A Transitioning Water Industry: Water Demand Management Policy in Post-Drought Australia

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ABSTRACT

Australia was forced to address water security concerns during a decade long Millennium Drought (2000-2010). During this time Australia experienced a drastic increase in policies supporting water conservation with a particular growth in demand side management (DSM) programs targeting the residential sector. This thesis analysed how DSM programs are affected by the end of a drought, using Melbourne, Australia as a case study. To analyse this, I reviewed non-price residential water DSM programs established by the Melbourne water utilities from the start of the Millennial Drought in 2000 to 2017 as well as the institution history of the Water industry. I found that there was a significant decline in DSM programs after the drought that may have been caused by a change in governance and institutional structures after the Liberal Party came into power between 2010 and 2014. These results will help assess the feasibility of implementing DSM during extended water crises and whether these policies can be sustained post-drought when they are no longer critical for water conservation.

KEYWORDS

Residential demand management, water conservation, mitigation, urban water management, post-crisis, industry transition

INTRODUCTION

As water is a finite resource, many countries, particularly those with semi-arid climates, have recently experienced challenges in meeting water demand (Leblanc et al. 2011). Semi-arid regions are particularly vulnerable to periodic droughts and are believed to be more susceptible to global climate change (El-Beltagy and Madkour 2012). Although many regions are prone to extended periods with limited precipitation, the majority of Australia comprises of semi-arid dessert climate and is therefore susceptible to nation-wide water management challenges (Australia and Productivity Commission 2009).

Australia was forced to address water demand during the Millennium Drought of 1997-2009. The drought was so severe that agricultural production decreased significantly and a study found that the nation's Gross Domestic Product (GDP) decrease by 1.6% in 2002 due to drought conditions (Horridge et al. 2005, van Dijk et al. 2013). During the drought, Australia's government and water utility agencies implemented comprehensive, sustainable water management reforms (Leblanc et al. 2011), such as drought time procedures and water restrictions (van Dijk et al. 2013). Many water utility agencies and government bodies favoured water demand strategies to reduce water use and invested significant funds in building public awareness programs (White and Fane 2002).

In particular, water demand management became integral to Australia's drought mitigation strategies during the Millennium Drought. Demand management is defined as "any program that modifies (decreases) the level and/or timing of demand for a particular resource… programs are designed to promote conservation either through changes in consumer behaviour or changes to the stock of resource-using equipment" (Greenberg and Harshbarger 1993). These programs were found to be cost effective and further reduce impacts across a broad environmental spectrum (White et al. 2004) (Hass, 2012; White et.al, 2004). Many Australian water utilities continue to employ demand management strategies; however, since the drought ended there is no longer a pressing need, therefore it is unclear how many of these policies will be phased out.

Yet Australia's growing population and periodic droughts continues to place pressure on water resources (van Dijk et al., 2013; Liu et. al, 2017). A recent study found that more programs could be implemented or expanded to improve water conservation potential (Liu et. al, 2017). It is

unclear how policies and demand management programs have been affected by the end of the drought period and greater water availability.

In order to address this gap, I examine how Australia's water industry- specifically Melbourne, Victoria- has changed since the end of the drought by analysing trends in residential demand side management as well as the underlying political context. Furthermore, I examine how water policies have changed since the end of the drought and possible implications of ending DSM policies may have for the next drought. Determining the most effective regulatory bodies and compelling water policies may encourage further action to promote sustainable water measures so that Australia will be prepared for the next severe drought. I specifically aim to answer the following questions:

(1) How has the implementation of residential demand-side management programs changed since the drought ended in 2010 and why?
(2) What role did national, state, and local politics play in creating and sustaining these programs?
(3) How will DSM programs affect Australia's future drought resilience?

BACKGROUND

Paper Background

In this section I provide an in-depth site description for Melbourne, better define demand side management and discuss some of the prevailing theories on the topic of DSM and why I chose each aspect of the study.

Site Description

Australia

The commonwealth of Australia comprises of the entire continent of Australia with over 7.6 million km² and a growing population of 23.4 million people. The majority of its population reside in urban centres, predominantly in the states of New South Wales (NSW), Queensland

(Qld), and Victoria (Vic) (ABS, 2016). In terms of climate, Australia experiences an incredibly high variation in spatial and temporal rainfall patterns and has been described as the "driest inhabited continent" (McMahon et al., 1992; Smith, 1998). This poses challenges in ensuring water security and managing water policies.

Although water policy is controlled at the federal level by the Department of Sustainability, Environment, Water, Population and Communities, water distribution still varies by state in Australia. Currently water is allocated by state owned companies in Western Australia, South Australia and the Northern Territory. Queensland has areas with locally owned utilities, whereas the rest of Queensland, New South Wales and Victoria provide state owned bulk water to smaller utilities that are either owned by the state or local government (Byrnes 2013).

State level policies can vary drastically depending on the party in power at the time. The two prominent political parties are the Labor party and the Liberal party. Traditionally the Labor party is more democratic left leaning while the Liberal Party tends to be more conservative right wing (Byrnes, 2013). Since the state of Victoria provides a bulk water supply, transitions between political powers can have significant ramifications for the water industry.

Melbourne, Victoria

Victoria is located in South-eastern Australia and has a population of about 6.3 million people consuming over 3,700 gigalitres a year, which is over 20% of Australia's total residential water consumption (ABS, 2016). The state currently has over 18 operational water utilities, for a full list see Appendix A. As the majority of Victoria's population reside in the capital Melbourne, residential water use occurs within the city (Kenway et al. 2014). The city has one bulk water supplier operated by the Victorian government and three separate water retailers: Yarra Valley Water, South East Water, and City West Water. Currently, these utilities are directly overseen by the state government through the Department Environment, Land, Water and Planning (DELWP) (Figure 1c). However, Melbourne's water industry structure went through different phases before the present structure was put in place.

Demand side management

Demand Management is defined as "any program that modifies (decreases) the level and/or timing of demand for a particular resource… programs are designed to promote conservation either through changes in consumer behaviour or changes to the stock of resource-using equipment" (Greenberg and Harshbarger 1993). Water Demand Side Management (DSM) solutions include financial tools such as home water audits and water efficient product rebates, discounts, and exchanges. Community outreach tools such as awareness and education campaigns also act as cheaper form of water demand management by informing the public on their water use.

DSM Programs attempt to reduce the public's consumption of water through various methods that can be characterized as price and non-price. These methods can be applied to various sectors such as agriculture, residential, or industry. Price DSM uses water pricing to discourage water consumption while non-price encompasses a variety of tactics meant to modify consumer behaviour. For the purposes of this study I focused on residential non-price strategies categorized as public outreach, incentives for installing technological improvements, and water restrictions (Kennedy et al, 2008). However, I did not analyse water restrictions in this paper as they are enforced according to a strict protocol coinciding with drought conditions and are therefore predictable. Instead, I analyse public outreach methods and incentives for installing technological improvements. For a full description of categories and definitions, see Table 1.

Table 1. Non-Price DSM Categories. Categories and definitions adapted from Greenberg and Harshbarger, 1993)

	Definition
Outreach	
Education	Programs targeted at children, students, and schools to promote water conservation habits
Campaign	Efforts to target a specific population or the general public in order to raise awareness of water use
Incentives	
Exchange	Residents can swap an old inefficient product for a new technology that is more efficient
Rebate	If residents decide to buy a new water water efficient product they can be partially refunded
Discount	Utilities work with water efficient technology companies to provide discounts on products for customers
Audit	Utilities send a representative to inspect a home and calculate water usage as well as possible areas for improvement

Demand management techniques were analysed because of their cost effectiveness. As a cheap effective way to manage water use, demand management plays a critical role in reducing water demand, particularly in the residential sector. A study done on Sydney's water industry found that water demand management programs provided a greater benefit in terms of cost efficiency compared to alternative water conservation methods such as building new infrastructure (White and Fane, 2002). As a result, it is in the water industry's best interest to place an emphasis on demand management techniques as a cheap way to curb water use. Furthermore, a key component of developing any drought resiliency plan is securing public awareness and education programs (Wilhite et al. 2014). Thus, I postulate that drought prone areas such as Australia should implement many of these programs continuously as droughts are often seasonal.

However, many studies debate the effect that DSM programs have on residential water use (Michelsen et al. 1999, Kenney et al. 2008). Authors such as Maggioni claim that only mandates or water restrictions are effective in reducing residential water use (Maggioni 2015) while others maintain that non-price DSM can be effective when implemented correctly (Inman and Jeffrey 2006). In my thesis I used the underlying assumption that DSM is effective at reducing water consumption but remained sceptical of their direct impact on Melbourne's water consumption as a variety of factors may have also contributed.

Literature review

DSM implementation in Melbourne

There have been multiple studies suggesting the effectiveness of DSM as a method to reduce water consumption specifically in Melbourne. Some argue that the introduction of DSM could potentially reduce water consumption and mitigate drought risk in Australia (Birrell et al. 2005, Kenway et al. 2014). Both of these papers utilized modelling techniques. Low et al. presents the success of water conservation techniques, including supply and demand side water management applied in Melbourne. They found Melbourne's water conservation techniques during the drought to be successful because of an underlying confidence in the water supply provided by expensive alternative water supply sources. The authors believe long term implementation of public demand management would not necessarily be as effective. They conclude that the drought offered Melbourne an opportunity to implement critical water management reforms that otherwise would not have been done but concede that DSM was inefficiently executed (Low et al. 2015). The literature describes Melbourne as a city with a long history of DSM employment, however the implementation remains inefficient.

Institutional Context of DSM

Other studies were critical in understanding the underlying institutional context behind DSM implementation. Liubinas and Harrison discusses the impact that a specific DSM campaign in Melbourne had on the population and how that campaign was affected by political transitions. (Liubinas and Harrison 2012). Furlong et al. describes how Melbourne has begun transitioning towards "Integrated Urban Water Management" (IUWM) through the context of water industry phases. These phases are marked by transitions in policies and changing governance systems. The authors found that changes in government regimes may promote innovation and the OLV promoted collaboration and strategy development amongst utilities. (Furlong et al. 2016a) These articles are helpful to understand phase shifts in Victoria and Melbourne's water industry as well as public opinion and how that affects DSM.

METHODS

Case study

In order to determine how Australia's water industry has responded to the end of the drought, I focused on Melbourne, Victoria as a case study. By analyzing Melbourne, assumptions can be drawn about similar cities throughout Australia. Residential water consumption is highest in urban centers and since the majority of Australia's population live in cities such as Melbourne, most of Australia's population is affected by changes in demand side management (DSM) programs. Furthermore, my pilot study indicated that the state of Victoria has the most ongoing DSM programs of any Australian state. This indicates Victoria may have progressed further than the rest of Australia in terms of DSM implementation and could possibly be used as an exemplar of what the rest of the nation could be.

My research centered around two periods: drought and post-drought. Although there are differing accounts of when the drought began, I used 2000 as the start year. There were indications of drought starting in 1997, however in 2001 El Nino brought severe dry weather forcing water utilities to address the severe lack of water (Van Dijk, 2013). Furthermore, water officials noted that there was little effort to manage for drought conditions until 2000 (Furlong et al. 2016b). For the purposes of this paper the drought period lasts 2000 - 2010 and the post-drought period lasts from 2011 until the present (2017).

Data Collection

In order to answer study question (1) on how DSM implementation has changed since the drought, I compiled a data set of historical water demand management programs active from the early 2000s until 2017 primarily using Liu et al. (Liu et al. 2017). This dataset includes the start and end years, which utilities participated, and what organization funded the program. To simplify data for initial analysis, I divided demand management program types into two categories: outreach and initiatives (Table 1). I did this to analyse any patterns of favourability between the categories. I determined the importance of DSM to each water industry organization by reading their annual reports and management strategies.

To research the political context of DSM in question (2), I researched the institutional structure of Melbourne's water industry as well as the political history. This was done by reviewing pertinent literature on the water industry as well as water management policies at the national, state and local level. (Ferguson et al. 2013, Low et al. 2015, Furlong et al. 2016b). This information was then compiled into a timeline of the water industry in terms of reform and political backdrop. Once this data was synthesized, it was overlaid with the prevelant DSM programs to visualize any trends.

Lastly, I collected residential water consumption data for Melbourne from 2000 - 2017 from Melbourne Water annual reports and the Australian Bureau of Statistics (ABS, 2016). This was used as a supplement to already collected data. Water consumption data provided context for residential uptake of DSM programs.

The drought period of 2000 – 2010 was used as a baseline to directly compare the post-drought period of 2011 - 2017. DSM programs are compared with regards to their longevity, successfulness gauged from the literature, as well as their political and institutional context. Water use data is used to supplement these findings to analyse whether significant reductions in DSM programs seem to alter water use patterns.

RESULTS

I begin my results with the underlying history of the water industry as it reveals the context behind implementation of DSM programs. The timeline is divided into four periods: pre-1990s, 1990 -2000, 2000 - 2010, and 2011 - 2017. Each of these periods start at the macro national policy level then focus specifically on Melbourne's water industry. Next, I discuss my DSM program findings, starting with individual utility's efforts to implement them then discuss the timeline of DSM programs in relation to the political history. I finish with my water consumption data.

Political framework

Pre-1990s

In 1886, Australian states were first given the rights to manage and allocate water resources through state-controlled agencies (Tisdell et al. 2002). Previously, "riparian rights" were honoured,

meaning that water rights were coupled with land ownership. The Irrigation Act of 1886 ended this system and created a centralized authority on water resources but did not forbid private water supply schemes (Smith, 1998). An emphasis was placed on expanding water resources through infrastructure projects, exemplified by a Victorian water report claiming that "if Victoria is to continue to progress… it must be by means of irrigation. No price it may be said is too high" (Powell, 1976). An emphasis on expanding water infrastructure led to an over-allocation of reduced cost water with no incentives to conserve water (Tisdell, 2002).

From 1891 to 1989, the Melbourne Metropolitan Board of Works (MMBW) operated under the state government as well as the Victorian Water Act. It provided water, sewerage, and waterway management to the entire Melbourne community. However, the MMBW was considered to be ineffective and was therefore placed into Victoria's Water Resources Department in 1985 (Abbott et al. 2011). The Victorian Water Act of 1989 effectively turned MMBW into a company overseen by the Department of Land Water and Planning (previously known as the Department of Sustainability and Environment as well as the Department of Environment and Primary Industries). This structure of government supervised companies still holds to this day.

The Victoria Water Act established the first attempt at a state mandated demand management strategy with mandated Drought Response Plans for each retailer. These response plans had to include water restrictions (from Stage 1- least severe to Stage 4- most severe) and enforcement measures (Vic Water Act, 1989).

Pre-drought period: 1990- 2000

By 1990 there was a need to address multiple issues in the national water sector including environmental degradation, rising water demand, increasing costs, and aging infrastructure (Tisdell et al, 2002). The national government also undertook water management reforms that focused on economic efficiency and ecological sustainability. These reforms were primarily the result of federal and state policy agreements to adhere to international treaties, primarily the UN Commission of Environment and Development meeting of 1992 (UNCED, 1992). The Council of Australian Governments' National Water Reform Framework of 1994 prompted water sectors to create integrated water management solutions.

After the national reforms passed, the Department of Sustainability and Environment (DSE) was formed in the Victorian State government and became responsible for water policy. This department oversaw all of Victoria's water utilities including MMBW. However, in 1991 it was completely dissolved to form the Melbourne Water Corporation (MWC) which was later split into the 4 entities that exist presently: MWC as a bulk supplier and three retailers (Yarra Valley Water, City West Water, South East Water). During this period the state government governed water management through two departments called the Department of Sustainability & Environment (DSE) and the Essential Services Commission (ESC) (Figure 1a). This structure impeded communication between utilities and lead to inefficient decision making and analysis (Crase et al., 2007).

In 1997 the Australian Millennium Drought began, though few water officials reacted with water conservation policies as they did not know the eventual drought severity. However, by the late 1990s, studies found that water use in the Murray-Darling Basin (Eastern Australia's primary source of water) was reaching its prescribed maxima (AATSE, 1999). As a result, water agencies began implementing initiatives aimed at stabilizing domestic water use through market-based incentives, regulations, and educational programs (Tisdell, 2002). However, a water industry official noted that there was "no real drive for changing the way water management and planning was done until the millennium drought began having an impact on Melbourne's water resources around the year 2000" (Furlong et al., 2016).

Drought period: 2000-2010

By the new millennium, all of Australia was experiencing the effects of the drought. Due to the drought intensity the national government had to intervene in state water industries. In 2004 the National Water Initiative (NWI) expanded Australia's water market considerably and created the National Water Committee. Similar to a cap and trade approach, this allowed the federal government to limit water allocation (Fargher 2012). Further top-down control was influenced under the Water Act of 2007 which created the Murray Darling Basin Commission placing the Murray-Darling Basin- and most of Eastern Australia's water resources- under federal control. However, Victoria did not agree to participate until 2008, after they were promised AUD$1 billion in water infrastructure upgrades.

After the drought began in 2000, the Victorian state government began taking a much more hands-on approach to water management. The DSE created 5 regional water management strategies for Victoria which included ideas for public awareness campaigns, water efficiency measures, system sustainability, and stakeholder engagement. At this time, the Labor Party controlled the state government and used the DSE to enact water policies which became highly politicized due to the water shortages (Furlong et al., 2016). The state promoted local utilities to create stormwater and reuse schemes by offering plentiful funding opportunities, so much so that it became the "golden age of recycled water" (Furlong et al., 2016). As a result, utilities created teams with the sole purpose of diversifying water supplies and creating innovative water management strategies to promote water saving. Federal grants also offered state utilities the opportunity to invest in large projects.

By 2010, the drought had become so severe that the Vic government authorized an expensive pipeline and desalination plant to be built in order to provide alternative water sources. The $19 billion AUD project was meant to provide an alternate supply of water but was never utilized. The state government was criticized for the lack of transparency in their decision making and lost the public's trust in their methods for water management. (Furlong et al., 2016). Public disapproval of the project was apparent when the 2010 state election replaced the Labor Party with the Liberal Party.

However, from 2000 to 2010 many new water demand management schemes were introduced at the national, state, and local level. The federal government managed to pass the National Water Efficiency Labelling and Standards Act (WELS) which mandates that all indoor water products be rated based on water efficiency. This scheme is still in effect to this day (WELS, 2005). Due to multiple demand management practices implemented across Melbourne, per capita water use in the city decreased by almost 50% between 1997 and 2012 (Low et. Al, 2015). Some of these demand management techniques included financial incentives such as rebate programs and discounts for water efficient products, funding for rainwater harvesting projects, enforcing water use restrictions, and promoting water conservation through advertising campaigns.

Post-drought period: 2011- 2017

In 2010 state and federal elections were held, bringing a new administration and policy focus. National water policy reform stagnated. After the drought ceased, an Australian government advisory body recommended that states stop funding large water infrastructure projects. (Australia and Productivity Commission 2009)(Productivity Commission, 2011). While in Victoria, the newly empowered Liberal Party used the expensive desalinization plant as a focal point of their platform for water reform and dubbed it a failure. Going forward they aimed water policy at public appeasement and discrediting the previous party's reforms (Ferguson et al., 2013).

Once in power, the Liberal Party restructured the water industry by creating the Office of Living Victoria (OLV) in 2012 as an independent government department under DEP to implement new water reforms (Figure 1b). Although technically a branch of the state government, the OLV was not directly under the influence of the DSE and ESC. This office had oversight of the Victorian utilities but did not necessarily intervene in management techniques. The OLV offered AUD$50 million in grants to integrated water management projects, however no large-scale projects were completed (Furlong et. al, 2016).

Water policy became much more fragmented as the OLV required individual water utilities to cut costs (Baker and McKenzie, 2014). Furthermore, water utilities developed mandated sub-regional water management plans without developing an overarching framework; Melbourne alone was divided into 5 regions (Melbourne Water, 2014). As a result, individual utilities became communicative and relied heavily on stakeholder consultations (Furlong et al., 2016). It became the individual retailer's responsibility to manage water systems.

The 2014 state election brought yet another change in party back to the Labor Party which immediately dissolved the OLV into Department of Environment, Land, Water, and Planning (DELWP) (Figure 1c). This structure stands to this day as the DELWP is directly overseen by the state government and maintains a relationship with Melbourne's water utilities. DELWP created the Victorian Water Plan to dictate water policy in a "hands-off" approach, where utilities are mandated to create integrated water management frameworks discussed below.

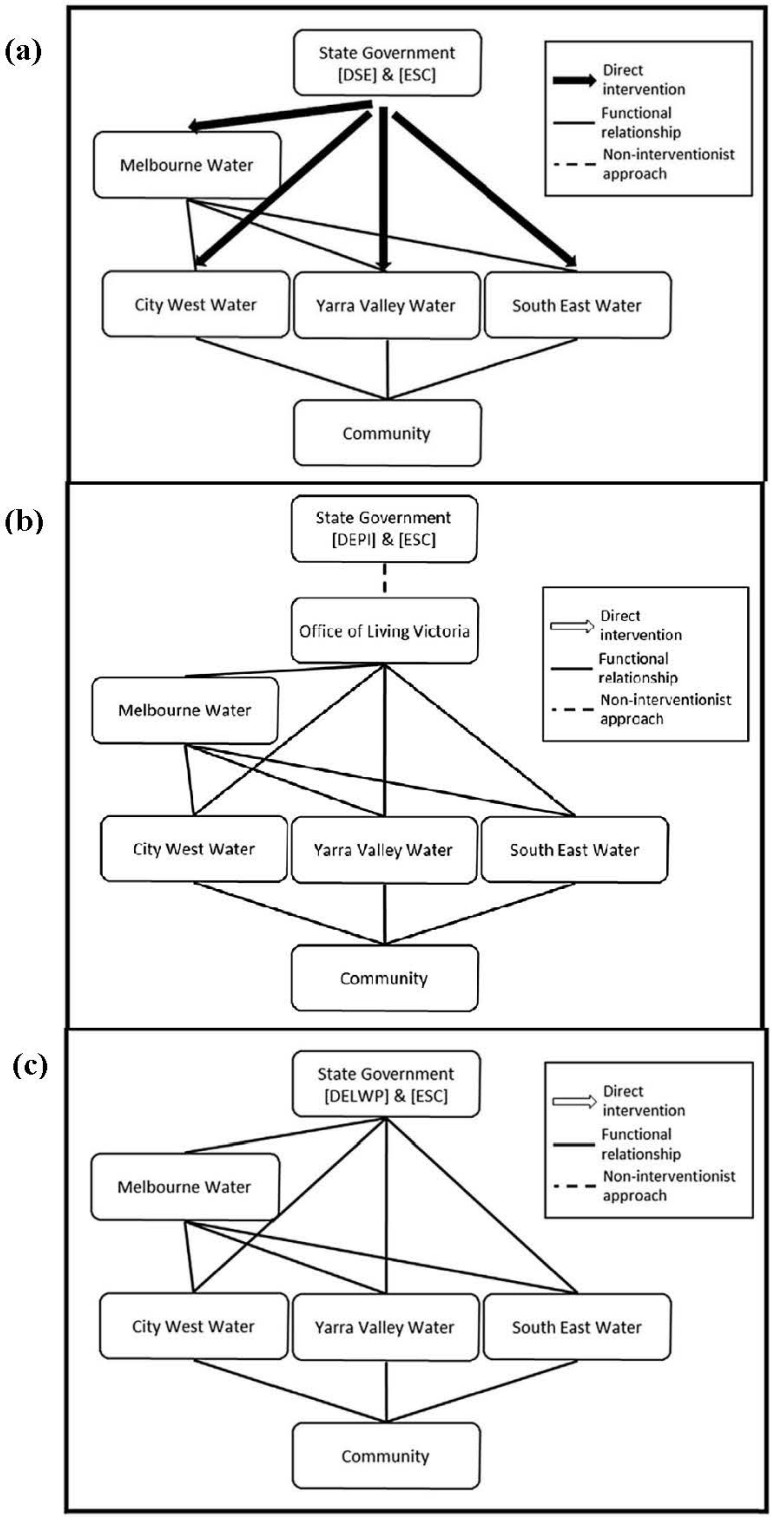

Figure 1. Melbourne's Water Industry Structure Phases. Taken from Furlong et al, 2016. (a) Structure from the 1990s until 2011. (b) the restructuring from 2012-2014 by the Liberal government. (c) the current structure of the Labor government's water industry since 2014.

Demand-side management

Individual Water Utility Implementation

Water management frameworks were developed by individual utilities as well as through partnerships among the entire water industry. These reports placed a heavy emphasis on integrated urban water management, sustainable practices, and drought response. All of the available reports mentioned residential DSM, however most used vague language. YVW's mentioned "water efficiency" to "encourage water saving while enjoying the benefits of water" but did not elaborate or mention a framework for reference (Appendix B). This pattern can be seen in every water management framework report published online by Melbourne's water entities. The most recent Drought Preparedness Plan include use of "customer behaviour modification and efficiency programs" as an action to retaliate every level of drought risk from low to high. These action items are go so far as to list previous DSM programs such as T155 and a commitment to uphold these efforts. There are no details of future actions to be taken by the government or water utilities.

Furthermore, the water utilities of Melbourne exhibit different emphases on DSM as evident by their annual reports. Although every report mentioned maintaining water efficiency, all mentioned alternative water sources as a method for increasing water use efficiency while only 74% mentioned both outreach and campaign methods of DSM efforts (Appendix B). Only one report mentioned each type of residential DSM category (SEW AB 10/09). Education campaigns were mentioned the most out of all residential DSM programs appearing in 82% of reports. Individual utilities' dedication to DSM can also be gauged by their advertising efforts online. The only consistent DSM tool found on every water industry organization's website was "tips"- a form of public education (Table 2). An individual utility's efforts to promote DSM may be reliant on the political backdrop of the time.

Table 2. Ongoing DSM programs highlighted online. Addresses whether or not a specific type of DSM program was available or advertised on each water utility website.

Name	Acronym	Online Water Saving Tips	T155	Educational Program	Residential Audits	Discounts on Water Saving Devices	Shower Head Swap Program	Rebates
Melbourne Water	MW	Yes	No	Yes	No	No	No	No
South East Water	SEW	Yes	Yes	Yes	No	No	Yes	No
City West Water	CWW	Yes	Yes	Yes	No	Yes	Yes	No
Yarra Valley Water	YVW	Yes	Yes	Yes	Yes	No	No	Yes
Department of Environment Land Water and Planning	DEWLP	Yes	Yes	No	No	No	No	No

Political parties' implementation

Once the Millennial Drought began to recede after 2010, there was a steady decrease in DSM programs available to the residential sector (Figure 2). By 2013, all of the DSM schemes that began during the drought period were terminated. Only four of those DSM programs ended before the end of the drought was declared in 2010. However, all of the drought period programs were ended in 2012 after the OLV was created. 2013 and 2014 have the lowest number of DSM programs on record. During the Liberal state government only two programs were introduced, one of which, the showerhead exchange program, was originally from the Labor government. After the Labor party was re-elected in 2014, three existing programs were initiated, particularly the toilet replacement program, community rebate, and T155. These programs are further discussed below.

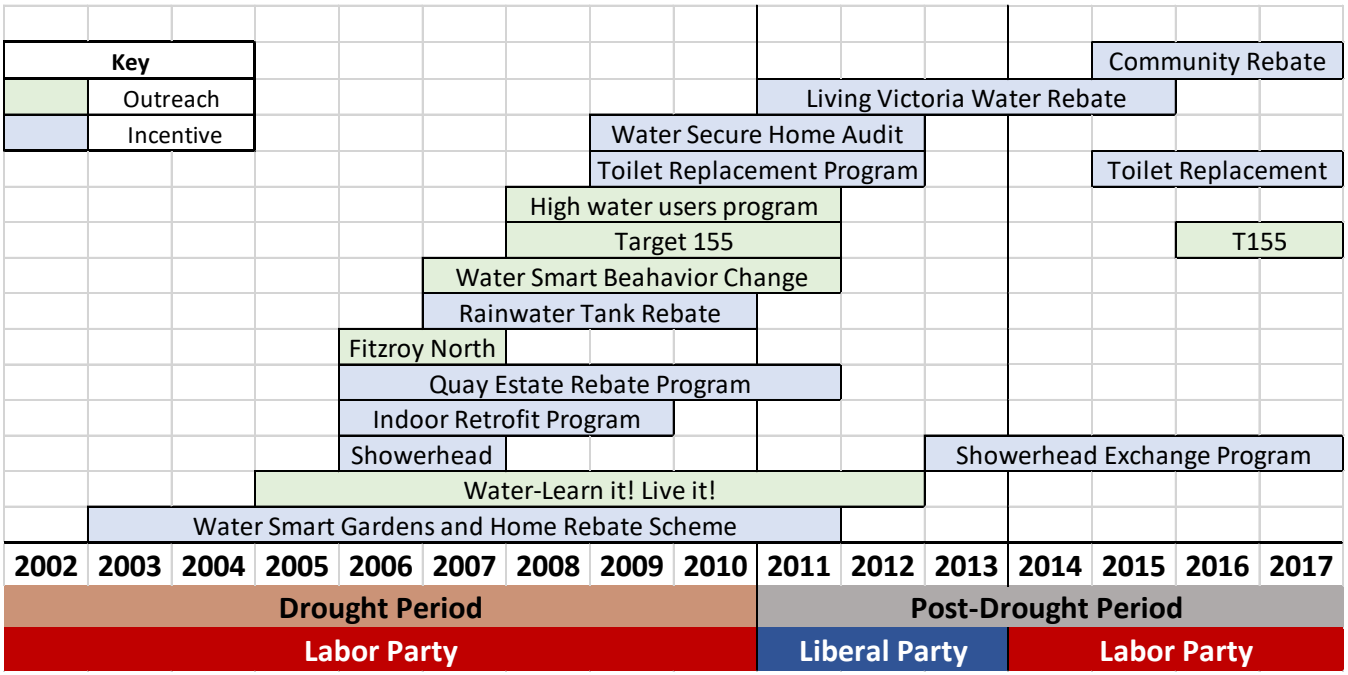

Figure 2. Timeline of key DSM programs. DSM programs are organized into two categories: outreach and incentive. They are overlaid on the drought and post-drought periods as well as the political parties in power.

Outreach- Target 155

One of the most widely publicized campaigns in Melbourne was Target 155 (T155). The state funded campaign ran from 2007 until 2011. The goal of the campaign was to reduce residential water usage in Melbourne to 155 Litres per person per day from a high of 180 L/p/day in 2008 (Lubinas and Harrison,). During this time the campaign used targeted advertising techniques and social media to inform the public on water usage. T155 targeted various income levels and communities using mass media campaigns as well as targeted advertising. There appears to be no estimates of how many households were exposed to this campaign and how much residential water consumption decreased as a result of it. However, because it was tied with the Labor government (in power from 2000-2010), it was quickly terminated after the 2010 election brought the Liberal party into office. A study done in 2011 found that 71% of water consumers believed T155 had helped reduce water consumption and that the Liberal party should not have abolished the program (Ker 2011). Once the Labor party was re-elected, the program was re-

established in 2016 by DELWP and is currently promoted by the three water distributors online (Table 2). The Labor party also re-established previous incentive programs as well.

Incentive- showerhead exchange program

The showerhead exchange program also continues to be offered by the state government and is distributed by local utilities. Originally running in 2006/2007, the program was reintroduced in late 2013. Offering residential water users the option to replace an inefficient showerhead with a high WELS rated showerhead gives them the opportunity to save 11,000 litres of water per person per year (YVW ABS 2017). Since 30% of residential water use is from showers, this can result in a significant reduction in water use (Melbourne Water Outlook 2018). In 2017, it was reported that over 190,500 efficient showerheads had been exchanged since the start of the program (YVW AB 2016).

Residential water use

Although there was a steady decrease in residential water usage before the drought break in 2010, there has been an overall increase since. Water consumption reduced from 247 L/p/day in 2000 to 147 L/p/day in 2010. In 2015, it rose to 165 L/p/day and was last measured at 161 L/p/day in 2017. The water consumption trends of the entire residential sector follow the same trends (Figure 3).

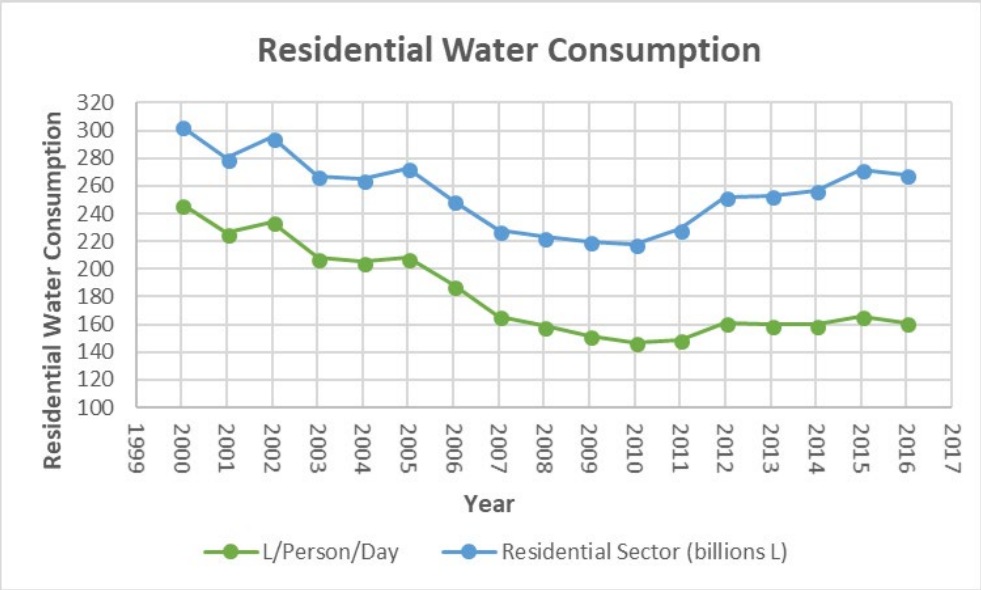

Figure 3. Timeline of Melbourne's Residential Water Consumption. Gathered from Melbourne Water Outlook 2018 and Australian Bureau of Statistics.

DISCUSSION

My results yielded a historic framework of the water industry where structural and political transitions coincided with changes in DSM implementation. Furthermore, utility companies were found to give little priority to their DSM efforts in annual reports, management strategies, and online resources. Lastly, I noted the increase in water consumption since the end of the drought period. By pulling from my results and the literature, I answer my central research question and sub questions.

I access (1) how demand side management has changed from the drought to post drought era and why. I argue that the decline in programs is harmful to the water industry. (2) Next, I explore the political backdrop of DSM, arguing that program implementation is inherently politicized in order to (3) predict the future transitions of Melbourne's water industry and (4) make suggestions on how to better integrate DSM into water management frameworks.

DSM as a Tool to Reduce Water Consumption

In terms of demand management, there are significant shifts between the drought and post drought period. The steep decline in programs after 2010 as well as the lack of publication of existing programs by utilities shows a waning interest in DSM. Trends in implementation and program type have changed between the Drought and Post-Drought period.

Industry trends

The history of Melbourne's water industry indicates a pattern of phases where certain water management strategies are favoured by the water industry. Before the 1990s there was a focus on creating large infrastructure whereas from 1990-2000 the industry emphasised economic efficiency, hence the creation of three private distributors. During the drought period from 2000-2010 there was an emphasis on recycled water and DSM programs evident by the number of publications advertising utility's efforts to reduce water consumption. However, the post-drought era after 2010 focused on "integrated urban water management (IUWM) frameworks". Every water utility has published numerous reports on their efforts to integrate these frameworks.

Although the current IUWM phase may appear progressive, in reality the framework structure is very generalized and does not offer specific actions needed. This is problematic for DSM implementation because they will often mention "consumer behaviour and efficiency programs" without elaboration. This leaves individual utilities to interpret what type of DSM programs to initiate without any top-down guidance. Furthermore, because DSM programs are given a relatively priority on planning frameworks, they are often set neglected for larger projects. CWW listed "efficient use of water by the community" and education programs as #13 and #28 priorities in their urban water strategy (CWW Urban Water Strategy 2018).

DSM implementation trends

Currently, the only type of DSM program consistently implemented across all four Melbourne utilities are educational programs. These target a wide audience by publishing water conservation tips online. These education programs appear to be more feasible as long-term

solutions because they are cheap to administer and therefore do not have to rely on government funding, which can change drastically depending on drought conditions. The majority of funding for education programs during the drought period came from federal grants and from the state government after the drought (Furlong et al. 2016). This category remains to be the cheapest option of DSM programs.

There may be a link between DSM and residential water consumption as trends in DSM implementation seem to reflect residential water use patterns throughout both periods. 2012 marks the year with the highest residential water consumption as well as the year all drought period DSM programs concluded. The results suggest residential water consumption corresponds to DSM implementation. Furthermore, a decrease in water consumption in 2016 coincides with the reintroduction of two DSM programs. Kenway et al.'s model supports this argument, finding that the introduction of DSM programs could reduce water use by 40 GL (Kenway et al. 2014). This cannot be determined solely based on the aforementioned patterns; a dedicated study would have to be done in order to certify that DSM programs in Melbourne have an effect on residential water consumption.

There may be alternate explanations for the apparent increase in residential water consumption during the Post Drought Period. Regardless of the number of DSM programs available, it is possible the Post Drought programs are less effective. Consumers may be indifferent to water conservation measures in the post-drought Period compared to the drought period.

However, residential water consumption has yet to rise back to pre-drought levels, almost seven years after the water restrictions were released. The utilities often attribute that success to residential DSM programs (Water Outlook 2018). Programs such as Target 155 (T155) were often glorified as the main contributor to reducing residential water use during the Drought Period (SEW AB 2017, CWW AB 2017, Melbourne Liubinas and Harrison 2012).

The significant reduction in residential water usage between 2007 and 2010 is attributed by many to the T155 campaign. T155 was widely advertised as a success by both the Victorian government and utilities (Liubinas and Harrison 2012) [Need more sources]. The success of this campaign is attributed to their targeted advertisement campaigns that made residents concerned about water conservation (Liubinas et al. 2012). However, the campaign appears to have been deemed a success by those who implemented it. By marking it as a success, the government could claim credit for any water conservation and promote their public image. As the banner for DSM

programs, it provided residents with a name to attribute their water reductions to. Because the campaign was not mandated it made residents believe their direct actions contributed to a larger water saving scheme. In addition, the T155 campaign was politically viable as a cheaper alternative to DSM programs that offer incentives and made the Victorian government appear to actively intervene in water use. The reintroduction of T155 in 2016 may prove to be another political effort of the Labor party to regain the public's trust in their capability to manage the water systems of Melbourne.

A study conducted by YVW determined that non-price DSM measures are preferred to pricing methods. Residential water users wanted YVW to further encourage sustainable water usage "focussing on behavioural change and other similar measures to those that were implemented during the Millennium Drought" (YVW Urban Water Strategy, 2018). As a result, utilities can benefit from implementing DSM measures in terms of increasing public image and consumer satisfaction. The study also reveals that residents associate DSM programs specifically with the drought era meaning that consumers were much more likely to be exposed to DSM efforts during the drought era than post drought era. This concept is consistent with the significant decrease in the number of DSM programs offered in the post-drought era.

Since the drought period ended, there was a significant reduction in DSM measure which may in turn have affected residential water consumption rates. The most popular form of DSM remains to be outreach as it can be cheaply maintained compared to incentive programs which are most often implemented by government entities. A focus on IUWM lead to the dismissal of DSM strategies. The decline in DSM programs is unfortunate because they can impact both residential water consumption as well as public opinions of the water industry. Which brings me to my second argument that DSM implementation is inherently political in nature.

Political Framework

National

Although the Australian national government was heavily involved in DSM implementation during the drought, the post-drought period saw a drastic reduction in national measures to promoting residential water demand management. As the drought was no longer a

pressing concern for the public, it became favourable for state and national politicians to promote other agendas that had otherwise been put on hold during the Drought Period. As a result, national grants funding DSM programs ceased. (Furlong 2016).

State

The drought period brought multiple restructuring efforts at the state level. The Victorian Water industry became decentralized with the creation of multiple utilities in the 1990s, which Maggioni would argue is less effective in water management systems (Maggioni 2015). However, some suggest that Melbourne's response to the Millennium Drought was successful due to these restructuring efforts (Ferguson et al. 2013, Furlong et al. 2016). I argue that the consistent nature of the industry due to a stable political party presence during the drought period allowed for the successful implementation of DSM measurements that reduced residential water consumption.

Restructuring efforts after the drought were primarily the result of transitions between political parties in power. There was a transition from the Labor to Liberal Party in 2000 and then a shift back in 2014. Figure 2 shows that significant shifts in DSM programs occurred immediately after the Liberal party formed the OLV to replace the existing state department. This suggests that shifting from opposing political parties may destabilize DSM efforts. In the hopes of discrediting the previous party, they not only created a new governing structure for the water industry of Victoria, but discontinued and discredited previous DSM programs from the previous administration (Furlong et. al, 2016). In addition to slowing the bureaucratic water management process, this may have confused consumers. This year also coincides with an increase in water consumption by residential users (Figure 3).

Local

In the post-drought era, politicians no longer needed to touch on water management as it was not a pressing public concern. Attention was placed on other arenas that were otherwise neglected during the drought. No legislation on water management has passed in the post-drought era (DELWP 2017). As a result, it was no longer viable to advertise DSM efforts as a method to score political points. Similar trends were seen in the water utilities as they shifted their priorities

from water conservation to profit-driven or infrastructure projects This is evident by the lack of attention DSM programs receive in utilities' annual reports and management strategies. During the Drought Period, the utilities experienced financial losses so the post drought period offered an opportunity to make a profit.

Future of Melbourne's water industry & recommendations

DSM is becoming increasingly important as water demand is expected to steadily rise in Melbourne due to population growth and an increase in homes with large gardens (Birrell et al. 2005). Melbourne's water industry will have to cope with an increase in demand as well as the threat of periodic drought (Carrão et al. 2016). Currently there are drought preparedness plans in place, however the recommended use of DSM is unclear. This will most likely lead to slow uptake of DSM programs by residents, taking longer to reduce water consumption. Furthermore, if there is another transition of political power or industry structure shift, DSM may further be neglected by the water industry leading to further vulnerability to drought impacts.

Melbourne faces many challenges moving forward in terms of water demand management, however this thesis offers suggestions on improvements. Due to the individualistic nature of Melbourne's water industry, it is often the utility's responsibility to take initiative during the post-drought era. Because political opinion has shifted focus away from water management, the state government incentives are no longer available. As a result, Melbourne utilities should work together to create a management framework that includes detailed descriptions of the best DSM strategies to employ during drought and non-drought times. In order to effectively report this, they will first need to support research on DSM methods. Maintaining and monitoring a long-term DSM measure would better help utilities identify which DSM techniques should be employed during a drought. Furthermore, I suggest creating a post-drought water management action plan to supplement existing drought response plans. Immediately after the drought period is the best time to do this as water management still maintains some political traction and there is increased public awareness. The state government can further augment these endeavours by creating guidelines for proper DSM implementation during drought and post-drought periods. Secondly, they can initiate DSM programs that are long running, so that shifts in political power will not affect their longevity.

Limitations and future directions

This study was impeded primarily by resource limitations. The biggest constraints were lack of access to DSM funding data and personal testimonies from water industry officials. Price DSM strategies were omitted as well as an in-depth description of which programs are known to be most effective since there is an abundance of literature already available in the two topics.

For future studies, I would recommend semi-structured interviews with water industry officials, politicians, and a sample of residents in order to verify opinions on DSM programs. Furthermore, a model might be a better predictor of the impact of post-drought conditions on DSM programs particularly if applied to multiple locations across the globe.

Conclusion

This thesis has implications for the future of water planning, particularly for areas prone to periodic drought. Since Australia is known to go through periodic drought cycles, it can be projected that it will soon endure another drought that will require Demand Side Management. As previously mentioned, Victoria is a leading state in terms of DSM but is still subject to post-drought declines. Therefore, the rest of Australia is further behind in DSM implementation and at a higher risk for drought impacts.

This lesson can be applied not only nationally, but internationally- particularly here in California. Similar to Australia, California is subject to period droughts and must utilize DSM to reduce water consumption (Turner et al. 2016). During the last significant drought, there were many residential areas that increased water consumption rather than decreased, showing that reactionary drought response methods may have been ineffective (Park et al. 2015). Applying DSM post drought may better prepare Californians for drought times so that they may better reduce their water consumption. Many water industries around the world will also soon face water scarcity challenges and will turn to DSM. It is important that these measures are not implemented too late.

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APPENDIX A

Table A1. Victoria Water Utility Companies. List of names and acronyms for existing water utilities in Victoria

Company Name	Acronym
Barwon Water	BW
Central Highlands Water	CHW
City West Water	CWW
Coliban Water	CW
East Gippsland Water	EGW
Gippsland Water	GW
GM Water	GMW
Goulburn Valley Water	GVW
GWM Water	GWMW
Lower Murray Region Water	LMRW
Melbourne Water	MW
North East Water	NEW
South East Water	SEW
South Gippsland Water	SGW
Wannon Region Water	WRW
Western Water	WW
Westernport Water	----
Yarra Valley Water	YVW

Figure A2. Map of Victorian Water Utilities. Taken from Victorian Water website.

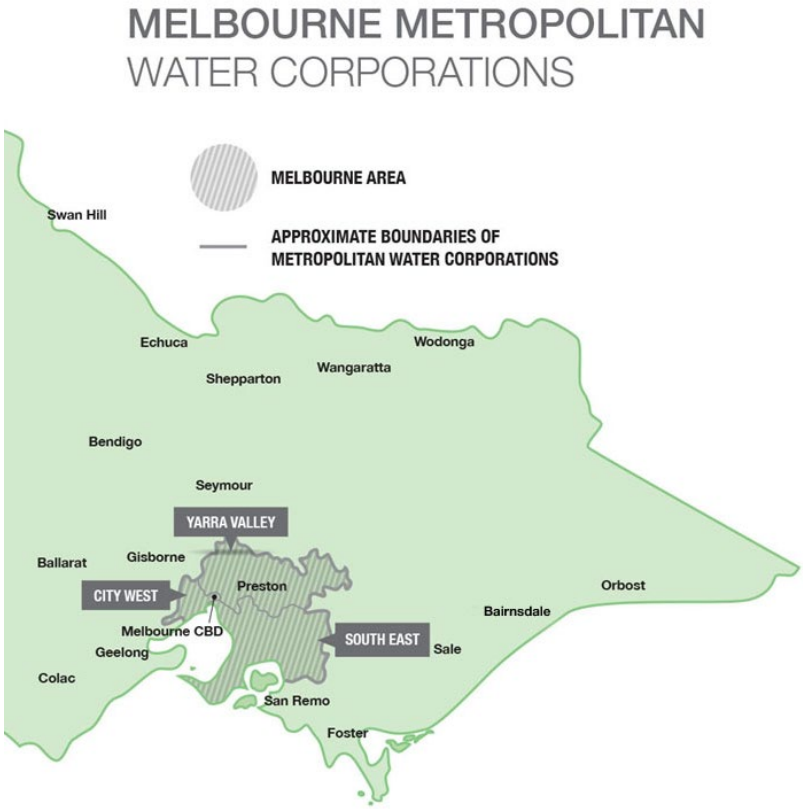

Figure A3. Map of Melbourne Water Utilities. Taken from Victorian Water website.

APPENDIX B

Table B1. Annual Reports by year. Outlines what type of DSM programs are mentioned in each utility's annual report.

	17/16	16/15	15/14	14/13	13/12	12/11	11/10	10/09
Melbourne Water	AWS	AWS, Outreach-Education	AWS, Outreach-Education, Incentives-rebate	N/A	N/A	N/A	N/A	N/A
City West Water	AWS, Outreach-Campaign	AWS, Outreach-Education & Campaigns, Incentives-Rebates & Exchanges	AWS, Outreach-Education & Campaigns, Incentives-Rebates & Exchanges	AWS, Outreach-education & campaign	AWS, Outreach-Education & Campaigns, Incentives-Rebates & Exchanges	AWS, Outreach-Campaigns, Incentives-Exchanges	N/A	N/A
South East Water	AWS, Outreach-education & campaigns, Research, Partnerships	AWS, Outreach-education & campaigns, Research, Partnerships	AWS, Outreach-education & campaigns, Incentives-audits Research,	AWS, Outreach-Education & Campaigns, Incentives-Rebates & Exchanges	AWS, Outreach-Education & Campaigns, Incentives-Rebates & Exchanges	AWS, Outreach-Education	AWS, Incentives-Rebates & Exchanges	AWS, Outreach-education & campaigns, Incentives-audits & rebates and exchanges
Yarra Valley Water	AWS, Outreach-Education, Incentives-Exchanges	AWS, Outreach-Education, Incentives-Exchanges	AWS, Outreach-Education, Incentives-Rebates & Exchanges	AWS, Outreach-Education, Incentives-Exchanges	AWS, Outreach-Education, Incentives-Exchanges	AWS, Outreach-Education & Campaigns, Incentives-Exchanges	N/A	N/A

Start Year	End Year	Name of Program	Type	Participating Utilities	Funded By
2003	2011	Water Smart Gardens and Home Rebate Scheme	rebate	Victorian government	vic gov
2005	2012	Water-Learn it! Live it!	education	all	vic gov
2006	2007	Showerhead exchange program	exchange	CWW, SEW, YVW, BW, CHW	retailers
2006	2009	indoor retrofit program	audit, exhange	CHW	CHW
2006	2011	Quay Estate Rebate Program	rebate	BW	BW
2006	present	Fitzroy North Water Saver	outreach	CWW	CWW
2007	2010	Rainwater Tank Rebate Program	rebate	BW	BW
2007	2011	Water Smart Behavior Change Program	campaign	all	retailers/ vic gov
2008	2011	Target 155:Kiosks	outreach	all	retailers
2008	2011	High water users program	outreach	all	retailers
2008	2011	Target 155	campaign	Melbourne Utilities	retailers/ vic gov
2009	2012	toilet replacement program	rebate	CWW, CHW	vic gov
2009	2012	Water Secure Home Audit	Audit	BW	BW/consumer
2011	2015	Living Victoria Water Rebate Program (Home and Garden)	rebate	Victorian government	vic gov
2013	present	Showerhead exchange program	exchange	CWW,YVW,BW,CHW	retailers
2015	2016	toilet replacement program	discount	CWW	CWW/ consumer
2015	present	Community Rebate Program	rebate	Victorian government	vic gov

Table B2: DSM Programs by start date. Gathered from Liu et al. 2017, includes start and end dates, DSM type, participating utilities and funding information.