April | 12

Water Conservation in the South Platte Basin:

Using the City of Fort Collins as a Case Study to Evaluate the Effectiveness of Four Policy Options

Hanna Schum

Advisor: Robert Fusfeld

CBA Advisor: Dr. Andy Sharma

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

PROBLEM DEFINITION 2

INTRODUCTION 2

METHODS 3

Criteria for a Successful Policy 6

ISSUE ANALYSIS 7

Water is Scarce in Colorado 8

Groundwater 9

Increasing Water Supply 9

Population Growth in Colorado 11

Colorado's Climate 12

South Platte Basin 12

Major Water Stakeholders 12

Background: City of Fort Collins 15

PROPOSED SOLUTIONS 16

Policy Option 1: Education and Outreach 17

Policy Option 2: Incentives and Rebates 19

Policy Option 3: Regulatory Measures 22

Policy Option 4: Tiered Rate Structure 24

COST-BENEFIT ANALYSIS 29

Social Discount Rates 30

Price Elasticity of Water Demand 30

Cost-Benefit Analysis Summary 31

Policy Option 2: Cost-Benefit Analysis.......... 33

Policy Option 3: Cost-Benefit Analysis.......... 34

Policy Option 4: Cost- Benefit Analysis.......... 36

WEAKNESSES AND LIMITATIONS.......... 37

STRATEGIC RECOMMENDATION.......... 38

REFERENCES.......... 41

Appendix A - Policy Option 2: Incentives and Rebates Calculations.......... 45

Appendix B – Policy Option 3: Regulatory Measures Calculations.......... 50

Appendix C - Policy Option 4: Tiered Rate Structure Calculations.......... 52

LIST OF TABLES

Table 1: Brief Explanation of the Four Policy Options in Fort Collins ... 3

Table 2: Historic and Projected Treated Water Demand in Fort Collins (1960-2035) ... 4

Table 3: International and Interstate Documents Affecting Colorado's Water Supply ... 8

Table 4: City of Fort Collins Utilities' 2010 Incentives and Rebates Provided to Customers ... 20

Table 5: Monthly Residential Single-Family Water Rates (2011) ... 25

Table 6: Matrix of the Net Present Value for Each Policy Option ... 32

Table 7: Policy Option 2: Incentives and Rebates NPV ... 33

Table 8: Policy Option 2: Summary of Costs and Benefits ... 33

Table 9: Policy Option 3: Regulatory Measures NPV ... 34

Table 10: Policy Option 3: Summary of Costs and Benefits ... 35

Table 11: Policy Option 4: Tiered Rate Structure NPV ... 36

Table 12: Policy Option 2: Incentives and Rebates Costs (Program Year 0) ... 45

Table 13: Policy Option 2: Incentives and Rebates Costs (Program Year 1 -7) ... 46

Table 14: Policy Option 2: Incentives and Rebates Benefits (Program Year 0) ... 47

Table 15: Policy Option 2: Incentives and Rebates Benefits (Program Year 1-7) ... 48

Table 16: Policy Option 2: Incentives and Rebates – NPV – SDR 5% ... 49

Table 17: Policy Option 2: Incentives and Rebates – NPV – SDR 7% ... 49

Table 18: Policy Option 2: Incentives and Rebates – NPV – SDR 10% ... 49

Table 19: Policy Option 3: Regulatory Measures - Costs ... 50

Table 20: Policy Option 3: Regulatory Measures - Benefits ... 50

Table 21: Policy Option 3: Regulatory Measures – NPV – SDR 5% ... 51

Table 22: Policy Option 3: Regulatory Measures – NPV – SDR 7% ... 51

Table 23: Policy Option 3: Regulatory Measures – NPV – SDR 10% ... 51

Table 24: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 0.5 52

Table 25: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 1 53

Table 26: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 2 53

Table 27: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 0.5 54

Table 28: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 1 54

Table 29: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 2 54

LIST OF ACRONYMS

AF	acre-foot or acre-feet
AFY	acre-feet a year
MG	million gallons
CWCB	Colorado Water Conservation Board
GPCD	gallons per capita per day
GPCY	gallons per capita per year
MAF	million acre-feet
RSF	residential single-family
DBP	decreasing block price
IBP	increasing block price
HOA	homeowners association
SDR	social discount rate
NPV	net present value
PV	present value
Qd	quantity demanded
HECW	high-efficiency clothes washers
HET	high-efficiency toilets
HED	high-efficiency dishwashers
SWSI	Statewide Water Supply Initiative
TAZ	traffic analysis zone
NEPA	National Environmental Policy Act

EXECUTIVE SUMMARY

This policy memorandum evaluates the effectiveness of water conservation policies utilized in the South Platte Basin of Colorado. Using the City of Fort Collins as a representative case study, this analysis examines four different water conservation measures used to reduce demand among residential single-family (RSF) households, which include: 1) education and outreach; 2) incentives and rebates; 3) regulatory measures; and 4) a tiered rate structure. Although the conclusions of this analysis are unique to Fort Collins, they can be used for comparison when evaluating other water policies implemented throughout the state.

Proper water management and planning in Colorado's Front Range region will be crucial in the next few decades to accommodate future population growth. By 2050, Colorado will be subject to an estimated water shortage in the municipal and industrial sectors of between 32 and 66 percent. The South Platte Basin, including the subset Metro Basin, will likely see the largest total population growth in Colorado, and is estimated to reach six million people by 2050. Given the severity of this issue, in addition to city and state budget constraints, this analysis attempts to evaluate the cost-effectiveness of each conservation strategy, and its ability to reduce water demand.

Fort Collins Utilities has implemented four general conservation measures to close the city's projected water gap by 2020. In order to accomplish this goal, the city must reduce use from 144 to 130 gallons per capita per day (gpcd) by 2020, for a total annual water savings of 277 million gallons (MG). Each policy option was judged on its ability to meet the gpcd goal, its net present value (NPV), as well as various qualitative measures, such as equitability and political feasibility.

This analysis concludes that Policy Option 4: Tiered Rate Structure is the optimal policy for Fort Collins moving forward. This option not only had a positive NPV under all nine scenarios calculated, but also achieved the city's goal of reducing RSF water use to less than 130 gpcd. It is recommended that the city implements a tiered rate structure coupled with basic educational measures, in order to ensure a more sustainable future for Fort Collins, and the South Platte Basin of Colorado.

PROBLEM DEFINITION

Due to a projected water shortage of 32 to 66 percent in Colorado by 2050, effective methods of reducing per capita residential water use will be necessary in the Front Range, the most populous region in the state, in order to meet future water demands.[1]

INTRODUCTION

The demand for residential water in the Front Range region of Colorado is increasing at a rate that will exceed supply in the near future. In order to cope with probable shortages, proper water management and planning will be critical in the coming years. The Front Range of Colorado is the most populous region in the state, with the majority residing in the Arkansas, Metro, and South Platte Basins. For this reason, predicted water shortages for the municipal and industrial sectors in Colorado are between 32 and 66 percent by 2050, meaning between 538,000 and 812,000 acre-feet (AF)[2] of additional water will be needed annually to meet these demands. Agriculture demands are not included in this estimate, because supply limitations will most likely decrease the number of irrigated acres in the state. For this reason, demand will be reduced in the agricultural sector.[3]

The South Platte Basin, including the subset Metro Basin, will see the largest population growth in the state over the next four decades, with a projected population estimated to reach six million people.[4] Because of Colorado's arid climate and limited access to water, the Front Range will see a serious water shortage if a proactive approach to reduce demand is not undertaken by water providers.

There are multiple residential water conservation methods used to reduce demand in the South Platte Basin, and their cost and effectiveness vary. Given the urgency of this issue, in addition to state and city budget constraints, it is important to examine the efficiency of the various policies. This analysis will use Fort Collins as a representative city and will examine its water conservation plan for RSF

[1] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 5-8.

[2] One acre-foot is 325,851 gallons (approximately the amount of water 2 to 3 families use in 1 year).

[3] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 5-8.

[4] Ibid., 4-3.

customers, which includes four strategies: 1) education and outreach; 2) incentives and rebates; 3) regulatory measures; and 4) a tiered rate structure.

This policy memorandum is intended to evaluate four policy options separately, even though in practice, they are nonexclusive. Given the magnitude of the projected water gap in the state, it is important that each individual policy option is effective at reducing water demand. The next section, Methods, will define the criteria for a successful policy.

METHODS

In this report, Fort Collins is used as the representative city because it is one of the largest cities in the South Platte Basin and the utility is publicly owned.[5] Fort Collins has also been actively pursuing water conservation since 2003, leading to the accumulation of a large body of data with which to inform the final recommendation. Although conclusions drawn from this analysis will be unique to Fort Collins, they can be used for comparison when evaluating other water conservation policies throughout the state, because many other water providers use similar tactics.

Fort Collins has proposed four general policies that are explained in Table 1.

Table 1: Brief Explanation of the Four Policy Options in Fort Collins

Policy Option 1: Education and Outreach	A conservation public information campaign, adult education programs, school education programs, conservation giveaways, xeriscape demonstration garden, xeriscape design clinics, and sprinklers audits.
Policy Option 2: Incentives and Rebates	High-efficiency clothes washer (HECW) rebates, high-efficiency toilet (HET) rebates, high-efficiency dishwasher (HWD) rebates, low-income retrofit program, zero-interest loans, and irrigation technology rebates.
Policy Option 3: Regulatory Measures	Wasting water and soil amendment ordinances.
Policy Option 4: Tiered Rate Structure	A three-tiered increasing block rate (IBR) for RSF dwellings.

[5] State Demography Office, "Population Totals for Colorado Counties: Population Forecasts - years (2000 to 2040)," *Colorado Department of Local Affairs*, 2012, http://www.colorado.gov/cs/Satellite?c=Document_C&childpagename=DOLA-Main%2FDocument_C%2FCBONAddLinkView&cid=1251593369324&pagename=CBONWrapper (accessed January 6, 2012).

Fort Collins Utilities' goal is to reduce water consumption to 140 gpcd by 2020 (normalized to account for weather conditions).[6] Estimating the future water demand for Fort Collins Utilities is difficult, because the boundaries are not the same as the city limits. Fort Collins used Traffic Analysis Zone (TAZ) information to estimate projected population growth. Using TAZ, the city concluded that more growth would occur in the next 15 years (2008 to 2023) than the following years (2024 to 2035). Obviously, population growth and water demand are correlated. It is estimated that by 2035, an additional 10,000 people will be served by the Utilities, with the total served population equaling approximately 157,700.[7] Table 2 shows the projected treated water demand assuming a gpcd of 185 and 161.[8]

Table 2: Historic and Projected Treated Water Demand in Fort Collins (1960-2035)[9]

Year	Historic Service Area		Projected Service Area		
	Population (1,000)	Demand (AF)	Population (1,000)	Demand 185 gpcd (AF)	Demand 161 gpcd (AF)
1960	27.5	7,277			
1965	38.2	10,109			
1970	48.4	12,808			
1975	60.4	15,984			
1980	73.7	19,504			
1985	85.0	22,494			
1990	95.9	29,316			
1995	106.2	30,168			
2000	118.0	31,690			
2005	130.3	32,694			
2010			137.4	34,219	30,416
2015			144.4	36,497	32,498
2020			148.5	38,144	34,032
2025			152.4	39,749	35,529
2030			155.1	41,098	36,803
2035			157.7	42,425	38,059

[6] Normalized values are adjusted to estimate average expected use based on "normalized" 1930-1995 weather conditions. Source: Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 18.

[7] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 24.

[8] Ibid.

[9] Ibid.

Using population to calculate projected water use can be complicated, because there are large contractual users that can greatly alter the gpcd estimate. For this reason, the city did not include the large contractual users in its gpcd. These were individually calculated, and then added to the population-based demand. These calculations reflect the forecast for treated water demands.[10]

Raw water is used for irrigation of parks, golf courses, a cemetery, school grounds, and other uses. Fort Collins reports that raw water demands range between 3,000 and 4,000 AF annually. Although it makes sense that raw water demands will also increase in the future, the city believes that more water rights will be provided to account for those increases, therefore future raw water demand will not be calculated in this analysis.[11]

Fort Collins Utilities does not serve everyone inside the city limits and serves some customers outside of the city limits. Two other districts serve residents within the city, which include the Fort-Collins-Loveland Water District and the East Larimer County Water District.[12] In 2010, Fort Collins Utilities served approximately 23,937 AF (7.8 billion gallons) of water to 129,000 customers, in a 35 square mile area.[13] Of these customers, RSF households were the Utilities' largest consumer (around 37 percent).[14] The city legally owns water rights that average over 70,000 AF (22.8 billion gallons) a year if they are fully usable. Legal and capacity constraints, however, restrict municipal use to about 31,000 AF (10.1 billion gallons).[15]

[10] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 24-25.
[11] Ibid., 25.
[12] Ibid., 3-5.
[13] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 13.
[14] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 3-5.
[15] Ibid., 9.

Since its conservation plan was submitted to the Colorado Water Conservation Board (CWCB) in 2008, the gpcd has been reduced to 144 (2010). Given Fort Collins' population projection for 2020, this will not be enough to close the water gap. By 2020, the demand in Fort Collins will exceed its allotted supply by an estimated 2,301 AF (750 MG).[16] This calculation makes the following assumptions:

1. Fort Collins Utilities does not create more supply through development projects nor agriculture to municipal transfers;
2. The projected population served by the provider is 147,680;
3. The projected large contractual demand of 8,510 AF is correct;
4. Three percent is added to the total demand, which accounts for water loss during the process; and
5. The average gpcd is 144 (normalized for weather conditions).[17]

Each of the four strategies will be evaluated based on their ability to reduce water demand among RSF households, which are Fort Collins' largest consumers of water.[18] The ultimate goal would be to conserve enough water to close the projected gap of 2,301 AF (750 MG) by 2020, which equates to 130 gpcd for the total population served. However, RSF consumption only accounts for 37 percent of demand. Assuming this percentage remains relatively stable, and the other water users in the service area conserve water at the same rate, RSF consumers would need to reduce consumption by 851 AF (277 MG). In order to account for this water gap, in 2020, RSF water use would need to equal 130 gpcd.[19] [20]

Criteria for a Successful Policy

Meeting the state's water demands, including municipal, industrial, agricultural, environmental, and recreational, will require a multifaceted approach.[21] This report is only addressing one stakeholder's consumption, namely RSF households. However, it should be viewed as part of a larger management

[16] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 1-49.
City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 1-18.

[17] Normalized values are adjusted to estimate average expected use based on "normalized" 1930-1995 weather conditions. Source: Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 18.

[18] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 3-5.

[19] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 1-18.

[20] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 1-49.

[21] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 1-5.

plan to reduce total water consumption. Four metrics are used to compare each policy option, which include:

1. Net present value;
2. Ability to reduce RSF water use to less than 130 gpcd by 2020;
3. Total water savings in the eight-year program (2012 through 2019); and
4. Total participants.

In addition to conducting a quantitative cost-benefit analysis (CBA), qualitative measures will be examined as well. Water is a necessity that cannot be treated similarly to other city projects. The issue of equity and political feasibility will be discussed throughout the analysis of the four policy options.

ISSUE ANALYSIS

This section will provide a background of the policy issue, starting with water in the state of Colorado, followed by the South Platte Basin, finally focusing on Fort Collins. There are many contributing factors to water scarcity in the South Platte Basin, including Colorado water law, population growth, climate, and increasing water demand from stakeholders, all of which will be explored in this section.

The population in the Southwest region of the U.S. is the fastest growing region in the country.[22] Foreseeing that water is a valuable resource in the region, several agreements and compacts were created to avoid overconsumption.[23] Although the amount of water available is dependent on such factors as snowfall, water in this region is relatively finite. As population continues to grow, proper management of the resource will become increasingly important.

[22] A. D. Konieczki and J. A. Heilman, *Water-Use Trends in the Desert Southwest—1950–2000*, Scientific Investigations Report 2004–5148 (U.S. Department of the Interior and U.S. Geological Survey, 2004), 1.

[23] Colorado Division of Water Resources, "A Summary of Compacts and Litigation Governing Colorado's Use of Interstate Streams," 2006, water.state.co.us/DWRIPub/Documents/compactsreport.pdf, 3.

Water is Scarce in Colorado

Various international and interstate compacts and agreements regulate the allocation of water supply in Colorado. Table 3 lists each international and interstate document that has affected water use in Colorado throughout history.[24]

Table 3: International and Interstate Documents Affecting Colorado's Water Supply[25]

International Treaties	
Convention with Mexico on the Rio Grande above Ft. Quitman, Texas	1906
Mexican Treaty on Rio Grande, Tijuana, and Colorado Rivers	1945
Interstate Compacts	
Colorado River Compact	1922
La Plata River Compact	1922
South Platte River Compact	1923
Rio Grande River Compact	1938
Republican River Compact	1942
Costilla Creek Compact	1944 (Rev. 1963)
Upper Colorado River Compact	1948
Arkansas River Compact	1969
Animas-La Plata Project Compact	1969
U. S. Supreme Court Cases	
Nebraska v. Wyoming (North Platte River)	325 U.S. 589 (1945)
Wyoming v. Colorado (Laramie River)	353 U.S. 953 (1957)
Agreements	
Sand Creek Memorandum of Agreement	1997
Pot Creek Memorandum of Understanding	2005

Although Colorado's rivers generate an average of 16 million AF (MAF) of water annually, only about one-third of this water remains in Colorado, while the rest supplies water to other states. Eighty percent of this water is on the Western Slope of the state, while about 80 percent of the state's population resides on the Eastern Slope.[26] This is one reason why the projected water gap for the Front Range region is so large.

---

[24] Colorado Division of Water Resources, "A Summary of Compacts and Litigation Governing Colorado's Use of Interstate Streams," 2006, water.state.co.us/DWRIPub/Documents/compactsreport.pdf, 3.

[25] Ibid.

[26] Colorado Water Conservation Board, "Water Management: Water Supply Planning," *Colorado Water Conservation Board*, http://cwcb.state.co.us/water-management/water-supply-planning/Pages/main.aspx (accessed December 14, 2011).

Groundwater

Groundwater[27] supplies 18 percent of the water used in Colorado. Nineteen of the 63 Colorado counties rely completely on groundwater for its domestic use. The agricultural industry uses an estimated 96 percent of the state's groundwater, because in many parts of Colorado, surface water is not available for irrigation.[28] The South Platte Basin uses an estimated 600,000 AF of groundwater a year, the majority of which is for irrigation (about 500,000 AFY), while the rest it for municipal and industrial consumption. The region's aquifers[29] include the South Platte Alluvial Aquifer and the Denver Basin Aquifers.[30] Counties in the Eastern Plains region are the largest consumers of groundwater, where there is little surface water and high agricultural production. Larimer County's groundwater withdrawals are consistent with the state's average of about 18 percent.[31]

Increasing Water Supply

Closing the city's water gap can be accomplished by reducing demand for water, or by creating more supply, through water development projects. Water development projects have been a source of contention in the past, where suggestions have been presented to develop the Colorado River Basin for the Front Range region. The South Platte Basin roundtable "believes that there is some available water to be developed from the Colorado River Basin, and that all of Colorado needs to work together to successfully develop it."[32] The amount of available water in the Colorado River Basin has not yet been

[27] Groundwater: water that flows or seeps downward and saturates soil or rock, supplying springs and wells.

[28] Ground Water Protection Council, "Colorado Ground Water Conditions," *Ground Water Protection Council*, 2007, http://gwpc.org/e-library/documents/state_fact_sheets/colorado.pdf (accessed January 24, 2012), 11.

[29] Aquifer: a geologic formation(s) that is water bearing. A geological formation or structure that stores and/or transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses.

[30] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources, "South Platte Basin Needs Assessment Report," Draft Report (2011), 1-1.

[31] Colorado Geological Survey, "Distribution of ground-versus surface-water withdrawals by county in 1995," *Ground Water Atlas of Colorado,* 1995, http://geosurvey.state.co.us/apps/wateratlas/images/jpeg.gif (accessed January 24, 2012).

[32] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources, "South Platte Basin Needs Assessment Report," Final Report (2011), 8-3.

quantified, and to date there is disagreement between basins about whether or not water will be transported across the state to accommodate for urban growth.[33]

Water development projects, such as construction of dams and reservoirs, are often the response to population growth. In recent years, this has proven to be a difficult method of creating supply, because of environmental considerations. Additionally, the origin of the supply can cause disagreement, which makes the process political.[34] Finally, several basins in Colorado are at or near development capacity.[35] Because of the environmental and political difficulties of water development projects, agriculture-to-municipal transfers are viewed as an alternative possibility. However, in order for these transfers to be successful, storage is needed to allow this seasonal supply to be used year-round.[36]

Fort Collins is planning to expand the Halligan Reservoir to increase its supply by an estimated 12,000 AF storing capacity. This project is in cooperation with the other local districts that provide water to users in Larimer County. The estimated cost for the city is around $14 million, if the permit is granted by the U.S. Corps of Engineers and complies with the requirements set forth by the National Environmental Policy Act (NEPA).[37] This analysis recognizes the need to increase water supply in the region. However, the Water Supply and Demand Management Policy, Resolution 2003-104, which included this project, was adopted by the city council in September of 2003,[38] and the project has not yet begun eight years later. This illustrates that water development projects, especially in the Front Range region of Colorado, tend to be slow moving and expensive. For these reasons, this analysis will only be focusing on decreasing demand. Although a balance between decreasing demand and increasing supply is necessary for future growth, water development projects are outside the scope of this report.

---

[33] For a more in-depth discussion of the history of transferring water from the West Slope to the East Slope of Colorado, see Peter D. Nichols, Megan K. Murphy and Douglas S. Kenney, "Water and Growth in Colorado: A Review of Legal and Policy Issues," Natural Resource Law Center, University of Colorado School of Law (2001).

[34] Peter D. Nichols, Megan K. Murphy and Douglas S. Kenney, "Water and Growth in Colorado: A Review of Legal and Policy Issues," Natural Resource Law Center, University of Colorado School of Law (2001), xii.

[35] Ibid.

[36] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources, "South Platte Basin Needs Assessment Report," Final Report (2011), 8-4.

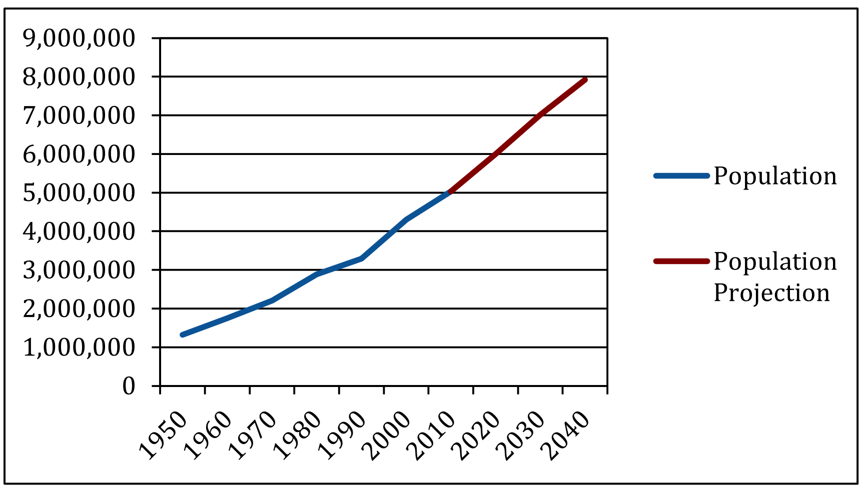
[37] The City of Fort Collins Utilities, "Halligan Reservoir Enlargement: Update," *The City of For Collins*, http://www.fcgov.com/utilities/what-we-do/water/halligan-reservoir-enlargement-project/update (accessed November 28, 2011).

[38] Ibid.

Population Growth in Colorado

The state of Colorado's population has grown substantially over the last six decades, and is projected to almost double by 2050.[39] Chart 1 illustrates that by 2040, the State Demography Office estimates that the population of Colorado will be 7,919,867.[40] It is projected that the Arkansas, Metro, and South Platte Basins, which make up the Front Range region of the state, will continue to have the largest populations. The West Slope will in fact grow at a faster rate than the Front Range, but will have less of an impact given the vast difference in total population.[41] Excluding all other factors, population growth alone will increase water scarcity within the next few decades.

Chart 1: Colorado Population and Population Projections from 1950 to 2040 [42] [43]



39 Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources, "South Platte Basin Needs Assessment Report," Draft Report (2011), 4-3.

40 State Demography Office, "Population Totals for Colorado and Sub-state Regions: Historical Census – years (1790 to 2010)," *Colorado Department of Local Affairs*, 2012, https://dola.colorado.gov/demog_webapps/hcp_parameters.jsf (accessed January 6, 2012).

41 Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources, "South Platte Basin Needs Assessment Report," Draft Report (2011), 4-3.

42 State Demography Office, "Population Totals for Colorado and Sub-state Regions: Historical Census – years (1790 to 2010)," *Colorado Department of Local Affairs*, 2012, https://dola.colorado.gov/demog_webapps/hcp_parameters.jsf (accessed January 6, 2012).

43 State Demography Office, "Population Totals for Colorado Counties: Population Forecasts - years (2000 to 2040)," *Colorado Department of Local Affairs*, 2012, http://www.colorado.gov/cs/Satellite?c=Document_C&childpagename=DOLA-Main%2FDocument_C%2FCBONAddLinkView&cid=1251593369324&pagename=CBONWrapper (accessed January 6, 2012).

Colorado's Climate

Climate change will be an important factor in determining Colorado's future water supply. In Colorado, temperatures have increased an estimated 2^{o} F between 1977 and 2006, which clearly affects both the supply and demand of water resources. Climate models predict an increase in average annual temperature between 2.5^{o} F and 4^{o} F by 2050.[44] However, it is difficult to predict how climate change in Colorado will affect precipitation. There is no consensus on whether average precipitation will increase or decrease by 2050.[45] Despite not knowing the consequences of climate change, snow pack, runoff, and droughts will all be altered. Although climate change will be an important determiner of Colorado's future water supply, its effects are uncertain, and will not be estimated in this report.

South Platte Basin

The South Platte Basin covers the northeast region of Colorado, and is approximately 22,000 square miles. The largest cities in this region are Boulder, Fort Collins, Longmont, and Greeley. Similar to the state as a whole, the population is projected to double by 2050, bringing the total to between 1.8 and 2.1 million people. The Metro Basin, which includes Denver, is a subset of the South Platte Basin. Together, these basins are projected to reach 6 million people by 2050. These two basins account for 70 percent of jobs in Colorado and 60 percent of all Colorado revenues. Furthermore, both basins have a strong agricultural sector, further increasing the demand for water in the region.[46]

Major Water Stakeholders

Many industries have a stake in Colorado's future water supply. Although an in-depth analysis of all the various stakeholders is outside the scope of this report, this section will briefly acknowledge two: the agricultural sector and the oil and gas industry. Throughout history, agriculture has played a

---

44 University of Colorado at Boulder. Western Water Assessment., *Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adoption*, (Colorado Water Conservation Board, 2008), 32.

45 Ibid., 35.

46 Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 1-1.

significant role in the culture, development, and economy of Colorado. To this day, agriculture uses more water than any other stakeholder. The oil and gas industry's water demand is relatively new, and is driven by new technological advances in drilling. Although the latter uses a small fraction of the state's water, it illustrates how a new industry can change water demand in the future.

Agriculture Water Demand

Future agricultural water demand is just as important as municipal and industrial demand. Agriculture is a strong economic driver in the state and tied closely to its history and culture. In the South Platte Basin, agriculture uses approximately 3.2 MAF of water.[47] In addition, agriculture is a major contributor to the region's economy. In fact, the South Platte Basin diverts 26 percent of the state's water and produces 73 percent of the total agricultural sales in the state; meaning agriculture is 19 times as economically productive as the Colorado River Basin per AF of water.[48]

Given that agriculture is a main economic contributor in the Basin and uses water more efficiently than the Colorado River Basin, water transfers from the agricultural sector to the residential sector will not be explored in this analysis. Furthermore, the decrease in irrigated acres from planned agricultural-to-municipal transfers in the South Platte Basin (including the Metro Basin) is 19,000 acres of the total 831,000 acres. This equates to an approximate 2.3 percent decrease.[49] These planned water transfers alone cannot close the water gap in the region.

Oil and Gas Water Demands

Recently, the natural gas industry has become a water stakeholder in Colorado. A new drilling technique called hydraulic fracturing has become widely used to release natural gas that could not be captured using traditional drilling methods. Hydraulic fracturing, or "fracking," uses pressurized water and chemical additives to crack a shale in order to collect the trapped gas. This extraction process uses

[47] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 1-2.

[48] Peter D. Nichols, Megan K. Murphy and Douglas S. Kenney, "Water and Growth in Colorado: A Review of Legal and Policy Issues," Natural Resource Law Center, University of Colorado School of Law (2001), 6.

[49] Nicole Rowan, Ed Harvey, Meg Frantz and Hal Simpson, *state of Colorado Current and 2050 Agricultural Demands*, Memorandum (Colorado Water Conservation Board, 2010), 20.

around 3 to 7 MG (9.2 to 21.5 AF) of water per well.[50] The Colorado Oil and Gas Conservation Commission estimates that hydraulic fracturing will require 16,100 AF this year (2012), and by 2015, it will require 18,700 AF annually.[51] Obviously, these values are estimates that depend on variables such as the price of other energy sources, regulations, technological advances, and other factors.

Similar to all other water users in the state, the oil and gas industry has to adhere to the Colorado water laws when sourcing water for hydraulic fracturing. There are several ways the industry could secure water, which include, but are not limited to: transporting water from outside the state; purchasing irrigation water from landowners; purchasing treated or raw water from water providers; purchasing waste water from treatment plants; diverting water from wells or aquifers; and reusing or recycling well construction water.

When oil and gas companies purchase water form a public water provider, instead of a private landowner, the possible consequences are very different. This is because many people who live in the Front Range region rely on their local utility to supply them with water. Despite this fact, utilities have chosen to lease water to private oil and gas companies. Confirmed providers include: Greeley (1,150 AF), Longmont (about 400 AF), Fort Lupton (441 AF), Loveland (amount not disclosed), Frederick (100 AF), Firestone (amount undetermined), South Adams County Water and Sanitation District (amount undetermined), and Walsenburg (arranged deal for at least 5 AF annually).[52] According to Beth Molenaar, Water Resource Engineer for the City of Fort Collins, Fort Collins has not leased any surplus water to the oil and gas industry.[53]

---

[50] Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resources., "South Platte Basin Needs Assessment Report," Draft Report (2011), 5.

[51] Colorado Oil and Gas Conservation Commission, "Water Sources and Demand for the Hydraulic Fracturing of Oil and Gas Wells in Colorado from 2010 through 2015," January 24, 2012, http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf (accessed February 20, 2012), 2.

[52] Bruce Finley, "Fracking of wells puts big demand on Colorado water," *The Denver Post*, November 23, 2011, http://www.denverpost.com/news/ci_19395984 (accessed December 10, 2011).

[53] Beth Molenaar, interview by Hanna Schum, *Email*, (December 9, 2011).

Background: City of Fort Collins

Fort Collins in located about 65 miles north of Denver in Larimer County. According to the U.S. Census, in 2010, the population of Fort Collins was 143,986, a 21.4 percent increase since 2000.[54] Additionally, about 25,000 students are enrolled at the Colorado State University. Originally, the city was established for agricultural production, but has since shifted much of this focus to a high-tech economy.[55]

Similar to the rest of Colorado, Fort Collins has an arid climate with an average of 15 inches annual rainfall and 300 days of sunshine per year.[56] For this reason, the agricultural sector depends heavily on irrigation. Fort Collins' water supply comes from the Cache la Poudre River Basin, the Colorado-Big Thompson Project, which includes the Horsetooth and Halligan Reservoir, and a smaller portion from the Michigan River Basin that flows into the Cache la Poudre River via the Michigan Ditch and Joe Wright Reservoir system (see Figure 1).[57]

The state of Colorado Water Conservation Act of 2004 (HB 1365) requires entities that supply 2,000 AF or more annually to submit a water conservation plan to the CWCB before receiving financial assistance from the CWCB or the Colorado Water Resources and Power Development Authority. Although Fort Collins is not currently seeking financial assistance, it voluntarily submitted a conservation plan to the CWCB in 2009, outlining a goal to reduce demand from approximately 160 gpcd to 140 gpcd by 2020.[58]

[54] U.S. Census Bureau, "State & County Quick Facts: Fort Collins (city), Colorado," *U.S. Census Bureau*, October 18, 2011, http://quickfacts.census.gov/qfd/states/08/0827425.html (accessed December 15, 2011).

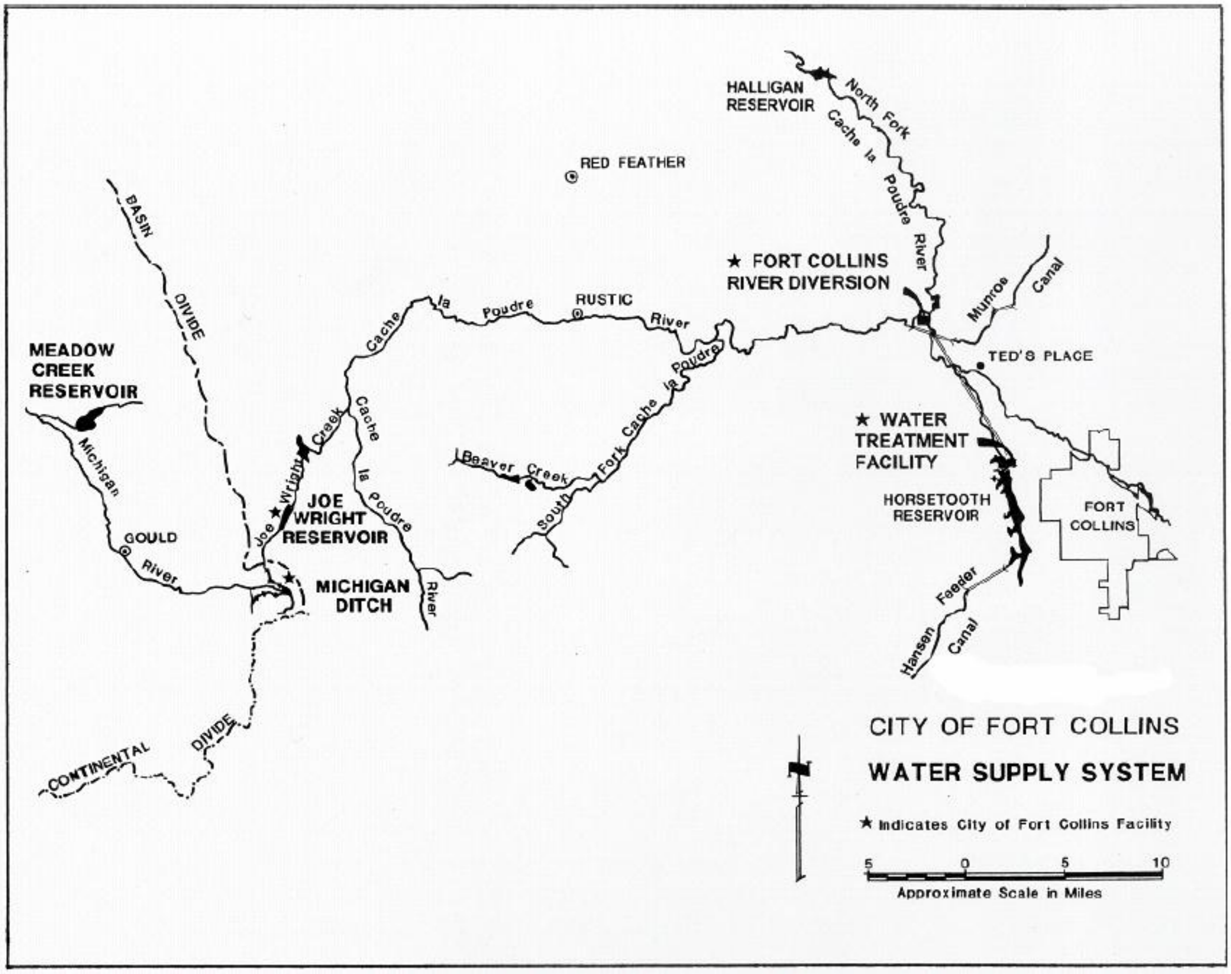
[55] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 3.

[56] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 3.

[57] Ibid., 6.

[58] Ibid., 19.

Figure 1: City of Fort Collins' Water Supply System[59]



PROPOSED SOLUTIONS

There are four general methods used in Fort Collins' water conservation plan for RSF households, which include:

1. Education and Outreach;
2. Incentives and Rebates;
3. Regulatory Measures; and
4. Tiered Rate Structure.

The first three policy options are all non-price methods, while a Tiered Rate Structure uses a pricing mechanism to reduce water consumption. This analysis will compare the advantages and disadvantages

[59] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 8.

associated with each policy option. For the purpose of consistency, the most recent recorded year, 2010, will be used when comparing each policy.

Policy Option 1: Education and Outreach

Education and outreach measures are intended to build public awareness surrounding water conservation issues, and take a long-term approach relying on potential behavioral changes over time.[60] In 2010, Fort Collins utilized seven educational and outreach measures for RSF consumers. These initiatives include: a conservation public information campaign; adult education programs; school education programs; conservation giveaways; xeriscape demonstration garden; xeriscape design clinics; and sprinkler audits.[61] Although the City has proposed adding additional measures, for the purpose of this report, only implemented measures will be examined.

Using education and outreach initiatives are considered to be a "best practice" by the CWCB, because raising awareness is the first step to encouraging consumers to adopt water saving behavior and install water saving appliances and fixtures. Since the CWCB considers this an important element of water conservation, it requires that each water provider include public education, customer water use audits, and water saving demonstrations in its program. For this reason, almost every water provider in the state couples education and outreach with other water saving measures.[62]

Denver Water's outreach campaign "Use Only What You Need" is a prime example of a water provider using this policy option to its fullest potential. Its education and outreach initiatives are the largest in the state and one of the most well-known programs in the country. Denver Water uses clever marketing campaigns that appeal to water users. Since 2006, its marketing campaign has consisted of billboards, bus stops, print media, television, and other non-traditional marketing techniques. Its campaign, which reached an estimated 1.3 million customers, cost between $600,000 and $900,000

---

[60] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 1-18.

[61] Ibid.

[62] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 87.

annually, since 2006.[63] Although Denver Water's efforts have been publicized, there are some disadvantages to investing in public education and outreach, which is discussed in more detail in the following sections.

Policy Option 1: Advantages

Education and Outreach does not force any customers to conserve water; it merely serves as a method of influencing consumer behavior. Because of this, equity is not an issue with this policy option and there are no direct costs for the customer. In addition, Education and Outreach reaches a greater audience than both Incentives and Rebates, and Regulatory Measures. All customers are exposed to this policy in some way. For example, bill inserts are sent to each customer, which makes this policy option far reaching. Policy Option 4: Tiered Rate Structure is the only other policy that has the ability to reach the entire customer base. Finally, public education and outreach is politically feasible, because water conservation is voluntary and every customer is exposed to the same information.[64]

Policy Option 1: Disadvantages

The lack of evidence on the impact of education and outreach programs is the main disadvantage of this policy option. Even the CWCB states that water providers should not rely on any water savings from education and outreach alone.[65] Research has shown that education programs are only modestly beneficial.[66] Although non-price conservation measures, such as education and outreach programs, have been implemented by utilities across the country, there is little evidence proving that they are effective at reducing water demand.[67]

---

[63] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 90-92.

[64] Sheila M. Olmstead and Robert N. Stavins, "Comparing Price and Non-price Approaches to Urban Water Conservation ," *Fondazione Eni Enrico Mattei* , no. 225 (September 2008): 28.

[65] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 90.

[66] Douglas S. Kenney, Christopher Goemans, Roberta Klein, Jessica Lowrey and Kevin Reidy, "Residential Water Demand Management: Lessons From Aurora, Colorado," *Journal of American Water Resources Association* 44, no. 1 (February 2008): 195.

[67] Ari M. Michelsen, Thomas J. McGuckin and Donna Stumpf, "Nonprice Water Conservation Programs as a Demand Management Tool," *Journal of the American Water Resource Association* 35, no. 3 (June 1999): 594.

The second disadvantage is the cost of implementation. Knowing that education and outreach must be multifaceted and far reaching to receive any benefits, Fort Collins has implemented several initiatives. However, this policy option is costly to implement and decreases revenue, which is not ideal for a city with probable future budget deficits.

At first glance, a program such as Denver Water's appears to be relatively cost-effective. It reaches approximately 1.3 million customers, which costs them less than a dollar per customer per year.[68] The problem with this point-of-view is that there are no measurable benefits associated with Denver Water's campaign. Furthermore, the amount of appliance rebates or free water-efficient fixtures that could be provided to Denver Water's customers in place of this extensive marketing campaign is astounding. For example, the city could give out 12,000 to 18,000 water-efficient clothes washer rebates of $50 instead. This is just one example illustrating a need to compare the effectiveness of various programs.

Policy Option 2: Incentives and Rebates

Fort Collins' incentive and rebate program includes: HECW rebates, HET rebates, HED rebates, zero-interest loans for conservation, and sprinkler equipment rebates. All of these measures were utilized in 2010, totaling 3,143 rebates and loans, amounting to $121,333 (see Table 4).[69] Additionally, the City participated in the Larimer County Youth Corps retrofit program, which installed showerheads, faucet aerators, toilet tank bags, and shower timers in low-income homes at no charge. The Youth Corps estimated the showerheads and faucet aerators resulted in water saving of 2.4 MG annually.[70] This number could be an overestimate, given that a study done in Boulder, Colorado, found that showerhead replacement had no statistically significant effect on water use.[71]

---

[68] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 90-92.

[69] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 5-6.

[70] Ibid., 6.

[71] Aquacraft Water Engineering and Management, ""Project Report: Measuring Actual Retrofit Savings and Conservation Effectiveness Using Flow Trace Analysis"," Prepared for the City of Boulder, Colorado, Utilities Division, Office of Water Conservation (1996).

Table 4: City of Fort Collins Utilities' 2010 Incentives and Rebates Provided to Customers[72]

Rebate/Incentive	Rebate/Incentive Amount	Quantity	Total Amount Spent
ENERGY STAR® Certified Clothes Washer Rebate	$50	1,249	$62,450
WaterSense Toilet Rebate	$35	497	$17,395
Recycling Old Toilet Rebate	$15	440	$6,600
ENERGY STAR® Certified Dishwasher Rebate	$25	780	$19,500
Zero-Interest Loan for Clothes Washers and Water Line Replacement	n/a	13	$15,388
Sprinkler Equipment Rebate	$15-$150	164	n/a
Total		**3,143**	**$121,333**

High-efficiency retrofits and appliance rebates are a commonly used conservation tool by municipalities.[73] The CWCB places high-efficiency fixtures and appliance rebates in its list of best practices, stating that Colorado has a significant opportunity for indoor water use conservation.[74] The average indoor RSF household's water consumption is used by toilets (26.7%), showers (16.8%), faucets (15.7%), clothes washers (15%), leaks (13.7%), other domestic uses (2.2%), baths (1.7%), and dishwashers (1.4%).[75] Replacing appliances and fixtures such as toilets, showerheads, faucets, and clothes washers, with more efficient technologies can lead to substantial long-term water savings.

Policy Option 2: Advantages

The major advantage with high-efficiency appliance and retrofit rebates is that the effectiveness of the program is easier to estimate than Education and Outreach, and Regulatory Measures. In this case, Fort Collins was able to track the amount spent on rebates and the projected water savings associated with the program. Additionally, the water savings from this policy option are long-term. For example, if Fort Collins had to cut all education and outreach measures, the water savings provided by those initiatives

[72] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 5.

[73] Lori S. Bennear, Jonathan M. Lee and Laura O. Taylor, "PARTICIPATION INCENTIVES, REBOUND EFFECTS AND THE COST-EFFECTIVENESS OF REBATES FOR WATER-EFFICIENT APPLIANCES," Duke Environmental Economics Working Paper No. 11-10 (2011), 1.

[74] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 158.

[75] Amy Vic, *Handbook of water use and conservation: [homes, landscapes, businesses, industries, farms]* (Amherst, Massachusetts: Waterplow Press, 2001), 15.

would probably decrease. Oppositely, once appliances and fixtures are replaced, benefits will be realized for the lifetime of the product.

The return on investment for households can be better than initially presumed, because of reductions in energy and wastewater. Fixture and appliance replacement can result in a reduction of household energy consumption, because high-efficiency technologies such as dishwashers, clothes washers, faucets and showerheads all use hot water, therefore a reduction in water leads to a reduction in energy. Some water providers charge customers for wastewater. This cost will also decrease with decreased water use.[76]

Policy Option 2: Disadvantages

One disadvantage to high-efficiency appliances is that there may be a rebound effect (also referred to as a take-back effect). The rebound effect refers to the potential increased use of the given resource, associated with a decrease in the cost of the service provided by the new appliance. For example, decreasing the cost of washing clothes will lead to more loads being washed more frequently.[77] This behavioral change can also take place for other reasons besides a decreasing cost of service. Unsatisfactory waste removal capabilities of high-efficiency toilets or cleaning capabilities of clothes washers and dishwashers can also result in a rebound effect. Regardless of the reason, water savings seen from high-efficiency appliances will be lower than engineering estimates suggest.[78] However, the rebound effect is difficult to estimate. A study done in North Carolina of 683 households concluded that there was no rebound effect seen in HET.[79] Although the specific rebound effect is unknown for water-efficient appliances in Fort Collins, it is likely that one exists, which would cause the estimated water savings of this policy option to be high. Unfortunately, the rebound effect in Fort Collins cannot be obtained, but this issue can be considered when evaluating the efficiency of this policy

[76] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 165.

[77] Lori S. Bennear, Jonathan M. Lee and Laura O. Taylor, "PARTICIPATION INCENTIVES, REBOUND EFFECTS AND THE COST-EFFECTIVENESS OF REBATES FOR WATER-EFFICIENT APPLIANCES," Duke Environmental Economics Working Paper No. 11-10 (2011), 2-3.

[78] Ibid., 3.

[79] Ibid., 3-4.

A second disadvantage of rebates and retrofits is the fact that many customers are likely to purchase water-efficient technologies without the rebate.[80] This does not affect the amount of water conserved by the technologies, but does challenge the cost-effectiveness of the program. If Fort Collins did not offer rebates to customers in 2010, how many of them would have bought those appliances anyway? In a study done in North Carolina, the authors concluded that 47 percent of the households would have bought a high-efficiency toilet, even without a rebate.[81] This, however, may vary greatly depending on factors such as weather in the region, household income, and other conservation measures, such as educational programs, which reinforce the need for conservation. Therefore, conclusions drawn from a study done in North Carolina cannot be directly used for Fort Collins.

Policy Option 3: Regulatory Measures

In 2010, Fort Collins implemented two RSF regulatory measures, which included: a wasting water ordinance, and a soil amendment ordinance. Both were utilized to deter water waste and encourage efficiency.

The wasting water ordinance refers to investigating complaints by the community under the *Fort Collins Municipal Code* wasting water ordinance. In 2010, 26 complaints were investigated. The soil amendment ordinance requires builders to add organic matter to the soil before planting turf grass to increase root depth and water penetration.[82] This is enforced through a visual inspection of each property. Fort Collins did not state the outcome of these investigations and inspections, nor the projected price or water savings from each initiative;[83] therefore, estimates from the City of Greeley and Denver Water are used in the CBA (refer to Policy Option 2: Cost-Benefit Analysis for more information).

Mandatory or regulatory measures, as compared with rate structures, use a command-and-control model to limit water consumption. Some common regulatory measures, not utilized by Fort Collins,

[80] Lori S. Bennear, Jonathan M. Lee and Laura O. Taylor, "PARTICIPATION INCENTIVES, REBOUND EFFECTS AND THE COST-EFFECTIVENESS OF REBATES FOR WATER-EFFICIENT APPLIANCES," Duke Environmental Economics Working Paper No. 11-10 (2011), 3.
[81] Ibid., 4.
[82] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 7.
[83] Ibid., 8.

include restrictions on the total quantity of water used in a billing cycle, and restrictions on particular water uses, such as lawn watering and car washing. The empirical evidence is mixed regarding the impact of these programs on reducing water consumption.[84] It is difficult to measure the impact of regulatory programs, because they are often times combined with several other water conservation measures.[85] Kenney, et al., notes, "the response of households to changes in price is likely to differ when restrictions are in place."[86] This is important when comparing the efficiency of different water conservation methods. If water restrictions lessen the effectiveness of a price increase, then the two measures are working against each other.

Policy Option 3: Advantages

Because of the enforcement and administrative costs, command-and-control models have received criticism for their lack of efficiency. This, however, is a debated topic among scholars, because unlike the other policy options, regulatory policy is the only one that provides a certain outcome.[87] This analysis makes the assumption that because regulatory measures can provide more certainty, many utilities continue to use them when implementing water conservation programs, despite high administrative costs.

Policy Option 3: Disadvantages

The main argument against regulatory water conservation measures is that they require monitoring and enforcement.[88] Unlike the other three policy options, in order for this policy to work effectively, the utility provider must enforce these measures.[89] Fort Collins has not implemented water restrictions, and instead has a wasting water ordinance. Since enforcement of this regulation is only

[84] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 29.

[85] Douglas S. Kenney, Christopher Goemans, Roberta Klein, Jessica Lowrey and Kevin Reidy, "Residential Water Demand Management: Lessons From Aurora, Colorado," *Journal of American Water Resources Association* 44, no. 1 (February 2008): 192-207.

[86] Ibid.

[87] Heather E. Campbell, Ryan M. Johnson and Elizabeth Hunt Larson, "Prices, Devices, People, or Rules: The Relative Effectiveness of Policy Instruments in Water Conservation," *Review of Policy Research* 21, no. 5 (2004): 640.

[88] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 5.

[89] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 81.

initiated by complaints from neighbors, the cost of enforcement is relatively low compared to programs that have implemented watering restrictions. For example, in 2010, only 26 complaints were investigated in Fort Collins. Denver Water, on the other hand, employs water use enforcement officers to uphold its strict seasonal water restrictions. The tradeoff between different levels of enforcement is that Denver Water's regulatory measures, although more costly, reach a greater population.

The other disadvantage is that regulatory measures alone are unlikely to reach the goal of reducing RSF use to 130 gpcd. Additionally, the water savings associated with regulatory measures are very difficult to track, and the effectiveness of this policy option cannot be easily determined. Because of this, Fort Collins should not depend on regulatory measures to reduce their demand by enough to account for future population growth.

Policy Option 4: Tiered Rate Structure

In 2003, Fort Collins changed its rate structure to encourage water conservation. Up until then, residential customers paid a set rate per 1,000 gallons no matter how much the household used. Fort Collins Utilities believes that this economic incentive for residents to use water more efficiently has proven to be an effective method at reducing water demand.[90] A three-tiered rate structure is used for RSF households, meaning customers pay a base charge per household with a cost per 1,000 gallons of water, which increases in price at a 7,000- and 13,000-gallon mark.[91] Each year, both the base price and each tier price increase by three percent (see Table 5).

[90] City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 5.

[91] City of Fort Collins Utilities, *Single-family and Duplex Water Rates*, http://www.fcgov.com/utilities/residential/rates/water (accessed December 26, 2011).

Table 5: Monthly Residential Single-Family Water Rates (2011)[92]

Monthly Single-Family Water Rates		
	Base Charge	$14.42
Tier	**Volume Charge, per 1,000 Gallons**	
1	0-7,000 Gallons	$2.23
2	7,001-13,000 Gallons	$2.56
3	Over 13,000 Gallons	$2.95

Utilities can use several pricing options for residential customers. First, water can be metered or unmetered. If a household is unmetered, it is charged a flat rate regardless of how much water it consumes.[93] In this case, households are encouraged to consume water until their own marginal benefit of water consumption is driven down to zero, which does not encourage water conservation.[94] Typically, when communities move to metered pricing, water consumption drops dramatically.[95] Since 2005, all Colorado water providers serving more than 600 taps are required to meter all customers (Colorado Revised Statutes 37-97-103 "Water Metering Act").[96] Given that most Colorado households are already metered, the majority of savings from this mechanism has already been realized.

Once metered, utilities have several pricing options. First, residents can pay a set rate per unit of water consumed (typically 1,000 gallons). Compared to a flat rate unmetered system, residents are more likely to use less water, because their charges increase as consumption increases. Until 2003, Fort Collins used this pricing scheme.

Rate structures that encourage conservation are either tiered (also called increasing block pricing), or seasonal. Under a tiered rate structure, the marginal price of water depends on the quantity

---

[92] City of Fort Collins Utilities, *Single-family and Duplex Water Rates*, http://www.fcgov.com/utilities/residential/rates/water (accessed December 26, 2011).

[93] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 17.

[94] Ibid.

[95] Ibid.

[96] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 34.

consumed.[97] There are two types of tiered rate structures, which include: increasing block price (IBP) structures, and decreasing block price (DBP) structures. As the name implies, IBP structures charge a higher marginal price at higher levels of consumption. The block size is usually fixed for one type of customer (i.e. RSF households). In Colorado, this is one of the most popular rate structures, utilized by providers such as Fort Collins Utilities, Denver Water, and Colorado Springs Utilities.[98]

DBP structures work in the opposite direction, offering a discount at higher volumes. Clearly, only IBP structures incentivize water conservation, while DBP structures are typically used by regions trying to attract manufacturing industries.[99] Subsidizing the price of water to attract certain industries is unlikely to lead to a positive long-term outcome, because communities with water supply issues attract these industries, without taking into account future shortages.[100] For this reason, some states prohibit public water utilities from implementing DBP structures.[101]

A seasonal water rate structure is the other type of water conservation method currently utilized in the U.S. Seasonal rates typically increase the price in the summer months, when the demand for water is the highest.[102] Economically, this method makes sense. Charging more for a resource during periods of scarcity signals to customers the need to reduce consumption.

Rate structures are unique to each utility, and it is almost impossible to find two water providers utilizing the exact same rate structure. Each utility has its own set of revenue requirement and objectives of its rate structure. Climate, water supply, future population growth, current water use, capital costs,

---

[97] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 17.

[98] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 37.

[99] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 17.

[100] Ibid.

[101] Ibid., 18.

[102] Ibid., 18.

among others, all play a role in determining a rate structure.[103] Key considerations when designing a rate structure include:[104]

1. Sizing blocks appropriately;
2. Setting the block price differential so that it incentivizes conservation;
3. High base service charges can weaken the effect of the block rates; and
4. Billing cycles and water tracking can influence customers' response to the rate structure.

Setting the price for the blocks in a rate structure is extremely important in order to achieve the level of intended conservation. Clearly, a water provider could set each block at a price so high that households would never risk using water at that price level. Since this strategy is not politically feasible, this report will not be exploring the option of pricing water absurdly high.[105] For residential use, the size of the first tier should be based on the monthly (or bimonthly, depending on the billing cycle) average indoor use.[106] Indoor use is generally viewed as necessary consumption, while outdoor use is not. For this reason, customers should ideally be able to stay within the first block if they are only using water for necessary consumption.

The majority of IBP structures have very small incremental increases between each block. For example, in Fort Collins, the price increase from block one to block two is only 33 cents for every additional 1,000 gallons of water. This may not be enough to signal to customers that they should reduce water use.[107] Increasing the block differential in Fort Collins may better promote water conservation.

Setting the base charge is complicated in itself. If the base charge is set too high compared to the block differential, customers may be less likely to conserve water since the incremental price increase may be small relative to the set amount customers must pay per billing cycle.[108] For example, looking at

---

[103] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 36.

[104] Ibid., 38-39.

[105] In the late 1970's, the City of Tucson, Arizona adopted marginal cost water prices, which increased the cost substantially. One year later, the entire city council was voted out of office because of the water rate increase. As cited by: Sheila M. Olmstead and Robert N. Stavins, "Comparing price and nonprice approaches to urban water conservation," *Water Resources Research* 45 (April 2009), 6.

[106] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 38.

[107] Ibid., 39.

[108] Ibid., 38.

Fort Collins' tiered rate structure, what if the base charge was $30 dollars instead of about $15? It is likely that households would be less responsive to a block increase, because that amount relative to the $30 base charge would be much smaller.

In order for a conservation rate structure to work effectively, the billing cycle must to be prompt and informational, so that customers notice a change in their water bill and can determine the possible causes. Monthly billing cycles are more useful than bimonthly or quarterly billing cycles, because it establishes a relationship for the household between their water use and an increase or decrease in their bill.[109] An example of this is seasonal rates. If a city has a rate structure that increases for three months in the summer, but only bills their customers bimonthly or quarterly, it does not give them enough time to respond to the increased price. Consumers will be less likely to associate their increased lawn watering with their high bill if their billing cycle is too long. Additionally, information included with the bill is important. Providing households with a history of their usage and comparing them to their neighbors are two ways to encourage response.[110]

Policy Option 4: Advantages

The main argument for a tiered rate structure is efficiency. Price-based approaches to water conservation are more cost-effective than nonprice-based approaches and utilities will typically witness an increase in total revenue.[111] Although utilities are required to cover costs, but are not permitted to profit from providing water, the extra revenue could be given back to the community in the form of rebates, educational material, and high-efficiency retrofits, which would benefit the community.

From a societal perspective, rate structures can be very beneficial at accomplishing two main goals: increasing revenue for the water provider and stabilizing future water use.[112] If a water conservation program can be self-sufficient and not depend on tax revenue, society will be better off. If

---

[109] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 38.

[110] Ibid.

[111] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 5.

[112] Colorado WaterWise and Aquacraft, Inc., *Guidebook of Best Practices for Municipal Water Conservation in Colorado*, (Denver, CO: Colorado WaterWise, 2010), 44.

citizens are already paying for their water, they should not have to pay taxes to fund water conservation programs. Additionally, self-sufficiency provides greater stability over the long run, because it ensures that the program can continue to promote conservation even when other programs are being cut.

Policy Option 4: Disadvantages

A strong argument against increasing the price is equity. High-income households tend to be less responsive to an increase in the price of water. If a community increases the price of water to reduce demand, the low-income households will unfairly carry the burden of water conservation. Although this may be the case, there are methods of reducing demand in an equitable manner. First, a tiered rate structure allows low-income households to remain in a lower price tier if it chooses to do so. It should be noted that this is only true in RSF households, not multi-family households, because the latter pays a share of the total household consumption and does not have control over that cost.[113] This may be the reason that Fort Collins' tiered rate structure is only for RSF households and not multi-family households. As sub-metering becomes more popular, this may change.

COST-BENEFIT ANALYSIS

The CBA used in this memorandum is an *ex ante* CBA, which is conducted before program implementation. This section will compare the net present value (NPV) of each policy option, in order to evaluate cost-effectiveness. This CBA accounted for the following stakeholders: customers; the City of Fort Collins Utilities; and the city, county, and state governments.

A CBA was not calculated for Policy Option 1: Education and Outreach for two reasons. First, throughout Colorado and the U.S., education and outreach initiatives usually accompany other conservation methods, such as incentive and rebate programs. When considering any method of residential water conservation, informing the public about the program is crucial to its success, therefore it could not be considered as a stand-alone policy option in the CBA. Second, there is currently no

[113] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 34.

accurate approach used to calculate the water savings associated with education and outreach initiatives. Only costs could be calculated for Policy Option 1, which would be a misrepresentation of its effectiveness.

Social Discount Rates

An eight-year program is used for all policy options in this CBA. Because it is a multi-year program, a social discount rate (SDR) is used to make future costs and benefits comparable to current costs and benefits. This is because of time preference. A simple example illustrating why economists use discount rates is that a dollar today is worth more to a person than a dollar in the future. The present value (PV) of the costs and benefits are calculated using the amount of time between now and when the costs and benefits are incurred.[114] Because there is no consensus on what the SDR is for water conservation, this CBA uses three values for comparison, 5, 7, and 10 percent.

Price Elasticity of Water Demand

Part of setting a tiered rate structure is determining the price elasticity of water demand, or consumers' sensitivity to an increase in price. The elasticity of water demand is debated among scholars.[115] Using price as a mechanism to decrease water demand depends on the notion that residential water demand is not inelastic. A portion of water used by households is for basic needs, while the rest is used for watering lawns, washing cars, etc. Necessities tend to be relatively inelastic, because people will pay more for a resource that they depend on for basic survival. On the other hand, water used for unnecessary tasks are more responsive to price.

The elasticity for residential water demand may be explained by many functions, including: price, household income, family size, home and lot size, homeowners associations (HOAs), and weather.[116]

---

[114] U.S. Environmental Protection Agency, *Appendix A: Inflation and Discounting Factors*, www.epa.gov/oppt/coi/pubs/appa.pdf (accessed February 28, 2012), A-5.

[115] M. Espey, J. Espey and W. D. Shaw, "Price Elasticity of Residential Demand for Water: A Meta-Analysis," *Water Resources Research* 33, no. 6 (1997): 1369-1374.

[116] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 22.

Estimates of elasticity are averages and actual numbers can vary greatly from household to household. High-income households are less sensitive to an increase in price compared to low-income households. Additionally, price elasticity can increase by 30 percent or more when price information is provided on water bills.[117] For this reason, rate structures vary across communities to account for some of these variables that impact elasticity.

Considering that there are many different factors that determine price elasticity, and the actual value for residential water conservation is debated, this CBA uses three different values for price elasticity, 0.5, 1, and 2, for Policy Option 4: Tiered Rate Structure, to compare the effects of elasticity on each NPV.

Cost-Benefit Analysis Summary

Each policy option was calculated for the eight-year program from 2012 through 2019. Table 6 shows the comparison of CBA results for each policy option in the form of NPV. The three other criteria evaluated, RSF gpcd use by 2020, total gallons of water saved in the eight years of implementation, and total participants influenced by each policy, is included in the detailed sections for each individual policy option below.

The results of the CBA explain that Policy Option 4: Tiered Rate Structure has a positive NPV under all three discount rates, using all three values for elasticity. This is because there are no quantifiable costs associated with this policy option. The policy option with the most negative NPV was Policy Option 2: Incentives and Rebates.

[117] Sheila M. Olmstead and Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 25.

Table 6: Matrix of the Net Present Value for Each Policy Option[118]

	Total PV Benefits	Total PV Costs	Total NPV
Policy Option 2: Incentives and Rebates			
5% Social Discount Rate	$271,779	$2,764,383	($2,492,604)
7% Social Discount Rate	$269,446	$2,743,575	($2,474,129)
10% Social Discount Rate	$266,104	$2,713,781	($2,447,677)
Policy Option 3: Regulatory Measures			
5% Social Discount Rate	$93,225	$72,374	($20,852)
7% Social Discount Rate	$92,604	$71,580	($21,025)
10% Social Discount Rate	$91,715	$70,443	($21,272)
Policy Option 4: Tiered Rate Structure – Price Elasticity of 0.5			
5% Social Discount Rate	$19,089	$0	$19,089
7% Social Discount Rate	$18,733	$0	$18,733
10% Social Discount Rate	$18,222	$0	$18,222
Policy Option 4: Tiered Rate Structure – Price Elasticity of 1			
5% Social Discount Rate	$71,675	$0	$71,675
7% Social Discount Rate	$70,335	$0	$70,335
10% Social Discount Rate	$68,417	$0	$68,417
Policy Option 4: Tiered Rate Structure – Price Elasticity of 2			
5% Social Discount Rate	$174,146	$0	$174,146
7% Social Discount Rate	$170,891	$0	$170,891
10% Social Discount Rate	$166,231	$0	$166,231

[118] Refer to Appendices A, B, and C for complete calculations, assumptions, and sources.

Policy Option 2: Cost-Benefit Analysis

The CBA for Policy Option 2: Incentives and Rebates resulted in the most negative NPV under all three discount rates (Table 7).

Table 7: Policy Option 2: Incentives and Rebates NPV

	Total PV Benefits	Total PV Costs	Total NPV
Policy Option 2: Incentives and Rebates			
5% Social Discount Rate	$271,779	$2,764,383	($2,492,604)
7% Social Discount Rate	$269,446	$2,743,575	($2,474,129)
10% Social Discount Rate	$266,104	$2,713,781	($2,447,677)

This is because appliances and other water efficient technologies are costly for customers and rebates are costly for Fort Collins Utilities, relative to the value of water savings. Table 8 presents a summary of the costs and benefits calculated in this CBA.

Table 8: Policy Option 2: Summary of Costs and Benefits

Costs	Benefits
Rebates and zero-interest loans given out by Fort Collins Utilities.	Increase in tax revenue for city, county, and state governments.
Labor cost of administering the incentives and rebates.	Water savings for customers.
Cost of appliances or other water-efficient technologies for the customer.	

There are two positive elements of this policy option not represented by the NPV. First, this is the only policy option that benefits the city, county, and state governments through an increase in tax revenue. Second, the total water savings associated with this policy is more reliable, given that the estimates are based on water-efficient technologies and less on behavioral changes.

Some assumptions were made in this CBA, which include:

1. There is no rebound (or take-back) effect associated with customers using new water-efficient technologies;
2. Incentives and rebates increase each year by 10.5% for clothes washers, 17% for dishwashers, and 14% for all other technologies; and
3. Administering the incentives and rebate program requires a 0.7 full-time equivalent (FTE) staff member, which would increase each year as the amount of incentives and rebates increase.

For more information on the calculations made for this policy option, see Appendix A.

Policy Option 2 saves a total of 603,030,500 gallons of water. This amount would result in a gpcd of approximately 114, surpassing the goal of 130. Finally, 34,895 participants are influenced by this policy over the eight-year program. If it were not for the very negative NPV, this policy option would be favorable.

Total Participants: 34,895

Total Water Savings: ~603 MG

GPCD by 2020: 114

Policy Option 3: Cost-Benefit Analysis

The CBA for Policy Option 3: Regulatory Measures resulted in a negative NPV under all three discount rates (see Table 9).

Table 9: Policy Option 3: Regulatory Measures NPV

	Total PV Benefits	Total PV Costs	Total NPV
Policy Option 3: Regulatory Measures			
5% Social Discount Rate	$93,225	$72,374	($20,852)
7% Social Discount Rate	$92,604	$71,580	($21,025)
10% Social Discount Rate	$91,715	$70,443	($21,272)

Regulatory measures usually have high enforcement costs compared to water savings, which was the case for Fort Collins. Table 10 explains the costs and benefits that were calculated in the CBA.

Table 10: Policy Option 3: Summary of Costs and Benefits

Costs	Benefits
Enforcement costs of upholding the wasting water ordinance.	Water savings from water wasting violations.
Enforcement costs of inspecting new developments under the soil amendment ordinance.	Water savings from adding organic content to soil before planting turf grass for new developments.

This policy option relied on some significant assumptions, since there was no water savings data provided by Fort Collins. These assumptions include:

1. Utilities would need 0.6 FTE to enforce this policy option;
2. The number of wasting water violations is the same each year; and
3. The average annual number of new single-family homes built between 2002 and 2006 remains stable through the 8-year program.

Additionally, since Fort Collins did not have estimates of water savings for either measure, data from other cities were used. The City of Greeley has a similar soil amendment ordinance, so its estimates for water savings was recalculated and used for Fort Collins. Similarly, water savings for the wasting water ordinance was calculated using Denver Water's estimates (see Appendix B).

Although both Policy Option 2 and Policy Option 3 have negative NPVs, each NPV for Policy Option 3 becomes more positive as the number of program years increase. This is because soil amendment ordinances have long lasting effects, and increasing organic matter in soil before planting turf grass on new developments can have significant water savings, with no additional costs from year-to-year.

Fort Collins only enforced 29 wasting water complaints, which does not significantly reduce water use. Denver Water, for example, made over 5,000 stops in 2010, to either reward correct watering behavior, or issue violations. Although its enforcement costs are presumably much higher, Denver Water is more likely to change its customers' behavior, by reaching a greater audience.

Policy Option 3 does not reach as many participants as the other two policy options. By 2020, it is estimated that 25,732 total participants are influenced by this policy, and 417,030,427 gallons of water is saved. In the final program year (2019), this policy option reduced water use by 92,577,253, which would result in a gpcd of approximately 139.

Total Participants: 25,732

Total Water Savings: ~417 MG

GPCD by 2020: 139

Policy Option 4: Cost- Benefit Analysis

The cost-benefit analysis for Policy Option 4: Tiered Rate Structure resulted in a positive NPV using all three SDRs and values for price elasticity (see Table 11). This is because there are no costs associated with this policy option. The benefits were calculated based off the value of the water savings. Table 11 explains that the value for price elasticity has a substantial effect on the final NPV. For complete calculations, see Appendix C.

Table 11: Policy Option 4: Tiered Rate Structure NPV

	Total PV Benefits	Total PV Costs	Total NPV
Policy Option 4: Tiered Rate Structure – Price Elasticity of 0.5			
5% Social Discount Rate	$19,089	$0	$19,089
7% Social Discount Rate	$18,733	$0	$18,733
10% Social Discount Rate	$18,222	$0	$18,222
Policy Option 4: Tiered Rate Structure – Price Elasticity of 1			
5% Social Discount Rate	$71,675	$0	$71,675
7% Social Discount Rate	$70,335	$0	$70,335
10% Social Discount Rate	$68,417	$0	$68,417
Policy Option 4: Tiered Rate Structure – Price Elasticity of 2			
5% Social Discount Rate	$174,146	$0	$174,146
7% Social Discount Rate	$170,891	$0	$170,891
10% Social Discount Rate	$166,231	$0	$166,231

By 2020, it is estimated that 54,642 RSF customers will be served (Table 24). The total number of gallons saved, and the estimated gpcd by 2020 varies with price elasticity. A price elasticity of 0.5 results in a total of 142,855,191 gallons saved, and an estimated 130 gpcd. A price elasticity of 1 results in a total of 406,001,012 gallons saved, and an estimated 116 gpcd. A price elasticity of 2 results in a total of 864,094,110 gallons saved, and an estimated 93 gpcd. Clearly, this policy option reaches the goal of reducing gpcd to less than 130 using all three values for price elasticity. If Fort Collins happened to be more price inelastic than 0.5, then it would have to increase price by more than three percent annually in order to reach the goal by 2020.

Total Participants: 54,642

Total Water Savings: ~143 to ~864 MG

GPCD by 2020: 93 to 130

WEAKNESSES AND LIMITATIONS

The weaknesses and limitations in this analysis are primarily associated with lack of available data for the CBA and assumptions used to make the calculations. Specifically, calculating the water savings seen from education and outreach, and regulatory measures is difficult, because there is little research on each measure. Additionally, averages for the cost of water-efficient technologies was used to calculate the NPV for Policy Option 2, even though there are large price discrepancies from one product to another. Finally, there is little research on the take-back effect and SDR for water-efficient technologies. There are estimates for energy conservation, but not for water conservation. This may change as water becomes scarcer in the U.S.

In Policy Option 2: Incentives and Rebates, the zero-interest loans given out for water line replacement was not calculated in the CBA. This is because water savings is completely dependent on the size of the hole in the line, water pressure, and how long the customer goes without fixing it. An average would not adequately represent the savings, because residents can go a very long time without noticing a leak, if it is small, or fix it right away, if it is large. For this reason, it was not included in the CBA.

The CBA conducted for Policy Option 3: Regulatory Measures relied on recalculating data given by both the City of Greeley, and Denver Water. This makes the results less reliable than the other policies. Additionally, water savings estimates given for wasting water ordinances and soil amendments are variable. There is no definitive water savings associated with wasting water ordinances, because it relies on behavioral change, which is very difficult to track, unless it is the only water conservation method being used. The water savings from soil amendment requirements are dependent on the type of organic matter added, and the type of soil. For these reasons, the NPVs for Policy Option 3 are the most variable.

The last major weakness is not having the exact price elasticity for Fort Collins. In this analysis, three values were chosen in order to compare what effect each would have on water usage and NPV. Unfortunately, there are many factors that contribute to price elasticity, and it is possible that none of the three values in this analysis accurately represent Fort Collins. However, given that Policy Option 4 does not have any foreseeable costs, as long as price is relatively elastic in Fort Collins, this option would always result in a positive NPV.

STRATEGIC RECOMMENDATION

Based on the criteria outlined in the Methods section of this report, Policy Option 4: Tiered Rate Structure is the most cost-effective initiative pursued by Fort Collins Utilities. Considering there no additional administrative and enforcement costs, using price to signal the scarcity of the water in the region is the best option for the city moving forward. Although Fort Collins Utilities may want to use a combination of measures to achieve ideal levels of water savings, under budget constraints or other barriers, using price to manage demand should be the focus of its conservation plan. That said, for a tiered rate structure to be effective, consumers need to have a thorough understanding of their water usage and how the rate structure is designed. Pairing a tiered rate structure with informational bill inserts may help to achieve greater water savings.

Opponents of this recommendation may argue that using a market-based approach to reduce residential water consumption is not an equitable solution, given that low-income households' demand is more elastic, which results in the conservation burden falling on those households. Although this is a valid point, using a tiered rate structure enables households to remain within the lowest tier, if they prefer to do so. Additionally, the revenue generation from increasing the price of water could be returned to the low-income households to balance this inequity.

Although economists typically advocate pricing goods to reflect scarcity, opponents to this policy option would argue that this theory should not be applied to goods that are considered a necessity. This is a reasonable concern, but there is one main problem with this argument. The market does not set the price for water, under any pricing scheme. If the price of water were to be determined completely by the market, it would be substantially higher. Every utility in the U.S. determines the price of water, and cannot make a profit above their operating expenses. If a utility decides to use price to reduce water consumption by implementing the appropriate rate structure, then it is using a more market-based approach than other non-price measures, but is not completely letting the market dictate the price. Finally, many other necessities, such as food and fuel, are priced by the market and do reflect scarcity.

Proper water management and planning in Colorado's Front Range region will be crucial in the next few decades to accommodate future population growth. In current economic times, when states and cities are being confronted with major budget cuts, it does not make sense to implement water conservation measures that add to budget deficits. There are no monetary costs associated with implementing a tiered rate structure, and the revenue generated could be used to implement other conservation measures, returned to low-income households, or used for water development projects that increase supply.

Closing the projected South Platte Basin water gap of 32 to 66 percent by 2050 will require that all providers take a proactive approach in their own region to reduce water demand. Although using price as a mechanism to reduce water use may only be the best option for Fort Collins moving forward, all utilities should be constantly evaluating the effectiveness of their individual programs. If providers in the

South Platte Basin are able to close their individual water gaps, then the region as a whole will have a more sustainable future.

REFERENCES

Aquacraft Water Engineering and Management. ""Project Report: Measuring Actual Retrofit Savings and Conservation Effectiveness Using Flow Trace Analysis"." Prepared for the City of Boulder, Colorado, Utilities Division, Office of Water Conservation, 1996.

Bennear, Lori S., Jonathan M. Lee, and Laura O. Taylor. "PARTICIPATION INCENTIVES, REBOUND EFFECTS AND THE COST-EFFECTIVENESS OF REBATES FOR WATER-EFFICIENT APPLIANCES." Duke Environmental Economics Working Paper No. 11-10 , 2011.

Campbell, Heather E., Ryan M. Johnson, and Elizabeth Hunt Larson. "Prices, Devices, People, or Rules: The Relative Effectiveness of Policy Instruments in Water Conservation." *Review of Policy Research* 21, no. 5 (2004): 637-662.

Cascade Water Alliance. "Cascade WaterSense Toilet Replacement Program: Bellevue, WA." *Cascade Water Alliance.* October 12, 2011. (accessed March 12, 2012).

City of Fort Collins City Planning and Community Development. "Trends 2006." *City of Fort Collins.* www.fcgov.com/advanceplanning/pdf/trends2006-doc.pdf (accessed March 31, 2012).

City of Fort Collins Utilities. "Halligan Reservoir Enlargement: Update." *City of Fort Collins.* http://www.fcgov.com/utilities/what-we-do/water/halligan-reservoir-enlargement-project/update (accessed November 28, 2011).

—. *Single-family and Duplex Water Rates.* http://www.fcgov.com/utilities/residential/rates/water (accessed December 26, 2011).

—. "Water Conservation." Annual Report, Fort Collins, 2010, 1-18.

City of Greeley. "Water Conservation Plan: CIty of Greeley, Colorado." November 20, 2008. http://www.aquacraft.com/sites/default/files/pub/Mayer-%282008%29-City-of-Greeley-Water-Conservation-Plan.pdf (accessed March 31, 2012).

Colorado Division of Water Resources. "A Summary of Compacts and Litigation Governing Colorado's Use of Interstate Streams." 2006. water.state.co.us/DWRIPub/Documents/compactsreport.pdf.

Colorado Geological Survey. "Distribution of ground- versus surface-water withdrawals by county in 1995." *Ground Water Atlas of Colorado* . 1995. http://geosurvey.state.co.us/apps/wateratlas/images/jpeg.gif (accessed January 24, 2012).

Colorado Oil and Gas Conservation Commission. "Water Sources and Demand for the Hydraulic Fracturing of Oil and Gas Wells in Colorado from 2010 through 2015." January 24, 2012. http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf (accessed February 20, 2012).

Colorado Water Conservation Board. "Colorado's Nonconsumptive Needs and Project and Methods Implementation." Technical Assistance for Basin Roundtables, CWCB, and IBCC, 2011.

—. "Water Management: Water Supply Planning." *Colorado Water Conservation Board.* http://cwcb.state.co.us/water-management/water-supply-planning/Pages/main.aspx (accessed December 14, 2011).

Colorado WaterWise and Aquacraft, Inc. *Guidebook of Best Practices for Municipal Water Conservation in Colorado.* Denver, CO: Colorado WaterWise, 2010.

D'Audney, Laurie, interview by Hanna Schum. *Rebate History* (March 23, 2012).

Denver Water. "Solutions 2011." *Denver Water.* 2011. http://www.denverwater.org/docs/assets/44EC9CA1-A444-8348-68E2A8D5BD36DFA4/Solutions2011.pdf (accessed March 31, 2012).

Espey, M., J. Espey, and W. D. Shaw. "Price Elasticity of Residential Demand for Water: A Meta-Analysis." *Water Resources Research* 33, no. 6 (1997): 1369-1374.

Finley, Bruce. "Fracking of wells puts big demand on Colorado water." *The Denver Post.* November 23, 2011. http://www.denverpost.com/news/ci_19395984 (accessed December 10, 2011).

Ground Water Protection Council. "Colorado Ground Water Conditions." *Ground Water Protection Council.* 2007. http://gwpc.org/e-library/documents/state_fact_sheets/colorado.pdf (accessed January 24, 2012).

Kenney, Douglas S., Christopher Goemans, Roberta Klein, Jessica Lowrey, and Kevin Reidy. "Residential Water Demand Management: Lessons From Aurora, Colorado." *Journal of American Water Resources Association* 44, no. 1 (February 2008): 192-207.

Konieczki, A. D., and J. A. Heilman. *Water-Use Trends in the Desert Southwest—1950–2000.* Scientific Investigations Report 2004–5148, U.S. Department of the Interior and U.S. Geological Survey, 2004.

Mayer, Peter, Laurie D'Audney, and Dennis Bode. *Water Conservation Plan.* Fort Collins : City of Fort Collins Utilities, 2009, 1-49.

Michelsen, Ari M., Thomas J. McGuckin, and Donna Stumpf. "Nonprice Water Conservation Programs as a Demand Management Tool." *Journal of the American Water Resource Association* 35, no. 3 (June 1999): 593-602.

Molenaar, Beth, interview by Hanna Schum. *Email* (December 9, 2011).

Nichols, Peter D., Megan K. Murphy, and Douglas S. Kenney. "Water and Growth in Colorado: A Review of Legal and Policy Issues." Natural Resource Law Center, University of Colorado School of Law, 2001.

Olmstead, Sheila M., and Robert N. Stavins. "Comparing Price and Non-price Approaches to Urban Water Conservation ." *Fondazione Eni Enrico Mattei* , no. 225 (September 2008): 1-24.

—. "Comparing price and nonprice approaches to urban water conservation." *Water Resources Research* 45 (April 2009): 1-10.

—. "Managing Water Demand: Price vs. Non-Price Conservation Programs." *Pioneer Institute for Public Policy Research*, no. 39 (July 2007): 1-42.

Rowan, Nicole, Ed Harvey, Meg Frantz, and Hal Simpson. *State of Colorado Current and 2050 Agricultural Demands.* Memorandum, Colorado Water Conservation Board, 2010, 1-30.

State Demography Office, "Population Totals for Colorado and Sub-state Regions: Historical Census – years (1790 to 2010)," *Colorado Department of Local Affairs*, 2012, https://dola.colorado.gov/demog_webapps/hcp_parameters.jsf (accessed January 6, 2012).

—. "Population Totals for Colorado Counties." *State of Colorado: Department of Local Affairs.* September 2010. http://www.colorado.gov/cs/Satellite?c=Document_C&childpagename=DOLA-Main%2FDocument_C%2FCBONAddLinkView&cid=1251593369324&pagename=CBONWrapper (accessed November 2, 2011).

—. "Population Totals for Colorado Counties: Population Forecasts - years (2000 to 2040) ." *Colorado Department of Local Affairs.* 2012. http://www.colorado.gov/cs/Satellite?c=Document_C&childpagename=DOLA-Main%2FDocument_C%2FCBONAddLinkView&cid=1251593369324&pagename=CBONWrapper (accessed January 6, 2012).

Statewide Water Supply Initiative. Colorado Water Conservation Board. Colorado Department of Natural Resourcs. "South Platte Basin Needs Assessment Report." Draft Report, 2011.

—. "South Platte Basin Needs Assessment Report," Final Report, 2011.

U.S. Census Bureau. "State & County Quick Facts: Fort Collins (city), Colorado ." *U.S. Census Bureau.* October 18, 2011. http://quickfacts.census.gov/qfd/states/08/0827425.html (accessed December 15, 2011).

U.S. Environmental Protection Agency and U.S. Department of Energy. "Clothes Washers for Consumers." *Energy Star.* http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls?cd09-6557 (accessed March 12, 2012).

—. "Dishwashers for Consumers." *Energy Star.* http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?04d0-7f42 (accessed March 12, 2012).

U.S. Environmental Protection Agency. *Appendix A: Inflation and Discounting Factors.* www.epa.gov/oppt/coi/pubs/appa.pdf (accessed Feburary 28, 2012).

—. "Outdoor Water Use." *United States Environmental Protection Agency.* April 14, 2011. http://www.epa.gov/WaterSense/pubs/outdoor.html (accessed May 1, 2011).

—. "Sub-surface Drip Irrigation Cost Calculator." www.epa.gov/osw/conserve/rrr/greenscapes/tools/drip.pdf (accessed March 31, 2012).

—. "Tips for Consumers." *United States Environmental Protection Agency.* April 14, 2011. http://www.epa.gov/WaterSense/water_efficiency/cons.html (accessed May 04, 2011).

U.S. Environmental Protection Agency Water Sense. "Toilet." *Water Sense.* February 2, 2012. http://www.epa.gov/WaterSense/products/toilets.html (accessed March 31, 2012).

—. "WaterSense® Draft Specification for Weather-Based Irrigation Controllers Supporting Statement." November 19, 2009. epa.gov/watersense/docs/controller_suppstat508.pdf (accessed March 31, 2012).

United States Department of Energy. *Domestic Water Conservation Technologies: Using less water and energy is an investment in a sustainable future.* Washington, DC: National Renewable Energy Laboratory , 2002.

University of Colorado at Boulder. Western Water Assessment. *Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adoption.* Colorado Water Conservation Board, 2008.

Vic, Amy. *Handbook of water use and conservation : [homes, landscapes, businesses, industries, farms]*. Amherst, Massachusetts: Waterplow Press, 2001.

Appendix A - Policy Option 2: Incentives and Rebates Calculations

Table 12: Policy Option 2: Incentives and Rebates Costs (Program Year 0)[119]

Stakeholder					
	Rebate	**Amount**	**Quantity**	**Program Year 0**	
Utilities	ENERGY STAR® Certified Clothes Washer Rebate	$50	1249		$62,450
	WaterSense Toilet Rebate	$35	497		$17,395
	Recycling Old Toilet Rebate	$15	440		$6,600
	ENERGY STAR® Certified Dishwasher Rebate	$25	780		$19,500
	Zero-Interest Loan for Clothes Washers	$796	6		$4,775
	Multi-jet Rotating Nozzles Rebate	$38	79		$2,963
	Weather-Based Controller Rebate	$150	41		$6,150
	Rain Sensor Rebate	$23	44		$990
	Total				$120,823
	Program Costs		**FTE [120]**	**Labor Costs**	
	ENERGY STAR® Certified Clothes Washer Rebate		0.1		$10,000
	WaterSense Toilet Rebate		0.1		$10,000
	Recycling Old Toilet Rebate		0.0		$0
	ENERGY STAR® Certified Dishwasher Rebate		0.1		$10,000
	Zero-Interest Loan for Clothes Washers		0.1		$10,000
	Multi-jet Rotating Nozzles Rebate		0.1		$10,000
	Weather-Based Controller Rebate		0.1		$10,000
	Rain Sensor Rebate		0.1		$10,000
	Total Program Costs		0.7		$70,000
	Total Utilities Costs				$190,823
	Product	**Average Price**	**Rebate**	**Quantity**	**Total**
Customers	ENERGY STAR® Certified Clothes Washer	$796[121]	$50	1249	$931,617
	WaterSense Toilet	$177[122]	$35	497	$70,634
	ENERGY STAR® Certified Dishwasher	$584[123]	$25	780	$435,747
	Multi-jet Rotating Nozzles	$75[124]	$38	79	$2,963
	Weather-Based Controller	$499[125]	$150	41	$14,299
	Rain Sensor	$138[126]	$23	44	$5,060
	Total Customer Costs				$1,460,319
Total					**$1,651,142**

[119] Source for all rebate amount and quantities: City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 1-18.

[120] Assumption: Fort Collins estimates that is costs the city 0.1 FTE @ $10,000 annually to administer HET rebates. The same estimate was used for all other rebates, despite variance in the number of rebates given for each product. Source: Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins : City of Fort Collins Utilities, 2009), 1-49.

[121] Average price for ENERGY STAR® certified clothes washer in 2012 dollars. Source: U.S. Environmental Protection Agency and U.S. Department of Energy, "Clothes Washers for Consumers," *Energy Star*, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls?cd09-6557 (accessed March 12, 2012).

[122] Average price for WaterSense certified toilet in 2012 dollars. Cascade Water Alliance, "Cascade WaterSense Toilet Replacement Program: Bellevue, WA," *Cascade Water Alliance*, October 12, 2011, (accessed March 12, 2012).

[123] Average price for ENERGY STAR® certified Dishwasher. Source: U.S. Environmental Protection Agency and U.S. Department of Energy, "Dishwashers for Consumers," *Energy Star*, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?04d0-7f42 (accessed March 12, 2012).

[124] Average ($50-$100). Source: City of Fort Collins Utilities, "Water Conservation," Annual Report (Fort Collins, 2010), 6.

[125] U.S. Environmental Protection Agency Water Sense, "WaterSense® Draft Specification for Weather-Based Irrigation Controllers Supporting Statement," November 19, 2009, epa.gov/watersense/docs/controller_suppstat508.pdf (accessed Marcg 31, 2012).6.

[126] James City County, "Rain Sensor Rebate Facts," *James City County*, http://www.jamescitycountyva.gov/bewatersmart/RebatePrograms/Rain%20Sensors/RainSensorsFAQ.html (accessed March 31, 2012).

Table 13: Policy Option 2: Incentives and Rebates Costs (Program Year 1 -7) [127]

Stakeholder								
	Rebate	**Program Year 1**	**Program Year 2**	**Program Year 3**	**Program Year 4**	**Program Year 5**	**Program Year 6**	**Program Year 7**
Utilities	ENERGY STAR® Certified Clothes Washer Rebates	$69,007	$76,253	$84,260	$93,107	$102,883	$113,686	$125,623
	WaterSense Toilet Rebate	$19,830	$22,607	$25,771	$29,379	$33,493	$38,182	$43,527
	Recycling Old Toilet Rebate	$7,524	$8,577	$9,778	$11,147	$12,708	$14,487	$16,515
	ENERGY STAR® Certified Dishwasher Rebate	$22,815	$26,694	$31,231	$36,541	$42,753	$50,021	$58,524
	Zero-Interest Loan for Clothes Washers	$5,444	$6,206	$7,075	$8,065	$9,195	$10,482	$11,949
	Multi-jet Rotating Nozzles	$3,377	$3,850	$4,389	$5,004	$5,704	$6,503	$7,413
	Weather-Based Controller Rebates	$7,011	$7,993	$9,111	$10,387	$11,841	$13,499	$15,389
	Rain Sensor	$1,129	$1,287	$1,467	$1,672	$1,906	$2,173	$2,477
	Total Rebate Cost	$136,137	$153,466	$173,083	$195,302	$220,482	$249,031	$281,417
	Program Costs	**FTE**	**FTE**	**FTE**	**FTE**	**FTE**	**FTE**	**FTE**
	ENERGY STAR® Certified Clothes Washer Rebates	$11,050	$12,210	$13,492	$14,909	$16,474	$18,204	$20,116
	WaterSense Toilet Rebate	$11,400	$12,996	$14,815	$16,890	$19,254	$21,950	$25,023
	Recycling Old Toilet Rebate	$0	$0	$0	$0	$0	$0	$0
	ENERGY STAR® Certified Dishwasher Rebate	$11,700	$13,689	$16,016	$18,739	$21,924	$25,652	$30,012
	Zero-Interest Loan for Clothes Washers	$11,400	$13,338	$15,605	$18,258	$21,362	$24,994	$29,243
	Multi-jet Rotating Nozzles	$11,400	$12,996	$15,205	$17,790	$20,815	$24,353	$28,493
	Weather-Based Controller Rebates	$11,400	$12,996	$14,815	$17,334	$20,281	$23,729	$27,762
	Rain Sensor	$11,400	$15,205	$17,790	$20,815	$24,353	$28,493	$33,337
	Total Program Cost	$79,750	$93,431	$107,740	$124,735	$144,464	$167,374	$193,986
	Total Utilities Cost	$215,887	$246,896	$280,823	$320,037	$364,946	$416,406	$475,403
	Product							
Customers	ENERGY STAR® Certified Clothes Washer Rebates	$1,029,436	$1,137,527	$1,256,968	$1,388,949	$1,534,789	$1,695,942	$1,874,015
	WaterSense Toilet Rebate	$80,522	$91,795	$104,647	$119,297	$135,999	$155,039	$176,744
	ENERGY STAR® Certified Dishwasher Rebate	$509,824	$596,494	$697,898	$816,541	$955,353	$1,117,763	$1,307,782
	Multi-jet Rotating Nozzles	$3,377	$3,850	$4,389	$5,004	$5,704	$6,503	$7,413
	Weather-Based Controller Rebates	$16,301	$18,583	$21,185	$24,151	$27,532	$31,386	$35,780
	Rain Sensor	$5,768	$6,576	$7,497	$8,546	$9,743	$11,107	$12,661
	Total Customer Cost	$1,645,229	$1,854,826	$2,092,583	$2,362,488	$2,669,119	$3,017,739	$3,414,397
Total		**$1,861,117**	**$2,101,722**	**$2,373,406**	**$2,682,525**	**$3,034,065**	**$3,434,144**	**$3,889,800**

[127] Growth of rebates and incentives based off the average of the most recent three years. Clothes washers = 10.5%. Dishwashers = 17%. Average of clothes washers and dishwashers was used for all others = 14%. Source: Laurie D'Audney, interview by Hanna Schum, *Rebate History*, (March 23, 2012).

Table 14: Policy Option 2: Incentives and Rebates Benefits (Program Year 0) [128]

Stakeholder					
	Product	Average Price	Quantity	Sales Tax	Program Year 0
Government	ENERGY STAR® Certified Clothes Washer	$796	1249	7.55%	$75,052
	WaterSense Toilet	$177	497	7.55%	$6,646
	ENERGY STAR® Certified Dishwasher	$584	780	7.55%	$34,371
	Zero-Interest Loan for Clothes Washers Replacement	$796	6	7.55%	$361
	Multi-jet Rotating Nozzles	$75	79	7.55%	$447
	Weather-Based Controller	$499	41	7.55%	$1,544
	Rain Sensor	$138	44	7.55%	$457
	Total				$118,878
	Product	Average Annual Water Savings	Quantity	Gallons Saved Annually	Total Value of Water Saved
Customers	ENERGY STAR® Certified Clothes Washer	6542[129]	1249	8170958	$18,221
	WaterSense Toilet	4000[130]	497	1988000	$4,433
	ENERGY STAR® Certified Dishwasher	430[131]	780	335400	$748
	Zero-Interest Loan for Clothes Washers Replacement	6542[132]	6	39252	$88
	Weather-Based Controller	11600[133]	41	475600	$1,061
	Multi-jet Rotating Nozzles	6406[134]	79	506074	$1,129
	Rain Sensor	24061[135]	44	1058684	$2,361
	Total			12573968	$28,040
Total Benefits					**$146,918**

[128] Source for all rebates amounts and quantities: City of Fort Collins Utilities, "Water Conservation," Annual Report, 2010), 1-18.

[129] Average annual water savings for ENERGY STAR® certified clothes washers. Source: U.S. Environmental Protection Agency and U.S. Department of Energy, "Clothes Washers for Consumers," *Energy Star*, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls?cd09-6557 (accessed March 12, 2012).

[130] U.S. Environmental Protection Agency Water Sense, "Toilet," *Water Sense*, February 2, 2012, http://www.epa.gov/WaterSense/products/toilets.html (accessed March 31, 2012).

[131] Average annual water savings for ENERGY STAR® certified Dishwasher. Source: U.S. Environmental Protection Agency and U.S. Department of Energy, "Dishwashers for Consumers," *Energy Star*, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?04d0-7f42 (accessed March 12, 2012).

[132] Average annual water savings for ENERGY STAR® certified clothes washers. Source: U.S. Environmental Protection Agency and U.S. Department of Energy, "Clothes Washers for Consumers," *Energy Star*, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls?cd09-6557 (accessed March 12, 2012).

[133] U.S. Environmental Protection Agency Water Sense, "WaterSense® Draft Specification for Weather-Based Irrigation Controllers Supporting Statement," November 19, 2009, epa.gov/watersense/docs/controller_suppstat508.pdf (accessed Marcg 31, 2012).6.

[134] Assumption: Saves 65% of outdoor watering use (Source: "MP Rotator Water Saving Lawn Sprinklers," *Drip Works*, http://www.dripworks.com/category/mprot (accessed March 31, 2012) , which is an average of 27 gpcd (Source Amy Vic, *Handbook of water use and conservation: [homes, landscapes, businesses, industries, farms]* (Amherst, Massachusetts: Waterplow Press, 2001, 141)), equaling 6,406 gallons annually (27x365x0.65).

[135] U.S. Environmental Protection Agency, "Sub-surface Drip Irrigation Cost Calculator," www.epa.gov/osw/conserve/rrr/greenscapes/tools/drip.pdf (accessed March 31, 2012).

Table 15: Policy Option 2: Incentives and Rebates Benefits (Program Year 1-7)[136]

Stakeholder								
	Product	**Program Year 1**	**Program Year 2**	**Program Year 3**	**Program Year 4**	**Program Year 5**	**Program Year 6**	**Program Year 7**
Government	ENERGY STAR® Certified Clothes Washer	$82,932	$91,640	$101,263	$111,895	$123,644	$136,627	$150,973
	WaterSense Toilet	$7,577	$8,637	$9,847	$11,225	$12,797	$14,588	$16,630
	ENERGY STAR® Certified Dishwasher	$40,214	$47,051	$55,049	$64,408	$75,357	$88,168	$103,156
	Zero-Interest Loan for Clothes Washers Replacement	$411	$469	$534	$609	$694	$791	$902
	Multi-jet Rotating Nozzles	$510	$581	$663	$756	$861	$982	$1,119
	Weather-Based Controller	$1,760	$2,006	$2,287	$2,608	$2,973	$3,389	$3,863
	Rain Sensor	$521	$594	$677	$771	$879	$1,003	$1,143
	Total	$133,925	$150,978	$170,320	$192,272	$217,205	$245,547	$277,787
	Product	**Program Year 1**	**Program Year 2**	**Program Year 3**	**Program Year 4**	**Program Year 5**	**Program Year 6**	**Program Year 7**
Customers	ENERGY STAR® Certified Clothes Washer	$20,134	$22,249	$24,585	$27,166	$30,019	$33,170	$36,653
	WaterSense Toilet	$5,054	$5,761	$6,568	$7,488	$8,536	$9,731	$11,093
	ENERGY STAR® Certified Dishwasher	$875	$1,024	$1,198	$1,402	$1,640	$1,919	$2,245
	Zero-Interest Loan for Clothes Washers Replacement	$100	$114	$130	$148	$169	$192	$219
	Weather-Based Controller	$1,209	$1,378	$1,571	$1,791	$2,042	$2,328	$2,654
	Multi-jet Rotating Nozzles	$1,287	$1,467	$1,672	$1,906	$2,173	$2,477	$2,824
	Rain Sensor	$2,691	$3,068	$3,498	$3,987	$4,546	$5,182	$5,908
	Total	$31,350	$35,061	$39,221	$43,888	$49,123	$54,999	$61,596
Total Benefits		**$165,275**	**$186,039**	**$209,541**	**$236,159**	**$266,329**	**$300,547**	**$339,383**

[136] Growth of rebates and incentives based off the average of the most recent three years. Clothes washers = 10.5%. Dishwashers = 17%. Average of clothes washers and dishwashers was used for all others = 14%. Source: Laurie D'Audney, interview by Hanna Schum, *Rebate History*, (March 23, 2012).

Table 16: Policy Option 2: Incentives and Rebates – NPV – SDR 5%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit
0	2012	$1,651,142	0%	$1,651,142	$146,918	0%	$146,918
1	2013	$1,861,117	5%	$652,063	$193,315	5%	$67,730
2	2014	$2,101,722	5%	$270,893	$245,429	5%	$31,634
3	2015	$2,373,406	5%	$112,538	$303,992	5%	$14,414
4	2016	$2,682,525	5%	$46,793	$369,832	5%	$6,451
5	2017	$3,034,065	5%	$19,470	$443,889	5%	$2,848
6	2018	$3,434,144	5%	$8,107	$527,230	5%	$1,245
7	2019	$3,889,800	5%	$3,378	$621,065	5%	$539
Total				**$2,764,383**			**$271,779**
Total NPV							**-$2,492,604**

Table 17: Policy Option 2: Incentives and Rebates – NPV – SDR 7%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit
0	2012	$1,651,142	0%	$1,651,142	$146,918	0%	$146,918
1	2013	$1,861,117	7%	$639,875	$193,315	7%	$66,464
2	2014	$2,101,722	7%	$265,829	$245,429	7%	$31,042
3	2015	$2,373,406	7%	$110,435	$303,992	7%	$14,145
4	2016	$2,682,525	7%	$45,918	$369,832	7%	$6,331
5	2017	$3,034,065	7%	$19,106	$443,889	7%	$2,795
6	2018	$3,434,144	7%	$7,956	$527,230	7%	$1,221
7	2019	$3,889,800	7%	$3,315	$621,065	7%	$529
Total				**$2,743,575**			**$269,446**
Total NPV							**-$2,474,129**

Table 18: Policy Option 2: Incentives and Rebates – NPV – SDR 10%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit
0	2012	$1,651,142	0%	$1,651,142	$146,918	0%	$146,918
1	2013	$1,861,117	10%	$622,424	$193,315	10%	$64,652
2	2014	$2,101,722	10%	$258,579	$245,429	10%	$30,196
3	2015	$2,373,406	10%	$107,423	$303,992	10%	$13,759
4	2016	$2,682,525	10%	$44,666	$369,832	10%	$6,158
5	2017	$3,034,065	10%	$18,585	$443,889	10%	$2,719
6	2018	$3,434,144	10%	$7,739	$527,230	10%	$1,188
7	2019	$3,889,800	10%	$3,225	$621,065	10%	$515
Total				**$2,713,781**			**$266,104**
Total NPV							**-$2,447,677**

Appendix B – Policy Option 3: Regulatory Measures Calculations

Table 19: Policy Option 3: Regulatory Measures - Costs

Stakeholder			
	Program Costs	**Labor (FTE)[137]**	**Labor Cost**
Utilities	Wasting Water Ordinance	0.1	$10,000
	Soil Amendment Ordinance	0.5	$50,000
	Total Utilities Costs		$60,000
Total Costs			**$60,000**

Table 20: Policy Option 3: Regulatory Measures - Benefits

Stakeholder					
	Ordinance	**Quantity**	**Water Savings**	**Total Water Savings**	**Value of Water Saved**
Customers	Wasting Water Ordinance	26	4,756[138]	123,653	$317
	Soil Amendment Ordinance	709[139]	16,300[140]	11,556,700	$29,585
	Total Customer Benefits				$29,902
Total Benefits					**$29,902**

[137] Estimates extrapolated from Fort Collins' FTE estimates for rebates.

[138] Denver Water, "Solutions 2011," *Denver Water*, 2011, http://www.denverwater.org/docs/assets/44EC9CA1-A444-8348-68E2A8D5BD36DFA4/Solutions2011.pdf (accessed March 31, 2012), 6.

[139] The average for new single-family homes built between 2002 and 2006 in Fort Collins was used. Source: City of Fort Collins City Planning and Community Development, "Trends 2006," *City of Fort Collins*, www.fcgov.com/advanceplanning/pdf/trends2006-doc.pdf (accessed March 31, 2012), 32.

[140] City of Greeley, "Water Conservation Plan: City of Greeley, Colorado," November 20, 2008, http://www.aquacraft.com/sites/default/files/pub/Mayer-%282008%29-City-of-Greeley-Water-Conservation-Plan.pdf (accessed March 31, 2012), 35.

Table 21: Policy Option 3: Regulatory Measures – NPV – SDR 5%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit [141]
0	2012	$60,000	0.00%	$60,000	$29,902	0.00%	$29,902
1	2013	$60,000	5.00%	$21,022	$59,487	5.00%	$20,842
2	2014	$60,000	5.00%	$7,733	$89,389	5.00%	$11,521
3	2015	$60,000	5.00%	$2,845	$119,290	5.00%	$5,656
4	2016	$60,000	5.00%	$1,047	$149,192	5.00%	$2,602
5	2017	$60,000	5.00%	$385	$179,094	5.00%	$1,149
6	2018	$60,000	5.00%	$142	$208,995	5.00%	$493
7	2019	$60,000	5.00%	$52	$238,897	5.00%	$207
Total				**$93,225**			**$72,374**
Total NPV							**-$20,852**

Table 22: Policy Option 3: Regulatory Measures – NPV – SDR 7%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit [142]
0	2012	$60,000	0.00%	$60,000	$29,902	0.00%	$29,902
1	2013	$60,000	7.00%	$20,629	$59,487	7.00%	$20,452
2	2014	$60,000	7.00%	$7,589	$89,389	7.00%	$11,306
3	2015	$60,000	7.00%	$2,792	$119,290	7.00%	$5,551
4	2016	$60,000	7.00%	$1,027	$149,192	7.00%	$2,554
5	2017	$60,000	7.00%	$378	$179,094	7.00%	$1,128
6	2018	$60,000	7.00%	$139	$208,995	7.00%	$484
7	2019	$60,000	7.00%	$51	$238,897	7.00%	$204
Total				**$92,604**			**$71,580**
Total NPV							**-$21,025**

Table 23: Policy Option 3: Regulatory Measures – NPV – SDR 10%

Program Year	Year	Cost	SDR	PV Cost	Benefit	SDR	PV Benefit [143]
0	2012	$60,000	0%	$60,000	$29,902	0%	$29,902
1	2013	$60,000	10%	$20,066	$59,487	10%	$19,895
2	2014	$60,000	10%	$7,382	$89,389	10%	$10,998
3	2015	$60,000	10%	$2,716	$119,290	10%	$5,399
4	2016	$60,000	10%	$999	$149,192	10%	$2,484
5	2017	$60,000	10%	$368	$179,094	10%	$1,097
6	2018	$60,000	10%	$135	$208,995	10%	$471
7	2019	$60,000	10%	$50	$238,897	10%	$198
Total				**$91,715**			**$70,443**
Total NPV							**-$21,272**

[141] Assumes water savings for soil amendments continue through the 8-year program, but water wasting ordinances are annual, given they rely on behavior changes.

[142] Assumes water savings for soil amendments continue through the 8-year program, but water wasting ordinances are annual, given they rely on behavior changes.

[143] Assumes water savings for soil amendments continue through the 8-year program, but water wasting ordinances are annual, given they rely on behavior changes.

Appendix C - Policy Option 4: Tiered Rate Structure Calculations

Table 24: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 0.5

Stakeholder											
	Program Year	Year	Population Served[144]	RSF Consumers[145]	Current Use (gpcy)	Price (1,000 gal.)	% Change in price	Change in Qd	Total RSF Annual Use (gal.)	Annual Change in Qd (gal.)	Total Benefit
Customers	0	2012	140200	51874	52560	2.23	0%	0	2726497440	0	$0
	1	2013	141600	52392	51772	2.30	3%	-788	2712417667	-14079773	$32,340
	2	2014	143000	52910	50995	2.37	3%	-777	2698146826	-14270842	$33,762
	3	2015	144400	53428	50230	2.44	3%	-765	2683693815	-14453010	$35,219
	4	2016	145220	53731	49477	2.51	3%	-753	2658449623	-25244192	$63,360
	5	2017	146040	54035	48734	2.59	3%	-742	2633358926	-25090697	$64,864
	6	2018	146860	54338	48003	2.66	3%	-731	2608422799	-24936127	$66,398
	7	2019	147680	54642	47283	2.74	3%	-720	2583642249	-24780549	$67,964
Total										**-142855190.7**	**$363,907**

[144] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 1-49.

[145] Assumption: RSF water use remains 37% of total population served by Fort Collins Utilities.

Table 25: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 1

Stakeholder	Program Year	Year	Population Served[146]	RSF Consumers[147]	Current Use (gpcy)	Price (1,000 gal.)	% Change in price	Change in Qd	Total RSF Annual Use (gal.)	Annual Change in Qd (gal.)	Total Benefit
Customers	0	2012	140200	51874	52560	2.23	0%	n/a	2726497440	0	$0
	1	2013	141600	52392	50983	2.30	3%	-1577	2671111814	-55385626	$127,215
	2	2014	143000	52910	49454	2.37	3%	-1529	2616595479	-54516336	$128,975
	3	2015	144400	53428	47970	2.44	3%	-1484	2562946122	-53649356	$130,732
	4	2016	145220	53731	46531	2.51	3%	-1439	2500175241	-62770881	$157,548
	5	2017	146040	54035	45135	2.59	3%	-1396	2438863961	-61311280	$158,501
	6	2018	146860	54338	43781	2.66	3%	-1354	2378981200	-59882761	$159,452
	7	2019	147680	54642	42468	2.74	3%	-1313	2320496428	-58484773	$160,401
Total										**-406001012**	**$1,022,824**

Table 26: Policy Option 4: Tiered Rate Structure- Benefits - Price Elasticity of 2

Stakeholder	Program Year	Year	Population Served[148]	RSF Consumers[149]	Current Use (gpcy)	Price (1,000 gal.)	% Change in price	Change in Qd	Total RSF Annual Use (gal.)	Annual Change in Qd (gal.)	Total Benefit
Customers	0	2012	140200	51874	52560	2.23	0%	n/a	2726497440	0	$0
	1	2013	141600	52392	49406	2.30	3%	-3154	2588500109	-137997331	$316,966
	2	2014	143000	52910	46442	2.37	3%	-2964	2457247067	-131253042	$310,519
	3	2015	144400	53428	43655	2.44	3%	-2787	2332425789	-124821278	$304,162
	4	2016	145220	53731	41036	2.51	3%	-2619	2204930614	-127495175	$319,998
	5	2017	146040	54035	38574	2.59	3%	-2462	2084338128	-120592487	$311,753
	6	2018	146860	54338	36260	2.66	3%	-2314	1970278989	-114059138	$303,709
	7	2019	147680	54642	34084	2.74	3%	-2176	1862403330	-107875659	$295,862
Total										**-864094110**	**$2,162,970**

[146] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 1-49.

[147] Assumption: RSF water use remains 37% of total population served by Fort Collins Utilities.

[148] Peter Mayer, Laurie D'Audney and Dennis Bode, *Water Conservation Plan*, (Fort Collins: City of Fort Collins Utilities, 2009), 1-49.

[149] Assumption: RSF water use remains 37% of total population served by Fort Collins Utilities.

Table 27: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 0.5

Program Year	Year	Total Benefit	SDR 5%	SDR 7%	SDR 10%
0	2012	0	0	0	0
1	2013	32340	11331	11119	10816
2	2014	33762	4352	4270	4154
3	2015	35219	1670	1639	1594
4	2016	63360	1105	1085	1055
5	2017	64864	416	408	397
6	2018	66398	157	154	150
7	2019	67964	59	58	56
Total NPV		**363907**	**19089**	**18733**	**18222**

Table 28: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 1

Program Year	Year	Total Benefit	SDR 5%	SDR 7%	SDR 10%
0	2012	0	0	0	0
1	2013	127215	44571	43738	42545
2	2014	128975	16624	16313	15868
3	2015	130732	6199	6083	5917
4	2016	157548	2748	2697	2623
5	2017	158501	1017	998	971
6	2018	159452	376	369	359
7	2019	160401	139	137	133
Total NPV		**1022824**	**71675**	**70335**	**68417**

Table 29: Policy Option 4: Tiered Rate Structure- NPV - Price Elasticity of 2

Program Year	Year	Total Benefit	SDR 5%	SDR 7%	SDR 10%
0	2012	0	0	0	0
1	2013	316966	111053	108977	106005
2	2014	310519	40023	39275	38204
3	2015	304162	14422	14153	13767
4	2016	319998	5582	5478	5328
5	2017	311753	2001	1963	1910
6	2018	303709	717	704	684
7	2019	295862	257	252	245
Total NPV		**2162970**	**174054**	**170801**	**166143**