Evaluation of Best Practices for Urban Water Conservation and Water-Smart Growth Implementation in Utah

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EVALUATION OF BEST PRACTICES FOR URBAN WATER CONSERVATION

AND WATER-SMART GROWTH IMPLEMENTATION IN UTAH

by

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ABSTRACT

Evaluation of Best Practices for Urban Water Conservation and Water-Smart Growth Implementation in Utah

by

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Water conservation policies and programs have been developed and implemented throughout the United States for several decades and constitute a key strategy for meeting future water demands. As governmental leaders and policy makers face increasing freshwater scarcity and supply unpredictability along with rising costs and decreased federal funding, Best Practices (BPs) in conservation are increasingly important to facilitate decision-making in choosing which strategies to employ. This project uses policy analysis to review and summarize various BPs using both academic and professional literature. National fixture efficiency standards enacted in 1992 are credited as among the leading factors reducing indoor water use across the nation, in both water-rich and water-poor locations. Since significant strides have been achieved in reducing indoor water use, this project focuses on outdoor (landscape) water conservation approaches since they are of particular importance in arid regions. We conducted a preliminary literature and guidebook review to determine which BPs were most commonly recommended and had the most supporting evidence for their effectiveness. We evaluated additional primary and secondary data sources (i.e., municipal codes, case studies, journal articles, best practice manuals from the industry). We analyzed implementation challenges for the Utah context through the lens of Schneider and Ingram's (1997) policy design theory where they recognize that "policy must serve multiple goals of solving problems, reflecting interests, being accountable, serving justice and engaging and enlightening citizens" (p. xi) and that it also needs to be well contextualized. We provide information relevant to all Utah communities, but distinguish information of particular relevance to Eagle Mountain City, Utah, which is one of the fastest growing communities in the USA. Eagle Mountain City represents current Utah urban expansion into areas previously not settled due to lack of water, and has unique opportunities to implement water-smart infrastructure in the construction phase of development. We found that strategies deployed throughout the United States can have varying results, and lack of empirical data documenting implementation and results can inhibit BP analysis and improvement. We recommend that policy and program implementers should more explicitly define goals, document societal outcomes, and analyze results for effective evaluation and transferability of lessons learned between municipalities. We further recommend that BPs targeting the correct design, installation, and maintenance of landscapes and irrigation systems be utilized, since such policies could be the outdoor equivalent of the 1992 efficiency standards that were instrumental in reducing indoor water use across the nation.

(178 pages)

PUBLIC ABSTRACT

Evaluation of Best Practices for Urban Water Conservation and Water-Smart Growth Implementation in Utah

Ivy Thomson

Policies and programs have been utilized throughout the United States (U.S.) to reduce water use as a strategy to ensure sufficient water supplies for future demand. As governmental leaders and policy makers face increasing freshwater scarcity and supply unpredictability, along with rising costs and decreased federal funding, Best Practices (BPs) in water conservation are increasingly important to facilitate decision-making in choosing which strategies to employ. This project uses policy analysis to review and summarize various BPs, referencing both academic and professional literature. National fixture efficiency standards enacted in 1992 are credited as among the leading factors reducing indoor water use across the nation in both areas with ample and scarce amounts of water. Since significant strides have already been achieved in reducing indoor water use, this project focuses on outdoor (landscape) water conservation approaches since they are of particular importance in arid regions. We conducted a preliminary literature and guidebook review to determine which BPs were most commonly recommended and had the most supporting evidence for their effectiveness. The most comprehensive list of recommendations was provided by Colorado WaterWise and Aquacraft, Inc.'s *The Guidebook of Best Practices for Municipal Water Conservation in Colorado – Technical Guide* (2010). We evaluated Colorado WaterWise and Aquacraft, Inc. (2010) along with more primary and secondary data sources (i.e., municipal codes, case studies, journal articles, best practice manuals from the industry). We evaluated implementation challenges for the Utah context through the lens of Schneider and Ingram's (1997) policy design theory, where they recognize that "policy must serve multiple goals of solving problems, reflecting interests, being accountable, serving justice and engaging and enlightening citizens" (p. xi) and that it also needs to be well contextualized. We provide information relevant to all Utah communities, but distinguish information of particular relevance to Eagle Mountain City, Utah, which is one of the fastest growing communities in the USA. Eagle Mountain City represents current Utah urban expansion into areas previously not settled due to lack of water, and has unique opportunities to implement water-smart infrastructure in the construction phase of development. We found that strategies deployed throughout the United States can have varying results, and lack of empirical data documenting implementation and results can inhibit BP analysis and improvement. We recommend that policy and program implementers should more explicitly define goals, document societal outcomes, and analyze results for effective evaluation and transferability of lessons learned between municipalities. We further recommend that BPs targeting the correct design, installation, and maintenance of landscapes and irrigation systems be utilized, since such policies could be the outdoor equivalent of the 1992 efficiency standards that were instrumental in reducing indoor water use across the nation.

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CHAPTER I

INTRODUCTION

As water supplies become scarcer and more unpredictable in the western United States (U.S.), demand-side water management strategies are increasingly important to stretch available supplies and delay or negate developing costly water infrastructure in the face of rapid regional development and declining or contested public revenues (Christian-Smith and Gleick 2012, Fleck 2016, Vickers 2018). Governmental leaders and policy makers grapple with many challenges related to providing equitable access to limited water supplies, ensuring appropriate water quality for different types of uses, and balancing human and environmental needs for water (Endter-Wada 2014). Well-designed policies, laws, and regulations are needed to address these challenges. For instance, the U.S. Energy Policy Act of 1992 set minimum efficiency standards for toilets, showers, urinals, and faucets manufactured in the U.S. after 1994, and these standards have been credited as a leading factor reducing indoor water use across the nation (Brelsford and Abbott 2017; Diringer et al. 2018; Donnelly and Cooley 2015; Dyballa and Hoffman 2015; National Conference of State Legislatures 2015; Rockaway et al. 2011; Vickers and Bracciano 2014; William and Mayer 2012). Notably, corresponding policy action to address outdoor water use efficiency is lacking. Outdoor water use constitutes the majority of potable water use in most municipalities located in the arid and semiarid region of the U.S. West.

To help water managers address these challenges and provide direction for governmental leaders and policy makers, Utah's Governor Herbert commissioned a

Recommended State Water Strategy (Utah Water Strategy Advisory Team 2017), outlining key policy and science issues. Conservation and efficiency measures are identified as top priorities for meeting future water needs, and leaders are working to implement the vision as set forth in the report. Though approximately 82% of Utah's diverted water is used in agriculture (Office of Legislative Research and General Counsel 2012), surveys demonstrate Utahns support maintenance of the agricultural sector and are not willing to see significant amounts of water transferred from agriculture to municipal uses (Endter-Wada, Hall, Jackson-Smith, and Flint, 2015; Envision Utah, n.d.). Though urban water demand is less flexible than agricultural water demand, researchers have demonstrated that there is appreciable capacity to conserve water applied to outdoor landscaping in the municipal and industrial sectors (Endter-Wada et al. 2008; Frost et al. 2016; Kilgren et al. 2010; Kjelgren, Rupp, and Kilgren 2000; Mayer, Lander, and Glenn 2015; Utah Division of Water Resources 2010).

Best Practices (BPs) in conservation are increasingly important to facilitate decision-making in choosing which strategies municipal planners and water managers should employ in order to maximize both water and financial efficiencies. This thesis uses policy analysis to review and summarize various BPs using both academic and implementation literature. We conducted a preliminary literature and guidebook review to determine which BPs were most commonly recommended and included the most supporting evidence for their effectiveness. The most comprehensive list of recommendations was provided by Colorado WaterWise and Aquacraft, Inc.'s *The Guidebook of Best Practices for Municipal Water Conservation in Colorado – Technical Guide* (2010). We evaluated this resource along with more primary and secondary data sources (i.e., municipal codes, case studies, journal articles, other best practice manuals from the industry). The general purpose of this research was to provide all Utah governmental leaders, planners, and water managers with BPs best suited for reducing outdoor urban water demand. A more specific purpose was to provide information of particular relevance to Eagle Mountain City, Utah, which is one of the fastest growing communities in the nation and part of current urban expansion into areas of Utah previously not settled in large part due to lack of water (Figure 1). This city seeks to conserve water while accommodating growth and has a unique opportunity to implement water-smart infrastructure in the construction phase of development.

Chapter 2 of this thesis discusses seven foundational BPs that are essential for any municipality's water conservation toolkit. While these BPs have been implemented in many locations across the U.S., lack of thorough data and program evaluation has prevented consistent replication and improvement. Such information would facilitate better understanding of how local governments can modify and implement these more generally-defined BPs to best suit their specific contexts. Thus, we support other researchers in calling for more data and program analysis, but add the need for attention to the specific design of BPs and their implementation in particular and varying contexts for better evaluation of implementation.

Chapter 3 of this thesis examines four regulatory and customer-side BPs that target urban landscape water use in particular. This examination is done in light of the Utah pioneers' very early historical use of what are now considered smart growth strategies. These current landscape BPs account for a golden trifecta of proper design, installation, and maintenance practices that maximize landscape water and irrigation system efficiency (Colorado WaterWise and Aquacraft, Inc. 2010; Utah Water Strategy Advisory Team 2017). These BPs are especially crucial for rapidly developing communities, where municipalities have the opportunity to direct various decision makers (e.g., developers, Home Owner Associations (HOAs), and residents) to construct water-smart development and neighborhood and property infrastructure to maximize water savings over the long term. Such policies could be the outdoor equivalent of the 1992 efficiency standards that were instrumental in reducing indoor water use across the nation.

In both Chapter 2 and Chapter 3, we evaluate implementation challenges for the Utah context through the lens of Schneider and Ingram's (1997, xi) policy design theory. They recognize that “policy must serve multiple goals of solving problems, reflecting interests, being accountable, serving justice and engaging and enlightening citizens,” and that it also needs to be well contextualized. We provide specific contextualized examples of these policy design and implementation issues in relation to Eagle Mountain City.

Chapter 4 concludes this thesis with a discussion of the overall conclusions of this research.

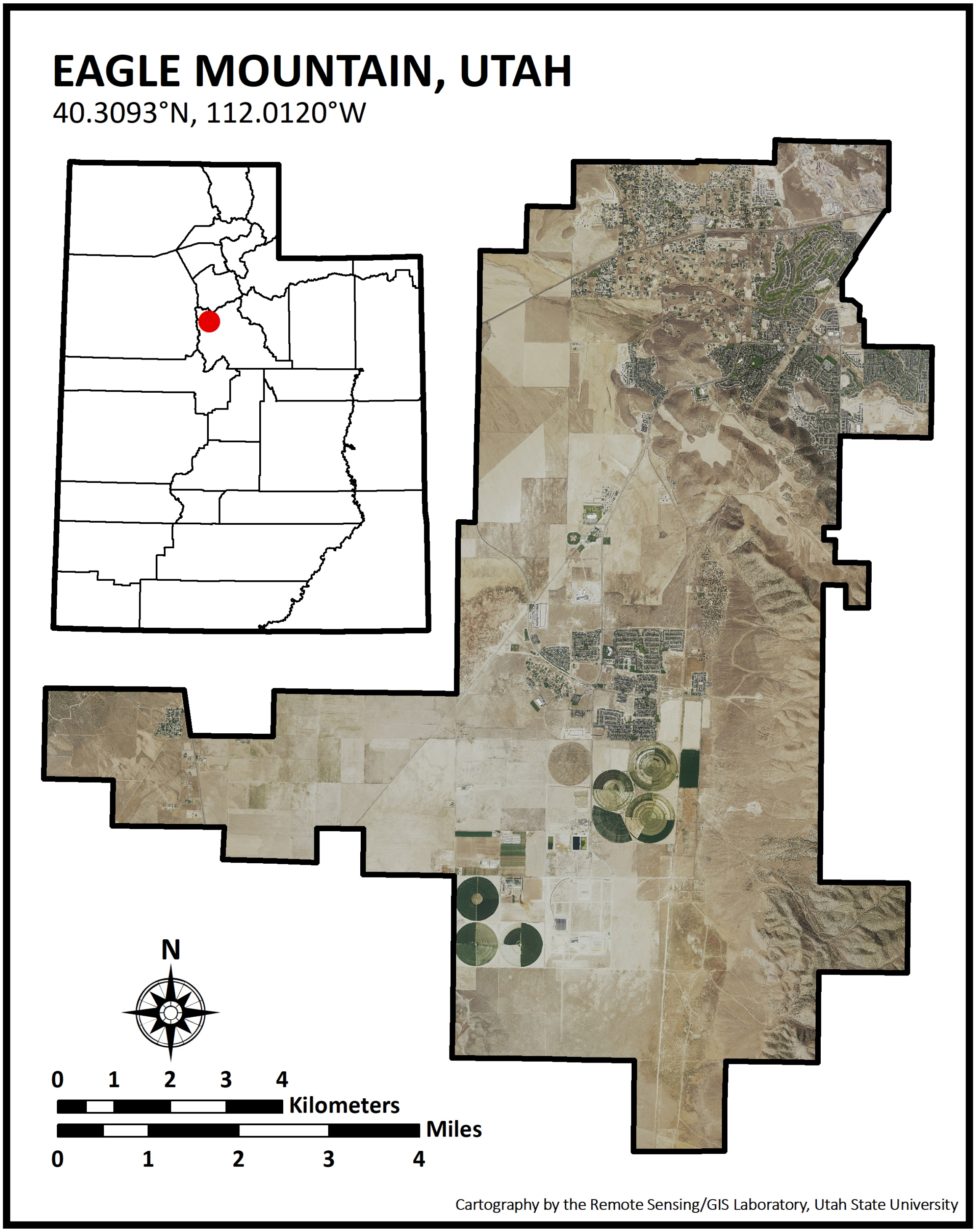

Figure 1: Map of Eagle Mountain City, Utah

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CHAPTER II

EVALUATION OF COMMON BEST PRACTICES FOR URBAN WATER CONSERVATION [1]

ABSTRACT

Water conservation policies and programs have been developed and implemented throughout the United States for several decades and constitute a key strategy for meeting future water demands. As governmental leaders and policy makers face increasing freshwater scarcity and supply unpredictability along with rising costs and decreased federal funding, Best Practices (BPs) in urban water conservation are increasingly important to facilitate decision-making in choosing which strategies to employ. This policy analysis article reviews and summarizes various BPs using both academic and professional literature. It focuses on outdoor (landscape) water conservation approaches since they are being prioritized in light of significant gains already made in indoor water conservation and are of particular importance in arid regions. We find that strategies deployed throughout the United States can have varying results, and lack of empirical data documenting implementation and results can inhibit BP analysis and improvement. We recommend that policy and program implementers more explicitly define goals, document societal outcomes, and analyze results for effective evaluation and transferability of lessons learned between municipalities.

[1] This chapter is co-authored with Dr. Joanna Endter-Wada

INTRODUCTION

Nearly two decades into the twenty-first century, water has become a top public policy issue throughout the United States (U.S.) (Chistian-Smith and Gleick 2012). Its prioritization on the policy agenda has to do with the many water-related challenges society confronts related to providing equitable access to the small proportion of freshwater on the planet, ensuring appropriate water quality to support different types of uses when and where needed, and balancing human and environmental needs for water (Endter-Wada 2014). A recent review of 17 state water plans (Bateman et al. 2018) documents the wide-ranging and persistent procedural, legal, technical, financial, and public involvement challenges governments are confronting in their long-range water planning; particularly in the face of climate change effects.

Water managers have traditionally relied upon increasing water supplies to meet current and projected needs through building large, government-subsidized infrastructure projects to capture, store, and convey water from its source to often distant locations where it is actually put to use (Reisner 1993). Due to declines in funding for water infrastructure, and concerns over its often-negative environmental consequences, an alternative approach focused on stretching existing supplies has emerged (Chistian-Smith and Gleick 2012; Harvey 1991). This demand-side approach (or "soft-path approach") has received less attention than supply-side strategies (or "hard-path approaches"), though the paradigm may be shifting (Brooks, Brandes, and Gurman 2009). Nearly all analysts of contemporary U.S. water challenges agree on the need to develop innovative strategies to promote water conservation and efficiency, and they seek leadership in developing models that can be successfully shared and adopted in other locations. Such leadership is especially important in the U.S. West, where governmental leaders and policy makers are grappling with how to meet water demand for very rapid population growth in a region of scarce and increasingly unreliable water supplies.

It is common for municipal or state officials to take the lead in developing policies, laws, and regulations that are later adopted by other community institutions (Berry and Berry 2007). These policies should be informed by best science practices and findings. Kuhn and Fleck (2019) illustrate how Colorado River Compact negotiators in the early 20th century chose information convenient to their policy goals and overallocated Colorado River water, perpetuating challenges that have become critical today. Yet, as a positive example, Connecticut enacted the first state water efficiency in 1989 (National Conference of State Legislatures 2015). Those standards set maximum flow rates for water fixtures manufactured, sold, and installed in Connecticut after 1990. A few other states followed their example, culminating in the federal government's implementing national standards in the U.S. Energy Policy Act of 1992 (EPAct 1992). The federal legislation "set minimum efficiency standards for all toilets, showers, urinals and faucets manufactured in the United States after 1994" (National Conference of State Legislatures 2015). Fixture efficiency standards are credited as a leading factor in reducing indoor water use across the entire nation (Brelsford and Abbott 2017; DeOreo, Mayer, Dziegielewski, and Kiefer 2016; Diringer et al. 2018; Donnelly and Cooley 2015; Dyballa and Hoffman 2015; Frost et al. 2016; Rockaway et al. 2011; Vickers 2018; Vickers and Bracciano 2014; William and Mayer 2012).

Another example of local leadership leading to more broad policy adoption is work done by the Metro Mayors Caucus in Colorado. Between 2004 and 2005, the Metro Mayors Caucus in Colorado drafted and signed a Memorandum of Understanding on Water Conservation and Stewardship. After it was signed by 28 jurisdictions and endorsed by 16 organizations, the Caucus worked with the Colorado WaterWise Council to write the document "Best Management Practices (BMPs) for Water Conservation." The Colorado Water Conservation Board adopted these BMPs as an appendix to the Colorado Model Water Conservation Plan in 2005. In California, the California Landscape Contractors Association (CLCA) was involved in the creation of the Water Conservation in Landscaping Act, which helped develop and launch a performance-based landscape water certification industry program in 2007. The CLCA was also a critical stakeholder in meetings leading to the Water Conservation in Landscaping Act of 2006, achieving policy amendments regarding tree irrigation and irrigation audits (California Landscape Contractors Association, n.d.).

In Utah, a Recommended State Water Strategy (2017) commissioned by Utah's Governor Herbert, outlined key policy and science issues to help water managers meet Utah's water challenges. Conservation and efficiency measures are identified as top priorities for meeting future water needs. Whereas water supply infrastructure was traditionally financed via state and federal funding, governmental leaders and policy makers are recognizing the need to increasingly support demand-side approaches. Utah's Board of Water Resources approved a program loaning up to $3 million per year for secondary water meter installations, and Utah's legislature and governor allocated ongoing funding to water conservation rebates for the first time in state history ("New Water Program" 2016; Gayle 2018).

Leaders are working to implement the vision set forth in Utah's Recommended State Water Strategy in their respective stewardships. Though 82% of Utah's diverted water is used in agriculture (Office of Legislative Research and General Counsel 2012), surveys reveal that Utahns support the maintenance of the agricultural sector and are not willing to see significant amounts of water transferred from agriculture to municipal uses (Endter-Wada, Hall, Jackson-Smith, and Flint, 2015; Envision Utah, n.d.). Urban water demand is less flexible than agricultural water demand (you can't "fallow a subdivision," as heard in professional circles), yet researchers have demonstrated that there is appreciable capacity to conserve water applied to outdoor landscaping in the municipal and industrial sectors (Endter-Wada et al. 2008; Frost et al. 2016; Kjelgren, Rupp, and Kilgren 2000; Mayer, Lander, and Glenn 2015; Utah Division of Water Resources 2010).

Though conservation measures for urban outdoor water use have been practiced in the U.S. for decades, a review of both peer-reviewed and professional literature found relatively few resources detailing best practices (BPs) specifically for landscaping ordinances and policies affecting outdoor water use. Such policies affecting the infrastructure of outdoor water use are invaluable for communities experiencing rapid population growth, as they have the opportunity to influence current and future water demand before capital investments are "baked in" (Brelsford and Abbott 2017).

Since Utah's governmental leaders and policy makers are increasing statewide efforts to define and meet water conservation goals, we provide a review of various guidebooks describing various BPs for water conservation, along with academic and professional resources to aid implementation. The framework eventually adopted for this review was inspired by, and adapted from, the 14 BPs outlined in *Guidebook of Best Practices for Municipal Water Conservation in Colorado* by Colorado WaterWise and Aquacraft, Inc. (2010). Those BPs encompassed the majority of recommendations seen in our initial literature review and ones favorably reviewed in other guides.

The goal of this chapter is to identify BPs most relevant to the contemporary Utah context where major urban and suburban land use transformations are occurring in the state's highly concentrated urban and suburban core of the Wasatch Range Metropolitan Area (Li et al. 2017, 2019). Toward that end we 1) prioritize BPs relevant to outdoor use and exclude BPs for indoor water consumption, and 2) divide the remaining BPs between ones that are foundational for both established and newly developing areas (this chapter), and those we consider especially crucial to municipalities or neighborhoods experiencing rapid expansion or development (the next chapter).

The purposes and organization of this chapter are as follows: The "Methods" section will describe our policy analysis methods, including data collection, analysis, and presentation. The "Selected Best Practices" section summarizes BPs selected for their broad applicability in both established and developing municipalities and regions. It also provides major resources and an abbreviated academic literature review for each BP to facilitate implementation by governmental leaders and identify where further research is needed. The "Policy Design of BPs" section covers issues relevant to designing and implementing BPs to fit various contexts and emphasizes the need for equity in the way water conservation is promoted. The "Conclusion" section presents some summation and closing thoughts.

METHODS

Data Collection

The data collection for this thesis consisted of identifying BPs for urban water conservation and efficiency that are commonly recommended in the literature. In conducting peer-reviewed literature searches using a variety of key terms, we quickly identified several important guidebooks that have been prepared by experienced professionals and prominent non-profits working within the urban water sector. Though we did not find any guidebooks provided directly from academic sources, most guidebooks reference both academic and professional literature as well as provide examples of the practices that they review and recommend. We conducted additional literature searches on the main BPs to identify case studies and models of implementation.

Data Analysis

We conducted a preliminary literature and guidebook review along with primary and secondary data sources (i.e., municipal codes, case studies, journal articles, best practice manuals from the industry). We determined that the BPs most commonly recommended, and accompanied by the most supporting evidence, were provided by Colorado WaterWise and Aquacraft, Inc.'s *The Guidebook of Best Practices for Municipal Water Conservation in Colorado – Technical Guide* (2010). Their project team selected and presented 14 BPs after conducting a literature review of significant BP reports and publications from California, Texas, Georgia, and Colorado, and vetted their work through water professionals and industry experts. Their recommendations have largely been supported by subsequently published literature. The 14 best practices they identified were presented in three sets referred to as “suites”: 1) six foundational, no-excuse best practices, 2) the foundational best practices plus three regulatory best practices, and 3) a complete package of both prior suites plus five customer-side best practices. Their recommendation of how to stage, or sequence, groups of best practices for implementation also stood out as unique in the literature. We evaluated additional academic and professional literature and subsequently adapted the Colorado WaterWise and Aquacraft, Inc. (2010) framework in presenting our review and recommendations.

We also conducted policy analysis by evaluating the seven BPs we focus on for application to the Utah context through the theoretical lens of *Policy Design for Democracy* by Schneider and Ingram (1997) and literature on environmental justice. Given that water is the property of the public and essential for life, all citizens have an interest in equitable access to water and how it is used in Utah. The issues of how we design policies to address growing scarcity are increasingly urgent and are being prioritized on the state’s policy agenda. Schneider and Ingram’s work is significant for its rare emphasis on policy design instead of policy processes, and its focus on how contexts give rise to, and are shaped by, different types of policies. Utah municipalities are located in a variety of different geographic and social contexts, implying that policies implemented within even a single state will likely vary as local governmental leaders respond to different needs. We use insights from Schneider and Ingram to discuss implementation issues. Finally, this chapter’s reliance on Schneider and Ingram’s policy design framework implies that administrators and managers should predetermine the goals and problems to be solved and what can be measured to evaluate water conservation success.

Data Presentation

Based upon our data collection and data analysis, we present an evaluation of seven BPs that we determined to be most significant for advancing urban water conservation in general. This thesis chapter largely utilizes Colorado WaterWise and Aquacraft, Inc.'s (2010) six foundational best practices with three major changes that respond to new information and developments since publication of their guidebook.

First, Colorado Water Wise and Aquacraft, Inc. (2010) include "integrated resources planning, goal setting, and demand monitoring" as one of their six foundational, no-excuse BPs. It was aimed at incorporating both supply-side and demand-side water management options. Today, most governments and utilities recognize the need to engage in water demand management as a source of new supply, a cost saving measure, and a prerequisite to building new water supply projects. Since its inception in 2008, the growth and success of the annual Water Smart Innovations conference is an indicator of the increased focus on water demand management. Instead, we substitute "integrated land and water planning" as the first BP in our framework, since this integration is increasingly critical to connect land use development decisions with water-supply decisions to gain long-term outdoor water efficiencies, especially in rapidly growing areas.

Second, we add a best practice from the Metro Mayors Caucus: demand reduction during a water crisis. Though the Metro Mayors Caucus is unique in putting this forth as a best practice, there are distinct differences between policies and measures implemented for short-term water savings and long-term water savings. Since this BP focuses on short-term water savings in response to an immediate need, we include it as the second BP in this chapter as a companion to our first BP of integrated land and water planning, which focuses on long-term water savings.

Third, our literature review confirms the statement by Colorado WaterWise and Aquacraft, Inc. (2010, 82) that, "the published literature on water waste ordinances is virtually non-existent" even a decade later. They define a water waste ordinance as "a local regulation that explicitly prohibits the waste of water and clarifies enforcement and penalties" (p. 23). Though their report suggests water waste ordinances as a stand-alone best practice, we think the lack of published literature, combined with mixed results on that particular method's effectiveness, warrants a change from recommending "water waste ordinances" as a specific best practice. Instead, we modify and broaden that best practice to be "address water waste," allowing for other water waste mitigation strategies. We call for more research to support documenting and monitoring water waste.

Table 1 lists the seven common BPs for urban water conservation covered in this chapter, and shows how they correspond to the six foundational BPs identified in Colorado WaterWise and Aquacraft, Inc.'s (2010) technical guide.

Table 1: BPs Covered in this Chapter and Correspondence to Foundational BPs in the Colorado WaterWise Guidebook (2010)

BP#	*This Thesis Chapter*	*BP#*	*CO WaterWise Guidebook (2010)*
1	(Substitution) Integrated land and water planning	2	Integrated resources planning, goal setting, and demand monitoring
2	(New Addition) Demand reduction during a water crisis	--	---

3	Metering, conservation-oriented rates and tap fees, customer categorization within billing system	1	Same
4	System water loss control	3	Same
5	Conservation Coordinator	4	Same
6	(Modification) Address Water Waste	5	Water Waste Ordinance
7	Public information and education	6	Same

We argue that these best practices are essential for any municipality. We also support other researchers in calling for more data and program analysis. While these foundational best practices have been successfully implemented in many locations across the nation, lack of thorough data and program evaluation has hindered replication, further implementation, and improvement. Such information can contribute to better understanding of how local governments modify and implement these more generally-defined BPs to fit their specific contexts, and would prove valuable to other communities seeking to design and adapt their own water conservation practices.

SELECTED BEST PRACTICES

Best Practice 1: Integrated Land and Water Planning

Integrated land and water planning seeks to resolve the "historic disconnect between land use development decisions and water-supply decisions" to result in quality development and reliable water supply (Blanchard 2018, 9). Colorado's Water Plan calls for 75% of citizens to live in communities which have integrated water conservation and land use by 2025 (Plautz 2019). Utah's Recommended State Water Strategy advocates for more explicit connections between water and land use planning for long-term water conservation success (Utah Water Strategy Advisory Team 2017). This connection is especially crucial for rapidly developing communities such as Eagle Mountain City, Utah, where community leaders can lay the framework for development to occur in ways commensurate with available water supplies. It is best accomplished by integrating water efficiency strategies and methods into municipal plans and regulations that shape the way land is developed, which includes how buildings are constructed and irrigated landscaping is designed and installed. Blanchard (2018, 10) states that "the specific techniques that can be used to integrate water efficiency into local land use documents are not always known to local planners, and the knowledge base of techniques is both nascent and growing." Despite its relatively recent introduction, this BP has been recognized as essential, and available literature on its implementation is increasing.

Leading professional land and water organizations have confirmed integrated land and water planning as an essential best practice. In 2012, the American Water Resources Association (AWRA) Policy Committee published *Case Studies in Integrated Water Resources Management: From Local Stewardship to National Vision* to "advance and develop a better understanding of integrated water resources management" (6). In 2017, The American Water Works Association published *M50 Water Resources Planning, Second Edition*, which advocates for Integrated Water Resource Planning. The Water and Planning Network was launched by the American Planning Association in 2017 to connect members to best practices in this area. The Water Research Foundation published a report and associated companion guide written by the Brendle Group and Western Resource Advocates which identifies opportunities where better integration can occur and has a specific focus on alternative water supplies (Fedak, Sommer, Hannon, Beckwith, et al. 2018; Fedak, Sommer, Hannon, Sands, et al. 2018). Table 2 below illustrates types of planning activities available for community planners to integrate land and water planning, and is taken from Fedak, Sommer, Hannon, Sands, et al. (2018, 4).

Table 2: Types of Planning Activities to Integrate Land and Water Planning

Long-Range Plans	**Codes and Regulations**	**Development Review Processes**
Baseline and Forecasting	Zoning Codes	Pre-application Meeting
Visioning and Goal Setting	Subdivision Regulations	Development Plan Application and Review
Scenario Planning and Alternative Analysis	Development Codes	Development Agreements and Fees
Stakeholder Engagement	Water Sustainability Ordinances	Permit Review and Inspections
		Post-occupancy Considerations

Source: Table is from Fedak, Sommer, Hannon, Sands, et al. (2018, 4)

Other organizations have issued guides and examples for implementing this practice. Blanchard's (2018) *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners* was prepared by the Pace Law School Land Use Law Center for Western Resource Advocates with funding from the Gates Family Foundation and the Babbitt Center for Land and Water Policy, a center of the Lincoln Institute of Land Policy. Blanchard (2018, 10) writes, "Based upon an examination of local plans and regulations from hundreds of communities around the country, this Guidebook includes a collection of community best practice examples that seek to address the goal of encouraging land use patterns and development policies that decrease per capita water use. While the Guidebook's narrative discusses what can be done, the community examples show what has been done." Featured case studies often link directly to cited municipal codes. For smaller municipalities with limited budgets, the author advocates for coordinating efforts with adjacent local governments and includes case studies of regional partnerships.

Net Blue is an initiative of the Alliance for Water Efficiency, the Environmental Law Institute, and River Network to facilitate water neutral growth, and provides research on water demand offset policies, along with model ordinances and a tool to calculate water offsets (Alliance for Water Efficiency 2019a). Members of the Alliance for Water Efficiency may also access their conservation tracking tool, which enables planners to develop long-range conservation plans and "track the implementation, water savings, costs, and benefits of actual conservation activities over time" (Alliance for Water Efficiency 2019b). Of note, Blanchard (2018) reviews scenario planning as part of integrated land and water planning. She states that "scenario planning is a powerful tool that ensures that multiple futures are taken into consideration so as not to commit all resources toward one uncertain future" (p 25). While some long-term planning teams have created different future scenarios and asked constituents which scenario they prefer, such as Envision Utah's 2014 *Your Utah, Your Future* study, Blanchard (2018, 27) states, "The challenge is not to pick the most likely or attractive future; rather, it is to develop the capacity to be prepared for all of them."

Fedak, Sommer, Hannon, Beckwith, et al. (2018) evaluated water supply diversification efforts using an integrated water management approach. They report among their key findings that 1) while coordinated planning between water and land use planners does occur, coordinated planning for alternative water supply development is less common, 2) benefits of coordinated planning include resolving conflicts among planning efforts and improving water and community sustainability, and these benefits tend to outweigh the costs, and, 3) institutionalized coordination between water and land use planners is a key solution and will look different in each community. They recommend "effective and deep" coordination of long-range plans, coordination of codes and regulations, and coordination of the development review process.

Westminster, Colorado has been a leader in integrated land and water planning for years. Their comprehensive plan is highly detailed and adopted by ordinance instead of resolution, making compliance a legal requirement (Blanchard 2018). It is innovative in linking land and water use. Staff merged the city's land-use plans with water use data by building GIS software to overlay water resources and associated infrastructure over the city's comprehensive plan. This enabled planners to easily see how much water proposed developments would use. Planners used the results to guide developers to better construction. Stu Feinglass, a former water resources analyst for the city, said, "We didn't want public works to determine how the city developed. We wouldn't be the ones to say no. What we could do is show [developers] how much water we have and ask them to be creative and make their development work with that" (Plautz 2019).

More cities could approach land and water integration similarly if people working in water management and land use planning coordinate and collaborate. To do so, having appropriate data on how much water people use is important; however, such data has been difficult to acquire. Working to overcome that challenge, California passed a law in 2016 requiring state and local agencies to share their water data (Plautz 2019). Coordination and collaboration should also be encouraged on greater scales than just within municipalities. On April 8, 2019, Congress approved a seven-state Drought Contingency Plan for Colorado River Basin states to share water cuts if supplies remain low. Though prior agreements required heavy cuts from agriculture, "most everyone agrees that the 2026 guidelines being developed will require some sacrifices from cities, even as they grow as economic engines" (Plautz, 2019). One urban water utility drought management practitioner "described how being part of a regional plan provided a sense of solidarity: *'No one wants to be the first guy who doesn't follow the plan or who opts out of a regional decision'"* (Dilling et al, 2019, 36). The authors reported this as a type of robustness; robustness being defined by Adger, Arnell, and Tompkins (2005) as being less sensitive to changing conditions.

Major resources on this BP are listed in Table 3.

Table 3: Major Resources on Integrated Land and Water Planning

Alliance for Water Efficiency. 2019. Net Blue: Supporting Water-Neutral Growth (a suite of resources). *Available at:* https://www.allianceforwaterefficiency.org/resources/topic/net-blue-supporting-water-neutral-growth
American Water Works Association. 2017. *M50 Water Resources Planning, Third Edition*. The American Water Works Association (USA).
American Planning Association. 2019. Water and Planning Network. *Networking Site:* https://www.planning.org/divisions/groups/water/
Blanchard, J. C. N. (lead author and editor). 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado. Available at*: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Fedak, R., Sommer, S., Hannon, D., Beckwith, D., Nuding, A., & Stitzer, L. 2018. *Integrating Land Use and Water Resources: Planning to Support Water Supply Diversification.* Report 4623A. Water Research Foundation (USA).
Fedak, R., Sommer, S., Hannon, D., Sands, R., Beckwith, D., Nuding, A., & Stitzer, L. 2018. *Coordinated Planning Guide: A How-To Resource for Integrating Alternative Water Supply and Land Use Planning*. Report 4623B. Water Research Foundation (USA).

Policy Committee. 2012. *Case Studies in Integrated Water Resources Management: From Local Stewardship to National Vision*. edited by Brenda Bateman and Racquel Rancier: American Water Resources Association.

Best Practice 2: Demand Reduction During a Water Crisis

A crisis or drought response plan prepares people for what to expect in times of shortage and relieves pressure on city elected officials, staff, and residents. Water utility customers must understand that short-term cuts in water use during crises are not the same as strategies adopted to achieve water efficiencies over the long term (Metro Mayors Caucus and Colorado WaterWise Council 2005). Institutions may utilize both a drought response plan and a crisis response plan, or they may create one plan covering varying crises and respective responses. Public involvement in developing these plans, and regular communication about these plans between municipalities and users, could help prevent or mitigate anger or vindictive behavior in response to usage restrictions during shortages. Such an incident occurred in 2018 in Utah's Benchland Water District where customers angry at being fined were suspected of draining 26 million gallons of water overnight from a reservoir (McGurk 2018; Stevens 2018). These plans could also help municipalities and governments see their credit ratings improve, as Moody's Corporation has invested in a firm which measures the physical risks of climate change, enabling governments to reduce such risks pertaining to their municipalities (Flavelle 2019).

Of note, water shortages in the U.S. West have generally been thought of as resulting from drought, and crisis and drought plans have received much attention in practical and academic literature. Responding to short- and long-term droughts is now a standard practice in the region, and building institutional capacity to address recurrent droughts deserves increased attention (Endter-Wada, Selfa, and Welsh 2009). However, this paradigm has been shifting from drought response to a pro-active risk mitigation and adaptation approach that is more mindful of the region's underlying aridity, which is being aggravated by climate change (Botterill and Cockfield 2017; Dilling et al. 2019; Miller et al. 2018; Stults and Woodruff 2017; Wilhite and Pulwarty 2018). Another traditional strategy has been supply-side water management strategies which are still advocated by some professionals, particularly those in the engineering profession (such as a 2016 argument made by Stakhiv, Werick, and Brumbaugh). However, Vickers (2018) emphasizes that demand management strategies (such as hardware repairs and changing water use mindsets and habits) result in long-term savings that have minimized or cancelled major water and wastewater infrastructure expansion plans.

The Metro Mayors Caucus and Colorado WaterWise Council (2005) report assesses this best practice's benefits with potential barriers and costs. The AWWA manual *Drought Preparedness and Response, Second Edition* is a complete walk-through on how to establish a Water Shortage Contingency Plan (Brown and Maddaus 2019). The California Water Efficiency Partnership (CalWEP) website provides an excellent Jumpstart Water Shortage Toolkit with the chapter "Model Water Shortage Contingency Plans." The toolkit chapter provides an overview of plan development, references resources and tools, and has examples of plans from around the state. Especially helpful are the discussions on water shortage stages, water shortage stage triggers, and sample water use restrictions with their respective earliest implementation stages. The same toolkit also has a chapter "Water Waste Ordinances and Enforcement Primer" that includes examples of ordinances used during drought, and a "Water Shortage Pricing Primer" chapter that includes surcharge options by rate structure and recommends that agencies adopt drought rates before they are needed. Gay and Borman (2018) cover how to prepare for crisis situations apart from droughts. Utilities must walk a fine line between selling enough water to obtain revenue and conserving water to provide enough for their customers during shortages. To help utilities in rate and revenue management in both drought and non-drought conditions, the Water Research Foundation published *A Balanced Approach to Water Conservation in Utility Planning* that includes a Drought Response Tool (Chesnutt et al. 2012). *Drought Management in a Changing Climate: Using Cost-Benefit Analysis to Assist Drinking Water Utilities* (Blue et al. 2015) examines the costs and benefits of recommended strategies for dealing with drought. Fu et al. (2013) found that while state drought plans typically address emergency responses well, they are generally weak in establishing strong goals, mitigation and adaptation, public involvement, plan updates, and implementation for longer-term strategies. These authors provide recommendations for drought officials to develop, enhance, or revise drought plans toward a more robust risk management approach. Blanchard (2018) suggests both preparing development moratoria for use in crisis situations and providing guidelines and case studies for how to do so in a way that the moratoria will be upheld as reasonable in case of legal challenges. Runyon (2019) reports on the water crisis in Paonia, Colorado resulting from a combination of leaky infrastructure and drought, and how that town's administrator is focused on creating a digital map of the town's water infrastructure to make their stewardship more water-resilient.

Kenney, Klein, and Clark (2004) examined the approaches of eight water providers during a Colorado drought and found that those with more stringent restrictions had the most savings, with mandatory restrictions achieving 18-56% savings and voluntary restrictions achieving 4-12% savings. Referring to Kenney, Klein, and Clark (2004), Mayer, Lander, and Glenn (2015, 10) state, "the best research on drought restrictions is now 10 years old." Since then, conflicting municipal and homeowner association policies have been found to defeat the effectiveness of city irrigation restrictions (Ozan and Alsharif 2013). Lavee et al. (2013) found that drought surcharges on high-consumption users led to significant reductions in water use, though annual increases on block rate structures did not. In England, Chappells, Medd, and Shove (2011, 713) found that by defining what is "non-essential," an outdoor hosepipe ban "inadvertently declares every other type of water-using behavior to be normal and acceptable" and "argue that the self-conscious switching of attitudes prompted by calls for restraint… is inevitably limited." They recommend paying "more attention to the socially materially embedded nature of everyday life through which the habits and routines of water consumption are reproduced (713)." The above insights are important for designing and implementing general BPs for specific contexts.

Planners may want to account for potential heat waves and increasing average temperatures from climate change in crisis planning. Guhathakurta and Gober (2007) found that an increase in daily low temperatures by 1° F in Phoenix, AZ is associated with a monthly increase in water use of 290 gallons by standard single family units. Analysis by Opalinski, Bhaskar, and Manning (2019) across 229 cities in the U.S. found that in response to a 1°C increase in monthly maximum temperature, municipal water use increased by 3.2% and 3.9% in dry cities in winter and summer, respectively, with smaller changes in wet cities.

Disproportional sharing of burdens from crisis situations may afflict minority communities, and planners should do what they can to mitigate those effects. Wikstrom et al. (2019, 21) caution that "race-and/or ethnicity-based injustice may be so institutionalized that even in a blue-green state like California, and in a state agency that has spent significant resources developing a database and index intended to combat environmental injustice, during emergency-based time pressures environmental injustice may nonetheless result." They argue water consumption levels should not be the sole focus of water decisions. Similarly, disproportional sharing of burdens may occur between industries, such as by placing most of Utah's urban water conservation burden on the residential sector and landscaping profession in *Utah's Regional M&I Water Conservation Goals* (Hansen, Allen, & Luce and Bowen Collins & Associates, Inc. 2019). This burden was increased by excluding formal participation and input from the landscaping industry in preparation and review of this report. Conversely, the California Landscape Stakeholder Advisory Group/Model Water Efficient Landscape Ordinance (MWELO) workgroup was formed in 2017 and formulated nearly 300 recommendations to improve California's MWELO (California Department of Water Resources, n.d.). California's Department of Water Resources is preparing a report summarizing those recommendations as the starting point for the next MWELO revision.

Major resources on this BP are listed in Table 4.

Table 4: Major Resources on Demand Reduction During a Water Crisis

Blue, J., Krop, R. A., Hiremath, N., Gillette, C., Rooke, J., Knutson, C. L., & Smith, K. 2015. *Drought Management in a Changing Climate: Using Cost-Benefit Analyses to Assist Drinking Water Utilities.* Report 4546. Water Research Foundation (USA).
Brown, C., & Maddaus, L. A. 2019. *M60 Drought Preparedness and Response, Second Edition.* Denver, CO: American Water Works Association. ISBN: 9781625763334
California Water Efficiency Partnership. n.d. "Tools and Trainings." https://calwep.org/our-work/conservation/.
Chesnutt, T. W., Fiske, G., Rothstein, E., Pekelney, D., Beecher, J., Mitchell, D., & Holt, D. 2012. *A Balanced Approach to Water Conservation in Utility Planning. United States of America.* Report 4175. Water Research Foundation (USA).
Gay, S. D., & Borman, S. D. 2018. *Emergency Planning for Water and Wastewater Utilities, Fifth Edition.* American Water Works Association (USA).
Metro Mayors Caucus, & Colorado WaterWise Council. 2005. *Best Management Practices for Water Conservation and Stewardship*. Retrieved from Metro Mayors Caucus: https://www.metromayors.org/DocumentCenter/View/15

Best Practice 3: Metering, Conservation-oriented Rates and Connection/Tap Fees, Customer Categorization within Billing System

Accurately metering water consumption, and billing regularly with a rate structure geared towards sending a strong conservation price signal, is fundamental to all water conservation efforts (Colorado WaterWise and Aquacraft, Inc. 2010). The literature contains various examples of rate structuring and connection fees for municipalities to consider in reviewing their current practices.

Metering: The literature suggests that people who pay for their water consumption use less water (Colorado WaterWise and Aquacraft, Inc. 2010). However, Endter-Wada et al. (2013) found that providing consumers with interpreted information about the appropriateness of their metered water use to meet landscape water needs was sufficient to achieve savings, even absent a price signal. Smart meters are encouraged since they provide real-time information and alert users to leaks. Advanced Metering Infrastructure

(AMI) systems are significant investments yet provide payoffs in important data provision, streamlined meter-to-cash operations, and enhanced customer service (Alliance for Water Efficiency, n.d.). Dedicated irrigation meters are separate meters used to measure outdoor water use, and are commonly installed at sites with substantial irrigation demand (Alliance for Water Efficiency, n.d.).

Rates: Various types of pricing systems have been successfully used across the U.S. These systems include water budget-based rates, increasing block rates, and seasonal rates. Theoretically, conservation-oriented rates connect excessive water use to the cost for new supplies, sending a price signal to customers. Practically, rates enable utilities to recover capital costs from high-volume users and maintain revenue stability as conservation reduces general water use (Colorado WaterWise and Aquacraft, Inc. 2010).

Connection/tap fees: "Most utilities will assess a charge [called a tap fee] to cover the cost of connecting the new development to the main water system" (Nuding, Leurig, and Hughes 2015, 9). While traditionally, based upon the size of the connection's water meter, conservation-oriented connection fees are partly based on the anticipated demand at the connection site. This incentivizes developers to install water-conservative fixtures and landscapes to ensure new buildings and customer water use are efficient from the start. To be both reasonable and accurate, connection fees should reflect both annual volumes and peak demand.

Customer categorization within billing system: Determining water use patterns within a service area is critical to effectively structuring rates and designing and directing water conservation programming. Metering is the key in being able to do this.

Colorado WaterWise and Aquacraft, Inc. (2010) provides a good overview of metering, rates, and connection/tap fees with foci on Colorado implications and regulations, while Vickers (2001) uses sample regulations from across the nation. The American Water Works Association has complete manuals for both meters (2012) and water rates, fees, and charges (2017). Both the Water Research Foundation (2011) and Alliance for Water Efficiency (Schlenger, 2019) have extensive guidance resources. Bruek, Williams, Varner, and Tirakian (2018) outline the parallels and differences between AMI systems in the water and electric utility industries, writing for water utilities considering AMI use. CalWEP includes a chapter entitled "Water Shortage Pricing Primer" in their Jumpstart Water Shortage Toolkit available online. California water districts collaborated to produce an online resource guide to assist in the development and implementation of water budget-based rates (Budget Based Rates, n.d.). This website includes case studies such as Coachella Valley Water District's use of "shadow bills," or bills sent three months prior to the new budget-based rate implementation that included both the amount due under the current rate structure and the amount that would have been due under the upcoming budget-based rate structure (Budget Based Rates, n.d.). Blanchard (2018) references meters, rates, and connection/tap fees throughout her guidebook, including various case studies and sample language for incorporation into comprehensive plans. Westminster, Colorado is considered a leader in conservation connection/tap fees. Their connection/tap fee ordinance is included in Colorado WaterWise and Aquacraft, Inc. (2010). *Water Connection Charges: A Tool for Encouraging Water-efficient Growth* (Nuding, Leurig, and Hughes 2015, 4) was the first report of its kind, focusing "on the extent to which water connection charges are encouraging water-saving design in new construction and landscaping before ground is broken."

Secondary water "is untreated 'raw' water, usually sourced from a lake or stream" (Nuding 2018, 2), and is commonly used for irrigation purposes on outdoor landscapes via unmetered water systems throughout Utah and other arid western states (Richards 2009). This arrangement has reduced demand on potable water systems, but water managers have sought ways to curtail the unlimited water use that comes from paying a fixed fee for these traditionally unmetered systems. A 2018 report by Bowen Collins & Associates, Inc. and Allen & Luce Hansen, Inc. found that the Utah Division of Water Resources may be underestimating unmetered secondary irrigation water use by as much as 34% for large water districts. Endter-Wada et al. (2013) reported that pressurized secondary water use decreased by 30% in Utah's Weber Basin Water Conservancy District when secondary meters were added and customers were provided meter data interpretation and customer billing messaging. In 2018, Utah Senator Jacob Anderegg attempted to pass SB 204, which would require water districts to phase in metering for all untreated secondary water provided through pressurized systems. Though the 2018 bill failed, in 2019 Anderegg succeeded in passing a revised bill, SB 52, that requires secondary water providers to 1) install secondary meters on all *new* service connections after April 1, 2020, 2) submit a secondary metering plan to the Division of Water Resources by December 31, 2019, and 3) report annual water use data to the Division of Water Rights. SB 204 accomplishes a few of the recommendations put forth by Nuding (2018), and additional legislation could require installation of meters when water supply lines and other infrastructure need repair or replacement as a precursor to requiring universal secondary metering (Nuding 2018). Of note, in 2009 Richards reported that most information available on secondary water metering was pieced together from utilities and irrigation companies. A decade later, additional research and information on this subject is still relatively scarce, and more resources would be useful for planners and managers. The Secondary Water Metering report put together by the Utah Water Task Force (2019) in response to SB 52 could be a starting point for researchers and policy makers.

Research findings tend to support using price signals for water conservation, with caveats depending on context and implementation. With some exceptions, research usually shows that water price elasticity is small but significant, and authors call for more sophisticated price structures (Arbués, García-Valiñas, and Martínez-Espiñeira 2003; Lavee et al. 2013; Maggioni 2015). Baerenklau, Schwabe, and Dinar (2014) found an 18% reduction in water use over a three-year period from an increasing block rate schedule; though Wichman, Taylor, and Von Haefen (2016) estimate that water prices would have to be increased by an average of more than 50% to achieve the same 13% reduction in water use achieved by prescriptive policies. They report that prescriptive policies, such as restrictions on outdoor water use, resulted in uniform responses across income levels while also achieving reductions from households with irrigation systems and histories of high consumption. Gaudin (2006) found that price elasticity increases by 30% or more when bills include price information, which enables conservation targets to be reached with smaller rate increases. Mitchell and Chesnutt (2013) conducted an independent evaluation of California's East Bay Municipal Utility District's year-long pilot project providing home water reports to 10k homes. They used a normative comparison to learn that receiving home water reports of indoor and outdoor water use resulted in 5% water savings. Nuding, Leurig, and Hughes (2015, 4) surveyed 800 water connection charge structures used by communities in Georgia, North Carolina, Arizona, Colorado, and Utah. Examining single-family home connection charges, they found that few communities are utilizing connection/tap fees to increase water conservation, with the result that within most communities, "no matter the size, location, or outdoor landscaping of the home, every single-family residential unit pays the same amount to be connected to the water system if they use a standard-sized residential meter." The report includes case studies and recommendations for more equitable treatment of water users.

Major resources on this BP are listed in Table 5.

Table 5: Major Resources on Metering, Conservation-oriented Rates and Connection/Tap Fees, Customer Categorization within Billing System

Alliance for Water Efficiency. Metering and Submetering (a suite of resources). *Available at*: https://www.allianceforwaterefficiency.org/resources/metering
American Water Works Association. 2012. *M6 Water Meters — Selection, Installation, Testing, and Maintenance, Fifth Edition*. American Water Works Association. ISBN: 9781583218624
American Water Works Association. 2017. *M1 Principles of Water Rates, Fees and Charges, 7th edition.* American Water Works Association. ISBN: 9781625761910
Blanchard, J. C. N. 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners*. Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Budget Based Rates. n.d. "Water Budget-Based Rates: A Tutorial for Considering a Budget-Based Water Rate Structure." http://budgetbasedrates.com/.
California Water Efficiency Partnership. n.d. "Tools and Trainings." https://calwep.org/our-work/conservation/.
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado*. Retrieved from Denver, CO: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf

Nuding, Amelia. 2018. *Accelerating the Implementation of Secondary Water Metering in Utah*. Prepared by Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/accelerating-the-implementation-of-secondary-water-metering-in-utah/
Nuding, A., Leurig, S., & Hughes, J. 2015. *Water Connection Charges: A Tool for Encouraging Water-efficient Growth*. Prepared by UNC Environmental Finance Center, Western Resource Advocates, and Ceres. *Available at:* https://westernresourceadvocates.org/publications/water-connection-charges-a-tool-for-encouraging-water-efficient-growth/
Schlenger, Donald. 2019. *Advanced Metering Infrastructure: A Guidance Manual for Utilities*. Ridgewood, New Jersey 07450: Don Schlenger & Associates, LLC. *Available at*: https://www.allianceforwaterefficiency.org/resources/topic/advanced-metering-infrastructure-guidance-manual-water-utilities
Schlenger, D. L., Hughes, D. M., & Green, A. 2011. *Advanced Metering Infrastructure—Best Practices for Water Utilities*. Report 4000. The Water Research Foundation.
Vickers, A. 2001. Handbook of Water Use and Conservation. Amherst, Massachusetts: WaterPlow Press. ISBN: 1931579075

Best Practice 4: System Water Loss Control

This is the utility-side practice often offering the most water and cost savings at a system level (Colorado WaterWise and Aquacraft, Inc. 2010). When water loss programs are properly implemented, the cost recovery time is often measured in days, weeks, and months rather than years (Thornton, Sturm, and Kunkel 2008). Vickers (2018) states, “Fix leaks, the most basic and oft-repeated admonition by water utilities to the public, is not always advice that they follow themselves.” Sayers et al. (2016) found that 11 water utilities increased their average real (leakage and other physical) losses from 70 to 83 gallons/connection/day from 2011 to 2015. Vickers (2018) emphasizes the need for ongoing maintenance and repair of aging and leaking water distribution infrastructure, which is a major source of avoidable system losses because water systems often function for about 100 years before seeing total replacement. The AWWA Water Loss Control Committee (2003) states:

> With perhaps hundreds of water utilities billing sales of half or less of the total water they manage, it is essential that industry professionals, regulators, and policymakers begin to place emphasis on sound water accounting and loss control by water suppliers. Water and revenue loss recovery stands among the most promising water resource initiatives in North America. It makes sense to take steps to recover this water and revenue in order to mitigate the effects of drought and water shortages and to do so before developing new water sources and expensive supply infrastructure.

Not only does it make logical sense to recover lost utility water, but it may also become a legal imperative. In the U.S. West, "appropriative rights [to water] extend only to beneficial use, and therefore there is no right to use water wastefully" (Getches, Zellmer, and Amos 2015, 113). Beneficial use is defined by Colorado's 1969 Water Right Determination and Administration Act as "the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made" (Colorado Water Center). "All prior appropriation states consider domestic, municipal, agricultural, and industrial uses to be beneficial…[However], just because a use is among the types listed... does not mean it will be deemed 'beneficial' under the circumstances or for all time. Yesterday's beneficial use may be unreasonable or wasteful, and thus impermissible, today" (Getches, Zellmer, and Amos 2015, 90). Getches, Zellmer, and Amos (2015, 113) further write, "State laws and court decisions interpret 'beneficial use' as requiring that water use be 'reasonable' or 'reasonably efficient.' Standards for reasonableness or efficiency change as the demand for scarce resources grows and conservation technology improves, leading to stricter regulation." The California Water

Resources Control Board substantially changed the Imperial Irrigation District's use of water by requiring major conservation efforts after finding that the district's inefficient delivery and distribution systems were resulting in the loss of hundreds of thousands of acre-feet of water (Getches, Zellmer, and Amos 2015, 114).

The American Water Works Association (AWWA) (2016b) manual *M36 Water Audits and Loss Control Programs* is the industry standard and details the new best practice auditing method developed jointly by the International Water Association and AWWA. The AWWA provides free water audit software to help utilities use this method (AWWA Water Loss Control Committee 2003). In *Best Practice in Water Loss Control: Improved Concepts for 21st Century Water Management*, the AWWA (2015) discourages use of percentage indicators, instead advocating quantified performance indicators to measure progress. One example is for utilities to stop using the term "unaccounted-for water" and instead use "non-revenue water" with its associated performance indicators (e.g., unbilled metered consumption, unbilled unmetered consumption, systematic data handling errors) since "all water entering a distribution system can be defined as a component of either authorized consumption or water loss" (American Water Works Association 2015). The AWWA (2016a) white paper includes guidelines for effective water audit and loss control regulatory programs, case studies of successful programs, and areas where further research is needed.

After Sturm, Gasner, and Andrews (2015) demonstrated the importance of validating data inputs, the manual by Andrews et al. (2016) was published to provide clear methodology on how to validate water audit data. Trachtman et al. (2019) provide a manual complimentary to the AWWA's M36, detailing additional strategies. Fanner et al.

(2007) review proactive leakage management techniques and how to implement them, highlighting work done in the United Kingdom. As water use has become more efficient over the years, utilities have experienced revenue shortfalls. *Defining a Resilient Business Model for Water Utilities* by Hughes et al. (2014) helps utilities address revenue gaps.

The Alliance for Water Efficiency provides a sample non-revenue water policy template for adoption, as well as issuing a report card of state laws pertaining to water efficiency and conservation (2016, 2017). The Natural Resources Defense Council provides model state legislation for utility water loss audits as well as a compilation of what policies have been adopted by different states with links to the associated legal codes (2016, 2018). Western Resource Advocates (2019) provides links to state ordinances such as Georgia's Water Stewardship Act, which requires water providers to implement water loss control programs. The Utah Division of Water Resources (DWR) published *Detecting Leaks in Utah's Municipal Water Systems* (2013) with case studies, recommendations and resources. Among them, the DWR recommends that all municipal water suppliers in Utah, which are required to submit an updated water conservation plan every five years to the DWR, should at that time include a water audit conforming to AWWA standards. Vernal, UT hires a consultant service to survey a quadrant of the city each year for about $5,000 per year, which results in frequent identification of both customer side leaks and utility side leaks (Division of Water Resources 2013). After Salt Lake City, UT conducted an audit conforming to AWWA standards in 2003, the city implemented an active leak detection program with a dedicated full-time employee (Division of Water Resources 2013).

Major resources on this BP are listed in Table 6.

Table 6: Major Resources on System Water Loss Control

Alliance for Water Efficiency. 2016. Managing Water Loss and Recovering Revenue: A Water Loss or Non-Revenue Water Policy Template for Local Adoption. Retrieved from https://www.allianceforwaterefficiency.org/sites/www.allianceforwaterefficiency.org/files/assets/Water-Loss-Policy-Statement_FINAL_2016.pdf
Andrews, L., Gasner, K., Sturm, R., Kunkel, G., Jernigan, W., & Cavanaugh, S. 2016. Level 1 Water Audit Validation: Guidance Manual. Report 4639A. The Water Research Foundation.
American Water Works Association. 2016. *M36 Water Audits and Loss Control Programs, Fourth Edition*. American Water Works Association. ISBN: 9781625761002
AWWA Water Loss Control Committee. 2003. Committee Report: Applying Worldwide BMPs in Water Loss Control. *Journal of the American Water Works Association*, 95(8), 65-79. doi:10.1002/j.1551-8833.2003.tb10430.x
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado*. Retrieved from Denver, CO: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Fanner, P. V., Sturm, R., Thornton, J., Liemberger, R., Davis, S. E., & Hoogerwerf, T. 2007. *Leakage Management Technologies.* The Water Research Foundation.
Hughes, J., Tiger, M., Eskaf, S., Berahzer, S. I., Royster, S., Boyle, C., . . . Noyes, C. 2014. *Defining a Resilient Business Model for Water Utilities.* Report 4366. The Water Research Foundation.
Natural Resources Defense Council. 2016. *Model State Legislation for Utility Water Loss Audits*. Retrieved from: https://www.nrdc.org/sites/default/files/Model-State-Legislation-for-Utility-Water-Loss-Audits.pdf
Natural Resources Defense Council. 2018. *Cutting Our Losses: State Policies to Track and Reduce Leakage from Public Water Systems.* Retrieved from https://www.nrdc.org/resources/cutting-our-losses
Thornton, J., Sturm, R., & Kunkel, G. 2008. *Water Loss Control, Second Edition*. McGraw-Hill Education (USA).
Trachtman, G. B., Cooper, J., Sriboonlue, S., Wyatt, A. S., Davis, S. E., & Kunkel, J., George. 2019. *Guidance on Implementing an Effective Water Loss Plan*. Report 4695. The Water Research Foundation.
Utah Division of Water Resources. 2013. Detecting Leaks in Utah's Municipal Water Systems. In *Utah State Water Plan*. Retrieved from https://water.utah.gov/wp-content/uploads/2019/01/DetectingLeaksInUtah.pdf
Western Resource Advocates. 2019. *Advancing Sustainable Urban Water Management Through State Policy: State Water Policy & Program Database*. Retrieved from https://westernresourceadvocates.org/state-water-policy-program-database/

Best Practices 5: Conservation Coordinator

Every public institution serious about successful implementation and management of water conservation needs someone to lead those efforts. While large water utilities employ full-time conservation coordinators, smaller institutions may designate responsibilities to a staff member with other primary assignments. Conservation coordinators should have equal footing with other planning divisions in the institution (Metro Mayors Caucus and Colorado WaterWise Council 2005). This BP is closely tied to BP 7 below, "Public information and education," as conservation coordinators are likely to lead those efforts.

The professional knowledge, training, skills and experience necessary to be an effective water conservation coordinator have been increasingly recognized and elevated within academic institutions and the water industry. Colorado WaterWise and Aquacraft, Inc. (2010) suggest typical qualifications institutions would want to look for when hiring candidates, some of which are shown in Table 7. Conservation coordinators should be active in professional organizations and meetings focused on water conservation, such as the annual Water Smart Innovations conference, and familiar with large and growing academic and industry literatures on water conservation theory and practice. For instances, information and tools supporting water conservation work has become the primary focus of national organizations such as the Alliance for Water Efficiency and the federal WaterSense Program within the U.S. Environmental Protection Agency. Conservation coordinators need to be able to take lessons and insights gained other places and determine how to best design and apply approaches that will work in their utility given their water context and customer characteristics.

Table 7: Sample of Typical Qualifications Required for a Water Conservation Coordinator from Colorado WaterWise and Aquacraft, Inc. (2010, 76)

Knowledge of:
Principle and practices of public administration, particularly municipal government
Public administrative research methods, techniques, and methods of report presentation
The organization of highly complex resource management programs
Water conservation laws, regulations, practices, and techniques
Environmental planning
Landscape water efficiency practices
Ability to:
Conduct original research and to make sound administrative analyses relating to policy and management problems
Communicate verbally with customers, clients, and the public in face-to-face, one-to-one settings, in group settings and using a telephone
Acceptable experience and training:
A bachelor's degree or associates degree in business or public administration, environmental science, or in any field which specializes in the management of natural resources, or a related field; one to three years of experience in water or resource conservation. Other combinations of experience and education that meet the minimum requirements may be substituted.
Landscape Irrigation Auditor certification; Horticulture, Landscape Architecture or Design, and Turfgrass Management certification or equivalent.

Key resources for urban water conservation coordinators include comprehensive manuals or assessments. Colorado WaterWise and Aquacraft, Inc. (2010) argue Vickers (2001) should be required reading for any conservation coordinator. Green and Maddaus (2010) author *Water Conservation for Small and Medium-Sized Utilities*. Maddaus, Maddaus, and Maddaus (2017) author the AWWA's manual on conservation programs. CalWEP's online Jumpstart Water Shortage Toolkit includes multiple chapters with examples of programs implemented in California that conservation coordinators can use for ideas and resources. Utah's Division of Water Resources (n.d.) has part of their website dedicated toward resources "designed to develop, update and implement your water conservation plan (WCP) and water conservation programs." DeOreo et al. (2016) provide an assessment of water use in the residential sector.

Conservation coordinators can also benefit from resources more focused on specific aspects of urban water use. They could consider the work of Dziegielewski and Kiefer (2010) that defines and describes metrics and case studies, and evaluates methods for estimating indoor and outdoor water use. DeOreo (2011) provides an insight in cautioning that 37% of homes are under-irrigating and would likely increase water use under standard conservation programs such as those promoting weather-based irrigation controllers or improved irrigation scheduling. Campbell, Johnson, and Larson (2004) recommend that programs should be administered one-on-one, which could help address DeOreo's findings. Farag et al. (2011) and Glenn et al. (2015) developed several landscape water assessment and monitoring tools to direct and tailor conservation programs for greater effectiveness.

Rebates and subsidies are popular programs administered by conservation coordinators but require care in their implementation. Though New Mexico rebate program participants reduced water use by 33% (Price, Chermak, and Felardo 2014), Maggioni (2015) found that in Southern California mandates to cut outdoor water uses correlated with decreased per capita water use, but water rates and subsidies for water saving devices did not. Maggioni (2015) recommends that rebate programs utilize only very effective water efficient fixtures. In Nevada, Sovocool, Morgan, and Bennett (2006) report that over a five-year study, cost and conservation benefits of xeriscape over turf were confirmed through a turf replacement program. Reductions immediately followed conversion to xeriscape and were sustained through subsequent years. Xeriscapes greatly lowered peak summer water use, reducing water bills by 50% annually and 70% in the summer. Xeriscape participants reported that those landscapes resulted in average annual reductions of 26.4 hours of labor and $206 in other maintenance costs. The authors model different scenarios for what incentives would be required for average payback times and three- and five-year return on investment (ROI) periods.

Researchers have pointed out that though many conservation programs have been implemented, few have been evaluated to determine their effectiveness (Glenn et al. 2015; Hogue and Pincetl 2015; Rockaway et al. 2011). Kleiman et al. (2000) report that water conservation programs usually measure end-users' success in implementing recommendations, but programs also should be evaluated to ensure they meet participants' needs. White, Milne, and Riedy (2004) recommend demand "backcasting," modeling, and end use measurements as pre-requisites for evaluation of water efficiency programs, but advanced metering infrastructure has since enabled better evaluation. Glenn et al. (2015) developed several assessment and monitoring tools, which were used to implement and evaluate landscape water audits. After conducting a literature review, Mayer, Lander, and Glenn (2014, 24) state:

> Best practices for evaluating and monitoring the impact of outdoor water efficiency programs have yet to be established. Excellent research has been conducted, and data logging with end use analysis appears to be one of the most important and useful techniques, but overall approaches have not been standardized and results are often not comparable.

Maddaus, Maddaus, and Maddaus (2017) address this issue by detailing conservation performance measurement, tracking and reporting in the AWWA's manual on conservation programs. We call on researchers to further develop these tools, and conservation program administrators to use tools such as these to evaluate their programs so that future programs can be planned and implemented incorporating insights learned.

Major resources on this BP are listed in Table 8.

Table 8: Major Resources Available for Water Conservation Coordinators

California Water Efficiency Partnership. n.d. "Tools and Trainings." https://calwep.org/our-work/conservation/.
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado*. Retrieved from Denver, CO: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Green, Deborah, and William Maddaus. 2010. *Water Conservation for Small and Medium-Sized Utilities*. Denver, CO: American Water Works Association.
Maddaus, M. L., Maddaus, W. O., & Maddaus, L. A. 2017. *M52 Water Conservation Programs: A Planning Manual, Second Edition.* American Water Works Association (USA). ISBN: 9781625762139
Utah Division of Water Resources Conservation Program. n.d. "Water Conservation Plans." Utah Division of Water Resources. https://conservewater.utah.gov/wcp.html.
Vickers, A. 2001. *Handbook of Water Use and Conservation*. Amherst, Massachusetts: WaterPlow Press. ISBN: 1931579075

Best Practice 6: Address Water Waste

Conceptually and in principle, recognizing and addressing water waste is fundamental to conserving water. As described in BP 4 on system water loss control, water law in the West is structured around putting water to beneficial use. Managers need mechanisms by which they are allowed to enforce rules against waste. Waste has been addressed by various means such as water waste ordinances, alerting users who apply more water than their landscapes require, and campaigns that encourage reporting neighbors who are wasting water. However, water waste needs to be clearly defined and measured rather than just relying on visual cues and assumptions. Explicit standards can legitimately identify water waste and protect water customers who are using appropriate amounts of water for their specific need and context.

Glenn et al. (2015) employed a Landscape Irrigation Ratio (LIR) to identify residential locations with water use considered inefficient or excessive, and utilized a water audit program to provide those users with information and problem-solving skills to apply appropriate amounts of water. Endter-Wada et al. (2013) partnered with Weber Basin Water Conservancy District to assess metering of water use in pressurized secondary systems, and successfully reduce excessive water use through meter data interpretation and customer billing messaging. The Southern California Association of Governments' Regional Comprehensive Plan addresses water waste by "develop[ing] and implement[ing] tiered water-pricing structures to discourage water waste" (Blanchard 2018, 57). A water budget approach that combines regulation, education, and incentives, such as the Irvine Ranch Water District in California, is another means of reducing waste. Over six years of its early implementation of this approach, the district reported a 45% decline in water use (Kjelgren, Rupp, and Kilgren 2000). As of January 2016, the district reports a 50% reduction in their residential per capita water use since budget based rates were adopted in 1991 (Budget Based Rates, n.d.).

Though municipal codes may contain water waste ordinances, policies should be updated with more details of how waste will be identified and penalties (typically fines) enforced for infractions. Smaller entities may have challenges with sufficient staff resources for enforcement, while other institutions such as special districts may not have the jurisdiction to enact a water waste ban ordinance. Typically, a water utility requests a city council to pass such an ordinance and incorporate it into the municipal code

(Colorado WaterWise and Aquacraft, Inc. 2010). Municipal policymakers may want to include developers and homeowner associations in these discussions to prevent conflicts between institutional policies (Dyckman 2008; Ozan and Alsharif 2013).

Unfortunately, “the published literature on water waste ordinances is virtually non-existent” (Colorado WaterWise and Aquacraft, Inc. 2010, 82). A decade later, a search for the term “water waste ordinance” in an online search engine dedicated to academic literature produced 36 results. However, the chapter “Water Waste Ordinances and Enforcement Primer” in CalWEP’s online Jumpstart Water Shortage Toolkit, has a thorough discussion. This chapter 1) introduces California’s state statutes that mandate water conservation, 2) contains a summary of a survey of water conservation ordinances, 3) summarizes trends observed in recent ordinances and provides additional resources, and 4) includes an appendix detailing language from water conservation ordinances across California. Data gathered from over 200 water waste ordinances were used to formulate the chapter. Water waste ordinances tended to contain a definition of wasteful or non-essential uses, penalties, an enforcement mechanism, and exemptions. Clear trends in their California data indicated that while older statutes define violations in an open-ended manner, more recent enactments tend to define violations in more specific terms. Newer ordinances also tend to list specific examples of potential violations while older ordinances more generally state that wasteful or negligent use is not permitted (California Water Efficiency Partnership). *Utility Operations BMP Implementation Guidebook* authored by the California Urban Water Conservation Council states that, “the implementation of a water waste ordinance, regulation, terms of service, or other means… should take into consideration the difference between new development, existing users, and water shortage measures [used during drought]" (8).

Both Blanchard (2018) and Colorado WaterWise and Aquacraft, Inc. (2010) include several examples of water waste ordinances from municipalities in Colorado, each with varying levels of detail. Blanchard (2018) includes discussion, implementation techniques, and examples of water waste code provisions. Arvada, Colorado has an administrative restriction on water use with code explicitly prohibiting "waste of water" and authorizes the Director of the Utilities Department, in code, to shut off water services to a property when an "extreme waste of water" occurs (Blanchard 2018, 271). Utah communities may have similar codes, but some enforcement has backfired (McGurk 2018). Sisser et al. (2016, 23) caution, "even once an ordinance exists, confusion and lack of awareness exist among homeowners which may reduce the effectiveness of the ordinance. An ordinance alone is not sufficient to achieve water conservation, unless it is backed up by supportive programs (e.g., information sharing, community organizing)." More research is needed to understand how to design and enforce water waste ordinances, especially as experience and literature suggests results can be ineffective, or worse, backfire (Campbell, Johnson, and Larson 2004; McGurk 2018). This research would facilitate answers as to what would constitute effective and reliable means of enforcing water waste ordinances for managers so that enforcement results in equity among water users rather than retaliation against administrators.

Major resources on this BP are listed in Table 9.

Table 9: Major Resources on Addressing Water Waste

Blanchard, J. C. N. 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Budget Based Rates. n.d. "Water Budget-Based Rates: A Tutorial for Considering a Budget-Based Water Rate Structure." http://budgetbasedrates.com/.
California Water Efficiency Partnership. n.d. "Tools and Trainings." https://calwep.org/our-work/conservation/.
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado.* Retrieved from Denver, CO: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf

BP 7: Public Information and Education

Nearly all BPs require some form of public information and education. These "encompass social marketing, school education, public outreach and education, and other information efforts aimed at raising awareness and fostering a culture of conservation and behavior change" (Colorado WaterWise and Aquacraft, Inc. 2010, 87). Public information has been called the "mortar that holds together all other program elements" (Colorado WaterWise and Aquacraft, Inc. 2010, 87). There are many different types of efforts and programs which can be used under different forms of social marketing. Lee and Kotler (2011, 7) write that "social marketing is about (a) influencing behaviors, (b) utilizing a systematic planning process that applies marketing principles and techniques, (c) focusing on priority target audience segments, and (d) delivering a positive benefit for society."

Institutions of various sizes and budgets have implemented water conservation public information and education programs throughout the world. Manuals regarding how to facilitate sustainable behavior change are readily available (Colorado WaterWise and Aquacraft, Inc. 2010; Lee and Kotler 2011; McKenzie-Mohr 2011; Silva et al. 2010; Vickers 2001). An institution's conservation coordinator is likely to lead the public information and education efforts, and should follow the recommendations listed in that BP section to incorporate program analysis to evaluate effort effectiveness. Maddaus, Maddaus, and Maddaus (2017) include a chapter on stakeholder involvement relevant to this BP.

Although "save-water campaigns are the most common tools for promoting household water conservation," the academic literature on public information and education campaigns debates their effectiveness (Syme, Nancarrow, and Seligman 2000, 539). A meta-analysis of research reported water savings from conservation education programs from 2-12% (Inman and Jeffrey 2006). Hostetler et al. (2008) found after two years of exposure to an environmental education program, homeowners did improve some in knowledge, attitudes, and behavior, while the control group did not change. Yet Fielding et al. (2013) report that although all interventions in an Australian study led to significant savings in water use, after about 12 months, consumption returned to pre-intervention levels in all cases. "Evaluations…have been grossly underused in relation to information campaigns. Often, no information on how to improve media campaigns is acquired" (Syme, Nancarrow, and Seligman 2000, 573). Glenn et al. (2015) discuss methodological issues involved in both assessing water conservation behavior and refining approaches for program delivery. We call on program designers, and implementers and researchers, to more thoroughly analyze programs and results so effectiveness of these strategies can be improved.

Though calls for well-designed information campaigns to correct misperceptions among water users may be warranted (Attari 2014), messaging has been found to negatively affect attitudes toward conservation, and researchers have begun to find interesting patterns of combinatorial program effects that should be considered when designing programs (Liang, Henderson, and Kee 2017). The specific context in which these information campaigns are launched should also be considered. Bremer, Keeley, and Jager (2015) argue educational efforts to improve landscape irrigation use should focus on homeowners in more expensive and/or newer homes since that demographic waters more frequently and routinely. Yet Kilgren et al. (2010) make the case for situational problem solving, reporting that the type of irrigation system installed on public school properties overshadowed the impact of multiple interventions directing custodians to conserve water. We note further that desired voluntary conservation efforts depend both on the need and on meeting the motivations of target users. Aisbett and Steinhauser (2014) suggest that as the need for water conservation increases, and the public value of savings is greatest, voluntary conservation increases substantially.

Major resources on this BP are listed in Table 10.

Table 10: Major Resources on Public Information and Education

Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado*. Retrieved from Denver, CO: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Lee, N., & Kotler, P. 2011. Social marketing: influencing behaviors for good. SAGE Publications, Inc. (USA)
Maddaus, Michelle L., William O. Maddaus, and Lisa A. Maddaus. 2017. *Water conservation programs: a planning manual*. Second ed, *AWWA manual; M52*. United States of America: American Water Works Association.

McKenzie-Mohr, D. 2011. *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing, Third Edition.*). Canada: New Society Publishers.
Silva, T., Pape, D., Szoc, R., & Mayer, P. 2010. *Water Conservation: Customer Behavior and Effective Communications*. Report 4012. The Water Research Foundation.
Vickers, A. 2001. *Handbook of Water Use and Conservation.* Amherst, Massachusetts: WaterPlow Press. ISBN: 1931579075

POLICY DESIGN OF BEST PRACTICES

Policy Design Theory

The policy design theory of Schneider and Ingram (1997) focuses on how policies are designed and implemented. The authors emphasize the need to understand the societal and issue contexts within which policies arise, and the ways they are framed and conveyed to citizens. Schneider and Ingram explain how public policies have underlying patterns and logic. The ideas embedded in policies have real consequences as citizens experience them through the translation dynamics of messages, lessons, interpretations, conceptions of government and the role of citizens, and through participation patterns that occur during implementation. Schneider and Ingram further emphasize the iterative and dynamic process of framing, designing, and translating policies over time (Figure 2).

For reasons carefully examined in Schneider and Ingram's work, administrators and managers need to be judicious in choosing, designing, and implementing best practices. Recognition of the fact that policies evolve and help to shape future societal and issue contexts means administrators and managers must also understand that policies will require flexibility and adaptability over time. Consequently, research, documentation, and evaluation of the effectiveness of urban water conservation policies and programs is an important part of implementation.

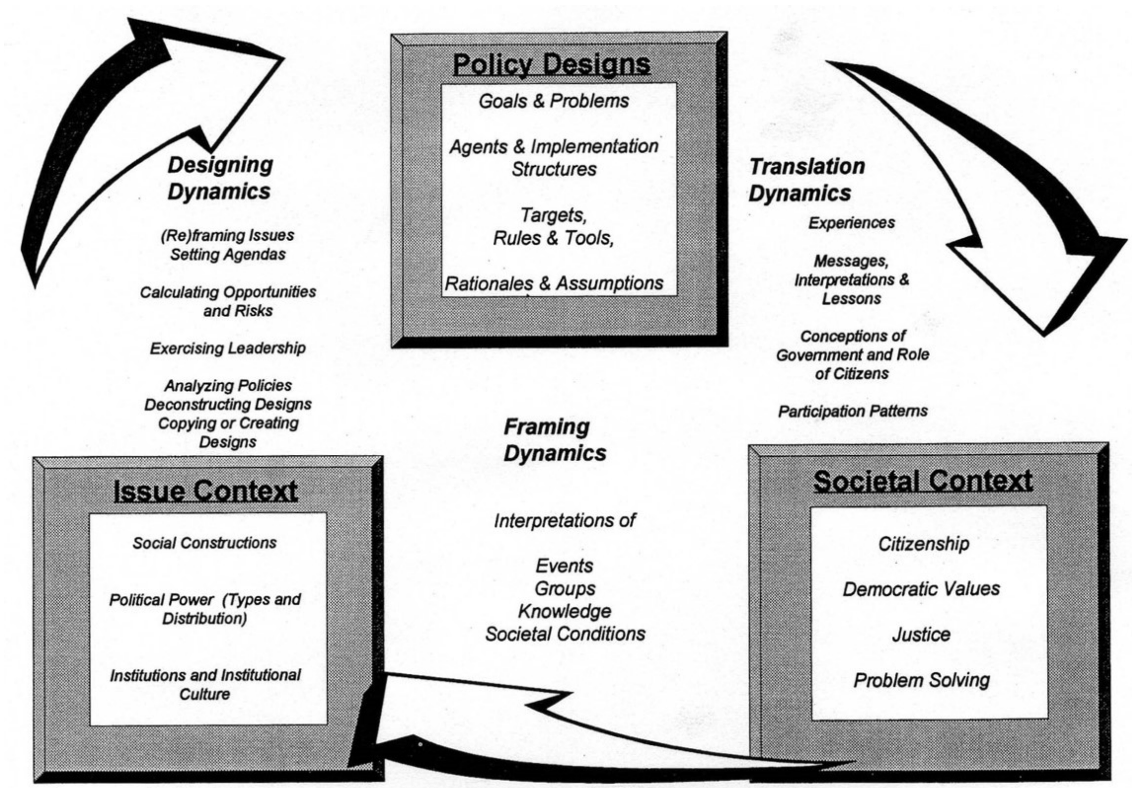

Figure 2: Reproduction of Figure 4.1 from Schneider and Ingram (1997, 74) showing causal portrayal of how characteristics of the policy context become embedded in policy designs and subsequently have effects on democratic values that reproduce or transform the context.

For our purposes here, we focus on the top box in Figure 2, which specifies several key elements of policy designs. Schneider and Ingram (1997) contend that policy designs contain elements that should be accounted for, such as: target populations (who receives benefits and burdens), goals or problems to be solved (values to be distributed), agents and implementation structures, rules (that guide or constrain action), rationales (that explain or legitimize the policy), and assumptions (the logical connections that tie the other elements together).

Policy Design Elements for Urban Water Conservation BPs

In Table 11, we summarize the policy design elements listed above for each of the urban water conservation BPs that were covered in the preceding section. This analysis illustrates the considerations that need to go into designing effective BPs. Since policy designs must fit the contexts in which they will be implemented, more detailed analysis and debate would be needed to shape the specific design features for each location and for specific strategies. For example, a municipality such as Eagle Mountain City (EMC), Utah, would define their policy design elements more specifically, tailoring their strategies to meet their specific context. As noted in the guidebooks and literature we reviewed, communities generally need a suite of BPs to have an effective approach to conservation. Table 11 also illustrates why that is so; individual BPs may target different groups or address different problems, while a suite of BPs provides for a more equitable, community-based approach to conservation.

In Table 12, we take Table 11 a step further by defining one possible strategy (out of many) EMC could implement to address each of the seven BPs covered in this chapter. Some strategies or steps are more reasonable for EMC, at this time, than others. For example, in 2018 EMC approved a new *Eagle Mountain General Plan* (their comprehensive planning document), in a process that occurs about once a decade. While it would not make sense to focus on revising that document now, another effective strategy to address *BP1: Integrated Land and Water Planning* would be to form a Water and Land Use Planning Integration Team and conduct internal assessments as outlined by Blanchard (2018). This would provide the collaboration and input between the two departments that was missing from the process of revising EMC's *General Plan*. We obtained information about local water districts relevant to that BP from an older EMC impact fee analysis (Lewis Young Robertson & Burningham, Inc., 2012). For *BP2: Demand reduction during a water crisis*, EMC has the option of creating a stand-alone Drought Response Plan, or updating their current Emergency Operations Plan (Eagle Mountain City 2008) to explicitly address drought response. For *BP 3: Metering, conservation-oriented rates & connection/tap fees, customer categorization*, we have highlighted conservation-oriented tap fees since EMC is already reviewing a consultant's report on recommended water rates. Eagle Mountain City staff have told us the city does not have the resources to hire a full-time conservation coordinator, so for *BP 5: Conservation coordinator* we recommend giving the job responsibilities and role of conservation coordinator to an existing staff member, until such time as EMC can afford (and the situation warrants) a dedicated staff member for that role. As for *BP7: Public information and education*, EMC staff already have active communication channels with their residents, including a regular electronic newsletter. Since EMC has a high rate of internal growth and development, we recommend focusing on the creation and dissemination of educational materials to new homeowners so that they are more likely to adopt desirable social norms supporting water conservation in their homes.

Table 11: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP1: Integrated Land and Water Planning	- Developers will bear some burden of operating within the confines of municipal regulations. - Occupants in new developments will benefit from water efficient designs. - Constituents will benefit from long-term water supply reliability.	- Goal is to guide development in arid regions to be more water efficient and to ensure sufficient long-term water supplies. - Problem is managing land use change, especially in rapid-growth areas, to avoid water shortages.	- Local planners integrate water efficiency strategies and methods into municipal plans and regulations.	- Local planners must act within boundaries of state and federal law. - Case studies of municipal innovation and guidelines toward effective policies are available to embolden municipal leaders and strengthen their case.	- Collaboration between land and water planners reduces the risk of municipalities running out of water.	- Leaders will encourage and enable land and water planners to collaborate and give them the resources to do so. - Planners have sound data and analysis on which to base decisions.
BP2: Demand reduction during a water crisis	- Outdoor water use by end users tends to bear the brunt of crisis reductions since indoor water uses meet more essential human needs.	- Goal is to not run out of water in order to furnish essential functions even when supplies are low. - Problem is dealing with drought and unforeseen crises.	- Local planners or utility managers can call for voluntary cutbacks or mandate reductions.	- Justifications to employ various strategies are found using case studies or may be within the scope of government plans.	- Having a plan in place sets expectations and eases the burden on utility employees and customers in the midst of crises.	- Administrative leaders will encourage best practices and/or enforce a plan. - They will provide for implementation funding and other resources.

Table 11: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP3: Metering, Conservation-oriented rates and connection/tap fees, customer categorization within billing system	- Meters and rates target all metered end users and allow for water use analysis and comparisons. - Connection/tap fees incentivize developers to install water-efficient infrastructure.	- Goal is to incentivize lowering long-term water consumption. - Problem is to determine how to best design and direct water conservation programs.	- Utility or municipal administrators or state policy makers via codes or ordinances.	- May be required by state laws or fit under the umbrella of municipal comprehensive plans.	- Users consume less water when it is metered and they receive information on how much they use and/or how much they pay for water. - Connection/tap fees encourage better and more equitable utility planning	- Meter readings are accurate and staff have the necessary resources to read and bill correctly. - Connection/tap fees are fairly and consistently implemented.
BP4: System water loss control	- Holds the water provider responsible for addressing utility-side leaks and aging water infrastructure inefficiencies.	- Goal is to reduce or eliminate utility-side water loss - Problem is that losses occur in storage and conveyance from supply sources to end use locations.	- Utilities via recommended audit methodologies and techniques.	- States may require action or municipalities may decide to do so on their own for better water and financial management (e.g., return on investment or ROI).	- Often offers the most water and cost savings at a system level from the utility-side.	- Utilities are invested in recovering lost water and revenue.

Table 11: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP5: Conservation Coordinator	- All urban water users through programs appropriately designed for different sectors.	- Goal is to have dedicated conservation staff – Problem is the need to have a point person to design, direct and implement water conservation programs	- A coordinator is hired full time or a current staffer is given the additional role of conservation coordinator.	- Usually a decision on the part of an institution. - Coordinator must help the city to act within municipal and state policies.	- Institutions need someone to lead water conservation efforts, connect professionally in the field, and do research and evaluation.	- Leaders have confidence in demand management as a strategy. - Institutions are willing to fund a conservation coordinator to realize end-user water savings.
BP6: Address water waste	- All urban end-users of water (residential, commercial, industrial, institutional).	- Goal is to reduce and eliminate end-user water waste – Problem is the existence of short- and long-term water inefficiencies.	- Water providers implement programs or policies to identify and control waste. –Municipalities can enact ordinances, while local districts can promulgate regulations.	- Programs are generally under purview of a comprehensive plan. - Ordinances generally specify enforcement mechanisms, which identify the people who have the authority to enforce the ordinance or the process for prosecuting violators, or both.	- Under prior appropriation water law, water must be put to beneficial use but without waste.	- Administrators have means and initiative to identify users with capacity to conserve and strategies to facilitate reduction in water use.

Table 11: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP7: Public information and education	- All urban end-users of water (residential, commercial, industrial, institutional).	- Goal is to influence water user behavior - Problem is finding ways to make water use more efficient and conserving.	- Utility or municipal staff implement voluntary and non-regulatory programs.	- Programs should operate within municipal comprehensive plans.	- Voluntary behavior change is often seen as preferential to mandated change.	- Utilities have the time and financial resources necessary to invest in methods such as social marketing.

Table 12: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation in Eagle Mountain City (EMC), Utah

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP1: Integrated Land and Water Planning EMC: Create a Water and Land Use Planning Integration Team (Blanchard 2018)	- Land use and water planners from EMC. - Representatives from the Central Utah Water Conservancy District, White Hills Water Company, and Cedar Valley Water Company could be included at appropriate times (Lewis Young Robertson & Burningham, Inc., 2012). - Local and regional stakeholders must participate or be briefed periodically.	- Goal is to guide EMC development to be more water efficient and to ensure sufficient long-term water supplies. - This first step enables EMC to "understand where it is in order to determine where it needs to go" (Blanchard 2018, 35). - Problem is water-efficient growth in a rapidly growing Utah desert community.	- EMC planners integrate water efficiency strategies and methods into municipal plans and regulations. - Specifically, EMC planners can work through the self-assessment questions provided by Blanchard (2018), and utilize the author's matrix of implementation techniques.	- EMC planners must act within boundaries of state and federal law related to land and water use.	- EMC recently completed a new comprehensive plan, yet city water managers were not involved in the process. - Collaboration between land and water planners helps EMC grow in a water-efficient way and reduces the risk of running out of water and/or having to acquire expensive new supplies.	- EMC leaders will encourage and enable land and water planners to collaborate and give them the resources to do so. - EMC planners have sound data and analysis on which to base decisions. - To ensure proper implementation of new plans, regulations, and processes, EMC staff must be regularly trained.

Table 12: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP2: Demand reduction during a water crisis EMC: Create a Drought Response Plan or update current EMC Emergency Operations Plan to explicitly address drought response (Eagle Mountain City 2008).	- EMC planners and staff will be responsible for plan preparation. -EMC city council and mayor will be responsible for city adoption. - EMC determines how to fairly manage shortages across sectors during a water crisis, maintain indoor water uses that serve more essential human needs, and prioritize cut-backs.	- Goal: EMC must not run out of water in order to furnish essential human needs and maintain its economy even when supplies are low. - Problem: How best to prepare measures for both risk-mitigation and reaction during drought to avoid potential conflicts within EMC.	- EMC leaders should adopt the plan enabling local planners and/or utility managers to call for voluntary cutbacks or to mandate reductions under various conditions.	- Justifications to employ various strategies are found using case studies or may be with the scope of government plans. - The plan may define (generally or specifically) indicators or thresholds that would initiate various elements of plan strategies.	- Having a plan in place sets community expectations and eases the burden on EMC utility employees and customers in the midst of crises. - EMC's current Emergency Operations Plan mentions drought as a possible natural hazard, yet does not define any actions for that specific situation.	- EMC public and administrative leaders will encourage best practices and/or enforce a plan. - They will provide for implementation funding and other resources. - Public involvement in developing the plan and regular communication of the plan between municipal leaders and water users could help prevent or mitigate anger or vindictive behavior in response to usage restrictions during shortages.

Table 12: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP3: Metering, Conservation-oriented rates and connection/tap fees, customer categorization within billing system EMC: - Analyze water use to promote conservation. - Incorporate conservation-oriented tap fees into building code	- Metering and rate structures can provide conservation-relevant information to all end users of water. - Conservation-oriented tap fees in EMC incentivize developers to install water-efficient infrastructure.	- Goal: Incentivize long-term lower EMC water consumption. - Problem: EMC is a new community facing rapid growth in a water-limited state.	- EMC staff prepare documents for incorporation into city code which is then adopted by city council and mayor.	- Fits under the umbrella of EMC's general plan.	- Installation of water-efficient infrastructure at the front end of EMC development facilitates long-term water savings. - More equitable administration of tap fees as water users putting less strain on the system pay less to be connected than higher water users.	- EMC staff have the support and resources they need to prepare information for incorporation into city code, and city leaders support incorporation.
BP4: System water loss control EMC: Conduct an AWWA standard audit on EMC water utility system	- EMC water utility addresses utility-side leaks and aging water infrastructure inefficiencies.	- Goal: EMC reduces or eliminates utility-side water loss - Problem: water loss occurs in storage and conveyance systems.	- EMC water utility implements response via suggested audit methods and techniques.	- EMC conducts the audit according to AWWA standards.	- Often offers the most water and cost savings at a system level from the utility-side. - Demonstrates to EMC water users that EMC is willing to hold their water system accountable.	- EMC invests in recovering lost water and revenue. - EMC is willing and able to allocate necessary resources for the audit and follow-up.

Table 12: Policy Design Elements Related to This Chapter's Seven Common BPs for Urban Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP5: Conservation Coordinator EMC: assign a staff member the duties of the city conservation coordinator until resources and circumstances allow for a full-time dedicated employee.	- Water users of EMC's water utility system through programs appropriately designed for different sectors.	- Goal: Have a dedicated EMC conservation staff person - Problem: need to have staff to design, direct, and implement water conservation programs within EMC.	- A current EMC staff member is given the additional role of conservation coordinator, with those responsibilities recognized in their job description.	- EMC administrators authorize the additional job responsibilities. - Coordinator must act within EMC and state policies.	- EMC needs someone to lead water conservation efforts, connect professionally in the field, do research and evaluation.	- EMC leaders have confidence in demand management as a strategy. - EMC leaders are willing and able to allocate funding, support, and other resources so the conservation coordinator can fulfill their responsibilities.
BP6: Address Water Waste EMC: identify water users with capacity to conserve and provides water audits to facilitate appropriate water use.	- Water users with the capacity to conserve in various sectors (residential, commercial, industrial, institutional).	- Goal is to reduce or eliminate EMC end-user water waste – Problem is the existence of short- and long-term water inefficiencies.	- EMC staff partner with USU CWEL and USU Extension for identification via WaterMAPS ™ and audits via Water Checks	- Programs and initiatives addressing water waste generally fall under the purview of EMC's comprehensive plan.	- Under prior appropriation water law, water must be put to beneficial use but without waste. - Enables EMC to address waste without water waste ordinances.	- EMC staff have the support and resources they need to invest in collaboration to address water resources. - Collaborators have the support and resources they need to maintain commitments.

Table 12: Policy Design Elements Related to this Chapter's Seven Common BPs for Urban Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP7: Public information and education EMC: dedicate resources towards developing and disseminating conservation materials and programs to locations identified in water use analyses.	- All water users in EMC (residential and CII) - Place special emphasis on new residents, many of whom are new homeowners, as they join EMC's water system.	- Goal: Equitable water savings within EMC - Problem: How to influence new water user behavior to be more water efficient and conserving before they adopt opposing social norms.	- EMC municipal or utility staff providing non-coercive and voluntary information.	- Materials and programs should support the goals in EMC's comprehensive plan.	- Voluntary behavior change is often seen as preferential to mandated change. - This approach provides an opportunity to instill desirable social norms and provide key information when and where it is needed.	- EMC leaders are willing and able to allocate funding, support, and other resources to invest in this conservation programming.

Ethical Duties to Water and to Each Other

We close this section on Policy Design of BPs with discussion of the overarching ethical considerations that need to be included in all urban water conservation BP formulation. Schneider and Ingram (1997) pay attention to how policies are designed out of their shared conviction that the content of public policy plays a vitally important role in a democratic society (ix). They recognize that “policy must serve multiple goals of solving problems, reflecting interests, being accountable, serving justice and engaging and enlightening citizens” (xi). Ethical contexts surrounding urban water conservation efforts include who bears the burdens and who receives the benefits of those efforts, and what ethical obligations we have to water itself and to each other in our use of it. Implementation of water conservation efforts should seek to make reductions in a just and equitable manner.

The Environmental Protection Agency (EPA) defines “environmental justice” (EJ) as “the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies” (2015, 4). Much of the EJ literature has focused on the disproportionate distribution of environmental harms and risks, but the EPA further defines “fair treatment” as “no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, *governmental* and commercial *operations of programs and policies”* (2015, 4; emphasis added). Renwick and Archibald (1998) found that lower income households in two California communities were more than five times as responsive to higher water prices than wealthier household groups, bearing a larger proportion of the urban water conservation burden during a drought. Wikstrom et al. (2019) argue that environmental and distributive injustice occurs when "racial and ethnic minority communities end up with disproportionately lower water allowances than majority communities" (12). These scholars found that mandatory water cutbacks applied in California to achieve a statewide 25% reduction in residential water use had "disproportionate negative consequences for Hispanic (and Other) populations even holding constant other factors such as income," notwithstanding the "significant resources [spent on] developing a database and index intended to combat environmental injustice" (21).

As to one reason why such environmental and distributive injustice occurs, Wikstrom et al. (2019) argue that their findings "provide additional empirical support of Pulido's (1996) point that environmentally unjust outcomes may result from ingrained institutional factors rather than explicit acts of discrimination" (21). Ostrom and colleagues have demonstrated that, particularly in the distribution and use of water, institutional design matters (Ostrom, Schlager, and Cox 2017; Ostrom 1990). "Minority burdens are so institutionalized that even well-meaning [and well-equipped] organizations operating in haste may lead to [disproportionate burdens on minority communities]" (Wikstrom et al. 2019, 21). Even having policies in place to reduce environmental injustice does not prevent it (Konisky 2015; Wikstrom et al. 2019).

To effectively evaluate conservation strategies while meeting equity objectives, Renwick and Archibald (1998) suggest that policymakers need to have some sense of the characteristics of the households in their service area. This will enable them to assess distributional implications of the strategies by determining the feasible set of policy instruments, knowing the extent to which specific policy instruments are expected to reduce aggregate demand, and understanding how different households are expected to reduce their demand in response to specific policy instruments. Wikstrom et al. (2019) believe tools such as the CalEnviroScreen database and index, developed to help combat environmental injustice, could be helpful when used to their full potential, and for further research, ask if there are institutional structures that can be changed to improve results. Further, before enactment of California's water restrictions, the State Water Resources Control Board (SWRCB) argued that using Residential Gallons Per Capita Day (R-GPCD) "is not appropriate… water use data for comparisons across water suppliers, unless all relevant factors are accounted for" (Cal EPA Water Board, 2015). The relevant factors affecting per capita water use they discuss are rainfall, temperature and evaporation rates, population growth, population density, socio-economic measures such as lot size and income, and water prices.

Each of our recommended BPs have aspects or strategies which should be addressed to further environmental justice. Strategies from all six BPs could be undertaken with seeking input from representatives of minority groups present in the area; in Utah, planners and managers can consult resources such as the Kem C. Gardner Policy Institute at the University of Utah for demographic decision support. Mandated water restrictions are a common strategy utilized during demand reductions in a water crisis. As discussed by Wikstrom et al. (2019), and as cited in Campbell, Johnson, & Larson (2004), poorer residents are less able to compensate for water cutbacks, and the highest water users in Wikstrom et al. (2019) still had between 150% and 430% of average gallons of water use per day *after* cutbacks, while those with the smallest cuts were left with only “somewhat more water than the average American person uses at home for the basics of flushing and body cleansing” (Wikstrom et al. 2019, 10). Poor communities’ housing and older housing stock will require more infrastructure replacement when addressing system water loss, mainly because of more inefficient plumbing, and less wealthy communities are unable to replace inefficient plumbing (Babcock, personal communication, cited in Campbell et al., 2004; Cal EPA Water Board, 2015; Wikstrom et al. 2019). Additionally, we’ve noted before that disproportional sharing of burdens may occur between industries, such as with the landscaping professionals’ exclusion of input in *Utah’s Regional M&I Water Conservation Goals* (while placing most of the water conservation burden on that profession) (Hansen, Allen & Luce, Inc. and Bowen Collins & Associates, Inc., 2019). Affected industries and stakeholders should be consulted in preparing BP strategies.

Finally, governmental leaders and policy makers have the opportunity to consider various ethical duties to water as they implement conservation policies and programs. The concept “duty of water” has been in use since the late 18th century and is currently defined as “the amount of water reasonably required to irrigate a substantial crop with careful management and without waste on a given tract of land” (Wescoat Jr. 2013b, 4759). The concept of duty of water has been changed over time according to socio-economic values associated with irrigation. Since its operational usage has been replaced by other means of water use efficiency, Wescoat Jr. (2013b, 4763) suggests that there are new opportunities to “reconstruct the duty of water” from water use standards to ethical duties.

The field of water ethics has expanded during a time more concerned about "duties *to* water and *to* vulnerable social groups than with the duty *of* water" (Wescoat Jr. 2013b, 4763). Asking "what happens if we shift from an emphasis on water rights to water duties, both with respect to property and more broadly with respect to human and non-human rights to water," Wescoat Jr. (2013b, 4763-4764) anticipates various emergent ethical duties and explores the "rights that have or have not been associated with them." The *duty of intensification* is central to conservation ethics in that there is much potential for additional advances in water use efficiency and productivity. These advances must anticipate setbacks, such as the Jevons Paradox. Developed by William Stanley Jevons, the concept has since been used to explore how the conservation of resources can be at risk for either *rebound* effects, when part of the conserved savings is negated, or *backfire*, actually resulting in counterproductive effects (Alcott 2005, Font Vivanco, Kemp, and van der Voet 2016; Grafton et al. 2018; Sorrell 2007; Ward and Pulido-Velazquez 2008). For instance, managers and planners should take care that conserved water from utilized BPs is directed towards less aggregate rather than greater aggregate water use (Wescoat Jr. 2013a). Manifestations of the need for the *duty of equitable access, allocation, and use* are seen in recent fights for equity based off deprivation by gender, race, class, caste, indigeneity, and location (Wescoat, Jr. 2013b; Baviskar 2007), such as court battles for paper water rights being transformed into actual wet water (The Ute Indian Tribe Political Action Committee 2018). These norms build off prior water duties rather than rejecting them, though one exception is the *Audubon Society v. Superior Court of Alpine County* 1983 court case in which public trust duties eclipsed private water rights (Wescoat Jr. 2013b). The *duty to ensure safe water and* *sanitation* has been evoked successfully in the sphere of water utilities that present the provision of high-quality, low-cost water without discrimination as a public duty. Wescoat Jr. posits that movements to establish human rights to safe water and sanitation might gain greater momentum if framed as a key part of social duties, following the lead of water utilities.

Duties to non-human beings have a mixed record of progress in theory and practice. Most societies include water provision for domesticated animals and access for specific species in humane treatment of animals, though this is considered a social duty and not an animal right to water. Instream flows have gained some legal momentum with limited implementation in Utah, and this duty could provide backing towards further expansion (Utah Water Strategy Advisory Team 2017). Wescoat Jr. (2013a) also explores the ethics of considering plant water needs, with implications for irrigated landscapes. The *duty to start watering* is a reclamation ethic used by irrigators around the world who cite the moral and functional imperatives they have to feed and clothe the world. The *duty to reduce watering* is a conservation ethic with original roots in prohibiting over-appropriation and waste, but has been unevenly utilized throughout law, policy, and practice. However, water competition has spurred progress in irrigation efficiencies, and these are heralded as being socially responsible. Wescoat Jr. (2013a, 10) states that “this is the most established moral philosophy in water resources planning.” When this duty is insufficient, the *duty to stop watering* as an ecological ethic is utilized as greater water scarcity and environmental impacts have resulted in land being taken out of irrigation. The *duty to continue watering* is a planting ethic. Wescoat asks if, just as there are strong moral and legal obligations to provide water for humans and animals in confinement, is there a similar duty to irrigate water-dependent, human-established plantings? He states, "there is no one overriding duty with respect to water, plant and human needs, but rather, a need to coordinate them in inspired, efficient, and equitable ways" (11).

Finally, Wescoat Jr. (2013b) states that "understanding emergent water norms involves close attention to the linkages among measurement, standards, values, and justifications" (4766). Understanding our ethical obligations in water use and administration will enable leaders and policy-makers to have theoretical foundations for the BPs they implement in their jurisdictions.

CONCLUSION

Adapting language by Kjelgren, Rupp, and Kilgren (2000, 1040), "Successfully conserving water on a short- or long-term basis…means changing the behavior of large numbers of people while … meet[ing] their expectations." This challenge requires consideration and/or implementation of all available and appropriate tools in the urban planners' and water managers' toolboxes. This review has sought to combine relevant and helpful information to guide those efforts and help public officials and managers consider why and how they might choose and implement different BPs for urban water conservation.

One key conclusion from our review is that, just as national indoor efficiency standards and regulations have resulted in long-term water savings across the nation in both water-rich and water-poor areas, new policies and regulations have the potential to reduce outdoor water use across multiple sectors. Though voluntary conservation is valuable, campaigns to achieve those efforts can be costly with undetermined results. As such, prescriptive policies have demonstrated more consistency with higher savings, and water managers must seriously consider these policies key to their efforts.

While these BPs have been implemented in many locations across the U.S., lack of thorough data and program evaluation have prevented consistent replication and improvement. Consequently, program administrators should encourage data acquisition, program analysis, and evaluation to enable improvements and replication. Progress in advanced metering infrastructure is vital to facilitating those efforts. Program administrators should also carefully document how their particular policies were designed and implemented—who were the target populations, what were the goals or problems to be solved, what agents or structures were involved in their implementation, what rules were used to guide or constrain action, and what were the rationales and assumptions behind the policies? Such information is vital for understanding why BPs meet with varying success in different locations and how BP modifications and adaptations can occur to make their designs and implementation more effective in specific local contexts in the future. Such information will help meet the need for policies that are well constructed, appropriately contextualized, and suitably flexible to deal with the long-term issues of growing water scarcity that will require changes over time. Thus, we support other researchers in calling for more data and program analysis, but add the need for attention to the specific design of BPs and their implementation in particular and varying contexts for better evaluation of implementation.

Another conclusion is that research is limited in some areas of prescriptive policies (e.g., water waste ordinances). Efforts should be undertaken to fill those gaps so policy makers and administrators feel empowered to appropriately employ and adapt those tools.

Finally, policy approaches to urban water conservation must be grounded and guided by our ethical duties – to water, to each other, and to other life that also depends on it. We would do well to keep this powerful yet simple principle at the center of the often detailed and technical deliberations that we engage in when designing public policies to distribute, use, and conserve Earth's limited freshwater resources.

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CHAPTER III

EVALUATION OF BEST PRACTICES FOR URBAN WATER-SMART GROWTH[2]

ABSTRACT

Municipalities in the arid West are grappling with managing urban water demand and rapid development of agricultural or open lands into urban areas. Best practices (BPs) for urban water conservation have been recommended over the years, with more available case studies demonstrating the long-term feasibility of municipal policy and program implementation. We review selected BPs recommended from literature including practical resources and academic publications that deal with affecting water use via planning and infrastructure. Without proper policy and regulations, unregulated and rapid development can lead to increased costs and water use and risks to homebuyers. Regulation of development may achieve long-term reductions in outdoor water use equivalent to the successful reductions in indoor water use from national appliance and fixture standards. We recommend water managers and municipal planners involve stakeholders in the planning and policy processes to implement BPs to achieve long-term conservation from infrastructural and behavioral change. Policies and program implementation will require adaptation over time as contexts change. However, we believe the required investments will help planners to direct urban development toward

[2] This chapter is co-authored with Dr. Joanna Endter-Wada

water-smart growth patterns and facilitate achievement of municipal water efficiency and conservation goals.

INTRODUCTION

Though many urban areas in the western United States (U.S.) were established in arid climates near consistent freshwater river supplies or shallow groundwater aquifers, urban and suburban populations have expanded into more water-scarce environments (Hilaire et al. 2008; Redman 1999). This expansion was made possible via investments in water infrastructure financed by federal and state funding. Urban expansion has accelerated today, as western states deal with the highest current and projected population growth rates in the country (Fleck 2016).

Urban expansion and associated water demand in the U.S. West have been directed by a long history of policies, laws, and regulations at multiple governmental levels. Land and water policy were tied together at the national level beginning in the 1800s as the federal government promoted populating and developing arid and semiarid lands in its western territories through policy actions such as passage of the Desert Land Act in 1877 (Harvey 1991). Laws directing how water was to be used and allocated were established and relegated to the states, resulting in prior appropriation law in the U.S. West that gave people who invested in water development some certainty as to their continuing rights to use water. Governing and regulatory authorities have adopted and refined land and water development directives as they have adapted to new information and evolving contexts. These long-term efforts have transformed the water-scarce U.S. West into the fastest growing region of the country today, and resulted in current policy challenges to direct and curb land and water resource consumption.

In recent decades, various directives have resulted in some significant successes for growth and water use management. The U.S. Energy Policy Act of 1992 (EPAct 1992) "set minimum efficiency standards for all toilets, showers, urinals and faucets manufactured in the United States after 1994" (National Conference of State Legislatures 2015). Those efficiency standards are credited as a leading factor reducing indoor water use across the nation, in both water-rich and water-poor locations, even in areas without aggressive local water conservation policies (Brelsford and Abbott 2017; DeOreo et al. 2016; Diringer et al. 2018; Donnelly and Cooley 2015; Dyballa and Hoffman 2015,;Frost et al. 2016; Rockaway et al. 2011; Vickers 2018; Vickers and Bracciano 2014; William and Mayer 2012). Once those infrastructure standards were put in place, water savings were realized over the long-term as new developments installed efficient appliances and fixtures during initial construction. This major federal policy has helped water managers stretch existing water supplies to ever-expanding urban populations.

Utah's historical and geographical context provides both unique and comparable insights for urban growth and water demand management in the U.S. West states. The settlement of Utah in the 1800s by pioneers of the Church of Jesus Christ of Latter-day Saints (Latter-day Saints) was confined to areas where water was plentiful and infrastructure could deliver it to settlements (Harvey 1991). This history is part of the reason that over 80% of the state's population is concentrated in the Wasatch Range Metropolitan Area, and where future growth is most likely to occur (Utah Foundation 2014).

Urban planning and rapid population growth have been characteristic of the Latter-day Saint pioneer settlements from their beginning. “Unlike the many western [Anglo] frontier settlements that developed as agricultural villages or mining towns, Salt Lake developed from the start as an urban community supported largely by manufacturing and commerce… Salt Lake’s population grew rapidly from 1,700 in the first winter of 1847, to 5,000 by the first settlement anniversary, to over 6,000 in 1850. Utah saw an increase in population growth of over 50% during each subsequent decade between 1850 and 1890” (Galli 2005, 115).

Latter-day Saint church leaders directed this rapid growth and development by adapting a settlement plan created by the first Latter-day Saint president, Joseph Smith, in 1833 entitled “City of Zion Plat” (Galli 2005, 111). The urban design principles utilized in this plat used “modern ideas of urban growth boundaries, land use regulation to direct growth, a town center, and surrounding protected greenbelt” (Galli 2005, 129). Farmers and their families lived within the city along with merchants and professionals, with their farmland located outside the city with additional open space. John Muir and other people who passed through the territory of Deseret remarked on the careful planning and subsequent beauty of the unique settlements. The City of Zion Plat was recognized as one of the earliest examples of smart growth urban planning by the American Institute of Certified Planners, which in 1996 awarded the plat the National Planning Landmark Award (Galli 2005, 129).

However, Utah’s urban growth and development patterns changed in the 20th Century to accommodate the expectations of a growing and diverse population, resulting in additional challenges for planning and water management. Development patterns over the last five decades have resulted in low-density and single-use tracts being built-out from existing communities (Galli 2005). New development is at least spatially associated with agricultural landscape changes (Li, Endter-Wada, and Li 2019), with increasing urbanization decreasing the stability and affecting the structure of agricultural land use (Daniels 1999; Li, Endter-Wada, and Li 2019). Irrigated agricultural lands are more affected by urban development than non-irrigated agricultural lands (Li, Endter-Wada, and Li 2019), with irrigated land conversions often motivated more by water use conversions than land use conversions (Baker et al. 2014). News articles regularly chronicle the negative effects of this development pattern in Utah (Edwards 1998; Egan 1999; LaRoe 2002; McNaughton 2019). Though 82% of Utah's diverted water is used for agriculture (Office of Legislative Research and General Counsel 2012), Utahns are not willing to transfer meaningful amounts of water from agriculture to urban uses (Endter-Wada, Hall, Jackson-Smith, and Flint, 2015; Envision Utah, n.d.).

Local government officials are returning to smart-growth principles as a tool to manage urban growth and water demand. The city of Santaquin, Utah has implemented smart-growth principles into their General Plan, with 2800 acres in agricultural protection zones. They require landscape buffers between new residential development and orchard farms, allow cluster development, and have given farmers and ranchers the ability to stay on private water systems (O'Donoghue 2016). The Utah Chapter of the American Planning Association awarded Santaquin an outstanding achievement award for its efforts to preserve its agricultural community. The master-planned Daybreak community in southwest Salt Lake County was built using smart-growth principles to save energy and water, and over the years has reaped national awards (Daybreak 2011; Daybreak

Communities 2019). Utah leaders often use it as an example of the value of present-day master planned communities (McKellar 2019).

With more advanced water infrastructure available, urban growth is rapidly expanding into areas of Utah previously not settled in large part for lack of water infrastructure. Utah State University's Center for Water-efficient Landscaping (CWEL) was approached by the mayor of one of these municipalities, Eagle Mountain City (EMC), who asked if CWEL could help them in their mission to conserve water while accommodating growth. A Recommended State Water Strategy written for Utah's governor outlined key policy and science issues to help decision-makers, and conservation and efficiency measures are identified as top priorities for meeting future water needs. Urban water demand is less flexible than agricultural water demand (you can't "fallow a subdivision," as heard in professional circles), but researchers have demonstrated that the majority of wasteful municipal and industrial water use is on landscapes (DeOreo et al. 2016; Kjelgren, Rupp, and Kilgren 2000; Mayer, Lander, and Glenn 2015; Utah Division of Water Resources 2010). DeOreo et al. (2016) demonstrate how average annual indoor water use in 23 utilities has declined by 22% since 1999, and argue the remaining area for conservation is outdoor water use. Thus, growing municipalities, such as EMC, have unique opportunities to implement water-smart infrastructure during the construction phase of development.

Urban water demand in rapidly growing municipalities may best be managed by policies directing development and associated infrastructure toward water-smart growth strategies. Brelsford and Abbott (2017) analyzed multiple drivers of water consumption in Las Vegas, differentiating between the established "core" of the city and the rapidly developing periphery. They found that the largest measurable factor driving water efficiency in the city as a whole (measured in gallons per capita per day or gpcd) is lower consumption from new homes due to installation of higher efficiency indoor fixtures and low-water landscaping. They state:

> Lower consumption from newly constructed homes is the single biggest measurable factor driving changes in average household water consumption in Las Vegas. This 'vintage effect' occurs in addition to separately measured changes in indoor characteristics and changes in lot size and vegetation composition…The fact that these 'long run' drivers had so much leverage on overall household water consumption over roughly a decade is a testament to Las Vegas' rapid growth and illustrates the importance of proactive policy to address the durable aspects of water infrastructure in fast-growing municipalities before these capital investments are 'baked in'(Brelsford and Abbott 2017, 109).

Though an outdoor equivalent of indoor building efficiency standards has yet to be implemented, municipalities may achieve comparable results by connecting developers to consumers via BPs in urban growth development. Yet Abbey (1998) stated in his handbook to U.S. landscaping ordinances, "Any search of the Internet, for instance, will reveal no great body of scholars working on [landscaping ordinances] that is so fundamental to the practice of landscape architects across the nation…this is the first attempt to bring academic rigor to this subject on a national scale" (p. 11). Not much has changed in the ensuing two decades as a review of both peer-reviewed and professional literature found relatively few resources specifically detailing BPs for landscaping ordinances and policies affecting outdoor water use. However, movements to better integrate land use development and water supply decisions are helping to shift this paradigm via utilization of a broader suite of land use policies and planning processes (Blanchard 2018; Fedak, Sommer, Hannon, Beckwith, et al. 2018; Fedak, Sommer, Hannon, Sands, et al. 2018). Blanchard (2018, 10) states that "this knowledge base of techniques is both nascent and growing." One such tool is water-smart growth planning, which Li, Li, and Endter-Wada (2017) define as, "direct[ing] the spatial distribution of urban growth toward a more water-sustainable growth pattern" (1068).

To help elected officials and staff of municipalities such as EMC meet their water conservation goals, we decided a "guide to the guidebooks" review of BPs for water conservation could help fill this gap. The framework for this review was inspired by, and adapted from, the 14 BPs outlined in *Guidebook of Best Practices for Municipal Water Conservation in Colorado* by Colorado WaterWise and Aquacraft, Inc. (2010). Those BPs encompassed the majority of recommendations seen in our initial literature review.

Our intentions in this chapter are to: 1) review concepts affecting urban growth and outdoor urban water demand management, 2) build on the concept of water-smart growth by providing specific BPs with associated resources municipalities and regions can utilize to implement water-smart growth practices from the ground up, and 3) in our "Policy Design of BPs" section, cover issues relevant to designing and implementing BPs to fit various contexts, emphasizing the need for equity in how policies are implemented.

CONTEXT FOR WATER-SMART GROWTH

Utilization of BPs for water-smart growth has the potential to achieve long-term water savings in tandem with protecting valued agricultural land and natural water resources. In the grand scheme, new development will be concentrated in higher density and directed to areas with a smaller impact on agricultural land and water resources. On the ground, individual landscapes and irrigation systems will be properly designed, installed, and maintained to maximize water efficiency. This section explains the potential of water-smart growth followed by the significance and complexity of urban landscape systems and the greater challenges of achieving efficiencies outdoors than indoors.

Connecting Urban Growth with Water Demand Management

Tools are being created to help municipalities transition to connecting urban growth and land use with water management. While 'smart growth' planning aims to sustainably develop land by eradicating urban sprawl, the smart growth literature has paid little attention to concerns about water quality and quantity. Water-smart growth planning, as developed by Li, Li, and Endter-Wada (2017), proves McKinney and Harmon's statement (2002, 3) that "good planning doesn't just place limits on growth and development," but demonstrates how leaders and planners can achieve near-equal amounts of developed land as traditional methods of development while preserving the integrity of local water resources and prime agricultural land. Li, Li, and Endter-Wada (2017) incorporated water considerations into a land-use model and found that, with full water-smart growth planning and implementation, Cache Valley, Utah could realize nearly equal amounts of developed land as current growth patterns through utilizing different rules that take water concerns into consideration. Westminster, Colorado has applied a similar approach of water-smart growth planning by building GIS software, which overlays water resources and infrastructure over the city's comprehensive plan to enable planners to direct or reject growth based on water supply (Plautz 2019).

Utilization of BPs with these tools may be a powerful strategy for achieving long-term water savings.

Significance and Complexity of Landscape Water Use

Urban landscape water demand and use occurs in multi-scalar environments with social-ecological interactions. Cook, Hall, and Larson (2012) propose a framework for understanding residential landscape dynamics. Though they tied their framework specifically to residential landscapes, their framework components could apply to the commercial, industrial, and institutional (CII) sector as well. Their components include: ecology of residential landscapes, management decisions, legacy effects, and multi-scalar human drivers. Each component is composed of multiple variables, providing various aspects of urban landscape water consumption and opportunities for conservation. *Ecology of residential landscapes* includes ecological properties (e.g. plant and faunal species composition and soil characteristics), ecological functions (e.g. evapotranspiration), and ecosystem services (e.g. regulation of microclimates). *Management decisions* refers to how the ecological properties and functions of landscapes are altered. *Legacy effects* are produced by prior land-use decisions, preexisting land-cover, and urban development patterns, "ultimately affecting ecological structure, function and services for centuries to millennia" (39). For example, "developers never expect an [homeowner's association (HOA)] to replace its landscaping. An HOA's ability to affect water conservation truly depends on the developer's incentive to add expensive and often invisible conservation measures" (Dyckman 2008, 49). Kilgren et al. (2010) found that irrigation infrastructure system effects overshadowed impact of water conservation interventions. Finally, *multi-scalar human drivers* affect landscape management and the associated ecological results of human behavior. In their review, Cook, Hall, and Larson (2012) found that drivers, such as governmental policies and broad-scale political-economic forces, had been studied less than attitudinal factors and household characteristics. Municipal and regional drivers, such as developers' plans, enable or constrain the choices individuals can make pertaining to their own landscaping decisions. The authors state “the development industry has powerful influence over broad-scale social-ecological outcomes” (38).

Their framework builds upon, and is consistent with, an earlier review by Hilaire et al. (2008). Hilaire et al. (2008) suggest that since landscape ordinances implemented after residential areas are built may face push-back, mandating water conservation procedures while housing is being planned may be more effective.

Similar to the legacy effects outlined above, outdoor urban water demand and use is affected by the phenomenon of path dependency (Brooks 2005; Burnham et al. 2016; Welsh and Endter-Wada 2017). Welsh and Endter-Wada (2017) define path dependency in this context as the following, “Once made, urban land and water development investment decisions take people down a certain path that is hard to reverse because it establishes, demonstrates, and reinforces a municipal demand for water that is protected above all other uses under prior appropriation water law in the western USA” (431). This effect has been demonstrated in the Colorado River Basin as in times of severe shortage, temporal allocation priorities (i.e., the “first in time, first in right” principle of prior appropriation) can be overridden by beneficial use preferences (i.e., the preference give to culinary or municipal use in times of shortage). Kuhn and Fleck (2019) chronicle how decision-makers throughout the 20th century ignored warnings of inadequate water supplies for desired farms and cities, leaving subsequent water managers and planners in a quandary. Welsh and Endter-Wada (2017) warn that, “without a fundamental paradigm shift connecting growth management and land use with water management, cities will continue to encourage traditional supply-side water management approaches through large-scale pipelines and infrastructure development to support growing populations” (431). Strategic policy and planning efforts are also needed to ensure that conserved water is channeled towards the intent for which the efforts were made, rather than the water being reallocated to fuel additional urban growth.

METHODS

Data Collection

The data collection for this thesis consisted of identifying BPs for urban outdoor water conservation and efficiency that are commonly recommended in the literature. In conducting peer-reviewed literature searches using a variety of key terms, we quickly identified several important guidebooks that have been prepared by experienced professionals and prominent non-profits working within the urban water sector. Each of these guidebooks contains academic and professional literature citations, as well as practical examples of the practices that they review and recommend. We conducted additional literature searches on the main BPs to identify case studies and models of implementation.

Data Analysis

We conducted a preliminary literature and guidebook review along with primary and secondary data sources (i.e., state and municipal codes, case studies, journal articles, best practice manuals from the industry). We determined that the BPs most commonly recommended, and accompanied by the most supporting evidence, were provided by Colorado WaterWise and Aquacraft, Inc.'s *The Guidebook of Best Practices for Municipal Water Conservation in Colorado – Technical Guide* (2010). Their project team selected and presented 14 BPs after conducting a literature review of significant BP reports and publications from California, Texas, Georgia, and Colorado, and vetted their work through water professionals and industry experts. Their recommendations have largely been supported by subsequently published literature. The 14 best practices they identified were presented in three sets referred to as "suites": 1) six foundational, no-excuse best practices, 2) the foundational best practices plus three regulatory best practices, and 3) a complete package of both prior suites plus five customer-side best practices. Their recommendation of how to stage, or sequence, groups of best practices for implementation also stood out as unique in the literature. We evaluated additional academic and professional literature, and subsequently adapted the Colorado WaterWise and Aquacraft, Inc. (2010) framework in presenting our review and recommendations for four BPs for urban landscape water conservation.

We also conducted policy analysis by evaluating the four BPs we focus on for application to the Utah context through the theoretical lens of *Policy Design for Democracy* by Schneider and Ingram (1997). Given that water is the property of the public and essential for life, all citizens have an interest in equitable access to water and how it is used in Utah. The issues of how we design policies to address growing scarcity are increasingly urgent and are being prioritized on Utah's policy agenda. Schneider and Ingram’s work is significant for its rare emphasis on policy design instead of policy processes, and its focus on how contexts give rise to, and are shaped by, different types of policies. Utah municipalities exist in a variety of different contexts, implying that policies implemented within even a single state will likely vary as local governmental leaders respond to different needs. We use their insights to discuss implementation issues. Finally, this chapter’s reliance on Schneider and Ingram’s policy design framework implies that administrators and managers should predetermine the goals and problems to be solved and what can be measured to evaluate water conservation success, as well as emphasizing the need for equity in policy implementation.

Data Presentation

Based upon our data collection and data analysis, we present an evaluation of four BPs that we determined to be most significant for advancing urban landscape water conservation. This thesis chapter adapts BPs from Colorado WaterWise and Aquacraft, Inc.’s (2010) second and third suites of regulatory and customer-side measures. Their BPs meant for indoor water savings are mostly excluded. The first BP in this chapter, “landscape water budgets, information, and customer feedback,” is the only BP not modified from Colorado WaterWise and Aquacraft, Inc. (2010). We discuss our adaptions below.

First, Colorado Water Wise and Aquacraft, Inc. (2010) include “rules and regulations for landscape design and installation and certification of landscape professionals" as one of their second suite three regulatory BPs. It has a two-part focus of utilizing rules and regulations to 1) ensure new landscapes were designed and installed to maximize water efficiency, and 2) require minimum training and certification requirements for landscape irrigation professionals. We take their first focus (creating rules for new landscape and irrigation system design and installation) and combine that into our third BP, "Water-efficient landscape design, installation, and maintenance practices," by discussing landscape ordinances and other possible rules and regulations. This thesis retains their second focus as the sole objective of our second BP, "minimum training requirements and certification of landscape professionals."

Second, Colorado WaterWise and Aquacraft, Inc. (2010) include "irrigation efficiency evaluations" as a standalone BP in their third suite. Irrigation efficiency evaluations (also called water audits or water checks) are a widely used tool in areas throughout the country, and are most effectively used on landscapes with "capacity to conserve." However, we feel a lack of research studies, combined with mixed results on this BP's effectiveness, warrants a change from being a specific BP to being addressed as a tool to help facilitate proper landscape maintenance in our third BP, "water-efficient landscape design, installation, and maintenance practices." We propose researchers and practitioners work to establish replicable programs that could make this a standalone BP in the future.

Third, Colorado WaterWise and Aquacraft, Inc. list "rules for new construction—residential and non-residential" as a regulatory BP in their second suite. However, their use of the BP focuses on indoor water use. We propose this BP is an essential strategy for maximizing long-term landscape water efficiency, describing it as "rules for new construction and landscape renovation."

Table 13 lists the four common BPs for urban landscape water conservation covered in this chapter and shows how they correspond to the original BPs identified in Colorado WaterWise and Aquacraft, Inc.'s (2010) technical guide.

Table 13: BPs Covered in this Chapter and Correspondence to Suite 2 and Suite 3 BPs in the Colorado WaterWise and Aquacraft, Inc. Guidebook (2010)

BP#	*This Thesis Chapter*	*BP#*	*CO WaterWise Guidebook (2010)*
1	Landscape water budgets, information, and customer feedback	7	Same
2	(Modification) Minimum training requirements and certification of landscape professionals	8	Rules and regulations for landscape design and installation and certification of landscape professionals
3	(Expansion) Water-efficient landscape design, installation, and maintenance practices for new and renovated landscapes	9	Water efficient design, installation, and maintenance practices for new and existing landscapes
--	Inserted into BP3	10	Irrigation efficiency evaluation
4	(Modification) Rules for new construction and landscape renovation [outdoor water use]	11	Rules for new construction—residential and non-residential [indoor water use]

We agree that these regulatory and customer-side BPs can provide substantial landscape water savings at a relatively lower cost for utilities to implement. In the context of rapidly developing communities in Utah, these BPs are especially important to get landscape infrastructure correctly designed and installed for realizing long-term water savings, and could be the outdoor equivalent of the 1992 national efficiency [indoor] standards (EPAct 1992). While these BPs have been implemented successfully across the nation, we recognize several of them are a relatively new focus in academia, and lack of thorough data and program evaluation has prevented improvement. Such information can contribute to better understanding of how local governments modify and implement these more generally-defined BPs to fit their specific contexts, and it would prove valuable to other communities seeking to design and adapt their own water conservation practices.

SELECTED BEST PRACTICES

BP 1: Landscape Water Budgets, Information, and Customer Feedback

Urban landscape irrigation consistently tends to account for 50% or more of a utility's annual water demand (DeOreo et al. 2016; Mayer et al. 1999). Landscape water budgets are a powerful tool to encourage water efficiency, and do so by "compar[ing] actual metered consumption against the legitimate outdoor water needs of the customer based on landscape area, plant materials, and [local] climate conditions" (Colorado WaterWise and Aquacraft, Inc. 2010, 97). Water budgets provide a customized target level of water use for each customer and their landscape, which is helpful as many irrigators are not aware when they are overwatering their landscapes. Water budgets can be implemented as a standalone tool for assessing water use or incorporated into a utility rate structure (also called "allocation-based rates"). A key benefit is the perceived fairness and equitable treatment of water users that water budgets afford. Mayer, De Oreo, et al. (2008, 126) found, "Most of the agency staff involved said the additional complexity of customer-specific water budgets was more than outweighed by the increased customer acceptance of the customized rate structure. Staff found that once customers understood the system, they preferred to have their rates based on the characteristics of their site rather than on an arbitrary or average value." These water budgets utilize an economic incentive as an alternative to strategies involving legal requirements subject to enforcement, such as landscaping ordinances described in later BPs.

Water budgets can help manage demand during drought crises. Mayer, De Oreo, et al. (2008, 127) argue that water budget rate structures have two key benefits during droughts.

> First, it establishes an empirical and quantifiable limit to the amount of water that a customer is entitled to use at a given price from a given tap. Second, it theoretically reserves a volume of water for the customer to use as he or she sees fit. Water budgets have the potential to protect the utility from overuse and to protect the customer from having his or her water allocated to other uses or micromanaged by the utility.

In addition, water budget enforcement programs automatically identify every customer using more than their allotment, enabling fair and uniform enforcement rather than relying on "water cop" approaches that depend on ticketing observed violations.

In an independent evaluation, Pekelney and Chesnutt (1997) documented a 37% decline in water consumption resulting from the Irvine Ranch Water District's (IRWD) implementation of water budget rate structure and customer outreach, as well as a 35% decline in consumption in San Juan Capistrano, and a 20% decline in the Otay Water District. As of January 2016, IRWD reports a 50% reduction in their residential per capita water use since budget based rates were adopted in 1991 (Budget Based Rates, n.d.). Baerenklau, Schwabe, and Dinar (2014) found that water demand was reduced by about 17% over a three-year period after introducing a fiscally neutral increasing block rate water budget price structure on residential water demand. Pérez-Urdiales and Baerenklau (2019) found that the efficiency signals provided by water budgets had a measurable effect on consumer behavior, rebutting concerns that water budget rates are too complex for customers to understand.

American Water Works Association (2017b) details water budget rates, including implementation strategies, case studies, and more references. Mayer, DeOreo, et al. (2008) offer a full report on water budget and rate structures and provide case studies illustrating the successes and challenges involved in implementation. Blanchard (2018) describes various means of incorporating water budgets into codes and linking them to new development to facilitate long-term water savings. Various water budget tools are available, including one by the U.S. Environmental Protection Agency WaterSense program (WaterSense, n.d.). Californian water districts collaborated to produce an online resource guide to assist in the development and implementation of water budget-based rates (Budget Based Rates, n.d.).

Finally, water budgets have also been used as standalone programs to address water waste and increase landscape water efficiency. Glenn et al. (2015) developed a Landscape Irrigation Ratio (LIR) to identify residential locations with water use considered inefficient or excessive, and utilized a water audit program to provide those users with information and problem-solving skills to apply appropriate amounts of water. Endter-Wada et al. (2013) partnered with Weber Basin Water Conservancy District to assess metering of water use in pressurized secondary systems and successfully reduce excessive water use through meter data interpretation and customer billing messaging. This strategy provides an alternative approach to other strategies quantifying plant water use, such as the California-centric Water Use Classification of Landscape Species (WUCOLS) method or Simplified Landscape Irrigation Demand Estimation (SLIDE Rules) framework (Kjelgren, Beeson, Pittenger and Montague 2016).

Major resources on this BP are listed in Table 14.

Table 14: Major Resources on Landscape Water Budgets, Information, and Customer Feedback

American Water Works Association. 2017. *Principles of Water Rates, Fees and Charges*. 7th ed, *AWWA Manual*: American Water Works Association.
Blanchard, J. C. N. (lead author and editor). 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Budget Based Rates. n.d. "Water Budget-Based Rates: A Tutorial for Considering a Budget-Based Water Rate Structure." http://budgetbasedrates.com/.
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado. Available at*: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Mayer, Peter, William DeOreo, Thomas Chesnutt, David Pekelney, and Lyle Summers. 2008. *Water Budgets and Rate Structures—Innovative Management Tools*. Denver, CO.
WaterSense Water Budget Tool. n.d. U.S. Environmental Protection Agency. *Available at*: https://www.epa.gov/watersense/water-budget-tool.

BP 2: Minimum Training Requirements and Certification of Landscape Professionals

A golden trifecta of proper design, installation, and maintenance is essential to maximizing water efficiency on outdoor landscapes (Colorado WaterWise and Aquacraft, Inc. 2010; Inman and Jeffrey 2006; Irrigation Association and American Society of Irrigation Consultants 2014; Utah Water Strategy Advisory Team 2017; Vickers 2001). Requiring minimum training and certification for landscape and irrigation professionals helps address the first two of the three by ensuring that whoever performs landscape and irrigation designs and installations are qualified by industry and municipal standards. Though Utah's legislature has tended towards loosening professional licensing requirements (Glas and St. Clair, 2019), various forms of this BP ought to be considered at different levels of government as it protects homebuyers and owners from incompetent or property-harming work conducted by paid contractors. From observation and field research, the authors can report instances of hired landscape contractors doing inept work. One CWEL research participant who wanted a peer-review of his irrigation system reported that he'd had "lots of 'drop by' quotes from people who have no idea what they are doing," and hadn't received any consistent advice from advertised professionals on how to retrofit an irrigation system. Another reported that both they, and neighbors who had hired the same irrigation contractor, dealt with flooded basements after the contractor installed poor irrigation infrastructure. From research in Australia, Maheshwari (2012) reports "there are relatively few well-designed systems in operation, that a typical homeowner has limited knowledge of how to design and manage an irrigation system, and that the maintenance of systems is usually forgotten" (636). Field data across several studies conducted in the U.S. by authors of this paper are consistent with Maheshwari's findings. Hartin and McArthur (2007) studied 30 park, school district, commercial, and golf course sites in California for major causes of water loss. They found that over 70% of applied water was lost due mainly to irrigation system infrastructure issues (i.e. leaks, unmatched sprinklers, overspray, and improper pressure and line or head placement), validating a California's task force recommendation of including irrigation system installation and maintenance as a best practice in state water conservation legislation (Hartin et al., 2019).

Local ordinances and codes, including model landscape or building and plumbing codes, and the specification of training requirements, can be used to implement this best practice. Abbey (1998) states that beginning in the 1990s a trend started for “the inclusion of standards for those who are qualified to prepare landscape designs, irrigation plans, grading plans, tree surveys and tree preservation plans” (10). However, Trotter (2017, 3-4) from the Pacific Legal Foundation conducted what appears to be the first 50-state survey of occupational regulations of landscape contractors, and states that "landscaping is defined more or less broadly depending on the state", and found that "peculiarly, the activities one might most obviously consider to be landscaping are frequently exempted from statutory definitions for landscaping [e.g. mowing, installing irrigation systems, and placement of plant material]" which complicates the determination of what activities are subject to state regulation. Trotter (2017) reviews a hierarchy of regulatory options composed of private governance options (the least regulatory, third-party professional certification being an example), public regulations as a middle ground (e.g., general consumer protection statutes), and registration, certification, and licensure options requiring the most regulation. Trotter (2017, 21) argues that:

> Occupational licensing should not be the starting point for addressing concerns about problems created by a particular profession. Rather, only after the other numerous steps along the hierarchy are shown to be insufficient to address actual---not hypothetical---problems that are present with a given industry should the government resort to the most restrictive mode of regulation: licensing.

Currently, the only examination required by the state of Utah for landscape contractor licensure is the Utah Contractor Business and Law Examination (Utah Construction Trades Licensing Act Rule 2020). The only measure of an applicant's skill in the landscaping trade is by meeting two years full-time paid employment. Given that actual problems in landscape and irrigation system design and installation have persisted and been documented in Utah, as well as throughout the U.S. and internationally, recommendations for, at the very least, *minimum* training requirements and certification of landscape professionals in reports such as Colorado WaterWise & Aquacraft, Inc. (2010) and Utah's Recommended State Water Strategy (Utah Water Strategy Advisory Team, 2017) seem prudent and worthy of investigation and implementation. Certainly, too, minimum training requirements and certification may vary with what landscaping practice is being regulated. For instance, irrigation system design and installation require more expertise, has more impact on long-term water consumption, and carries greater risk of public harm if not done properly than general landscape maintenance activities.

The most detail for implementation of this BP is found in Colorado WaterWise and Aquacraft, Inc. (2010), which includes a list of additional resources with various certification programs. Though broader than just landscapes or irrigation systems, programs such as LEED certification also impact outdoor water use. Blanchard (2018) extensively covers options for mandatory or voluntary third party certification programs, including LEED. However, regarding Martinson (2018), landscapes designed to meet these certifications should be managed appropriately to maximize designed-for water efficiency. After finding that inappropriate day-to-day management by landscape maintenance firms severely inhibited the actual water efficiency of properly designed water-efficient landscapes, Martinson (2018) concluded that developing better management protocols and training should be a priority.

Though literature is rather scarce, there are insightful case studies of implementation. Castle Rock, Colorado "requires anyone designing, installing or maintaining properties within the Town to attend the Town's Landscape Registration Program and GreenCO's Best Management Practices Training and Exam" (Colorado WaterWise and Aquacraft, Inc. 2010, 114). For some irrigation installations, Santa Fe, New Mexico requires City Parks staff, as well as residential landscapers and commercial landscapers, to obtain Irrigation Certification from the New Mexico Association (Blanchard 2018). Blanchard (2018) also suggests communities may consider offering rebates for fees charged by third-party certification organizations to incentivize use of those programs, or even offer free training or certification to empower developers (or as in this case, landscape contractors) to build with those techniques in mind. In Texas, "[A] person may not sell, design, install, maintain, alter, repair, service or inspect an irrigation system–or consult in these activities," unless licensed by the Texas Commission on Environmental Quality (TCEQ) (Texas Commission on Environmental Quality). To help facilitate the efforts of those who prefer to do landscape design, installation, and maintenance themselves, Aurora, Colorado offers a free three-level Water Conservation course for residents with topics including DIY sprinkler systems and DIY water-wise landscape design, and attendees finish with what is essentially a free landscape plan for their property (Blanchard 2018). Municipalities in Utah interested in advocating for or requiring third-party certification or training requirements could use existing programs accredited by the U.S. EPA WaterSense such as the Qualified Water Efficient Landscaper (QWEL) or the Irrigation Association's training courses.

More research needs to be done to address gaps for this BP. Colorado WaterWise and Aquacraft, Inc. (2010) state that, "there are no established methods for measuring the effectiveness of training and certification for landscape professionals" (110). Little to no academic research has been found on the impact of landscape contractor training and certification (Mayer, Lander, and Glenn 2015; Quay et al. 2018). However, Chesnutt, Pekelney, and Erbeznik (2004) did assess a Landscape Performance Certification Program targeted to property managers, HOAs, and landscape contractors of customers with dedicated meters, and found the program cost effective with water savings from 256 to 991 gallons per day.

Major resources on this BP are listed in Table 15.

Table 15: Major Resources on Minimum Training Requirements and Certification of Landscape Professionals

Blanchard, J. C. N. (lead author and editor). 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado. Available at*: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Irrigation Association. *Available at*: https://irrigation.org
Qualified Water Efficient Landscaper. *Available at*: https:www.qwel.net/
Trotter, Caleb. 2017. "Constitutional Landscaping: An Analysis of Occupational Regulations of Landscape Contractors in the United States." 58 South Texas Law Review 367. *Available at*: https://ssrn.com/abstract=2913093

BP 3: Water-Efficient Landscape Design, Installation, and Maintenance Practices

While the prior BP focuses on the qualifications of the individual who is doing the design and installation of a landscape, this BP focuses on the "what to do and how to do it" of maximizing landscape water use efficiency through proper design, installation, and maintenance. Colorado WaterWise and Aquacraft, Inc. (2010) emphasize that "the seven basic principles of xeriscape, developed years ago by Denver Water (and others), remain the fundamental underpinning for conservation-oriented landscapes. These principles are: planning and design, soil improvement, grouping plants with similar water demands, practical turf areas, efficient irrigation, mulching, and appropriate maintenance" (126). Vickers (2001) adds one principle to this set: using native and low-water use plants. This BP, as expounded by Colorado WaterWise and Aquacraft, Inc. (2010), is largely based off of 39 very detailed guidelines described in the manual *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO and Wright Water Engineers 2008). Their guidelines, in Table 16 below, promote both water conservation and water quality. With permission, their manual was adapted to suit the Salt Lake City, Utah area (Salt Lake City 2011). Colorado WaterWise and Aquacraft, Inc. (2010) summarize the following principles and provide additional resources for implementation: site considerations, soil condition, plant selection, practical turf areas, hydrozoning, efficient irrigation, mulch, landscape installation, irrigation system installation, landscape maintenance, and irrigation system maintenance and operation. More recent manuals include the Alliance for Water Efficiency's *Sustainable Landscapes: A Utility Program Guide* (2019), Calkins (2012), Irrigation Association and American Society of Irrigation

Consultants (2014), and Meyer, Kjelgren, and Morrison (2009). Qualified Water Efficient Landscaper (QWEL) training, offered on-site and in part online, gives a good introduction to many of these principles (QWEL). Literature reviews pertaining to these components address nuances and research gaps (Cook, Hall, and Larson 2012; Dukes 2012; Endter-Wada et al. 2008; Hilaire et al. 2008; Kilgren et al. 2010; Kjelgren, Rupp, and Kilgren 2000; Mayer, Lander, and Glenn 2014; Quay et al. 2018).

Table 16: Summarization of GreenCO and Wright Water (2008) Best Management Practices for both Water Conservation and Water Quality

Sustainable Landscaping (12)	Fertilizer Application (12)
Xeriscape (21)	Pesticide and Herbicide Application (19)
Water Budgeting (13)	Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal (8)
Landscape Design (47)	Lawn Aeration (3)
Landscape Installation/Erosion and Sediment Control (11)	Lawn Waste Disposal/Composting (5)
Soil Amendment/Ground Preparation (13)	Mowing (5)
Tree Protection (11)	Mulching (11)
Tree Placement in the Urban Landscape (2+)	Drought and General Water Conservation Practices for Landscapes (23)
Tree Planting (1+)	Snow Removal and Management (7)
Irrigation Efficiency (12)	Production Practices for Nurseries, Greenhouses and Sod Growers (18)
Irrigation System Design (16)	Water Management Practices for Nurseries, Greenhouses, Sod Growers & Holding Yards (6+)
Irrigation System Installation (11)	Retail Practices for Nurseries, Greenhouses and Garden Centers (4)
Irrigation System Maintenance (8)	Park, Golf Course and Other Large Landscape Design and Management (21)
Irrigation Efficiency Audits (9)	Landscape Features in Low Impact Development (11)

Irrigation Technology and Scheduling (9)	Revegetation of Drainageways (3)
Irrigation Using Nonpotable Water (3+)	Riparian Buffer Zone Preservation (8)
Landscape Maintenance (15)	Education of Employees (11)
Trees and Other Woody Plant Care (19)	Education of the Public (+)
Herbaceous Plant Care (17)	Regulatory Awareness (+)
Turf Management (36)	

[a] The numbers in parentheses after each BMP indicate the number of listed key references for each practice, while a "+" sign indicates supplemental references are included apart from those designated as "key."

Of note, the various aspects of landscaping listed in Table 4 may be regulated with varying levels of ease. For instance, "topsoil" has no legal definition (Voyle 2012), yet sprinkler systems are highly defined and quantified. Regardless, many of these guidelines and other similar resources appear to be the basis for most components of model landscaping ordinances, such as California's Model Water Efficient Landscape Ordinance (MWELO) (CAL. CODE REGS. tit. 23, § 490-495 (2019)), yet literature explicitly connecting the rationale between practice and regulation is scarce. Two exceptions to this are Abbey (1998) and Arendt (1999). Abbey (1998) is the "first attempt to bring academic rigor to this subject [of landscaping ordinances] on a national scale," with the objective being to "survey the nation, define the nature of landscape ordinances, standardize the vocabulary, define various technical requirements and compare and contrast ordinances from different environmental regions" (11). Arendt (1999) utilizes local plans and ordinances to achieve conservation goals, with focus on land conservation, yet sections on water resources focus on quality not quantity. More recent publications on integrating land and water resources deal more comprehensively with a suite of strategies (e.g., plans, codes and regulations, development review processes) rather than just landscape ordinances (American Water Works Association 2017a; Blanchard 2018; Colorado WaterWise and Aquacraft, Inc. 2010, Fedak, Sommer, Hannon, Beckwith, et al. 2018; Fedak, Sommer, Hannon, Sands, et al. 2018).

Blanchard (2018) describes, in detail, landscape codes, guidelines, and various procedural strategies with case studies. Along with emphasizing that incorporating landscape regulations into local codes is essential for municipal water conservation, Blanchard (2018) cautions that "landscaping standards that are not sufficiently specific… can be hard to enforce, may be legally vulnerable, and can complicate project approvals. Landscaping requirements may be adopted through the zoning ordinance, subdivision regulations, design guidelines, or a stand-alone landscaping ordinance" (209). For example, in a letter from Julie Saare-Edmonds of California's Department of Water Resources (DWR) to landscape stakeholders who were providing input on revisions to the MWELO (March 6, 2019), the DWR decided that since only 130 of nearly 550 land use agencies reported on implementation of the ordinance, the DWR would suspend work on ordinance revision until work could be done to identify the barriers limiting implementation. The DWR acknowledged specific stakeholder comments on potential amendments to the ordinance, and planned to prepare a guidebook to help agencies implement the ordinance and facilitate compliance. Yet there are case studies of both successful mandatory and incentivized implementation of various principles using different strategies, and model landscape ordinances available for use. Instead of incorporating standards into city code, Westminster, Colorado adopted detailed Landscape Regulations in 2004, with requirements such as addition of soil amendments and landscape and irrigation plans except from individuals constructing their own homes

(City of Westminster 2004). Similarly, the Southern Nevada Water Authority (SNWA) developed a model landscape code restricting use of water-intensive vegetation with additional provisions (Blanchard 2018). Every local community adopted the code into their land use regulatory framework. Homes built after the regulations had a 38% reduction in water use, decreasing from 226 gallons per capita per day (gpcd) to 141 gpcd (Blanchard 2018). Various municipalities both incentivize (e.g., Silver City, New Mexico) or mandate (e.g., Aurora, Colorado) use of plants from pre-approved lists (Blanchard 2018). Cheyenne, Wyoming utilizes landscape standards in site plan regulations based off a point system favoring low-water use trees, shrubs, and ground cover. Aurora, Colorado prohibits installation of lawn, turf, or sodded area by single- and two-family homeowners without a valid lawn permit. Winter Park, Colorado developed much of its land use code to protect the health of the Frasier River, prohibiting outside irrigation anywhere in the town limits (Blanchard 2018).

Appropriate design and installation of irrigation systems and landscape plant material can equip urban landscapes for thriving with less water. However, maintenance and operation practices are also important to maximize water-efficiency, especially in cities where resident turnover occurs often. Irrigation efficiency audits (also called water checks) are one method to facilitate proper maintenance. Yet after reviewing the literature, Mayer, Lander, and Glenn (2014, 21-22) report, "there is little (if any) current data that show measured short- or long-term water savings from irrigation audits, and no studies were identified that evaluated the effect of irrigation system tune-ups, sprinkler head retrofits, and other measures to improve efficiency…Field studies of the performance of sprinkler system components used on actual landscapes are needed, as well as the effectiveness of water audit programs." Since then, Shimabuku, Stellar, and Mayer (2016) studied the impact of 2,000 sprinkler audits in Colorado and report that, though water savings varied by year, and audits may not produce as robust long-term benefits, the audits were an effective water conservation tool because of effectively educating homeowners around setting appropriate irrigation run times. Blanchard (2018) describes how local and county governments may utilize ordinances that require mandatory audits and inspections of irrigation systems for commercial entities, citing Allen, Texas as an example.

Aspects of human behavior are important to proper implementation of design, installation, and maintenance practices. The importance of these aspects may increase as technologies and strategies for addressing water use evolve. For example, automatic irrigation controllers used to depend on correct inputs of minutes and days for irrigation duration and frequency, and conservation program administrators struggled to get water users to change these inputs for different seasons. However, irrigation technology has evolved to where smart controllers now use evapotranspiration data from relevant weather stations to automatically program new irrigation schedules. Latest iterations of these controllers enable homeowners to characterize individual irrigation zones, and algorithms combine that data with weather station data for customized irrigation schedules. However, Morera et al. (2017) found that Florida homeowners "were less than moderately familiar with the majority of their landscape and irrigation system features," including components such as efficiency of irrigation system, sun and shade pattern, slope pattern of yard, plant types, water needs of plants, soil type, and plant root depths (937-938), which are key to correctly characterizing irrigation zones. Now that accurately describing an irrigated landscape is key, instead of just programming minutes and days, conservation programs and technologies seeking to maximize landscape irrigation efficiency should seek to account for human perception and behavior in relation to operation of these technologies.

Major resources on this BP are listed in Table 17.

Table 17: Major Resources on Water-Efficient Landscape Design, Installation, and Maintenance Practices

Abbey, Buck. 1998. *U.S. landscape ordinances: an annotated reference handbook*. United States of America: John Wiley & Sons, Inc.
Alliance for Water Efficiency. 2019. *Sustainable Landscapes: A Utility Program Guide*. Chicago, Illinois 60602: Alliance for Water Efficiency.
Blanchard, J. C. N. (lead author and editor). 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
California Model Water Efficient Landscape Ordinance. 2019. CAL. CODE REGS. tit. 23, § 490-495.
Calkins, Meg. 2012. *The sustainable sites handbook: A complete guide to the principles, strategies, and best practices for sustainable landscapes*. First ed. Hoboken, New Jersey: John Wiley & Sons, Inc.
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado. Available at*: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
GreenCO and Wright Water Engineers. 2008. *Green Industry Best Management Practices (BMPS) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability.* Denver, CO.
Irrigation Association and American Society of Irrigation Consultants. 2014. *Landscape Irrigation Best Management Practices*. Edited by Melissa Baum-Haley.
Meyer, Susan E., Roger K. Kjelgren, and Darrel G. Morrison. 2009. *Landscaping on the new frontier: Waterwise design for the Intermountain West*. China: Utah State University Press.
Qualified Water Efficient Landscaper. *Available at*: https:www.qwel.net/
Salt Lake City. 2011. *SLC Landscape BMPs for Water Resource Efficiency and Protection: For Landscape Professionals, Architects, Contractors, and Homeowners*. SLC, UT.

BP 4: Rules for New Construction and Landscape Renovation

The development industry has powerful influence over long-term water use, especially in rapidly growing areas. Urban water demand in rapidly growing municipalities may best be managed directing development and associated infrastructure in water-smart growth strategies. "In almost all cases, it is far more cost-effective to implement these alternative water-supply options and water conservation practices at the beginning of development as compared to retrofitting them at a later date" (Blanchard 2018, 17). This BP could be the outdoor equivalent of the national efficiency standards enacted in 1992 that has resulted in long-term indoor water savings across the nation. This BP encompasses water efficiency specifications municipalities can make voluntary or mandatory for new development. Voluntary specifications may be incentivized by means such as incorporating them into bonus density calculations currently in use. "All agreed-upon strategies and techniques should be mentioned in the comprehensive plan water element, but the details should be left for inclusion in other land use documents, such as zoning, subdivision and site-plan regulation, and building and plumbing codes" (Blanchard 2018, 54).

Multiple resources provide innovative strategies to direct water-efficient new development. Blanchard (2018) is a guide compiled from over 20 years of training programs and associated interactions and feedback with local leaders and professionals conducted by the Land Use Law Center. It shares details on a full suite of topics and case studies, including strategies such as water-demand offset policies, accessory dwelling units, development agreements, non-zoning incentives, and post-occupancy enforcement (including a discussion on engaging HOAs). Tools and strategies for integrating water efficiency into land use documents are detailed in full. Fedak, Sommer, Hannon, Sands, et al. (2018) provide case studies demonstrating innovative strategies in an accessible format. *Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies* (Environmental Protection Agency, 2006) reviews policy options available for states, local and regional governments, and utilities. Though conservation subdivisions are a planning technique usually employed to preserve open lands, the method has implications for water use, and Arendt (1999) reviews the method in full. Morris (2009) reviews development standards for utilities, including water distribution infrastructure.

A few suggestions are particularly noteworthy for Utah. Urban development is expanding into formerly unirrigated agricultural lands where soil conditions are less than optimal for urban landscapes. Lack of regulation here, and in other areas, is setting the stage for long-term challenges to water conservation. For example, during one summer while completing landscape water audits in Eagle Mountain City, CWEL staff documented that a homeowner installed landscape irrigation trenches without any soil preparation (Figure 3), visited multiple sites where excessive irrigation occurred because yards were too small to warrant automatic sprinkler systems, and noted various

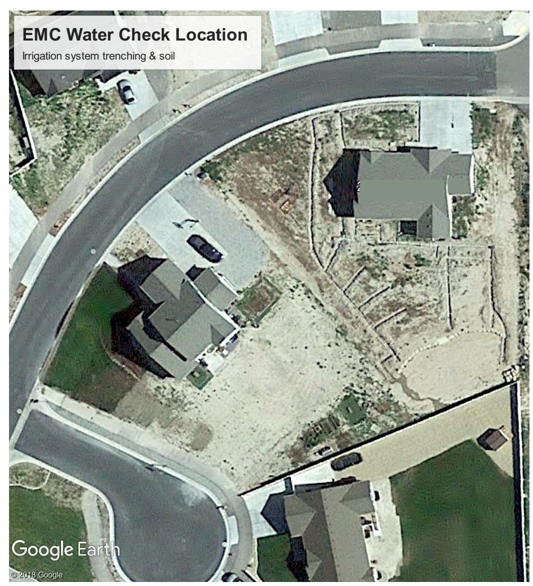

Figure 3: The homeowner on the right laid irrigation trenches without any soil preparation into formerly unirrigated agricultural soil (or rather, lack thereof) (Wuenschell, email message to authors, September 12, 2018).

instances where sprinkler systems were installed without considering possible future alterations in the landscape (Wuenschell, email messages to authors, September 5, 2018 and September 12, 2018).

Strategies to optimize long-term water use and efficiency should be utilized. Westminster, Colorado utilized soil amendments as one part of their overall conservation strategy. Westminster worked with the Northern Colorado Water Conservancy District and Front Range Community College to install and observe test plots using various types and quantities of amendments, and, based off their results, incorporated soil amendment requirements into their Landscape Regulations. A two-step inspection process, along with delivery receipts, helps ensure proper execution of the requirements (Schalk, email message to author, October 25, 2018). Blanchard (2018) details various strategies for enforcing landscaping requirements. Similarly, codes or regulations ensuring slopes are landscaped with appropriate plant material would minimize irrigation waste. Municipalities who lack the resources to require and enforce inspections may choose to do inspections based upon observed violations.

Irrigation systems are another area where municipalities may want to regulate development. Though automatic sprinklers are convenient, "municipalities should encourage the use of alternative watering systems, as manual irrigation is often more efficient than automatic systems since people will only water when they see it is needed" (Endter-Wada et al. 2008; Vickers 2001, 196,). Further, Kilgren et al. (2010) found that in comparing schools with automatic versus manual irrigation systems, schools with automatic irrigation systems exhibited greater water waste than those with manual systems, yet savings between schools in response to interventions also varied based on landscape size, system pressure, and custodian knowledge. Municipalities could consider requiring a minimum amount of landscaped area before allowing installation of an automatic sprinkler system. This would be especially useful in areas where developers utilize high-density cluster development, which often results in little landscape area.

An example of state initiative is CALGreen, formerly known as the California Green Building Standards Code adopted in 2007, which is the first state-mandated green building code in the U.S. (California Building Standards Commission, n.d.). It was enacted to address five divisions of building construction: planning and design, energy efficiency, water efficiency and conservation, material conservation and resource efficiency, and environmental quality (California Department of Housing and Community Development, n.d.). Since 2019 the CALGreen code requires that all residential development outdoor landscape irrigation areas must adhere to California's MWELO (VCA Green 2019).

As previously noted, new development is at least spatially associated with agricultural landscape changes (Li, Endter-Wada, and Li 2019), with increasing urbanization decreasing the stability and affecting the structure of agricultural landscapes (Daniels 1999; Li, Endter-Wada, and Li 2019). One strategy to protect greenspace is the use of conservation subdivisions, which involve revising codes to require that conservation principles be combined with zoning ordinances to protect greenspace in an interconnected network of conservation lands (Arendt 2004). Often this approach results in cluster development, or high density lots, with common open space. High density lots result in water savings over the long term (Blanchard 2018), with Envision Utah planners determining that per capita water demand drops by about half when switching from two housing units per acre to about 5 housing units per acre (Environmental Protection Agency). However, conservation subdivisions should be specifically designed to protect and restore biodiversity and ecosystem services, since simply increasing housing density and designating open space may be insufficient (Carter 2009). Wenger and Fowler (2001) suggest a classification for what lands can, or must, be included open space. Primary Conservation Lands must be included since they are of high environmental or historic value. Secondary Conservation Lands can be designated as areas that should be preserved whenever possible, or to the extent feasible.

A few of their suggestions are listed in Table 18.

Table 18: Selection of Primary and Secondary Conservation Areas as Recommended by Wenger and Fowler (2001, 29)

Primary Conservation Areas
Riparian zones of at least 75 ft width along all perennial and intermittent streams
Slopes above 25% of at least 5000 square feet contiguous area
Wetlands that meet the definition used by the Army Corps of Engineers pursuant to the Clean Water Act
Secondary Conservation Areas
Existing healthy, native forests of at least one contiguous area
Prime agricultural lands of at least five acres contiguous area
Existing trails that connect the tract to neighboring areas

Wenger and Fowler (2001, 5) describe the Georgia Community Greenspace Program as a method to provide "seed funding to help local governments in the rapidly growing areas of the state to permanently protect 20% of their land as greenspace… Not all open space qualifies under the Greenspace Program. Lands must be undeveloped or agricultural, and active recreational facilities such as ball fields and golf courses are specifically excluded."

Major resources on this BP are listed in Table 19.

Table 19: Major Resources on Rules for New Construction and Landscape Renovations

Arendt, Randall. 1999. *Growing Greener: Putting Conservation into Local Plans and Ordinances*. Washington, D.C.: Island Press.
Blanchard, J. C. N. (lead author and editor). 2018. *Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners.* Prepared by Land Use Law Center for Western Resource Advocates. *Available at:* https://westernresourceadvocates.org/publications/integrating-water-efficiency-into-land-use-planning/
Colorado WaterWise, & Aquacraft, Inc. 2010. *Guidebook of Best Practices for Municipal Water Conservation in Colorado. Available at*: http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
Environmental Protection Agency. 2006. *Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies*.
Fedak, Rebecca, Shelby Sommer, Derek Hannon, Russ Sands, Drew Beckwit, Amelia Nuding, and Linda Stitzer. 2018. *Coordinated Planning Guide: A How-To Resource for Integrating Alternative Water Supply and Land Use Planning*. United States of America: Water Research Foundation.
Morris, Marya. 2009. *Smart Codes: Model Land-development Regulations*. American Planning Association.

POLICY DESIGN OF BEST PRACTICES

Policy Design Theory

The policy design theory of Schneider and Ingram (1997) focuses on how policies are designed and implemented. The authors emphasize the need to understand the societal and issue contexts within which policies arise, and the ways they are framed and conveyed to citizens. Schneider and Ingram explain how public policies have underlying patterns and logic. The ideas embedded in policies have real consequences as citizens experience them through the translation dynamics of messages, lessons, interpretations, conceptions of government and the role of citizens, and through participation patterns that occur during implementation. Schneider and Ingram further emphasize the iterative and dynamic process of framing, designing, and translating policies over time (Figure 4).

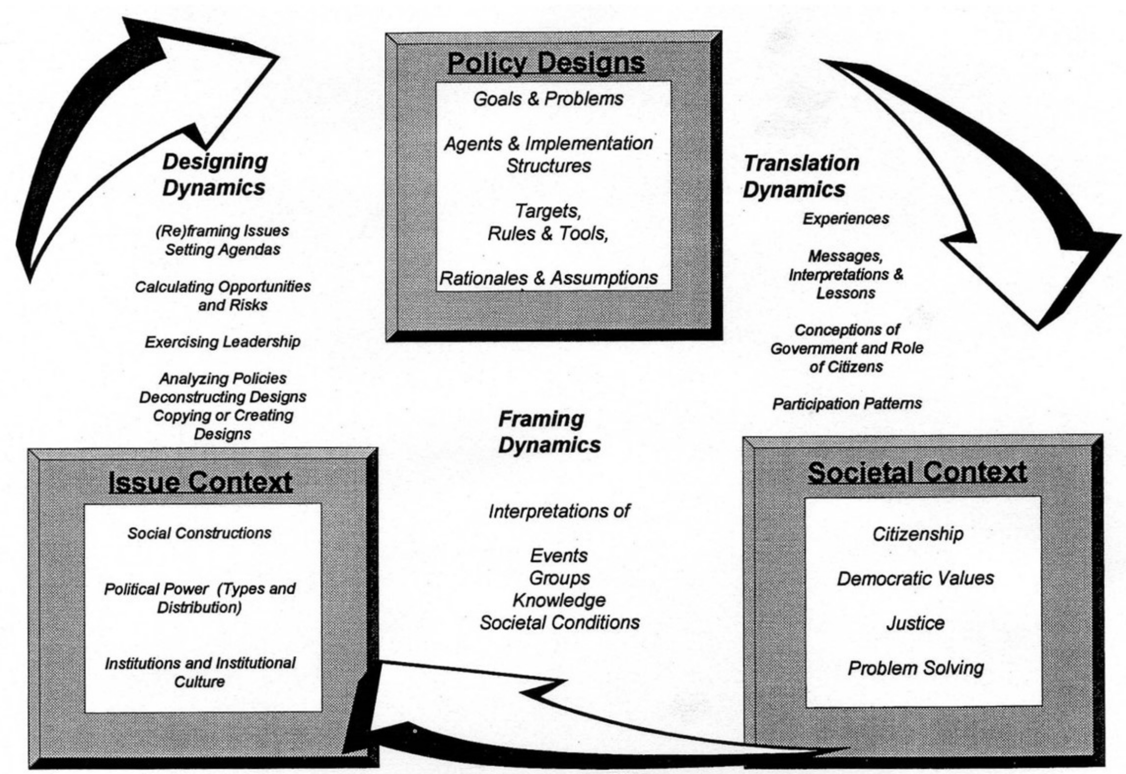

Figure 4: Reproduction of Figure 4.1 from Schneider and Ingram (1997, 74) showing causal portrayal of how characteristics of the policy context become embedded in policy designs and subsequently have effects on democratic values that reproduce or transform the context.

For reasons carefully examined in Schneider and Ingram's work, administrators and managers need to be judicious in choosing, designing, and implementing best practices. Recognition of the fact that policies evolve and help to shape future societal and issue contexts means administrators and managers must also understand that policies will require flexibility and adaptability over time. Consequently, research, documentation, and evaluation of the effectiveness of urban water conservation policies and programs is an important part of implementation. One strategy to achieve this goal is funding efforts to evaluate programs and policies and adding those evaluations to open databases, such as Western Resource Advocates (2019).

For our purposes here, we focus on the top box in Figure 4, which specifies several key elements of policy designs. Schneider and Ingram (1997) contend that policy designs should account for target populations (who receives benefits and burdens), goals or problems to be solved (values to be distributed), agents and implementation structures, rules (that guide or constrain action), rationales (that explain or legitimize the policy), and assumptions (the logical connections that tie the other elements together).

Policy Design Elements for Urban Water Conservation BPs

In Table 20, we summarize the policy design elements listed above for each of the urban water conservation BPs that were covered in the preceding section. This analysis illustrates the considerations that need to go into designing effective BPs. Since policy designs must fit the contexts in which they will be implemented, more detailed analysis and debate would be needed to shape the specific design features for each location and for specific strategies. For example, a municipality, such as Eagle Mountain City (EMC), Utah, would define their policy design elements more specifically, tailoring their strategies to meet their particular context. As noted in the guidebooks and literature we reviewed, communities generally need a suite of BPs to have an effective approach to conservation. Table 20 also illustrates why that is so; individual BPs may target different groups or address different problems, while a suite of BPs provides for a more equitable, community-based approach to conservation.

In the following Table 21, we take Table 20 a step further by defining one possible strategy (out of many) EMC could implement, or is already utilizing, to address each of the BPs covered in this chapter. In 2018, EMC and CWEL began collaboration to identify water users within the municipality who have the capacity to conserve water on their landscapes by utilizing GIS software and water billing information to determine which water users were allocating more water than their landscapes need. Another partner, USU Extension, offers and provides water audits to those customers. This is one strategy addressing *BP1: Landscape water budgets, information, and customer feedback*. For *BP2: Minimum training requirements and certification of landscape professionals*, EMC has the option to advocate, or require, that water users contract with professional landscapers who are certified by associations such as QWEL or the Irrigation Association. These efforts could be focused on developers and new home owners to promote proper landscape infrastructure for long-term water savings. For *BP 3: Water-efficient landscape design, installation, and maintenance practices*, EMC could adopt municipal landscaping regulations similar to those of Westminster, Colorado. This could be enforced by inspections upon observed violations only. Eagle Mountain City can utilize their existing pre-occupancy inspections, adding the step to check that landscape and irrigation systems meet municipal landscaping regulations to address *BP 4: Rules for new construction and landscape renovation*.

Table 20: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP1: Landscape water budgets, information, and customer feedback	- Water users of any sector may be required to irrigate within a budget. - Of note, developers may be required to construct new development within a given water budget.	- Goal is to eliminate excessive landscape irrigation. - Problem is lack of actionable information available to water users.	- Local planners or utility managers utilize a budget calculation and customer accounts to compare metered water use to legitimate landscape water need. - May or may not be incorporated into a rate structure.	- Water budgets are typically calculated from the landscape size and the water requirement of the plants in the landscape. - Metered water use is essential.	- Many irrigators are unaware of whether they are irrigating efficiently or have the capacity to conserve. - Protects the water utility from overuse. - Protects the water user from high water bills or having water reallocated or micromanaged.	- Planners and utility managers have sound data and software through which to conduct analysis and to justify and implement enforcement.
BP2: Minimum training requirements and certification of landscape professionals	- Landscape professionals and contractors must obtain proper certification. - Option to require certification of DIYselfers. -All future homeowners of landscape benefit.	- Goal is to ensure proper design and installation of landscape and irrigation systems - Problem is to maximize long-term water efficiency.	- Local ordinances and codes and the specification of training requirements.	- Must confirm proper jurisdiction since enactment could necessitate approval of city or county government for some code provisions.	- Trained and certified professionals are most capable of ensuring landscapes and irrigation systems meet mandated standards.	- Institutions have funding, resources for enforcement, and will help public find certified professionals. - Political environment supports the certification of contractors.

Table 20: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP3: Water-efficient landscape design, installation, and maintenance practices	- Depending on how the policy is crafted, developers, landscape professionals, HOAs, and/or DIYselfers are all examples of who will bear the burden of ensuring landscapes and irrigation systems meet municipal or state standards.	- Goal is to guide development and landscape remodels to be more water efficient. - Problem is to maximize long-term water efficiency.	- Local planners integrate water efficiency strategies and methods into municipal plans and regulations. - States may adopt model water efficient landscape ordinance.	- Local planners should act within the confines of their comprehensive plan or state requirements. - Case studies of municipal and state innovation and guidelines toward effective policies are available.	- Landscape irrigation tends to account for more than half of all outdoor water use. - A systems approach of proper design, installation, and maintenance is key to maximizing landscape and irrigation system water efficiency.	- There is tremendous variability in costs depending on what work is done, by whom, and the condition of existing landscape. - Utilities have the resources to enforce regulations.
BP4: Rules for new construction and landscape renovation	- Developers of new construction and those renovating existing landscapes bear the brunt of regulations. - Occupants will benefit from reduced water bills.	- Goal is to maximize long-term water efficiency through installation of proper infrastructure - Problem is ensuring this happens at the onset of development and at key points in time (i.e., remodels) of existing development.	- Local planners utilize the comprehensive plan, other land use documents, and building and plumbing codes.	- Local planners should act within the confines of their comprehensive plan or state requirements.	- Helps delay or negate the need for new water supplies in rapidly growing communities.	- Municipalities have the resources to enforce rules and regulations.

Table 21: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation in Eagle Mountain City (EMC), Utah

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP1: Landscape water budgets, information, and customer feedback EMC: - Analyze water consumer landscape irrigation need versus amount of water applied. - Provide water audits to consumers with excessive water use.	- Water consumers from residential, commercial, industrial, and institutional (CII) sectors. - Landscapes within EMC jurisdiction (such as city parks) would also be monitored.	- Goal is to eliminate excessive landscape irrigation. - Problem is water users often do not know the water needs of their landscape	- EMC planners and water utility managers partner with CWEL to utilize a budget calculation and customer accounts to compare metered water use to legitimate landscape water need. Partnerships with USU Extension to provide water audits to excessive consumers.	- The irrigation need is calculated using the landscape size and the water requirement of the plants in the landscape. - Metered water use specific to each consumer, available from billing, is essential.	- Many irrigators are unaware of whether they are irrigating efficiently or have the capacity to conserve. - Protects the water utility from overuse. - Protects the water user from high water bills or having water reallocated or micromanaged.	- EMC planners and utility managers have sound data and software through which to conduct analysis, via municipal resources or those from partnerships, and resources to conduct analysis and provide follow-up. - City leaders are supportive of these efforts to conserve water.

Table 21: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP2: Minimum training requirements and certification of landscape professionals EMC: recommend water users and developers hire landscaping professionals with training and certification (such as QWEL or Irrigation Association) for new landscapes and irrigation systems or renovations.	- The landscape professionals who design, and install landscapes and irrigation systems for water users within EMC's jurisdiction. - The water users within EMC's jurisdiction who are hiring landscape professionals.	- Goal is to facilitate proper design and installation of landscape and irrigation systems to maximize long-term water efficiency. - Problem is the long-term outdoor water waste that results from poorly designed, installed, and maintained irrigation systems and the need for professional training.	- EMC advocacy for certified professionals via city newsletters, new resident brochures, and online methods.	- Should fairly advocate various respected certification programs. - EMC could consult with municipal attorney to ensure adopted policies meet legal requirements.	- Proper design, installation, and maintenance of landscapes and irrigation systems are key to landscape water conservation. - Persistent problems from improper landscape and irrigation system design and installation suggest additional regulation (here, advocacy) is warranted.	- EMC has funding and resources for effective advocacy to help public find certified professionals.

Table 21: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP3: Water-efficient landscape design, installation, and maintenance practices EMC: Adopt municipal landscaping regulations (e.g., Westminster, Colorado)	- Anyone (e.g. developers, landscape professionals, HOAs, and DIYselfers) installing or renovating landscape or irrigation systems will bear the burden of abiding by municipal regulations.	- Goal is to guide landscape and irrigation development and renovations to be more water efficient. - Problem is the long-term outdoor water waste that results from poorly designed, installed, and maintained irrigation systems and need for educating water users and professionals.	- The EMC city council adopts municipal landscape regulations incorporating water efficiency strategies and methods. These are often prepared by city planners or consultants. While not incorporated into city code, they are still enforceable by EMC.	- EMC planners should act within the confines of their general plan or state requirements.	- Landscape irrigation tends to account for more than half of all outdoor water use. - A systems approach of proper design, installation, and maintenance is key to maximizing landscape and irrigation system water efficiency. - Including renovations will result in older landscapes conforming to water-efficient standards over time.	- EMC has a general (comprehensive) plan supporting the use of water-efficient strategies and methods for landscaping. - EMC has a city council willing to adopt municipal landscaping regulations - EMC has the resources to enforce regulations (may choose to do inspections upon observed violations).

Table 21: Policy Design Elements Related to this Chapter's Four BPs for Urban Landscape Water Conservation in Eagle Mountain City (EMC), Utah (continued)

Policy Design	*Target Populations*	*Goals to achieve or problems to be solved*	*Agents and implementation structures*	*Rules (to guide or constrain action)*	*Rationales*	*Assumptions*
BP4: Rules for new construction and landscape renovation EMC: Conduct pre-occupancy inspections that include checking that the landscape and irrigation system meet municipal landscaping regulations.	- Developers of new construction bear the brunt of regulations. - Occupants will benefit from reduced water bills and properly designed and installed landscapes.	- Goal is to maximize water efficiency over the long-term through installation of proper infrastructure at the onset of development. - Problem is dealing with very rapid growth and many different developers	- EMC planners add landscape inspection to the pre-occupancy inspection checklist and utilize their general plan, other land use documents, and building, plumbing and landscaping codes to ensure landscapes meet city standards.	- EMC planners should act within the confines of their general (comprehensive) plan or state requirements.	- Landscape irrigation tends to account for more than half of all outdoor water use. - Helps delay or negate the need for new water supplies in rapidly growing communities.	- EMC has the resources to add landscape inspections to pre-occupancy inspections and enforce city rules and regulations.

Translation Dynamics of New Construction vs Renovation of Existing Landscapes

The ideas embedded in water and land use policies have real consequences as citizens experience them through translation dynamics such as messages, conceptions of government and the role of citizens, and participation patterns that occur during implementation. Older policies or social norms that bolstered the importance of lush, green landscapes and plentiful water at low cost have reinforced expectations of use over time. However, this can change. National fixture standards mandated higher efficiency expectations for new buildings or construction, the market followed, and older buildings were "grandfathered" into code compliance at the point of fixture replacement or remodels. Municipalities should follow suit by mandating higher expectations for new development, and grandfathering existing landscapes by requiring landscape and irrigation system renovations to meet code as well.

Designing Dynamics of Calculating Opportunities and Risks

To help facilitate adoption of new urban growth and water demand management strategies, governments should provide clear organizational roles and regulatory predictability. Lane et al. (2017) studied two cases of municipal innovations in stormwater capture, and found that "clarification of the regulatory environment can enable, or facilitate, the wider uptake of innovation by providing legal and financial certainty, guiding decision-making and ensuring that risk is allocated to appropriate parties. This is particularly significant for the private sector which needs to be able to frame project costs in terms of risk" (46). By providing and enforcing specific and detailed construction codes and inspections, municipalities level the playing field for developers and landscaping professionals so they can compete fairly, as well as protecting consumers by ensuring houses and landscape and irrigation infrastructure are built to similar standards.

Such regulations protect against substandard development experienced by rapidly developing communities. Examples of poor workmanship in Utah are found even in the lauded master-planned community of Daybreak, where three HOAs are suing on behalf of more than 650 townhomes (Morgan 2017). Municipalities could further empower and protect homebuyers by directing conservation coordinators to provide homebuyers with information explaining how they can obtain properly designed, installed, and maintained landscape and irrigation systems, or by requiring developers to offer clients various water-efficient landscape and irrigation system plans with the option to have them installed prior to move in.

Municipalities should also consider the equitability of requiring one group of constituents to conform to certain standards (hiring only qualified and certified professionals) and not another. Research is scarce concerning the extent to which DIYselfers renovate their own landscape and irrigation systems, and even what percentage of general populations do their own landscape and irrigation work. We call for researchers to fill in those gaps. We also suggest that municipalities ensure DIYselfers are either qualified to do their own work, require DIYselfers to complete their own qualification program (not necessarily professional, but with access to professionals) or a consultation with a professional, or pass equivalents to building codes and require that work meets required standards irrespective of professional or program qualifications. Alternatively, municipalities could address equity among water users by mandating water users stay within customized water budgets, ensuring the utility is not taken advantage of, and the customer has the freedom to use their allotment as they wish. This approach addresses equity among water users and enables water users to exercise their own choices while operating within fair water allocations.

Issue Context of Institutions and Institutional Culture: HOAs

Regulatory roles and capabilities are also affected by the distribution of power among institutions and across governmental scales. Prior research has examined the inadvertent effects of policy actions that create differences between standards across factories or regions (Felder and Rutherford 1993; Fowlie 2009) and nested state and federal regulation (Goulder and Stavins 2011). Differences between regulations affecting urban water demand at the local level can occur between HOAs and municipalities as the former "can influence mandated water conservation strategies with post-construction landscape controls and amendments of covenants, conditions, and restrictions (hereinafter 'CC&Rs')" (Dyckman 2008, 18). Several states and municipalities have banned HOAs from restricting water conservation, though outdated CC&Rs and the expectations they created indirectly discourage those efforts. HOAs are an important consideration in rapidly growing communities, especially as "most major developers now employ covenants and HOAs to protect phased development" (Dyckman 2008, 23). In Utah, the Community Associations Institute estimates that 680,000 Utahns reside in association-governed communities (Egan 2018).

Though municipalities may struggle to have sufficient funding or personnel to enforce conservation practices, HOAs are able to contractually enforce (or not) or negate mandated conservation practices. Dyckman (2008) found that, though HOAs have traditionally inhibited water conservation efforts, certain governmental approaches could facilitate HOA water conservation. However, there are nuances between how municipalities can regulate existing versus new HOAs. Dyckman (2008) argues that "regulation is still a viable government tool…to activate water conservation efforts through new HOAs" since actual water savings can be achieved if conservation measures are implemented in the development process and within the developer's original CC&Rs (p. 49). She cautions "these measures may not have an immediate demand from homebuyers…so government regulation manufactures developer incentive" (p. 49). Retrofitting costs alone can justify this regulation. Another option may be to mandate that HOA developments reserve automatic irrigation systems for large common areas and utilize manual irrigation systems in small yards, as landscapes with manual irrigation systems tend to use less water than those with automatic systems. Wentz et al. (2019) argue that HOA landscaping regulations, by setting maximum rather than minimum vegetation regulations in the CC&Rs and enforcing them, could potentially reduce peak-season water use by up to 24%.

Existing HOAs are in a context requiring different conservation strategies. Dyckman (2008) reports that "the practical ability to locate the CC&Rs and to legally influence them through state legislation or local ordinances may be moot because…water use and conservation restrictions are rarely included in CC&Rs" (40). Additional challenges include an inability to locate HOAs for enforcement, the contractual relationship between landscape managers and the HOA are outside the CC&Rs, and legacy effects from the developer in built form, influence conservation efforts. For example, if a developer doesn't install individual meters for each structure, water billing conservation strategies are inhibited. However, HOAs are receptive to water conservation, especially when efforts result in cost savings and the landscape aesthetic is not compromised. Dyckman (2008) found that existing HOAs preferred to choose conservation measures appropriate to their respective HOAs, favoring education and incentive tools, and were receptive to utilizing city conservation services. However, with sufficient political support for more regulatory approaches, Dyckman (2008) recommends that cities could mandate conservation measures if states passed reporting requirement amendments of both HOA CC&Rs and rules and regulations, as well as mandating and funding state and city-level review for compliance. The city and/or state would also need to implement legislation mandating conservation applicable outside of drought, both in common areas and individual lots. Blanchard (2018, 229) details an agreement between a development project, Alamo Creek in Danville, California, and the East Bay Municipal Utility District (EBMUD), in which the EBMUD required zero-net impact with two gallons of water saved for each gallon used. To ensure permanent onsite conservation, the developer prepared a set of CC&Rs, indicating that "each water meter has a water budget based on the type of connection, building size, and lot size," along with enforcement strategies.

CONCLUSION

Schneider and Ingram (1997) state political power is a key contextual characteristic; one aspect is the power to make policy decisions, and therefore, decide issues directly. Governmental policy sets the foundation for equity among the many different decisionmakers involved in land use and water supply (i.e., policymakers, governmental leaders, planners, water utilities, landscaping and irrigation professionals, developers, HOAs, water users). A lot of people make decisions; therefore, standards should be set so that decision-makers are working together to achieve long-term water efficiencies in landscape and irrigation systems as well as water-smart growth. The BPs described in this paper may help achieve that vision.

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CHAPTER IV

CONCLUSION

As water supplies become increasingly scarce and unpredictable in the western United States (U.S.), demand-side water management strategies are essential to stretch available water supplies in order to delay or negate the need to develop costly additional water supplies in the face of rapidly developing western communities. Best Practices (BPs) in conservation are increasingly important to facilitate decision-making in choosing which strategies municipal planners and water managers should employ in order to maximize both water and financial efficiencies.

This thesis uses policy analysis to review and summarize various BPs using both academic and implementation literature. We conducted a preliminary literature and guidebook review to determine which BPs were most commonly recommended and had the most supporting evidence for their effectiveness. We break 11 BPs into two groups for discussion in chapters 2 and 3. We emphasize that the BPs are different policy designs comprising varying target populations, goals to be achieved or problems to be solved, agents and implementation structures, rules, rationales, and assumptions. As such, the BPs are best utilized in combination as a suite of tools and designed for the specific contexts in which they will be implemented. Such a strategy will maximize water efficiencies and likely increase the savings resulting from one or two strategies.

Seven foundational BPs are discussed in Chapter 3 that are essential for any municipality's water conservation toolkit. We call for more thorough data and program evaluation for these BPs. Such information would facilitate better understanding of how local governments can modify and implement these more generally-defined BPs to best suit their specific contexts. Thus, we support other researchers in calling for more data and program analysis, but add the need for attention to the specific design of BPs and their use in particular and varying contexts for better evaluation of implementation. We also note the particular mandate in prior appropriation water law that water is applied towards beneficial use. Not only does it make logical sense for utilities to recover lost utility water and address water waste in their municipal jurisdiction, but it may also become a legal imperative as water supplies get further stretched. Municipalities should also take steps to ensure that conserved water is directed towards a variety of socially appropriate uses rather than necessarily having the savings directed towards other consumptive uses.

Utah's historical and geographical context provides both unique and comparable insights for urban growth and water demand management in the U.S. West. Settlement of Utah in the 1800s by pioneers of the Church of Jesus Christ of Latter-day Saints was initially limited to areas easily accessible by water infrastructure, yet growth even in times of rapid population expansion was initially directed in ways conforming to modern smart-growth principles. Since then, urban development in the Wasatch Range Metropolitan areas has expanded into Utah's arid unirrigated agricultural lands, where governmental leaders and policy makers have the opportunity to direct current and future growth toward water-smart strategies to maximize water efficiency over the long-term before infrastructure is "baked in." Best practices facilitating the golden trifecta of proper design, installation, and maintenance of landscape and irrigation systems are reviewed and evaluated. These BPs could be the outdoor water efficiency standard equivalents of the indoor fixture efficiency standards that have reduced per capita water use across the nation.

As discussed in the second and third chapters, according to Schneider and Ingram's (1997) policy design for democracy, the various contexts in which water and land use policies are embedded impact citizens through translation dynamics such as messages, conceptions of government and the role of citizens, and participation patterns that occur during implementation. Older policies or social norms that fostered the importance of lush, green landscapes and expectations for plentiful water at low cost have reinforced these perceptions of use over time. However, this can change. National fixture efficiency standards mandated higher expectations for new buildings or construction, the market followed, and older buildings were "grandfathered" into code compliance at the point of fixture replacement or remodels. Municipalities should follow suit by mandating higher expectations for new development and grandfathering existing landscapes, but require landscape and irrigation system upgrades to meet newer code at points in time when people renovate. Encouraging upgrades through voluntary participation in a variety of programs as covered in Chapter 2 should be an ongoing effort.

As discussed in the third chapter, municipalities may further consider equity in policies by requiring both professionals and homeowners to have requisite qualifications or information for designing, installing, and maintaining landscape and irrigation systems. While homeowners may not need industry or third-party certifications, municipalities may want to consider requiring participation in programs or consultations to ensure DIYselfer landscapes meet codes and regulations. Another option could be requiring inspections to ensure landscape installations or renovations by both professionals and homeowners meet code. Alternatively, water budgets are one way to mandate that all water users use their appropriate allotment while allowing water users the freedom to allocate their water as they wish.

The risks and costs developers must undertake in order to maximize water efficiencies should also be accounted for. Municipalities can provide equitable treatment to developers and landscape professionals and level the private industry playing field by mandating or incentivizing use of BPs. Clarification and stability in the regulatory environment can provide legal and financial certainty, helpful guidelines, and risk transparency so the private sector can feel confident in pursuing water-smart innovation and investment decisions.

There are many decision-makers involved in the land and water use nexus. Governmental policy sets a foundation for all stakeholders to abide by, and standards should be set so that decision-makers are operating in concert with each other to achieve long-term water efficiency and water-smart growth goals.