Water Conservation Planning: Developing a Strategic Plan for Socially Acceptable Demand Control Programs

By

Samuel Helmle

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Faculty Approval:

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Dr. Patricia M. Shields

____
Ana Liza Garza

Table of Contents

Chapter 1: Introduction

Purpose

Water is essential for human life. A reliable supply of clean fresh water is essential to the life of a modern city. Finding, developing, and delivering the clean water needed by a city for support of population growth and economic development is the main function of water planning and supply agencies.

In the introduction to *Cadillac Desert*, Marc Reisner describes the appearance of the American west as seen from the air. He writes about the arid landscape and the fact that settlements in this region are few and far between. The natural weather patterns, in most of the land west of the 100th meridian, are too dry to support life. Reisner (1993, p.3) says that:

> Everything depends on the manipulation of water-- on capturing it behind dams, storing it, and rerouting it in concrete rivers over distances of hundreds of miles. Were it not for a century and a half of messianic effort toward that end, the West as we know it would not exist[1].

The Edwards Aquifer region of central Texas is located at the edge of the region Reisner describes as too dry to support life[2]. San Antonio is a large population center in this semiarid to arid region. The San Antonio metropolitan area reportedly has a total population of 1.7 million people and is one of the

[1] Reisner describes the inhospitable conditions and the fact that the western part of the country could not support life in present numbers if not for water projects.

[2] San Antonio area is located at 98˚ west longitude. This area is described is Goode's World Atlas as being in a transition zone between a Middle Latitude Desert and a Humid Subtropical Region. The region is semi arid to arid. Areas east of San Antonio generally get 20-40 inches of rainfall annually while areas west of San Antonio typically receive only 10-20 inches of precipitation. The ecoregion is classified as a Tropical/ Subtropical Steppe Province

fastest growing regions in the country.[3] Present projections indicate that the San Antonio region population is expected to double by the year 2050.[4] The sole source of water for the population of the city of San Antonio is the Edwards Aquifer, a large underground structure, and the city of San Antonio is the largest metropolitan area in the world that depends on a sole source of groundwater for its water supply.

The importance of water has led to a fragmented political atmosphere relating to control of this resource. Access to water resources has been limited by legal action and by federal, state, and regional regulation. Limitation on pumpage or access to water resources can determine the economic viability of entire regions. Many regions, such as the Edwards Aquifer region, currently find water in short supply and face ongoing challenges providing adequate supply to meet current and future demand. Permanent and comprehensive conservation programs emerge as a very important method of controlling water demand and extending the life of the water supply.

Organization

The research is divided into the following chapters to better focus attention on the problem and possible solutions:

- **Chapter 2: Setting:** The purpose of the setting chapter is to examine the literature about water supplies in the San Antonio region of central Texas to provide insight into the importance of water resources for the

[3] The San Antonio metro area is ranked 29th in the nation with a total population of 1,711,703 in the 2000 census and has a growth rate of 21.6%.
[4] SCTRWP population projections based on US Census Bureau data and contained in Table2-2 of the plan.

development of major population centers. This chapter investigates the types of information that water management agencies need to consider when developing water management plans. The goal of this chapter is to organize information from many different sources into a brief summary of the physical, historic, and legal conditions that exist in central Texas. Understanding the diverse interests and difficulties managing water resources in this region may provide some insight into general management principles.

- **Chapter 3: Literature Review:** The purpose of the literature review is to examine relevant literature about conservation planning and demand control, develop ideal type categories, and create a set of questions that can be used by water system planning groups to focus discussion when developing demand control programs. This literature emanates from many sources: government documents, legislation, court rulings, interest group literature and press releases, planning agency documents, books, and scholarly studies. One common thread running through all of these documents is discussion of the importance of water for human health and economic development.
- **Chapter 4: Methodology:** The questions developed from the literature review were submitted to a group of water management professionals to test the validity and usefulness of this model in real world situations. The population of water system managers is very small and a sample of these professionals was drawn using purposive and snowball sampling.

- **Chapter 5: Results:** The results chapter examines data gathered by distributing the developed questions to water resource management professionals and interviewing these people to determine the validity of the model developed by this research.
- **Chapter 6: Conclusion:** Many small water management groups, both privately owned and government-owned, have very small management teams. This research provides a useful tool for small water system managers. This research develops some interesting management questions about the social acceptability of policy formulation that could be explored in the future.

Research Purpose

The purpose of this research is to develop a set of questions that water supply agencies can use to determine the need for demand controls in their region and to explore the impact demand controls might have on area residents. The research examines water resource issues surrounding the Edwards Aquifer and the San Antonio area, since there has been a great deal of study about the hydrologic and atmospheric conditions in the region. The research also examines water supply and demand issues from many other regions worldwide to gain perspective and broaden understanding of the challenges faced by water supply agencies. Many water supply agencies are very small with limited resources available for investigating supply and demand options. This study is developed to assist small water supply groups focus attention on the issue of demand controls and develop policy that will be locally acceptable and ultimately successful.

Chapter 2: Setting

Purpose

The purpose of the setting chapter is to explain how the legal, regulatory, and physical environments can affect water system management and planning. To attempt to understand the dynamic anthropomorphic and geomorphic processes involved, this study examines literature about water supplies in the San Antonio region of central Texas. This brief case study provides insight into the types of information that water management agencies need to consider when developing water management plans. The goal of this chapter is to organize information from many different sources into a brief summary of the physical, historic, and legal conditions that exist in central Texas.

Our democratic form of government has encouraged the creation of many political subdivisions. The importance of water to human survival and economic development has created competing interests at many levels. The long history of controversy surrounding the use and apportionment of the Edwards Aquifer and other water resources should help water managers in this and other regions understand how competing interests influence resource management.

Background

San Antonio is one of the fastest growing regions in the country, and the city relies on the Edwards Aquifer as its sole source of water. The Edwards Aquifer is a large underground limestone (karst) structure that covers over 8000 square[5] miles and part or all of thirteen counties in central Texas (Votteler, 2004, p.260). The Edwards Aquifer is one of the largest karst[6] aquifers in the world and San Antonio is the largest city in the world[7] that uses a sole source of groundwater as its only water supply. The Edwards Aquifer is also one of the most studied and regulated water delivery systems in the country. This literature review will look at the problems with this groundwater storage structure, the legal atmosphere surrounding its use, and the complex management plans and goals for this water source. The literature will discusses projected supply shortages and the viability of demand controls and conservation programs as a means to extend the water resource.

History

San Antonio is the oldest city in Texas. It was established by Spanish missionaries along the banks of a reliable water source they named the San Antonio River. The first mission, San Antonio de Bexar, was established in 1718 and four more missions were built over the next few years. San Antonio was named the Spanish capitol of Texas in 1773 with a population of about 2000 people. The important part about the history of San Antonio is that it could not have been built without a reliable water source (Fehrenbach, 2002, p.1). The San Antonio River was fed by the San Pedro Springs, which, in turn, were fed by the Edwards Aquifer. This water source supplied the water needed by the missions to support their early agrarian society. The first recorded disputes over water in

[5] The Edwards Aquifer is a large karst groundwater formation that has a 4400 square mile contributing zone, 1500 square mile recharge zone, and 2100 square mile confined zone.
[6] A karst structure is defined as a geologic formation that is made mostly of limestone and characterized by sinks, ravines, and underground streams.
[7] San Antonio population is over 1.7 million people and the regional population is over 2.5 million.

the region were in 1731, when Canary Island settlers complained to the Spanish Governor that they were not receiving proportionate water rights (Plummer, 2000, p.19).

Physical Environment

Regional Characterization

Water is a regional problem. Goode's World Atlas helps to define the region and provides a little information about the natural processes of the area. The San Antonio area is located at 98˚ west longitude. This area is in a transition zone between a Middle Latitude Desert and a Humid Subtropical Region. The region is semi-arid to arid. Areas east of San Antonio generally get 20-40 inches of rainfall annually, while areas west of San Antonio typically receive only 10-20 inches of precipitation. The ecoregion is classified as a Tropical/ Subtropical Steppe Province. This region (see Figure 2.1) will naturally only support desert shrubs and semi-desert savanna vegetation (Hudson, 2000, pp. 14, 20, 28.).

The city of San Antonio is one of the fastest growing metropolitan statistical regions in the state. The metro area is ranked 29th in the nation with a total population of 1,711,703 in the 2000 census.[8] This represents an increase of over 300,000 since 1990 for a growth rate of 21.6%. The regional population is largely urban, and most people receive their water from municipal water supply agencies.

San Antonio is the largest population area in the Edwards Aquifer region, and San Antonio Water Systems is the largest regional water supply agency

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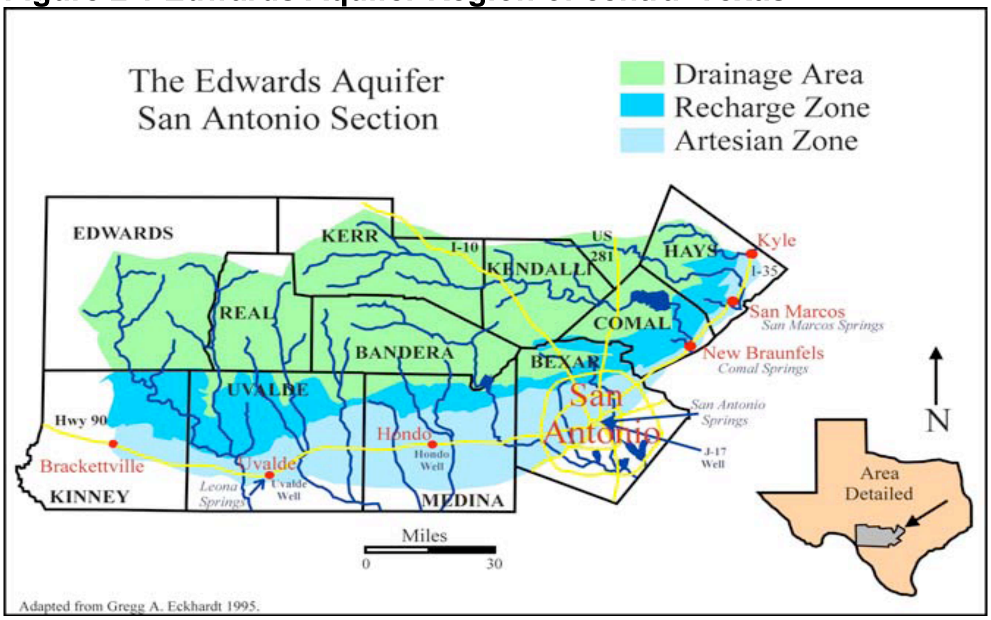
[8] Source is the United States Census Bureau.

serving over 1.14 million people.[9] San Antonio Water Systems pumped 52,690 million gallons of water in 2002 or almost 162,000 acre-feet.[10]

Figure 2.1 Edwards Aquifer Region of central Texas



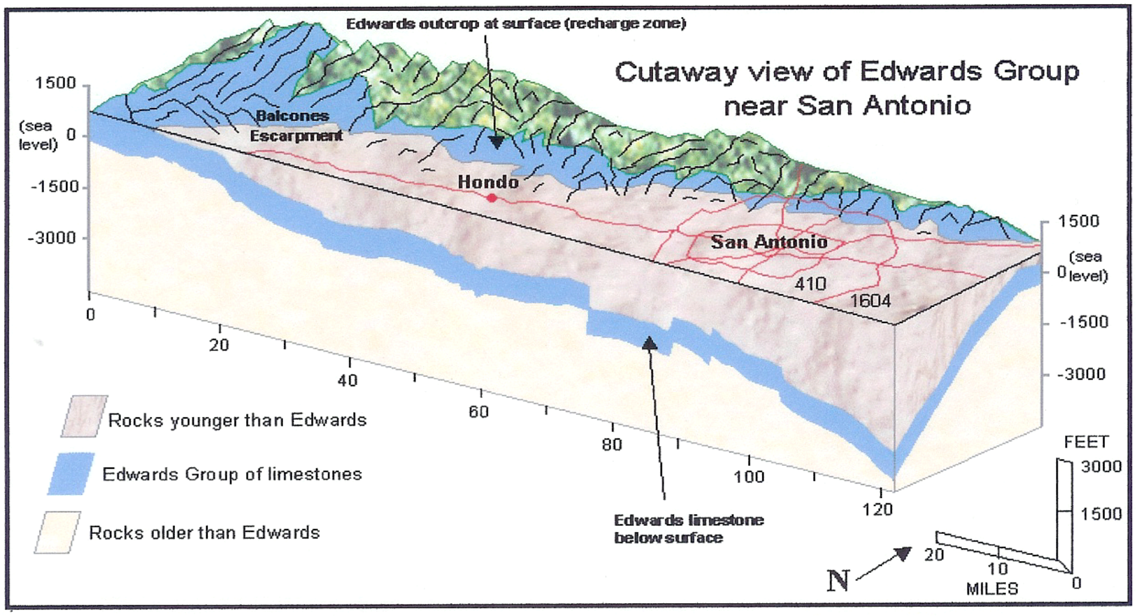
Source: Edwards Aquifer Homepage http://www.edwardsaquifer.net

Edwards Formation Characterization

The Edwards Aquifer (see Figure 2.2) is a large karst groundwater formation that has a 4400 square mile drainage area, a 1500 square mile recharge zone, and a 2100 square mile artesian zone. The Edwards Aquifer is a vast underground network of caverns, passages, and streams that carries a tremendous amount of water. The true volume of water contained in the aquifer is not known.

[9] San Antonio Water System "Water Statistics Book". 2002
[10] An acre-foot is equal to 325851.43 gallons.

Figure 2.2: The Edwards Aquifer



Source: Greg Eckhardt, Edwards Aquifer Homepage http://www.edwardsaquifer.net

Figure 2.2 provides a graphic representation of the distribution of the Edwards formation. This rock formation is about 160 miles long and as much as 40 miles wide. The rock can extend from the surface to over 3000 feet deep and can be from 300 to 700 feet thick.[11] This karst structure is made mostly of calcium carbonate and is recharged by water infiltration into the subterranean passages. Recharge of the aquifer can be accomplished by rain falling directly on the limestone outcroppings, but rivers and streams that flow into fissures and sinkholes in the rock do 70-80% of the recharge.[12] The fact that all recharge to the Edwards Aquifer is from surface water makes the entire structure susceptible to pollution from both natural processes, in the form of sedimentation (White et al. 1995) and from man-made contamination that can take many forms ranging from chemicals and household waste to petroleum spills.

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[11] Greg Eckhardt. Introduction to the Edwards Aquifer. 2004.
[12] Eckhardt. 2004. and White et al. 1995.

Figure 2.3: Edwards Formation

Source: This picture is from the 2002 Annual Report of the Edwards Aquifer Authority

Figure 2.3 is a picture of the typical structure of the rock formation taken deep within the aquifer by the Edwards Aquifer Authority. Water flow through the aquifer is mostly carried out by small honeycomb passages in the rock like the ones shown in Figure 2.3. The natural process is for the water to slowly dissolve the rock creating ever-larger passages. This highly faulted region has many large caverns and underground reservoirs. Water quality in the region is generally considered very good, although the water does carry a lot of calcium and various other minerals.

Karst structures are generally hard to delineate, as they are mostly subterranean. Water flow within the structure is equally hard to map. The Edwards Aquifer has many natural outlets, as do all karst aquifers, in the form of springs. The flow of water from the springs is vital to maintaining surface stream flow, habitat for many species of animals, and surface water rights.[13]

Legal Environment

One of the main problems with the Edwards Aquifer and other natural resources is that people cannot agree on the allocation of the resource. In the case water rights, what the earliest settlers of San Antonio called disproportionate water rights, this country has had a long history of argument over the control of the resource. The first real control measures, applied to the

[13] Votteler. 2002. San Marcos and Comal Springs contribute to the Guadalupe River and the San Marcos River. These rivers combine to create the freshwater inflow critical to marine life in San Antonio Bay and estuary.

Edwards region, came in the 1950s during what was the drought of record. Study of the boundaries and flow patterns began during the drought and the Edwards Underground Water District was formed in 1959[14] by Texas 59th Legislature. Throughout the next twenty years, there were attempts to regulate water. These efforts were mostly concerned with adequate supply and water quality. Throughout the entire period from the earliest settlement to the early 1990s, the right of capture ruled ground water allocation in Texas. The right of capture, generally called the rule of the largest well, traditionally meant that if water was under the land the owner had the absolute right to pump any amount as long as the water was not wasted.

Various legislative committees and area political leaders attempted to reach agreement about aquifer management plans during the 1980's. No real changes occurred until the Sierra Club filed a lawsuit against the Department of the Interior in 1991 claiming that that unlimited pumping from the aquifer constituted a "taking"[15] under the Endangered Species Act. The Sierra Club asked a federal judge to set pumping limits that would protect spring flow from the Comal and San Marcos Springs and protect the habitat of eight endangered species.[16]

Federal Judge Bunton decided for the Sierra Club February in 1993 and ordered that the spring flow from Comal and San Marcos Springs be maintained above 100 cubic feet per second to protect the endangered species in the springs and the river below. Judge Bunton directed the Texas Legislature to

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[14] SAWS Water Statistics Book. 2002. 1-29.
[15] EPA defines a "taking" as the loss of habitat that endangers the viability of a population.
[16] SAWS Water Statistics Book. 2002. 1-20

develop a management plan that would assure spring flow by May 1993. The result of this ruling was the creation of Senate Bill 1477. This bill created the Edwards Aquifer Authority and charged this regulatory body with management of the aquifer.[17]

The Edwards Aquifer Authority (http://www.edwardsaquifer.org) conducted hydrologic studies and gathered information, both historic and new, about the flow characteristics of the aquifer and the springs. Joe G. Moore and Todd Votteler were appointed court monitors for the aquifer to study the aquifer and recommend a comprehensive management plan. Over several years, many legal battles, and several legislative sessions, the court finally set pumping limits from the aquifer at 450,000 acre feet per year decreasing to 400,000 acre feet per year in 2008 (Votteler, 2002,p.276). There are also emergency pumping reductions required in the case of drought. All of the management plans are based on the level of the J-17 well in Bexar County reported as water level above sea level. The Comal Springs stop flowing when the level of the J-17 well reaches about 620 feet above sea level. Drastic and graduated pumping reductions are required when the J-17 level reaches 650 feet above sea level (Votteler, 2002, p.279).

Senate Bill 1, passed in 1993, established sixteen regional planning groups and required the Texas Water Development Board to coordinate the efforts of these groups to develop comprehensive regional water plans (Votteler, 2002, p.296). These plans would look at the present water use and project water

[17] Votteler. 2002. Moore. 2004. SAWS Water Statistics Book. 2002. 1-16.

demand and supply needs to the year 2050. The combined regional plans became the state water plan that was approved in 2002.

Regulatory Environment

Many federal agencies have regulatory oversight on water rights and water project development. The Environmental Protection Agency (EPA) is charged with setting guidelines that maintain water quality and protecting habitat for endangered species. The Bureau of Reclamation is charged with developing water projects for both agricultural and municipal use. The Army Corps of Engineers is charged with protecting navigable waterways and building and maintaining flood control dams (Reisner, 1993, p.173). The Army Corps of Engineers also builds water storage dams for use by management groups to develop and store water for distribution according to prior appropriations rules[18].

Several state agencies have some role in regulating water resources. The Texas Water Development Board is in charge of developing water resources and developing and administering the state water plan (TWDB).[19] The Texas Commission on Environmental Quality is charged with developing and administering plans to keep water supplies safe and wastewater treatment systems operating properly. Texas Parks and Wildlife is charged with helping maintain riparian habitat. These are only a few examples of how state agencies interject influence on local and regional water supply issues.

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[18] Under prior appropriations rules entities like cities, irrigators, and industrial concerns use historic records to determine appropriation of surface water rights.

[19] The TWDB website gives a mission statement and brief history of the board and the areas of responsibility. http://www.twdb.state.tx.us

The state of Texas has several major river systems that are partly or wholly within the borders of the state. Each of these river systems has a regulatory body that is in charge of developing and maintaining water and waste water systems in their area. One example of a river basin management group is the Lower Colorado River Authority (LCRA). This organization is a state agency that develops water plans for a huge section of central Texas. The LCRA builds and maintains wastewater treatment systems and municipal water distribution systems for many small communities throughout central Texas. River basin management groups like LCRA also take part in regional land use planning as a means of protecting the drainage basin and the water systems from possible damaging development.

The Texas Legislature divided the state of Texas into sixteen regional water-planning areas in 1993. Each regional planning group was required to develop a water management plan for regional water resources by 2002, have the plan approved by the Texas Water Development Board, and implement the plan. The South Central Texas Regional Water Planning Group,[20] or Region L, serves the central Texas area that includes the Edwards Aquifer Region. The water plan for Region L developed population projections[21], water use projections,[22] and water project development plans.[23] The water plan included

[20] South Central Texas Regional Water Plan, developed and published by the Texas Water Development Board. Austin, Texas.
[21] Population projections were developed from US Census Bureau data
[22] TWDB. Water use projections were developed from estimated historic water use. Actual water use was not measured until the mid 1990's when new regulations forced all entities with an Edwards Aquifer water well to install meters and report use.
[23] The 2002 state water plan projects that most regions of the state will be running actual water deficits by the year 2020.

conservation plans and demand control efforts as part of the comprehensive plan.

The Regional L water plan projects population in the Bexar County and San Antonio area will continue a steady increase from the present 1.7 million people to over 3 million by 2050.[24] Municipal water demand for the Bexar County region in 2000 was 306,000 acre feet. The Region L water plan projects that demand will increase to almost 532,000 acre-feet per year by 2050.[25] When all water uses are added together, municipal, industrial, mining, and electric generation, the total water demand by the year 2050 is projected to be 658,000 acre feet per year for Bexar County alone.[26] Figure 2.4 shows total water demand projections for all uses for all of Region L.

The regional water plan characterizes changes in water use that will reflect changes in the economic structure of the region. Present water use is 28% municipal and 59% agricultural. Population concentration in urban areas will modify this water use pattern significantly by 2050.[27] In 2050 almost 47% of all water use is expected to be municipal. Agricultural use is expected to decrease to only about 31% of total volume pumped.

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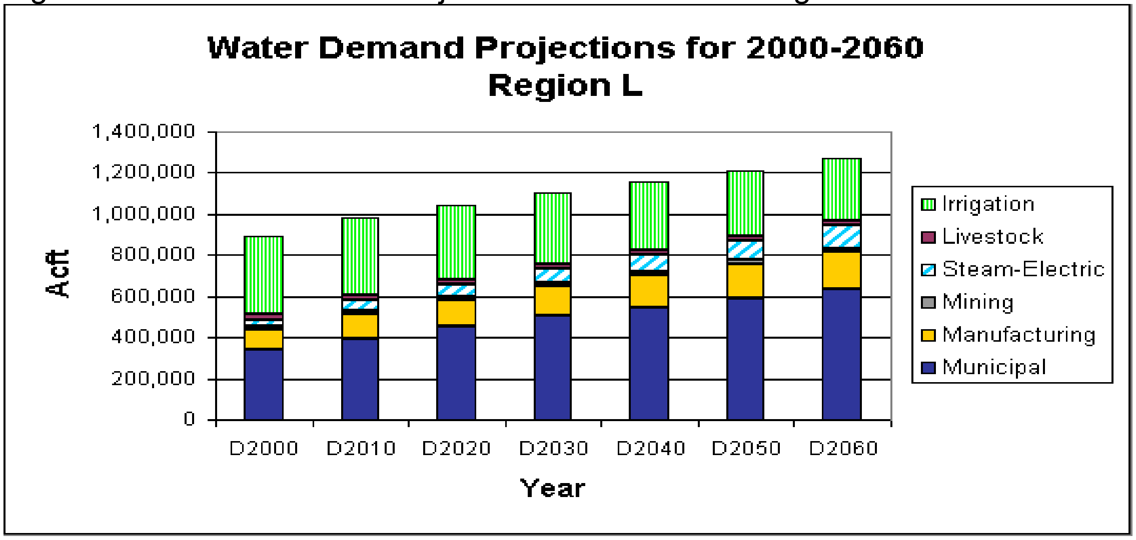
[24] TWDB. SCTRWP population projections based on US Census Bureau data and contained in Table2-2 of the plan.
[25] TWDB. SCTRWP. 2002.Table 2-4 page 2-13
[26] TWDB. SCTRWP.2002. Table 2-10 page 2-28.
[27] TWDB. SCTRWP. 2002.Table 2-11 page 2-29.

Figure 2.4: Water Demand Projections for the Texas Region L



Source: Texas Water Development Board: Region L 2002 Water Plan

Problems with water resource management in the state of Texas generally, and central Texas particularly, is instructive, but not unique. Many regions have experienced water shortages and water quality issues associated with supply and demand. The development of demand controls that the public will support is increasingly important. Many times people in charge of developing demand controls only look at the supply problem and the engineering controls needed to meet required reductions in usage. Social impact of policy should be considered as prominently as engineering controls for the development of successful programs. The remainder of this study will focus on social impact of demand control policy related to water system management.

Chapter 3: Literature Review

Purpose

The purpose of the literature review is to examine relevant literature about conservation planning and demand controls. This literature will be used to develop ideal type categories that are useful when exploring strategic planning for demand control policy. This research uses these ideal type categories to develop a set of questions that can be used by water system planning groups to focus discussion when developing demand control programs. There is fairly consistent agreement in the literature about the need to conserve water, develop new water sources to serve increasing populations, and develop demand control policy that will extend the utility of resources. The discussion of how to best achieve conservation goals usually centers on the best methods of reducing water use. This research focuses on value judgments about what our conservation goals should be and how to best achieve those goals.

Water system management and conservation is more than a local problem. The condition of water supply systems is a global concern, with previously water rich regions developing supply and conservation problems (Kallis, 2003). Each possible solution presents a new set of problems; the way local and regional water supply agencies cope with supply and demand control issues is a product of the local culture and value system. This research explores the need to develop socially acceptable policy that can achieve required use reductions so that the supply needs of a growing population can be met.

Conservation and Demand Control Defined

The terms “water conservation” and “demand control” are used liberally and sometimes interchangeably in the literature. These terms can have different meanings depending on the audience and the context in which they are used. *Webster’s Universal College Dictionary* defines conservation as the “controlled utilization or official supervision of natural resources in order to preserve or protect them or to prevent depletion”. Gifford Pinchot, considered by many to be the father of the conservation movement, defines “conservation as the use of natural resources for the greatest good of the greatest number for the longest time” (Pinchot as cited in Baumann, 1997, p.11). San Antonio Water Systems (SAWS), the largest single user of water in south central Texas, defines conservation simply as an “effort to improve water use efficiency in all areas” (SAWS Conservation Summary, p. 2). In the final analysis, Baumann maintains there is no comprehensive and easily operationalized definition of conservation that can be used or agreed on. The definition of conservation is a matter of perspective, “thus, the concept of conservation may mean reduction of use to some, development of new supplies to others, and the curtailment of certain uses of water to yet others” (Baumann, 1997, p.10). Baumann claims that one critical element left out of most constructions of “conservation” is the idea that controlling demand requires social acceptance of program goals and the cooperation of the public.

Demand controls are the methods used to increase efficiency of use and achieve the reduction of water use goals often set forth in conservation plans.

Demand controls often require changes in behavior on the part of the consumer or changes in the traditional use of water. Demand controls can take many forms from changing the type of shower head used in the house,[28] to prohibiting the use of potable water for landscape watering,[29] to disconnecting service for using more than the amount of water allotted for a given period of time.[30] Demand controls can be gently urged through educational programs or required by force of law in the case of declared emergencies such as drought.

This research will develop five practical ideal categories that water supply agencies can use to spur discussion about the planning process required for developing water conservation plans for municipal water systems.

Ideal Type Categories

The ideal type categories developed below are general areas for discussion. Water conservation is a very pragmatic exercise, and these categories should be used as a starting place to spur discussion, not as a complete model. Table 3.3 shows the five practical ideal type categories used in this study and provides references to relevant literature. The five ideal categories are **"vision statement and goals"**, **"legal environment"**, **"regulatory environment"**, **"physical environment"**, and **"demand controls"**.

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[28] The use of low flow appliances, like showerheads and toilets, is recommended as a primary way to reduce indoor water use in the Texas State Water Plan for 2002.

[29] Landscape watering is the largest single use of water for most water supply agencies in the western United States. The use of gray water or treated sewage for landscape watering is being used to reduce use of potable water in the landscape.

[30] The city of Colorado Springs, Colorado, in 2004, was in the 5th year of a severe drought and reduced water consumption by 50% in 1 year by limiting new service connections and disconnecting users who did not comply with strict demand controls.

Understanding information contained in each of these categories is important to developing an effective and socially acceptable conservation program.

Vision Statement and Goals

A properly written vision statement according to Mark Brown (Brown, 1998, p.18) "is future-focused, and defines what you want to become in the next three to ten years". The vision statement should be short and easy to understand. The vision statement should be free of jargon and should set out objective goals that are easily measured so you know when the goals are attained. The creation of a vision statement can be viewed as an exercise in problem solving. The problem, in this case, is creating a socially acceptable conservation program. The process of creating the vision statement should define the organizational goals and help create a standard and a time frame for completion[31]. Victor Cascella (2002,p.64) stipulates "the only way a business can ensure ongoing alignment between the improvements it makes and the goals it hopes to achieve is by measuring how well its processes are performing relative to its strategy".

Brown (1998,p18) points out that only "54% of all companies and government organizations have developed vision statements" and that "75% of these vision statements are poorly written and fail to provide a clear vision of where the organization wants to be in the future". Brown claims that a good vision statement must be

- Brief- employees must be able to remember the vision statement.

[31] Brown, Huff, and Cascella agree that the most common reason that organizations fail is that they do not clearly define their goals before starting a project. A program should have a vision and goals that are easily definable by every member of the organization.

- Verifiable- it should set measurable goals so that planning agencies know when the goals have been achieved.
- Focused- the vision should allow the organization to focus efforts on the major goals of the organization and the elements that will assure success of the program.
- Understandable by all employees- the organization must communicate its vision in a way that all employees have the same vision. Generic words and phrases may be interpreted in many ways, so the vision must be specific enough that everyone has the same interpretation.
- Inspirational- the vision must be communicated so that it motivates the employees to want to help the organization succeed.

Brown (1998, p.21) considers creation of a vision statement that has the above elements a vital first step in developing a strategic plan for the successful operation of an organization or program. The process of developing a vision statement and defining organizational goals that are easily understood by all is part of the process of developing a strategic plan that will succeed.

The next vital element is cooperation with that vision is a transformation from words to actions. Cascella (2002, p.62) says that “everyone should be able to answer the question, what does the strategy mean in terms I can act on?” Huff goes farther than cooperation saying the vision should be transformed into a “crusade”. Huff (2000, p.59) suggests that a “crusade taps into what makes us feel good about ourselves” and that this transformation of vision into a crusade will make people act on the vision as though it were a core value.

Gaining the cooperation of the public requires leadership and “leadership involves setting direction and implementing change” (D’Orsie, 2004, p.33). D’Orsie points out that implementing a successful program involves creating a vision, providing leadership, setting direction, “then aligning and motivating people to make the vision a reality” (D’Orsie, 2004,p.33). One of the goals of this research will be to ask water resource management professionals how important the development of a vision statement is in focusing the efforts of their organization toward creating a successful demand control program that pays attention to the needs of the customer and is socially acceptable to their customers.

This idea of cooperation with program goals extends beyond the employees of the organization in the case of water supply agencies. The cooperation of the public is vital to program success, and to gain the cooperation of the public, the organization must make the vision brief, understandable, and focused on the future. The exercise of creating a vision statement must provide verifiable measurable goals and inspire people to want the program to succeed. The organization must develop a vision statement that can communicate goals to employees, and the public, so that all interested parties believe the goals of the program are worth the sacrifice they may be asked to make. In the case of the water supply agencies, the customer/public must understand if there are limits in the amount of water available and how demand control programs will help to increase the efficiency of use, thereby extending the useful life of the resource.

Legal Environment

The second ideal type category is the legal environment. The literature suggests that the legal environment directly and profoundly affects water supply agencies in developing water conservation programs. Water, being a vital resource, is argued about by people on many levels. Interest groups form around issues associated with water. Kaika, Kallis, and Reisner show how local, national, and international interests compete to influence the legal atmosphere surrounding water. The courts and legislative bodies may take control of apportionment of natural resources and retain oversight or control access to resources over extended periods of time.[32] Votteler and Moore point out that the courts can have a profound effect on water resource planning by requiring the creation of legislation and new bureaucracies to control access to water resources.[33]

International Perspective

Kaika explains the very interesting and instructive relationship of international treaties on the creation of water law. The recently completed Water Framework Directive (WFD) is the European Union's holistic approach to water management. The WFD reaches across nation state boundaries and approaches water system management from a river drainage basin perspective. Water quality

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[32] The Texas State Legislature enacted law that complied with federal Judge Bunton's ruling. This legislation created the Edwards Aquifer Authority and required that the Texas Water Development Board create a statewide water management plan. These plans created comprehensive resource management plans based on water demand and future population growth projections through the year 2050.

[33] In the Edwards Aquifer example, the Sierra Club filed suit against the Department of the Interior to force reductions in water use from the aquifer by requiring the Environmental Protection Agency to enforce the Endangered Species Act protecting eight species dependant on adequate flow from the Comal and San Marcos Springs. This precipitated the passage of several pieces of legislation and the creation of new bureaucracies to control water.

and wastewater discharges are now integrated into one management scheme. The European Parliament is an international law making body that is not bound by parochial nationalism for policy-making directives. This decreases the power of local and national interests in creating water management law. Kaika (2003,p.300) reveals that the changes in European "water legislation did not come unexpectedly; it was a response to a rapidly changing political, economic, and social framework… at the local, regional, national, and European levels".

Kaika (2003.p. 302-305) points to three major social and legal paradigm shifts in Europe that have led to changes in the perception of water use and management:

1. Rescaling of decision making- Decisions are no longer made at the nation state level. This multiplies the number of power centers that function in the decision-making process and increases the complexity of the legal environment concerning water.
2. Number of actors required- The weakening of the nation state on water policy has introduced private sector control of water resources. The private sector is able to act across international boundaries more efficiently using market concerns rather than State led common consumption as the driving force for water management.
3. Environmental concern- Large numbers of governmental, regulatory, and interest groups interact on an international scale to represent social and economic values concerning environmental protection of water resources.

The rapidly shifting social structure in Europe has led to a rapidly changing legal environment. Water was long considered a common social good and part of the European heritage. People sharing these shifting social values now see water as a commodity that needs to be protected for economic and environmental reasons.

The idea of viewing water as a commodity to be manipulated, controlled, and conserved has spread across international boundaries and time. Water is very important for economic development as well as for the basic needs of life. Controlling water means controlling wealth and power.

Regional Perspective

Reisner (1993, p.124) provides insight into the water controversy in the western United States that gives some indication of the importance of a legal framework for controlling water resources. The Colorado River Compact is an example of a regional agreement to determine utilization of water resources. The Colorado River basin drains parts of Colorado, Nevada, Utah, New Mexico, Wyoming, and Arizona. Reisner details how representatives of these states along with California and Mexico came together in 1922 to decide the fate of the river. The river was arbitrarily divided into upper and lower basins with each basin allowed control of almost half the annual flow of 17.5 million acre feet of water (Reisner, 1993, p.125). One million acre-feet of water would be allowed to flow into Mexico. The water was mostly intended for agricultural use, as the population of the region was very sparse in 1922. Control of huge amounts of water meant control of economic development and wealth in the western United

States, so the control of this water resource spawned power struggles and political alliances. Politically powerful people throughout the United States teamed up with government agencies to control the water and the wealth of the region.

There were problems with apportionment of water from the very beginning. The flow estimates of the Colorado River were too high, so the signers of the compact could not get all the water they had bargained for causing problems with ratification of the treaty. The Colorado River Compact led to an unsuccessful legal framework to control apportionment of water. The controversy has involved several federal, state, and local agencies and has produced over 80 years of political wrangling and litigation about this very valuable resource. All the while, the demands on the resource have grown with the exploding population of the southwest. The result of the overuse of this resource is the decline of water quality and environmental degradation of the lower basin.[34]

Local Perspective

There are laws, like the Clean Water Act, that require certain standards for supply at the federal level. The Endangered Species Act gives the government broad control of natural resources to control use and protect habitat for endangered or threatened species.

The example of the way the federal courts assumed control of the ground water in the Edwards Aquifer of central Texas is a prime example of how the legal environment can affect water resource control and economic development.

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[34] Reisner (1993.p.460) points out that when the Colorado River flow reaches Mexico it is so laden with salts and sediments that it is unusable as potable water or for irrigation.

Traditional control of surface water was based on the old English allocation system. Groundwater was controlled, until recently, by the right of capture.[35] There are now several state laws that apportion ground water resources. Texas laws, such as the Texas Water Code, Senate Bill 1, and Senate Bill 1477, control access to and usage of both surface water and groundwater (TWDB, SCTRWP, 2002.p1-34).

Todd Votteler (2002,p.273) points out that the court system has been very involved in establishing legal control of water. In the case of central Texas and the Edwards Aquifer, the Sierra Club filed a lawsuit against the Department of the Interior in 1991 claiming that unlimited pumping from the aquifer constituted a taking under the Endangered Species Act and asked a federal judge to set pumping limits that would protect spring flow from the Comal and San Marcos Springs and protect the habitat of eight endangered species.[36]

Federal Judge Bunton decided for the Sierra Club, February 1993, and ordered that the spring flow from Comal and San Marcos Springs be maintained above 100 cubic feet per second to protect the endangered species in the springs and the river below. Judge Bunton directed the Texas Legislature to develop a management plan that would assure spring flow by May 1993. The result of this ruling was the creation of Senate Bill 1 and Senate Bill 1477 which have drastically changed apportionment of water in Texas by creating new

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[35] The right of capture, often called the rule of the biggest pump, meant that if the water was under your land you had the right to pump all the water you wanted to pump and use it for any reason you wanted to use it for as long as you did not waste it. Waste was defined as runoff.
[36] SAWS Water Statistics Book. 2002. 1-20

regulatory agencies to control water use and by limiting overall pumpage, effectively ending the traditional right of capture.

These examples illustrate how important the legal system is in determining apportionment of water resources and in mediating conflicts involving water. Water planning groups need to understand the legal environment (Moore, 2004,p.9-10. and Votteler, 2002,p.270), both legislative and court law, as it relates to the operation of their organization. Control of water can be divided among many political subdivisions. It is vital that water resource managers understand the legal environment surrounding the utilization of their water resource so that they can develop water management plans that will meet the legal requirements for their area.

Regulatory Environment

The regulatory environment grows out of the legal environment. The courts and legislative bodies often set policy and the regulatory agencies create the rules that carry out the policy. Regulatory agencies can be part of any level of government from the federal level, to the state, regional, and local levels. Many regulatory bodies also function at the international level. In the Untied States, our democratic system divides legal control of natural resources between numerous political subdivisions.[37] Location determines what international, federal, state, and local agencies have responsibility for control of water resources.

[37] The EPA, USGS, TWDB, and the Edwards Aquifer Authority are examples of agencies that have some role in defining and regulating water resources. Public health officials, water development groups and planning groups exist at all levels of government and all have some responsibility for management of water resources.

International Perspective

Kaika (2003,p.299-303) and Kallis (2003,p.223-227) discuss recent changes in the regulatory environment in Europe. The changing value system that led to the development of the European Union has basically dissolved traditional state control of resources and has placed primary regulatory control in the hands of a Council of Ministers for the development of the Water Framework Directive. The European Environmental Agency and the European Commission, which are composed of representatives from numerous competing factions and member nation states, guide these ministers in their work. The result of the changing legal environment has been creation of a regulatory scheme that focuses on an integrated approach to water management based on river basins. Water service providers are required to reduce toxic emissions and develop water-pricing schedules that allow for full cost distribution, eliminating state subsidies. The regulations also require that polluters pay the full cost of environmental cleanup. The increased cost to consumers has led to some civil unrest with people objecting to increased cost of water service.

Regional Perspective

Reisner (1993,p.144-168) talks about the changes in attitude over the years regarding the development and use of water resources in the western United States. In what he calls the "Go-Go Years"[38] Reisner talks about how the resources of the federal government were used by regulatory agencies like the Bureau of Reclamation and the Army Corp of Engineers to build dams on almost

[38] One of the chapters in "Cadillac desert" is called the "Go-Go Years" and it is devoted to discussion of the rapid construction of water projects from the 1930's to the 1970's.

every river system in the western United States. This use of federal regulatory agencies to promote development of the west and forever change the face of the American west basically came to an end in the 1970s with the changing social values that led to the growth of the environmental movement.

Layzer (2002, p.290) discusses the use of regulatory agencies in central Florida during the same 1930s to 1970s time frame. The goal, during this period, was to tame nature, and to expose as much land as possible to development. In central Florida, the goal was to drain the Everglades by building dikes and channels to control flooding. During the 1970s people began to realize how these drainage projects were damaging the ecosystem, and the policy of drainage was reversed with steps being taken to remediate the damage caused by previous projects.

Reisner (1993, p.169-196) points out that water resources, like the Colorado River,[39] are often controlled by competing interests over wide geographic ranges. The policies pursued by regulatory agencies can have profound effects on the operation of water supply agencies. Changing social values often result in changes in the water management regulation. Changing regulation greatly affects the operation of water supply agencies.

The reality of the water supply business is that powerful competing interests dominate it. Water supply agencies need to understand the regulatory environment to be able to develop supply programs and demand control

[39] Control of the water from the Colorado River is divided between the nations of Mexico and the United States, numerous federal agencies, several states, two river control groups, and dozens of cities within the basin and outside the basin. (Reisner 1993)

programs that will effectively address the requirements of all regulatory bodies involved in their regional water planning.

Local Perspective

State agencies like the Texas Water Development Board may have legal jurisdiction over water system operation and direct input into the planning process for both supply and demand controls. The South Central Texas Regional Water Planning Group (Region L) is the branch of the TWDB that is directly responsible for the Edwards Aquifer region. The Region L conservation-planning supplement provides guidelines that “are designed to assist new and existing conservation programs to pick the best of available options to help reduce water demand” (SCTRWPG, Supplement, p.1). These “Best Management Practices”[40] deal with projections of cost and estimates of water that can be saved over time. The suggested policies do not investigate the effect the policy may have on the environment or the social acceptability of the program, instead policies focus on the cost /benefit analysis.

It is important for water supply organizations to develop a very good understanding of the international, regional, and local agencies that exert direct or indirect influence on the development of water conservation policy. Development of a thorough understanding of the regulatory agencies involved in water system management and planning is absolutely vital in to developing a demand management plan that will be legal. Individual demand management

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[40] “Best Management Practices” is the name of a brochure produced and distributed by the TWDB to assist water system managers in the evaluation process of demand control programs.

plans have to meet the requirements of often competing interests of area regulatory agencies.

Physical Environment

Water resource development and delivery is dependent on the regional climate and regional geomorphic features.[41] The structure and function of the physical environment determines the availability and reliability of water supply. The water resource manager needs to understand what physical constraints exist that may affect development and utilization of area water resources.

All renewable freshwater resources are provided by precipitation of one type or another. The United States federal government operates the National Weather Service, which supplies the historic and dynamic weather data needed to understand local and regional weather patterns. Hudson (2000, pp.14, 20, 28) gives basic information about regional weather patterns and climatic conditions. Regional climate can vary from very hot and dry (the Sahara) to very cold and wet (the northwestern coastal regions of Europe and North America). Over time regional climate is fairly constant with predictable weather patterns.

One example of the importance of understanding the constraints of the physical environment is Southern California. El-Ashrey (1986, p.41) points out how the population of southern California has expanded beyond the ability of the physical environment to supply for the water needs of the population. Southern California, from Los Angeles to San Diego, is the largest urban area in the world that is dependent on imported water. The mean precipitation is 14 inches (El-

[41] Geomorphology is the study of the structure and function of the physical environment. Geomorphic features are defined in Webster's Dictionary as resembling or pertaining to the form of the earth or of its surface features.

Ashrey.1986.p.41) with most of the rain falling in the low demand winter months. The metropolitan area of Los Angeles began importing water in the 1920s from the Central Valley and the Owens Valley of California. The population soon outgrew these supplies so the city reached out several hundred miles to the east to import water from the Colorado River. The population of this region has outgrown all available water supplies and is facing reductions in available water due to legal action and environmental concerns in the Owens Valley and the Mono Lake region of the Central Valley.

Braswell (1998, p.12) and De Oliver (1999, p.379) claim that the volume of water needed by customers is determined partly by the local climate and partly by local and regional cultural practices. The Texas Water Development Board and the South Central Texas Regional Water Planning Group indicate that the highest water use for municipal systems is landscape irrigation. Cultural practices like using landscape plants that are regionally adaptable is important in reducing this high water demand.

Understanding the physical environment is very important to developing sound conservation and demand control strategies. The physical environment is the natural weather patterns and geomorphic structures, but it is also the demographics of the region. Regional cultural practices are very important in determining which demand control programs will be socially acceptable and in assuring that the customer/public will support programs that are regional smart (SAWS 2004).[42]

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[42] One of the regionally acceptable water use reduction plans is xeroscaping. This program encourages businesses and homeowners to plant regionally adapted plant varieties that require

Demand Controls

Water conservation, from the perspective of the water supply agency, is generally seen as a reduction in water use or water loss. Demand controls are the basis for municipal conservation programs. To create effective demand controls, water managers must understand their customer base and water uses.[43] Water conservation plans generally are created by engineers and pay very little attention to social implications involved in water use controls. Demand control practices require change of some kind and generally involve cost. The ratepayer or the taxpayer ultimately has to bear the cost of the demand control program, so the program must be socially acceptable.

Developing effective demand control policies and procedures that are acceptable to the community is a real problem. Spicer (2002, p1) points out that the effectiveness of conservation programs is dependent on the perception of the public about the overall water supply and the need to conserve. Perceptions influence attitude. Braswell (1998, p.43) and De Oliver (1999, p.387) suggest the attitude of the public directly influences the effectiveness of any conservation plan. Spicer claims that attitudes of the public are vital in implementation of conservation programs.[44] The literature suggests that people will cooperate with

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less water thereby permanently reducing water demand. This is a common practice for all regional water supply groups in the arid west.

[43] The TWDB (2001), Plummer (2000), De Oliver (1999), and Herff (2004) all characterize the types of water use by customers of municipal water systems. Effective conservation plans need to target high water use behaviors.

[44] Plummer (2000), Braswell (1998), Kallis (2003), and De Oliver (1999) all talk about the need for public acceptance of water programs. Education programs are important in developing public acceptance, but do have limitations.

regulators as long as the controls do not represent too large a change in the way they live their lives.

Water planners (TWDB, 2003) have developed conservation plans directed at areas that show the largest use and the least impact on personal practices. Most conservation programs concentrate on engineering controls rather than cultural changes (TWDB, 2004). Demand controls have a cost that may be monetary or could reduce the quality of life. The citizens of the community will approve the program by cooperating with it or not cooperating causing the program to fail. Baumann (1997,p.14-15) refers to beneficial usage of resources suggesting that if the cost of the demand control is higher, monetarily or in loss of utility, than the perceived benefit the program will not be accepted and supported.

The Texas water planning experience is an example of how regulatory agencies can work together to develop conservation plans that cover broad geographic regions and involve numerous political subdivisions. The Edwards Aquifer Authority, San Antonio Water Systems, and the South Central Texas Regional Water Planning Group have developed water conservation policies with suggested demand control programs. The Water Conservation Implementation Task Force of the Texas Water Development Board was established by the 78th Legislature and began work in 2004 to help water supply agencies quantify the costs and benefits of suggested water conservation programs. The task force is developing a “Best Management Practices” handbook to help water supply agencies evaluate individual demand controls.

Individual water supply agencies are given mandates to develop demand control plans, but are not told which demand control practices to use. The individual water supply organization must take the needs of their community into consideration when determining which of these conservation programs will be most acceptable and effective in their area (Strzelczyk, 2005).

The need for development of effective demand controls is illustrated by the experience of the San Antonio region of the Edwards Aquifer. Federal Judge Bunton imposed pumping limits on water used from the Edwards Aquifer. The city and the entire region will need to develop plans very soon to supply the water needed by the rapidly growing population and stay below the water use rates imposed by Judge Bunton (Votteler, 2002, p.273-275) Table 3.1 below combines population projections, water demand projections, and shows how the court-imposed pumping restrictions will lead to water deficits in the near future.

Table 3.1. Projected per capita water use: San Antonio region

Year	Population projections for Bexar County only	Municipal Water Demand Projections in acre feet	Pumping limits	Surplus or deficit	Per capita use	
2010	1,776,965	338,626	400,000	61,374	169	169
2020	2,130,820	381,015	400,000	18,985	159	159
2030	2,491,291	439,753	400,000	39,753	157	142
2040	2,817,681	493,649	400,000	93,649	155	126
2050	3,081,381	531,750	400,000	131,750	153	115

The blue figures used in the per capita column indicate the per capita maximum use that would have to be achieved to stay under the court-imposed pumping limits. These figures only consider Bexar County. Several more counties get most of their water from the Edwards Aquifer. These water use reductions are possible. In our home, we currently use under 100 gallons per day each without modifying our lifestyle in any way.

It would appear from the projection in Table 3.1 that a conservation program with serious demand controls could achieve the water use savings imposed by the court without having to develop new water projects and add new supply. The effort applied to this problem will indicate whether San Antonio is truly serious about solving this regional problem or as Plummer (2000. p.73) claims,

> San Antonio Water Systems has, in effect, co-opted the popular language of consensus-based planning to justify their cost intensive and ecologically destructive methods of providing water for an area whose population has simply outgrown the water resources of its hydrologic basin. The Interbasin water transfers that SAWS and other state agencies see as the solution to the region's supply problems simply exacerbate the problem by facilitating population growth while offering only short-term solutions to concomitant, increased water demands.

The controversy over water management strategies remains salient. Community values will ultimately have to decide the issue by supporting strong demand controls or supporting increased water importation and unlimited growth.

Table 3.2 below is from San Antonio Water Systems "*2002 Water Statistics Book".* The table gives an accounting of the resources expended on certain water demand reduction programs and can be used as an example of the cost of implementing demand control programs. These programs all focus on engineering control changes. Engineering controls are permanent and generally do not require people to change the way they live. The estimated water savings is very subjective in that there is no way to directly measure the effect of individual programs since all metering is cumulative. One example of the best guess-conventional wisdom about water savings for each demand control program currently available is the "Best Management Practices Handbook" distributed by the Texas Water Development Board or any number of other such publications. The truth about all of these estimates is that they are only estimates based on some standard set of conclusions that may or may not be accurate.

Table 3.2. Cost of Demand Reduction Programs

Program	Description/Goals	Evaluation Elements	Budget 2002	FY 2002 Expended	2002 Units	"Estimated" AF Saved	"Actual" 2002 $/AF	Notes
Plumbers To People	repair water leaks for low income customers	Gals. saved if repair was not completed	$ 375,800.00	$ 289,000.00	790	1185	$ 243.00	of visits to date each visit saves 1.5 AF based on a **2 yr.** Time period Most programs are based on 10 yr. time period. # of visits (1.5 AF)
Kick the Can	$75 credit off the water bill - limit two per household	No. of toilets replaced/gals saved over 10 yrs	$ 313,600.00	$401,475.00	5209	1500	$ 268.00	#toilets(1.88gals)(2.7peop)(5.05 flushes)(3652day)- data from the AWWA - REUWS and local census data
Residential Wash Right Rebate	$100 rebate (CPS has $100 also)	No. of machines/gals saved over 10 yrs.	$ 172,400.00	$ 153,800.00	1538	259	$ 583.00	#machine(7)(521.7)(15gals.)- data from AWWA - REUWS
Res. W/C Distribution Program	Distrubute Toilets to Residential Customers	No. of toilets/gals saved over 10yrs.	$ 376,250.00	$ 90,000.00	821	125	$ 720.00	#toilets(1.88gals)(2.7peop)(5.05 flushes)(3652days)- data from AWWA- REUWS and local census data. Cost include rental to habitat- 100 handicap, 781 round front
LISA	Free landscape irrigation analysis	Identified potential savings	$ 22,300.00	$ 4048 (does not incl. Tech Time)	463	192	$ 21.00	5614.26gal/mo(12mos.)(#audits)(2yr) - Based on first year before and after audit monthly water use at account level (Per Joanne Hunter) .
Home Audit	Indoor survey of leaks for residential customers	Identified potential savings	$ 74,035.00	$ 915 (does not include Tech Time)	624	12	$ 76.00	# Audits(8.9gpd)(730days-2yrs). Source: 8.9 gpd (EPA report on Contra Costa, Ca.w/ 39.5%showers were retrofited)
Lg Scale Audit/ Retrofit Program	Rebate up to 50% of the costs to upgrade/install water saving equipment	# participants; $/AF/ amt. of water saved	$ 244,650.00	$ 207,273.00	14	1013	$ 200.00	Rebate up to 50% of the cost with rebate not to exceed $200/AF over ten yrs. Savings determined through engineer reports provided by company and reviewed by SAWS staff.
Commercial Washing Machine Retrofit	Rebate for efficient washing machines - $100	No. of machines/amt. of water saved, $/AF	$ 14,500.00	$ 11,684.00	103	173	$ 113.00	Based on estimated # of loads a typical washing machine at an apt. gets a day from info received by washing machine companies. 15gal (10 Lds/day)(3652day)(# of machines)
Commercial Toilet Rebate Program	Rebate old toilets w/ ULFT's - $75	# toilets replaced/gals. saved over 10 yrs	$137,985.00	$ 80,932.00	873	279	$ 290.00	Based on REUWS for 78% of apartment participation and SAWS staff est. of usage for 22% of office toilets. 78%; #wc(1.88gals)(2.7)(5.05 flushes)(3652);22% #toilets(1.88gals.)(30flushes)(250)(10)
Comm.Toilet Distrubution	Distrubute Toilets to Commercial Customers	No. of toilets / water saved	$ 952,753.00	$ 806,241.00	9445	3024	$ 266.00	Based on REUWS for 78% of apartment participation and SAWS staff est. of usage for 22% of office toilets. 78%; #wc(1.88gals)(2.7)(5.05 flushes)(3652); 22% #toilets(1.88gals.)(30flushes)(250)(10)
Total Activity			$ 2,684,273.00	$ 1,964,436.00	19880	7762	$253.00	

Source: San Antonio Water System: 2002 Water Statistics Book

The experts agree that major demand control program initiatives can be divided into four major categories: outdoor water use, indoor water use, educational programs, and conservation pricing.

Outdoor Water Use

The highest municipal water use is landscape irrigation. Braswell (1998,p15) claims that as much as 60% of the water distributed in municipal water systems is used in landscape watering depending on the regional climate. As the highest single water use, outdoor water use is the demand category that is the easiest to reduce. Outdoor water use is a consumptive use with most water being lost to evaporation and transpiration. Outdoor uses such as landscape irrigation are often discretionary. Eliminating water used for discretionary consumptive uses like landscape irrigation or improving the efficiency of application can make a significant permanent reduction in water demand.

One controversial method that is being employed to limit the amount of water used in landscape irrigation is application of recycled or gray water to irrigate large public areas like golf courses and parks. Exall et al. (2004,p.4) discuss the guidelines developed by the World Health Organization and the United States Environmental Protection Agency to govern the use of recycled water. Texas Commission on Environmental Quality has recognized the possibility of transmission of contaminants in recycled water and developed regulations that control the use and distribution of recycled water. Chapter 210 of the Texas Water Code states that reuse water can be used to promote conservation of surface and ground water, to protect public health, and to ensure an adequate supply of water for present and future needs (TCEQ, 2002.210.2). It goes on to develop strict rules aimed at protecting public health.

Irrigation of parks and athletic fields does come with a price. The distribution of this non-potable water requires a separate distribution system requiring a large capital outlay. Exall et al. (2004.p3) points out the water used in recycled programs may not really be all that pure and could pose possible health concerns and environmental risks. Exall et al. (2004.p3) discuss the possible transmission of biological and chemical contaminants and the need for increased levels of wastewater processing that also increases the cost of producing recycled water. The city of San Antonio requires that “no daytime irrigation…with recycled water is allowed between 10:00 am and 8:00 pm" (SAWS. *Recycled Water User's Handbook*, p.7) presumably so that people using recreational grounds during the daytime hours will not be directly exposed to recycled water.

The use of recycled water can be very beneficial in reducing the amount of water used from the potable water supply for landscape irrigation; however the community must decide if the benefit of the program outweighs the cost. Other methods that can be employed to reduce potable water use in landscape irrigation include time clocks, soil moisture sensors, rain sensors, and improved application methods. Cultural practices include changing the type plants used in the landscape and improved gardening methods like mulching will also reduce water use. Each of these demand control programs has a monetary price and some type of social impact. Choosing which programs best suit the needs of the community is essentially a value judgment for the water system manager and the community.

Indoor water use

Water used inside the house is mostly used for necessary purposes. Water system managers generally focus on mechanical improvements to the home to reduce water use. The top uses of water inside the home are for cleaning, cooking, and sanitary use. El-Ashrey (1986,p.38) claims that indoor water use is very inelastic indicating that most people waste very little water inside the home and are not willing to change their cultural practices.

Bexar Metropolitan Water District (BEXARMET, *Water Efficiency*, p.1) indicates that 72% of the water used inside the house is used in the bathroom.

The largest water user is the toilet. Installation of low flow toilets and shower heads can save up to 70% of the water used in the bathroom without changing cultural habits at all. Baumann (1997, p.54) says that these estimates are just that, estimates with no real field measurement done. Water used inside the home is metered at the street and is not measured at each appliance within the home. It is not truly known if the estimated rates of water saved will truly be realized in practice.

One example of the way communities might encourage people to reduce indoor water use is to change water wasting appliances and fixtures is discussed in the "Best Management Practices" of the Texas Water Conservation Implementation Task Force (TWCTF). Area water utilities might plan to offer rebate programs to encourage the public to replace water-wasting toilets with ultra low flow toilets. The TWCTF claims that for each household that replaces all toilets with the low flow toilets the water saving could be 10.5 gallons per day per person. One example of the cost and water savings associated with this type of demand control program is the San Antonio Water System program that is currently giving $75 per old high flow toilet replaced to customers in their service area (refer to Table 3.2). The total cost of the program in 2002 was over $400,000. This expenditure was projected to save about 1500 acre-feet of water for a cost of $268 per acre-foot. This is not a small sum for the citizens of the community to pay for water savings, but it is less than the cost of developing new water supplies.

While the water savings produced by these demand control programs is difficult to quantify, the cost is certain. The public must accept this type of large-scale expenditure and believe that the benefit in water saved outweighs the cost of the program, or they will not support the subsidization of individuals at the expense of all. The public must feel the economic value of the water saved is more important than the cost of the demand control program.

Education

Education is suggested as a water saving device. Specialized curriculum has been developed for grade school children. One example of a public outreach educational program is being done by the city of San Antonio. The botanical gardens and the Master Gardeners program of the Texas Agricultural Extension Service are used to educate the public about landscape plants and cultural practices. Improved cultural practices and improved plant varieties are stressed as a way to reduce labor in the landscape as well as reducing water use.

De Oliver's (1999.p.386) study showed that all the educational efforts of the water system and government entities had very little effect on water use patterns. De Oliver's study analyzed census tracts for all kinds of common factors from education to income to political party affiliation and found that the level of income had the most effect on water use patterns. DeOliver claims that social pressure and social status had more influence on water use than concern for the environment or level of education. Braswell (1998, p.43) found that conservation programs had very little effect on water use patterns even during a declared emergency. In the drought of 1996 to 1998, the people of San Antonio were under what is called “stage 3” water restrictions. During this time of emergency the people of San Antonio used about 30% more water per household that the people of Austin, 60 miles north, who were under no water use restriction. These studies indicate that even when people are well educated and aware of a problem they can and do resist efforts by regulators to reduce water use. De Oliver’s (1999,p.386-387) study shows that as the education level and income level rise, water use rises regardless of the efforts of regulators.

The literature indicates that the overall effect of education programs on water use reductions is very limited at best. The most important factors in water use seem to be aesthetics and social pressure. The fact that water saved by each demand control is so difficult to measure exacerbates problems with quantifying the effect of education as a demand control tool. Education probably does have some effect, but, as with other demand control programs, public support is vital to the success of any education program.

Rate structure-Conservation Pricing

Discussion of rate structure necessarily involves discussion of value systems. In Europe, water is considered a common good and people traditionally paid very little or nothing for it. In many areas of this country, water has been used as a tool to spur development so the end users of the resource paid only a portion of the total cost of providing the service. Provision of water has long been a function of the government at some level, and water supplies are closely regulated with government agencies often operating water supply systems as a monopoly. Free market economists like Thomas Sowell, are beginning to argue that water should be priced in accordance with the free market system with price fluctuating with supply and demand, or that price elasticity and opportunity cost should be considered in setting water rates.

Baumann (1997, p.56) claims that the "economic approach treats per capita water use as a behavioral phenomenon". Baumann (1997, p.57) indicates that water demand can be expressed as an algebraic formula and listed as one of the items the consumer must purchase each month. He notes that the consumer cannot spend more than total income and thus has a budget constraint. The consumer can be expected to rationally reduce water use when the utility of the purchase of the resource becomes high enough to impinge on the other purchases the consumer needs or desires. Baumann (1997,p.59) notes that indoor water demand in the Untied States is generally thought to be inelastic while outdoor water demand is said to be elastic. What this means in practical terms is that people generally will use the same amount of indoor water regardless of price. Consumers are more sensitive to price changes and reduce outdoor water use as prices increase.

Water management professionals differ in their opinions about the effect of water rates on influencing consumer behavior. Sansom (2004, personal interview) suggested that increasing water rates is the only way to really influence reductions in usage. Baumann (1997,p56-59) feels that water rates do have some impact on water usage, but the real effect is hard to quantify, depending on the elasticity of income versus water rates. El-Ashrey (1986, p.38) stipulates that traditional municipal water rates (prices fixed on decreasing block rate for increased usage) do little to encourage conservation and that water was actually a very small portion of a family's total budget. Dalhuisen's (2003, p.306) meta-analysis of water rate structures found that "residential water demand is relatively price elastic, but income elasticities are relatively inelastic, under increasing block rate structures". His summary of water demand compared to income found that as people make more money their demand for water increases, but the types of water use become more elastic.

Dalhuisen (2003,p.306) also noted that people in Europe and the United States view water use differently, but that there were not enough data available to determine comparative demand elasticities. The European Union has changed the concept of water supply and demand in Europe. The regulatory agencies put in place by the European Union cut across national boundaries and focus water conservation efforts on river basins rather than nation states. People are now being asked to pay all of the cost of water supply and disposal. Kallis (2003, pp.224-227) reports that many European governments are beginning to privatize the water systems to avoid increased cost and regulation introduced by the European Union. This privatization is increasing water rates and is causing a disproportionate effect on poor people. Castro (2003, p.224) found that people in England strongly resist increased rate structures for water and in fact consider water as a common good. In London, only about 14% (Castro, 2003, p.223) of households have water meters at all, but water rates have increased rapidly and the increased cost is seen as a disproportionate burden on the poor. People in some European countries are being asked to pay the full cost of water for the first time, and some European countries are experiencing social unrest because of the changes in policy. Braswell (1998,p.42) points out that many poor people use water to irrigate gardens, supplementing their food supply, and that increased pricing places a larger burden on their family budget and may prevent them from producing food for the family.

The battle over rate structure is a battle between the old traditional subsidized water delivery system that views water as a common good and a new view of water as a tool to control development. Examples of this dichotomy in values are demonstrated by the actions of Texas Water Development Board and the opinions of economists like Thomas Sowell.

The Texas Water Development Board (2004, pp.19-24) recommends that water supply agencies in the state adopt what they call “Conservation Pricing”. The goal of conservation pricing is to develop behavioral changes in water use patterns of the customer. The policy suggests that water supply agencies adopt increasing block rates to discourage water use. It is felt that increasing cost will cause people to be more aware of water use. The water supply agency should provide educational opportunities in the bill so that customers can track their water use and understand how the rate structure will affect them. There should be no minimum use allotment as this might encourage people to use more water than they need. The rate should reflect the number of gallons used, and the price per each 1000-gallon block should increase 25% to 50% (TWDB, 2004, p21) above the price of the previous block. The study done by the TWDB “did find price elasticities of approximately -0.20, which translates into a reduction of 2% in water use for a 10% increase in price” (TWDB, 2004, p23).

Thomas Sowell (2000, p.11) argues that the price of water, and everything else, should not be controlled by the state but through free market theory of supply and demand. He believes that society should determine the cost of everything by the price people are willing to pay. Sowell thinks that government control of resources and prices was the reason the Soviet Union failed. Lionel Robbins (quoted by Sowell, 2000, p.1) defined economics as “the study of the use of scarce resources which have alternative uses”. When defined in this way we realize that the cost of water or anything else “is the value that it has in alternative use” (Sowell, 2000, p10). The free market theory espoused by Sowell would allow the price of water to fluctuate with market forces, and each person would have to determine how much of the commodity they were willing to buy at the available price. This economic theory requires a free market with a competitive supply available.

The reality of the water supply business is that water supply agencies operate under monopoly conditions. Each water supply agency has a protected market and is responsible for delivering water in a safe potable manner to all customers. The water business is very capital intensive, requiring a great deal of infrastructure in the form of pipes, wells, treatment plants, and equipment. Water resources are generally considered a common good and in most cases are heavily regulated by the state in an effort to assure a reliable safe supply. The trend in water rate structures appears to be moving toward the ratepayer contributing the actual cost of providing the resource, although many areas are still heavily subsidized. The question water suppliers must answer is how willing and able their customers are to absorb more of the cost providing the resource.

Preliminary Conceptual Framework

Table 3.3 illustrates the preliminary conceptual framework developed by the literature review. The conceptual framework guides this study and is used to organize the set of questions to be used by water resource planning groups for development of demand control policy. The preliminary conceptual framework provides references to literature that develops and validates each of the five ideal categories.

The review of this relevant literature was useful in creating the preliminary questions contained in Appendix 2 of this study. These questions were developed from the literature review and were organized according to the ideal categories developed in Table 3.3. These questions are designed to spur discussion in working groups investigating demand control programs. The questions are not designed to be a template or a checklist.

Table 3.3 Preliminary Conceptual Framework

Essential Components	Literature
Vision statement and goals should: • Be brief • Set verifiable goals • Be focused • Be understandable • Be inspirational • Engender cooperation	Huff. 2000 Brown. 1998. Cascella. 2002 D'Orsie. 2004
Legal Environment • International • Regional • Local	Moore. 2004. Reisner. 1993. Kallis. 2003. Kaika. 2003. Votteler. 2002 Texas Water Development Board. 2002

	Edwards Aquifer Authority. 2002. Texas State Legislature. 1993. 2003.
Regulatory Environment • International • Regional • Local	Votteler. 2002. Kallis. 2003. Kaika. 2003 Reisner. 1993. Texas Water Development Board. 2002. Edwards Aquifer Authority. 2002.
Physical Environment • Investigate how regional weather conditions affect water supply and needs for demand control programs.	El-Ashrey. 1986. Texas Water Development Board. 2002 South Central Texas Regional Water Planning Group. 2002. San Antonio Water Systems. 2004. Braswell. 1998. De Oliver. 1999. Hudson et al. 2000.
Targeting Demand Controls • Water supply • Water use characterization • Required demand control • Culturally acceptable demand control and conservation programs	Votteler. 2002 Strzelczyk.2005. Texas Water Development Board. 2002 Edwards Aquifer Authority. 2002. Baumann, 1997. Braswell. 1998. Dalhuisen. 2003 De Oliver. 1999. Exall et al. 2004. Hamff. 2004. Journal of Environmental Health. 2000. Kallis et al. 2003. Plummer. 2000. Sansom. 2004. Sowell. 2000 Spicer. 2002. Votteler. 2002.

Conclusion

Acceptance of demand reduction methods is vital for the success of any water management program. Program goals must be consistent with community values. Public support can be gained by asking for input and listening to community concerns rather than dictating desired outcomes.

Demand control programs seem to concentrate on what is possible mechanically. Mechanical controls are very important and can result in permanent reductions in water use. Mechanical controls can reduce the impact of reduced water use on the perceptions of the public. Perception is reality, and if demand controls can be achieved without forcing people to change lifelong habits, they will generally be more readily accepted. However, if demand controls are seen as being imposed by some unpopular power, the effort to reduce water usage will generally be rejected. Each of the demand controls presented has a cost. The cost may be monetary or social. In the final analysis the customer/public must accept the restriction of utility of the resource as necessary or the program will not succeed.

Study of relevant literature and development of ideal categories that can be used to develop policy is an interesting exercise, but for the model to have validity, it must be tested in real world situations. Chapter 4, the methodology chapter, discusses how the developed model was tested.

Chapter 4: Methodology

Purpose

This research uses the ideal categories developed using the preliminary conceptual framework to create a set of questions that can be used by water supply agencies to focus efforts of groups or individuals working on conservation and demand control programs. The validity and usefulness of this set of questions was tested by distribution to professional water system managers for their critique. The population of water system managers is very small compared to the general population, and a sample of these professionals was drawn by purposive and snowball sampling.

Sampling Method

The management of water resources is done by a relatively small group of individuals. Selecting a sample from this small cadre of management professionals fits well with what Babbie (2000, p.178) calls non-probability sampling. Both purposive sampling and snowball sampling are used to draw the sample for this study. Babbie (2000, p.179) states that purposive sampling is appropriate when the population for the study has a particular expertise or knowledge base, which is certainly the case with water system managers. Snowball sampling (Babbie, 2000, p.180) is appropriate when the population is small and hard to locate, which is also true of water resource managers.

All water resource management companies, utility districts, and cities operating water utilities in the state Texas are listed on the Texas Commission on Environmental Quality website. The individuals chosen from the central Texas region were managers of comparatively small companies or towns. Contacts for this study are summarized in Table 4.1. The study identified utility managers in seven states representing regional population centers in the Midwest, west, southwest, southeast, and the intermountain west in an attempt to broaden the perspective and generalize the results.

Table 4.1 Summary of Requests for Information and Responses.

Water management groups contacted			28
Regions represented			7
Local contacts	20	Local Responses	2
Regional contacts	8	Regional Responses	5

The initial request for information was done by e-mail. This contact was followed by phone calls. Local contacts were completed through personal visits. The people contacted in large regional population centers like Los Angeles and Phoenix did show some level of interest in this study, but did not have time to devote to participation. Many of the small local agencies contacted did not have a permanent management team or did not want to participate.

The sample size for this study was small. Babbie (2000, pp. 268-269) writes about problems with validity in survey research generally. This problem with validity of survey research is exacerbated by the small sample size in this study. This research is an initial attempt to investigate water system managers' attitudes about demand control programs, and the importance of social acceptability of demand control policy. Follow-up studies might expand the sample size to increase the validity.

Data Collection

The mode of data collection for this study was the focused interview. The data collected by this study is qualitative. This study is basically a case study with the case defined as demand control programs. The strength of the study should be developed by the direct experience of water management professionals from different regions. Yin (2003, p.68-69) thinks that the researcher must develop some important skills to do case studies effectively. The researcher must be able to develop good questions and actively listen for the answer in an unbiased way. The focused interview requires that the researcher develop concise questions and listen carefully to the answers so that the intent of the interviewee can be accurately recorded.

Interviews

The focused interview was used to examine the usefulness and validity of the set of questions developed from the conceptual framework. Yin (2003, p89) believes that the structured interview is one of the most important tools available for use in a case study. A structured interview does not necessarily follow a strict script. The structured interview can be a fluid conversation where the researcher guides the discussion. The questions developed for this structured interview were designed to be non-threatening and open-ended. The fluid nature of the conversation allowed follow-up questions to draw more depth of understanding from the experts. The focused interview does allow enough structure that the researcher can pursue a line of questions required by the research design, but allows the respondent enough flexibility to provide the benefit of their insight and experience.

Table 4.2 provides a summary of the operational goals of the research. The interview was used to develop depth of understanding about the validity of the developed model and the usefulness of the questions. The questions were designed to encourage and direct discussion not to act as a template for demand control programs. Each region and each agency within each region should develop an understanding of local conditions and local customer preferences. The opinions of the water resource management professionals interviewed provides insight into the difficulty experienced in their regions and should be instructive to other persons encountering similar problems.

Table 4.2: Operationalization of the Conceptual Framework.

Ideal Categories	Research Method	Evidence
Vision statement and goals	Structured Interview	The set of questions provide enough information and depth of understanding to effectively develop a statement of vision and goals.
Legal Environment	Structured Interview	The set of questions develops an understanding of the type of information needed to create a plan that is legal and can be defended.
Regulatory Environment	Structured Interview	The set of questions provides enough depth of understanding about the regulatory environment.
Physical Environment	Structured Interview	The set of questions does reflect the complexity and importance of the physical environment on water system management.
Targeting Demand Controls	Structured Interview	The set of questions does provide depth of understanding about demand controls and does encourage discussion of socially acceptability demand controls.

This table shows how the concepts developed in the preliminary Conceptual Framework are measured.

Local contacts interviews were done by personal contact. Interviews were conducted in March 2005 and lasted from 45 minutes to 1 hour. Telephone interviews with regional contacts lasted an average of 1 hour. Some regional contact interviews were done by submitting questions by e-mail. This was done for the respondent's convenience.

Chapter 5: Results

Purpose

The purpose of this chapter is to present the opinions of the water resource management professionals interviewed and explain how their experience validated or modified the model questions.[45] Each of the water management professionals contacted generously gave of their experience and gave permission for their names to be used in this study. The water management professionals were asked three basic questions:

1. Do the ideal categories make sense in the creation of strategic plans for demand control policy?
2. Will the questions asked provide enough depth of understanding, spur discussion, and increase understanding for each category?
3. What would you suggest to improve this model?

Respondents examined the set of questions developed by the research and provided responses based on their experience in their region and with their customer base. Each region of this country has water resource management supply and demand control challenges that are unique. The insight provided by the broad cross section of experience, represented by the diversity of the respondent group, should increase the validity and usefulness of this model.

Respondents

The respondents for this study are introduced below to provide the reader with a brief reference of their location and the experience they bring to the study.

[45] The model questions were introduced in Chapter 3 and are contained in Appendix 2.

Melissa Cribbins- Water Quality Analyst. City of Spokane, Washington.

Thomas Gross- Commercial Account Manager. Orland Utility Co. Orlando, Florida.

Wesley Hamff, PE. - Chief Engineer of Water Systems. New Braunfels, Texas.

Jan Klein- Water Conservation Coordinator. City of San Marcos, Texas.

Ann Seymour- Director of Strategic Planning- Colorado Springs Utilities, Colorado Springs, Colorado.

Albert Strzelczyk- General Manager, East Central Water Supply District. San Antonio, Texas.

Stephen West. Water Conservation Analyst. City of Eugene, Oregon.

Vision Statement

Each respondent agreed that creation of a vision statement is needed in developing goals for any program. Klein (2005, personal interview) believes that the exercise of creating the vision statement and goals helps to define the problem. Seymour (2005, personal interview) thinks that looking at the current state of usage and the efficacy of current demand control programs is an important first step in defining the problem and beginning to look for solutions. Respondents agree that creating a vision statement with time sensitive, measurable, verifiable goals is important to developing a successful strategic plan.

Respondents did not have suggestions for improving the questions developed in this category. Table 5.1 summarizes the questions suggested by the research about the utility of vision statements for defining demand control programs.

Table 5.1: Questions about the Vision Statement and Goals

Vision statement and goals	
Preliminary document	Final document
1. What is the need that should be addressed by this program? 2. What options do we have for addressing this need? 3. What are core values of the organization that must be upheld by this program? 4. Does the vision statement develop an easily understood focused goal for the organization? 5. What objective standards can be used to determine success of the program? 6. Are the goals measurable and verifiable?	1. What is the need that should be addressed by this program? 2. What options do we have for addressing this need? 3. What are core values of the organization that must be upheld by this program? 4. Does the vision statement develop an easily understood focused goal for the organization? 5. What objective standards can be used to determine success of the program? 6. Are the goals measurable and verifiable?

The table above reflects the comments of water management professionals concerning the vision statement portion of the model.

Legal Environment

Respondents agree that understanding the legal environment is very important in the general operation of a water resource supply agency. Many of the respondents pointed out regional peculiarities. Seymour (2005, personal interview) suggested that the questions in this category must be kept very general to allow for regional differences. Cribbins (2005, personal response) believes that the questions presented in this model did accurately capture the needs of demand control planning groups regarding depth of understanding and did not miss any vital areas involving the legal environment.

Respondents did not offer any specific improvements or adjustments to the questions presented in the model concerning the legal environment. Table 5.2 summarizes the questions suggested by this research about the importance of the legal environment in developing demand control policy.

Table 5.2: Questions about the Legal Environment

Legal Environment	
Preliminary document	Final document
1. Are there any current or past court decisions that affect the resource? 2. What federal laws affect management of the resource and development of demand control programs? 3. What state laws affect management of the resource and development of demand control programs? 4. What local laws affect management of the resource and development of demand control programs? 5. What are the water rights laws regarding resource apportionment and how do they affect access to water resources?	1. Are there any current or past court decisions that affect the resource? 2. What federal laws affect management of the resource and development of demand control programs? 3. What state laws affect management of the resource and development of demand control programs? 4. What local laws affect management of the resource and development of demand control programs? 5. What are the water rights laws regarding resource apportionment and how do they affect access to water resources?

The table above reflects the fact that no adjustments were made to the model, based on the comments provided by survey respondents, regarding legal environment.

Regulatory Environment

Responses about the regulatory environment suggest that vast regional differences truly do exist in water resource management. West (2005, personal response) suggested that the regulatory environment should be a known quantity by every water management professional. He thinks that the "the richer conversation might emerge from identifying the answers [to the model question] up front and asking the relevant follow-up questions to spur discussion". This response suggests that use of a skilled facilitator would be very helpful in focusing discussion within the planning group.

Strzelczyk (2005, personal interview) pointed out that understanding the multitude of regulatory agencies that directly affect the operation of water supply agencies is absolutely vital to daily operations. These agencies often present rules that are contradictory. While one regulatory agency may focus on safety and potability of the water, another may focus on public safety and require certain flow rates and reserve capacity, while still another agency may require reductions in water use to meet conservation planning goals.

Seymour (2005, personal response) discussed the impact that regional river basin management groups and interstate compacts have on water resource management. The involvement of interstate water management groups and national regulatory agencies, such as the Bureau of Reclamation, add many more layers of responsibility and difficulty creating water management plans that can be legally supported. West (2005, personal response) pointed out that the local water agency planning groups must know the requirements of each regulatory agency with oversight in their area to be sure that demand control programs conform to the mandates and guidelines presented by all agencies.

Respondents did not offer any specific improvements or adjustments to the questions presented in the model concerning the regulatory environment. Table 5.3 summarizes the questions suggested by this research about the regulatory environment surrounding water resource planning and demand controls.

Table 5.3: Questions about the Regulatory Environment

Regulatory Environment	
Preliminary document	Final document
1. What federal agencies have direct or indirect responsibility for the management and planning of water resource use? 2. What demand control programs do these agencies list as suggested or mandatory? 3. What state agencies have direct or indirect responsibility for the management and planning of water resource use? 4. What demand control programs do these agencies list as suggested or mandatory? 5. What regional agencies have direct or indirect responsibility for the management and planning of water resource use? 6. What demand control programs do these agencies list as suggested or mandatory? 7. What local agencies have direct or indirect responsibility for the management and planning of water resource use? 8. What demand control programs do these agencies list as suggested or mandatory?	1. What federal agencies have direct or indirect responsibility for the management and planning of water resource use? 2. What demand control programs do these agencies list as suggested or mandatory? 3. What state agencies have direct or indirect responsibility for the management and planning of water resource use? 4. What demand control programs do these agencies list as suggested or mandatory? 5. What regional agencies have direct or indirect responsibility for the management and planning of water resource use? 6. What demand control programs do these agencies list as suggested or mandatory? 7. What local agencies have direct or indirect responsibility for the management and planning of water resource use? 8. What demand control programs do these agencies list as suggested or mandatory?

The table above reflects the fact that no adjustments were made to the model, based on the comments provided by survey respondents, regarding the regulatory environment.

Physical Environment

Water resource management professionals generally think that understanding the physical environment is vital to understanding the challenges faced in developing demand control programs. Klein (2005, personal interview) suggested that one goal of any water management program should be a demographic study. This demographic study should, as Seymour (2005, personal interview) claimed, include characterization of historic and current water use patterns by different groups. Both of these professionals stated that the demand control model must explore the importance of seasonal variation in water demand. The model should also include a question about the regional industrial uses of water. The demographic study should include population projections and projected demands over for the next 20 to 40 years. This long range planning is very important due to the long period of time it takes to locate and develop additional water supplies and treatment systems.

Strzelczyk (2005, personal interview) thinks that the model should be modified to reflect the importance of system capacity. He pointed out that the system must have the pipeline size capacity and transport capacity to respond to emergency situations and to maintain adequate public safety. The carrying capacity of the system must use population projections to assure future needs are met. The extensive infrastructure required to provide reliable service requires constant maintenance so Strzelczyk would include questions about the manpower and equipment needed to maintain water systems.

Respondents, as reflected in the above narrative, offered several adjustments to the portion of the model that explores the physical environment. Table 5.4 summarizes the questions suggested by this research regarding the importance of the physical environment on development of sound demand control policy and the changes suggested by water management professionals.

Table 5.4: Questions about the Physical Environment

Physical Environment	
Preliminary document	Final document
1. Define the regional water supply drainage basin or recharge zone. 2. How do regional weather patterns affect the drainage basin or recharge zone? 3. What is the historic rainfall and recharge of the drainage basin or aquifer? 4. What is the historic water use pattern in the drainage basin or recharge zone?	1. Define the regional water supply drainage basin or recharge zone. 2. How do regional weather patterns affect the drainage basin or recharge zone? 3. What is the historic rainfall and recharge of the drainage basin or aquifer? 4. What is the historic water use pattern in the drainage basin or recharge zone? *5. What are the population projections for your region?* *6. How do the demographic distribution and cultural practices in your region affect water use?* *7. What are current industrial uses of water in your area?* *8. Is the water system infrastructure adequate to respond to projected population changes?* 9. *Does the water system have the staff and equipment needed to assure reliable delivery of service?*

The table above reflects adjustments made to the model, based on the comments provided by survey respondents, regarding the physical environment. The questions in italics reflect changes suggested by respondents.

Demand Controls

Determining the best demand control method presents many differences of opinion among water resource managers. The size of the water system may explain some of the friction. Strzelczyk (2005, personal interview) operates a small water system in central Texas where he personally knows each of his customers, grew up in the area, and lives in the neighborhood. His perspective, focusing on the needs of his customers, is quite different than Gross (2005, personal response) who is a commercial account manager for the City of

Orlando. Gross sees water demand in dollars and cents, speaking of elasticities of supply and demand rather than customer needs and desires. Water supply and demand control is necessarily a practical business. A pragmatic approach to demand controls must, as Klein (2005, personal interview) believes, focus on policy the community will support.

The first step in developing a comprehensive and effective demand control program, according to Klein and Seymour, is to characterize historic use patterns and project future demand. Seymour advises the water-planning groups prioritize demand groups. She thinks that water management agencies should look at technologies that can help industrial users reduce water demand. Strzelczyk points out that engineering changes provide permanent use reductions and are usually the least intrusive. Permanent engineering modifications to water systems and homes are, however, expensive and the community must value the changes enough to support them financially.

Seymour (2005, personal interview) would like to see questions about the cost/benefit analysis of demand controls. If there are additional water resources available in a region, the cost of bringing these new resources online must be weighed against the cost of demand controls. The community must decide whether it values potentially more expensive and possibly lower quality water resources or whether it values reduced water usage as the preferred method for meeting future supply requirements.

Gross (2005, personal response) thought that the model should be modified to explore economic concerns. He would like to add questions about how price of water affects demand elasticity. Gross would like to examine how willing consumers are to do expensive retrofits to implement demand controls measured as payback period for cost of implementation. Gross would add a question about rate structure, exploring how a tiered rate structure versus a flat rate structure would help control demand.

West, Strzelczyk, and Klein would focus more attention on community values. West and Strzelczyk think that people are more concerned about quantity and quality of supply than cost and environmental impact. Klein questions the effect of education on demand control and would like to explore community support of demand controls measured by response to educational programs.

Respondents, as reflected in the above narrative, offered several adjustments to the portion of the model that explores demand control. Table 5.5 summarizes the questions suggested by this model about demand controls and the suggested additions water management professionals think need to be added to make the model more effective.

Table 5.5: Questions about Demand Controls

Demand Controls	
Preliminary document	Final document
1. What are the water use patterns in your area? 2. How do demand controls affect total water use? 3. What do people in the region value, related to water use, and how will demand controls be encouraged and enforced? 4. What type of demand controls will people in the region support? 5. What are the infrastructure needs for the proposed demand control programs? 6. What are the capital expenses that will be incurred by the organization related to the demand control program? 7. What additional operating expenses if any will be incurred by the organization in relation to the demand control program? 8. What new personnel if any will be required to support the new demand control programs? 9. What are the environmental concerns if any associated with the demand control program? 10. How will the effect of the demand control program be measured? Are there any objective standards that can be used to measure success?	1. What are the water use patterns in your area? 2. How do demand controls affect total water use? 3. What do people in the region value, related to water use, and how will demand controls be encouraged and enforced? 4. What type of demand controls will people in the region support? 5. What are the infrastructure needs for the proposed demand control programs? 6. What are the capital expenses that will be incurred by the organization related to the demand control program? 7. What additional operating expenses if any will be incurred by the organization in relation to the demand control program? 8. What new personnel if any will be required to support the new demand control programs? 9. What are the environmental concerns if any associated with the demand control program? 10. How will the effect of the demand control program be measured? Are there any objective standards that can be used to measure success? *11. How can public education programs affect resource demand? Are there objective standards for measurement of the effect of educational programs?* *12. How can rate structure be used to effect demand reduction?* 13. *What is the cost of the demand control program compared to cost and availability of new water supplies?*

The table above reflects adjustments made to the model, based on the comments provided by survey respondents, regarding demand controls. The questions in italics reflect changes suggested by respondents.

Conclusion

Professionals in the water utility business come from many different disciplines. There are regional differences in the legal, regulatory, and physical environments surrounding the provision of public water services. This study draws on the experience and expertise of water management professionals from around the nation to test the validity and usefulness of the demand control model developed from review of relevant literature. The overall impression presented by these water utility professionals is that the model presented by this research is effective and could be very useful. The very generous input provided by these people helps strengthen the model by increasing perspective and utility of the model. This increased perspective develops a greater appreciation of the daily challenges faced by water supply professionals.

Chapter 6: Conclusion

This study developed a model that can be used as a guide to spur discussion in water resource management groups investigating demand control policy. There has been a great deal of literature produced about the effectiveness of different types of demand control programs. Each state has numerous water planning groups and regulatory agencies that mandate demand controls in some form or another. There does not seem to be specific guidance on what type of demand control must be used, and there was certainly no template found that would assure water management groups that their policy meets the requirements of federal, state, or regional planning agencies. The thing that most discussions of demand control omit is the importance of people, the acceptance of the public. Most planning agencies focus on the effect of engineering controls and the power of the state to enforce requirements.

Each region and each local water supply agency is faced with unique challenges. Attempting to create a template that would serve all regions effectively at all times would, as Seymour said, be an exercise in futility. Creating a template would restrict planning groups from having the freedom to explore local values and local and regional realties for water resource management.

This study has developed a dynamic model, rather than a template, that can be used by water supply agencies to spur discussion within strategic planning groups investigating what type of demand control policy they can implement successfully to meet ever-increasing demand for fresh potable water. This model focuses attention on the importance of people and the fact that placing demand controls in effect, asks people to modify their behavior. Water professionals must realize that the support of their community is vital to the success of any program.

The initial questions formulated from the literature review are located in Appendix 2. These questions represented the basics of strategic problem solving and policy development according to the water management professional respondents. Appendix 3 is the final questions developed through the interview process with the critical input of these respondents. The improvements to the original model set of questions dealt with the economics and realities of operating a water utility.

Respondents did remark that a study like this could be very useful. Small water management agencies with limited resources could use a set of questions like this to assure that proper consideration be paid to all vital areas. The importance of water for the health of people and the economic development of communities suggests that there be ongoing research about ways to influence reductions in usage and extend the utility of resources. Demand controls are one way to achieve this goal.

Appendix 1

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Appendix 2

Initially Developed Questions

Vision Statement

The process of developing a vision statement can be very useful in focusing the effort of the organization

1. What is the need that should be addressed by this program?
2. What options do we have for addressing this need?
3. What are core values of the organization that must be upheld by this program?
4. Does the vision statement develop an easily understood focused goal for the organization?
5. What objective standards can be used to determine success of the program?
6. Are the goals measurable and verifiable?

Legal Environment

Understanding the legal environment surrounding the water resource is vital to creating demand control programs that can be legally supported.

1. Are there any current or past court decisions that affect the resource?
2. What federal laws affect management of the resource and development of demand control programs?
3. What state laws affect management of the resource and development of demand control programs?

4. What local laws affect management of the resource and development of demand control programs?
5. What are the water rights laws and apportionment and how do they affect access to water resources?

Regulatory Environment

Understanding the regulatory environment surrounding the water resource is vital to demand control programs that can be legally supported.

1. What federal agencies have direct or indirect responsibility for the management and planning of water resource use?
2. What demand control programs do these agencies list as suggested or mandatory?
3. What state agencies have direct or indirect responsibility for the management and planning of water resource use?
4. What demand control programs do these agencies list as suggested or mandatory?
5. What regional agencies have direct or indirect responsibility for the management and planning of water resource use?
6. What demand control programs do these agencies list as suggested or mandatory?
7. What local agencies have direct or indirect responsibility for the management and planning of water resource use?
8. What demand control programs do these agencies list as suggested or mandatory?

Physical Environment

Understanding the physical environment is vital to understanding the regional water supply and determining the need for demand controls.

1. Define the regional water supply drainage basin or recharge zone.
2. How do regional weather patterns affect the drainage basin or recharge zone?
3. What is the historic rainfall and recharge of the drainage basin or aquifer?
4. What is the historic water use pattern in the drainage basin or recharge zone?

Demand Controls

Understanding how demand controls affect water use, what type programs are available to organizations, and how people respond to changes in water use patterns is vital in developing culturally acceptable programs.

1. What are the water use patterns in your area?
2. How do demand controls affect total water use?
3. What do people in the region value, related to water use, and how will demand controls be encouraged and enforced?
4. What type of demand controls will people in the region support?
5. What are the infrastructure needs for the proposed demand control programs?
6. What are the capital expenses that will be incurred by the organization related to the demand control program?

7. What additional operating expenses if any will be incurred by the organization in relation to the demand control program?
8. What new personnel if any will be required to support the new demand control programs?
9. What are the environmental concerns if any associated with the demand control program?
10. How will the effect of the demand control program be measured? Are there any objective standards that can be used to measure success?

Appendix 3

Final Developed Questions

Vision Statement

The process of developing a vision statement can be very useful in focusing the effort of the organization

1. What is the need that should be addressed by this program?
2. What options do we have for addressing this need?
3. What are core values of the organization that must be upheld by this program?
4. Does the vision statement develop an easily understood focused goal for the organization?
5. What objective standards can be used to determine success of the program?
6. Are the goals measurable and verifiable?

Legal Environment

Understanding the legal environment surrounding the water resource is vital to creating demand control programs that can be legally supported.

6. Are there any current or past court decisions that affect the resource?
7. What federal laws affect management of the resource and development of demand control programs?
8. What state laws affect management of the resource and development of demand control programs?
9. What local laws affect management of the resource and development of demand control programs?

10. What are the water rights laws regarding resource apportionment and how do they affect access to water resources? Are there any current or past court decisions that affect the resource?
11. What federal laws affect management of the resource and development of demand control programs?
12. What state laws affect management of the resource and development of demand control programs?
13. What local laws affect management of the resource and development of demand control programs?
14. What are the water rights laws regarding resource apportionment and how do they affect access to water resources?

Regulatory Environment

Understanding the regulatory environment surrounding the water resource is vital to demand control programs that can be legally supported.

1. What federal agencies have direct or indirect responsibility for the management and planning of water resource use?
2. What demand control programs do these agencies list as suggested or mandatory?
3. What state agencies have direct or indirect responsibility for the management and planning of water resource use?
4. What demand control programs do these agencies list as suggested or mandatory?

5. What regional agencies have direct or indirect responsibility for the management and planning of water resource use?
6. What demand control programs do these agencies list as suggested or mandatory?
7. What local agencies have direct or indirect responsibility for the management and planning of water resource use?
8. What demand control programs do these agencies list as suggested or mandatory?

Physical Environment

Understanding the physical environment is vital to understanding the regional water supply and determining the need for demand controls.

1. Define the regional water supply drainage basin or recharge zone.
2. How do regional weather patterns affect the drainage basin or recharge zone?
3. What is the historic rainfall and recharge of the drainage basin or aquifer?
4. What is the historic water use pattern in the drainage basin or recharge zone?
5. What are the population projections for your region?
6. How do the demographic distribution and cultural practices in your region affect water use?
7. What are current industrial uses of water in your area?
8. Is the water system infrastructure adequate to respond to projected population changes?

9. Does the water system have the staff and equipment needed to assure reliable delivery of service?

Demand Controls

Understanding how demand controls affect water use, what type programs are available to organizations, and how people respond to changes in water use patterns is vital in developing culturally acceptable programs.

1. What are the water use patterns in your area?
2. How do demand controls affect total water use?
3. What do people in the region value, related to water use, and how will demand controls be encouraged and enforced?
4. What type of demand controls will people in the region support?
5. What are the infrastructure needs for the proposed demand control programs?
6. What are the capital expenses that will be incurred by the organization related to the demand control program?
7. What additional operating expenses if any will be incurred by the organization in relation to the demand control program?
8. What new personnel if any will be required to support the new demand control programs?
9. What are the environmental concerns if any associated with the demand control program?
10. How will the effect of the demand control program be measured? Are there any objective standards that can be used to measure success?

11. How can public education programs affect resource demand? Are there objective standards for measurement of the effect of educational programs?
12. How can rate structure be used to effect demand reduction?
13. What is the cost of the demand control program compared to cost and availability of new water supplies?