake of efficient appliances.

Table 2. Scenario forecast results, in KL/household/annum.

Demand	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14
Baseline	218.6	162.2	146.0	142.0	140.4	148.4	160.7	164.5	165.9
Low behaviour maintenance	218.6	162.2	146.0	142.0	140.4	149.6	161.4	165.1	169.1
High behaviour maintenance	218.6	162.2	146.0	142.0	140.4	146.4	159.4	161.6	160.5
No influences	218.6	212.1	205.1	202.4	201.5	199.9	199.6	198.5	197.4

Demand	14-15	15-16	16-17	17-18	18-19
Baseline	165.9	164.9	163.8	162.7	161.6
Low behaviour maintenance	170.4	169.4	169.0	167.8	166.8
High behaviour maintenance	159.5	158.5	157.4	156.3	155.3
No influences	196.2	195.1	193.8	192.5	191.3

Figure 6 show the results for total residential consumption calculated by multiplying the per household (connection) forecasts with the number of residential connections in Barwon's revised corporate plan submitted in February 2012. Barwon's initial forecasts (December 2011) show lower demand than ISD's forecasts until 2016-17. Barwon's revised forecasts (February 2012) show a lower demand in 2010-2013 and then a subsequent increase in demand in years 2015-2019, when compared to ISD forecasts.

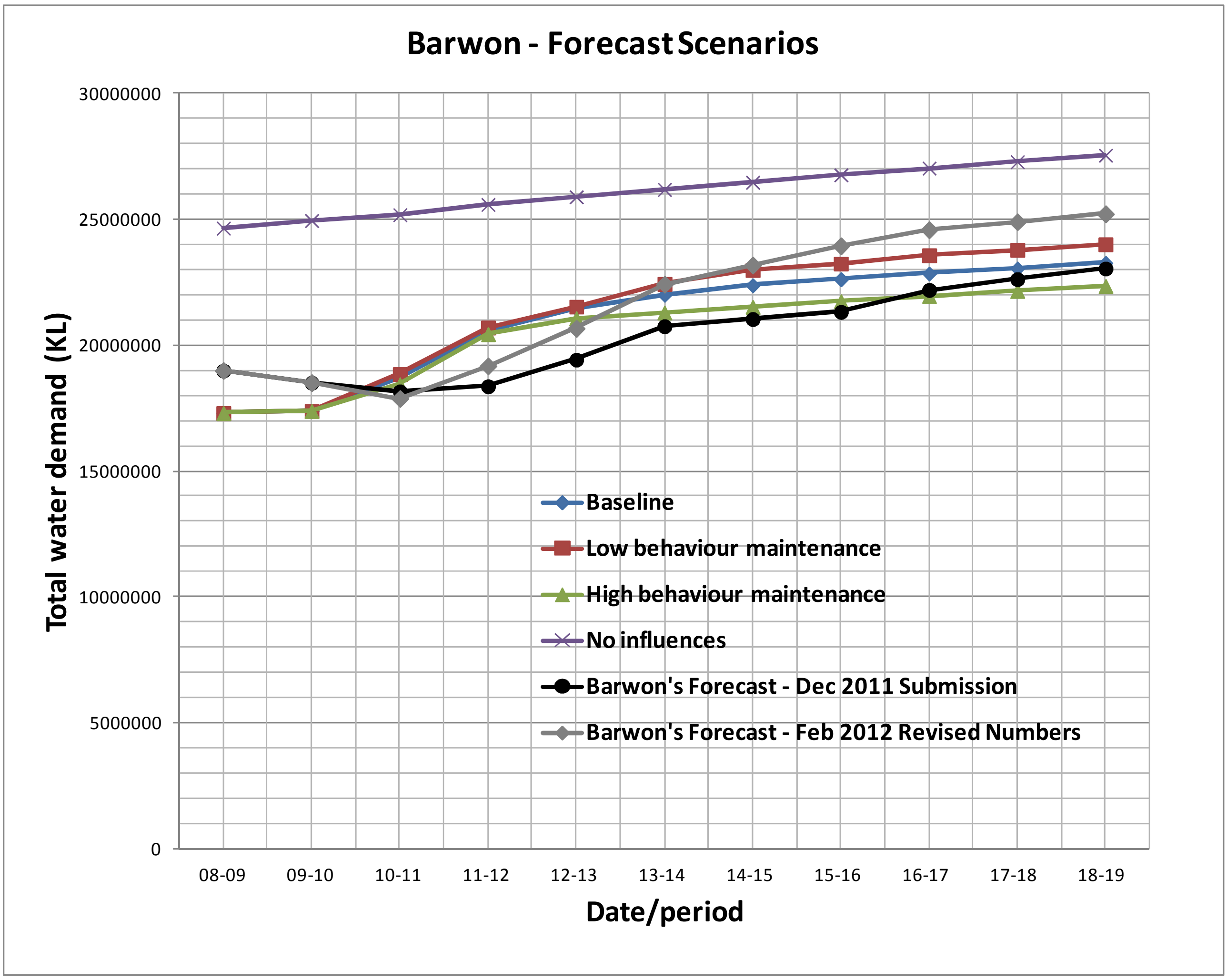

Figure 6. Water demand comparison: total water demand in the Barwon region.

5. Appliance/product uptake for validation

The tables below show the base composition/trends of water related appliances/products used in the Barwon validation scenario. The term "base trends" is used because the actual penetration of appliances is modulated depending on the demographic characteristic of the consumer (e.g. higher income consumers will typically comprise more efficient appliances). The Victorian base composition relates to the standard appliance trends that is typically used for the Melbourne region, and which is also (*currently*) used for the all other regions in the scenario outside the Barwon region (i.e. Apollo Bay, Skenes Creek, Marengo, Colac, Fairhaven, Aireys Inlet, and Lorne). The Barwon composition tables were used for the Barwon region, which comprises a higher proportion of inefficient products.

Showerhead		Jul-04	Jul-05	Jul-06	Jul-07	Jul-08	Jul-09	Jul-10	Jul-11
Victorian composition (% of households)	***	14.7	15.5	16.4	17.2	18.1	18.9	19.8	20.7
	**	11.3	11.9	12.5	13.1	13.7	14.2	14.8	15.4
	*	15.6	16.4	17.3	18.1	18.9	19.7	20.5	21.3
	Standard	58.4	56.1	53.9	51.6	49.4	47.2	44.9	42.7
Barwon Region composition (% of households)	***	2	3	5	10	15	20	24	28
	**	6	7	7	8	10	10	10	10
	*	11	12	13	14	15	15	15	15
	Standard	81	78	75	68	60	55	51	47

Washing machines		Jul-04	Jul-05	Jul-06	Jul-07	Jul-08	Jul-09	Jul-10	Jul-11
Victorian composition (% of households)	FL 5*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FL 4.5*	0.0	0.0	0.0	0.0	0.0	4.1	4.6	5.1
	FL < 4.5*	14.4	16.6	19.0	21.7	24.6	23.7	26.6	29.7
	TL 4.5*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TL 4*	0.7	1.2	1.8	2.4	3.1	7.0	8.6	10.3
	TL <4*	84.9	82.2	79.2	75.9	72.2	65.2	60.2	54.9
Barwon Region composition (% of households)	FL 5*	0	0	0	0	0	0	0	0
	FL 4.5*	0	0	0	0	0	0	0	0
	FL < 4.5*	7	9	11	13	15	17	19	21
	TL 4.5*	0	0	0	0	0	0	0	0
	TL 4*	0	0	1	1	2	2.5	2.5	3
	TL <4*	93	91	88	86	83	80.5	78.5	76

TL = Top Loader Washing Machine, FL = Front Loader Washing Machine

Toilets		Jul-04	Jul-05	Jul-06	Jul-07	Jul-08	Jul-09	Jul-10	Jul-11
Victorian composition (% of households)	Dual 4.5/3	9.0	10.7	12.5	14.6	16.8	19.2	21.7	24.5
	Dual 6/3	15.8	16.1	16.4	16.7	16.9	17.1	17.2	17.3
	Dual 9/4.5	22.5	22.7	22.8	22.9	22.8	22.6	22.4	22.0
	Dual 11/6	16.6	16.7	16.8	16.8	16.8	16.7	16.5	16.2
	Mixed dual	6.9	6.9	7.0	7.0	6.9	6.9	6.8	6.7
	Single 9	7.3	6.7	6.1	5.5	4.9	4.4	3.8	3.3
	Single 11/12	7.3	6.7	6.1	5.5	4.9	4.4	3.8	3.3
	Mixed Single	14.7	13.4	12.2	11.0	9.9	8.8	7.7	6.6
Barwon Region composition (% of households)	Dual 4.5/3	8	10	12	13	14	14	16	17
	Dual 6/3	8	9	10	10.5	10.5	10.5	10.5	10.5
	Dual 9/4.5	15	15	15	15	15	15	15	15
	Dual 11/6	10	10	10	10	10	10	10	10
	Mixed dual	5	5	5	5	5	5	5	5
	Single 9	13.5	12.8	12.0	11.6	11.4	11.4	10.9	10.6
	Single 11/12	13.5	12.8	12.0	11.6	11.4	11.4	10.9	10.6
	Mixed Single	27.0	25.5	24.0	23.3	22.8	22.8	21.8	21.3

Dishwasher		Jul-04	Jul-05	Jul-06	Jul-07	Jul-08	Jul-09	Jul-10	Jul-11
Victorian composition (% of households)	Efficient	0.4	0.6	0.9	1.3	1.6	2.0	2.5	3.0
	Old std	28.8	29.5	30.1	30.7	31.1	31.5	31.7	31.9
	New std	1.0	1.6	2.4	3.2	4.1	5.2	6.3	7.6
	None	69.9	68.2	66.6	64.9	63.1	61.3	59.4	57.5
Barwon Region composition (% of households)	Efficient	0	0	0.5	0.5	0.7	0.8	1	1.4
	Old std	30	32	33	34	35	36	38	39
	New std	1	1	1.5	2	2.5	2.8	3	4
	None	69.0	67.0	65.0	63.5	61.8	60.4	58.0	55.6

Evaporative air-conditioner		Jul-04	Jul-05	Jul-06	Jul-07	Jul-08	Jul-09	Jul-10	Jul-11
Victorian composition (% of households)	Efficient	9.0	9.3	9.6	9.9	10.2	10.4	10.6	10.8
	Standard	9.0	9.3	9.6	9.9	10.2	10.4	10.6	10.8
Barwon Region composition (% of households)	Efficient	15	16	17	17.5	18	18.2	18.4	18.5
	Old std	15	16	17	17.5	18	18.2	18.4	18.5

6. Appendix A - Water Restrictions Schedule for the Barwon Region

Barwon Region

Postcodes: 3236, 3243, 3242, 3241, 3332, 3331, 3221, 3212, 3214, 3215, 3218, 3219, 3220, 3224, 3222, 3223, 3225, 3226, 3227, 3216, 3240, 3228, 3230, 3235, 3239, 3328 (partially 3249, 3321, 3333, 3342, 3211)

Restriction Schedule:

27th October, 1967	Stage 1 Water Restrictions	By-Law No. 3 and 4
22nd August, 1968	Restrictions lifted in all regions	
10th September, 1982	Stage 3 Water Restrictions	By-Law No. 151
21st November, 1982	Stage 4 Water Restrictions	By-Law No. 151
8th June, 1983	**Restrictions lifted in all regions**	
30th January, 1998	Stage 1 Water Restrictions	By-Law No. 177
12th December, 1999	Stage 2 Water Restrictions	By-Law No. 178
14th November, 2000	Stage 1 Water Restrictions	By-Law No. 181
1st July, 2001	**Water restrictions lifted in all regions**	
1st July, 2006	Stage 1 Geelong Central Supply Region	By-Law No. 187
16th September, 2006	Stage 2 Geelong Central Supply Region	By-Law No. 187
1st November, 2006	Stage 3 Geelong Central Supply Region	By-Law No. 187
9th December, 2006	Stage 4 Geelong Central Supply Region	By-Law No. 187
27th October, 2007	Stage 4 Water Restrictions – Daylight Saving	By-Law No. 187
5th April, 2008	Stage 4 Water Restrictions – Winter	By-Law No. 187
22/7/2008	**Water Restriction By-Law No. 189 implemented**	
1/11/2008	Stage 4 Water Restrictions – Daylight Saving	By-Law No. 189
5/4/2009	Stage 4 Water Restrictions – Winter	By-Law No. 189
4/10/2009	Stage 4 Water Restrictions – Daylight Saving –	By-Law No. 189
March 1, 2010	Stage 3 Water Restrictions	By-Law No. 189

Apollo Bay/Skenes Creek/Marengo

Postcodes: 3233

Restriction Schedule:

13th February, 2001	Stage 2 Water Restrictions	By-Law No. 181
13th March, 2001	Stage 4 Water Restrictions	By-Law No. 181
23rd April, 2001	Stage 2 Water Restrictions	By-Law No. 181
1st July, 2001	**Water restrictions lifted in all regions**	
1st December, 2001	Stage 1 Water Restrictions	By-Law No. 181
6th May, 2002	**Restrictions lifted**	
1st December, 2002	Stage 1 Water Restrictions	By-Law No.181
10th January, 2003	Stage 2 Water Restrictions	By-Law No.181
30th April, 2003	**Restrictions lifted**	
1st December, 2003	Stage 1 Water Restrictions	By-Law No. 181
30th April, 2004	**Restrictions lifted**	
1st December, 2004	Stage 1 Water Restrictions	By-Law No. 181
14th February, 2005	Stage 2 Water Restrictions	By-Law 181
19th March, 2005	**Restrictions lifted**	
1st December, 2005	Stage 1 Water Restrictions	By-Law 181
6th May, 2006	**Restrictions lifted**	
1st November, 2006	Stage 2 Water Restrictions	By-Law 187
28th July, 2007	**Restrictions lifted**	
1st December, 2007	Stage 2 Water Restrictions	By-Law 187
Continuing – July, 2008		
22/7/2008	**Water Restriction By-Law No. 189 implemented**	
25/4/2009	**Restrictions lifted – PWSP in place**	
1/11/2009	Stage 2 Water Restrictions	By-Law 189

Colac:

Postcodes: 3322, 3251, 3249, 3250

Restriction Schedule:

30th November, 2006	Stage 2 Water Restrictions	By-Law 187
28th July, 2007	**Restrictions lifted**	
26th April, 2008	Stage 2 Water Restrictions	By-Law 187
22/7/2008	Water Restriction By-Law No. 189 implemented	
30/8/2008	**Restrictions lifted – PWSP in place**	

Fairhaven/Aireys Inlet and Lorne

Postcodes: 3231, 3232

Restriction Schedule:

19th May, 2007	Stage 2 Water Restrictions	By-Law 187
28th July, 2007	**Restrictions lifted – PWSP in place**	
22/7/2008	Water Restriction By-Law No. 189 implemented	
22/7/2008	**PWSP in place**	

7. Appendix B - Pre-Restrictions Demand and Price Data

Actual and forecast water demand

		Determination Figures	*Actuals*	*Difference*	*Percentage*
2005-06	Residential	24835.00	24835.00	0.00	0.00%
	Non Residential	13625.00	13625.00	0.00	0.00%
	Total	38460.00	38460.00	0.00	0.00%
2006-07	Residential	19787.33	19797.00	9.67	0.05%
	Non Residential	11465.96	11459.00	-6.96	-0.06%
	Total	31253.29	31256.00	2.71	0.01%
2007-08	Residential	17636.24	18624.74	988.50	5.60%
	Non Residential	11228.72	10748.85	-479.86	-4.27%
	Total	28864.96	29373.60	508.64	1.76%
2008-09	Residential	19208.48	18992.92	-215.57	-1.12%
	Non Residential	12229.74	10565.00	-1664.74	-13.61%
	Total	31438.22	29557.92	-1880.30	-5.98%
2009-10	Residential	21055.13	18509.80	-2545.33	-12.09%
	Non Residential	13405.47	9403.47	-4002.00	-29.85%
	Total	34460.59	27913.27	-6547.32	-19.00%
2010-11	Residential	21838.64	17887.30	-3951.34	-18.09%
	Non Residential	13904.32	9622.62	-4281.69	-30.79%
	Total	35742.95	27509.93	-8233.03	-23.03%
Total		101641.77	84981.11	-16660.65	-16.39%

Price data - nominal

Charges	*Type*	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Supply charge Water (annual)	*Water FC*	140.83	151.90	108.72	123.76	136.24	150.63
Tier 1	*Water VC*	0.90	0.97	1.43	1.63	1.79	1.98
Tier 2	*Water VC*	-	-	-	-	-	-
Tier 3	*Water VC*	-	-	-	-	-	-
Supply charge Wastewater (annual)	*Sewerage FC*	174.83	188.58	360.55	410.44	451.85	499.59
Volumetric wastewater	*Sewerage VC*	1.08	1.17	-	-	-	-

Customer data

Customer type	*Water customers - domestic*	*Water customers - non-domestic*
2005-06	115 090	9954
2006-07	117 044	10 129
2007-08	119 731	10 819
2008-09	121 818	11 089
2009-10	123 484	10 634
2010-11	126 004	11 301

8. Appendix C - Barwon's Actual and Forecast Data

		2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
December 2011 Submission	**Corporate Plan Forecasts connections**	**Actuals**	**Actuals**	**Actuals**	**Corporate Plan 2011/12 - 2015/16**							
	Residential	121813	123866	125983.771	128202.144	130420.518	132638.892	134857.266	137075.64	139295.277	141514.915	143734.552
	Metered Water consumption											
	Residential	18992804	18509800	18163472.5	18365020.7	19423724.8	20752522.1	21028057.1	21305593.6	22167889	22589477.1	23008337.4
Revised February 2012	**Corporate Plan Forecasts connections**											
	Residential	121813	123866	126011	128231	130436	132662	134929	137204	139482	141731	143984
	Metered Water consumption											
	Residential	18992804	18509800	17887302	19176585	20672197	22426695	23186111	23950769	24587657	24901514	25216026

Intelligent Software Development Pty Ltd

Level 1, 27 Chesser Street
Adelaide, South Australia 5000

ACN 122 044 599
ABN 22 122 044 599

Phone: +61 (0)8 8343 8455
A/H: 0412 662 544
Fax: +61 (0)8 8260 8100

Email: info@intelligentsoftware.com.au
Web: www.intelligentsoftware.com.au