Water Master Plan

City of Greeley

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Table of Contents

Executive Summary **1**
Driving Factors and Key Objectives 1
Future Demand: Unlimited Growth Potential 1
New Supply Options 2
Treatment and Transmission Alternatives 3
Financial Results 5
Implementation and Future Updates 5

Chapter 1. Introduction **7**
The Water Master Plan Process 8
Driving Factors and Key Objectives 9
Population and Economic Growth 9
Increasingly Limited Raw Water Opportunities 9
State and Federal Regulations 10
Aging Infrastructure 11
Major Policy Challenges 12
Guiding Principles and Policy Resolution 12
City of Greeley Adopted Water Policies 13
Conclusion 14

Chapter 2. Greeley's Water History **15**
Greeley's Early Water History (1886 – 1907) 15
Colorado-Big Thompson Project (1934 – 1957) 16
Milton Seaman Reservoir Construction and High Mountain Reservoirs Purchase (1945 – 1947) 17
Greeley-Loveland Irrigation System (1961 – Present) 18
Windy Gap Project (1969 – 1985) 19
Conclusion 19

Chapter 3. Greeley's Current System **21**
Colorado's Water Supply and Water Law 22
Raw Water Sources 22
Cache La Poudre River Basin Water Rights 23
Big Thompson River Basin Water Rights 23
Upper Colorado River Basin Water Rights 24

Non-potable Supplies 25
Drought Planning and Yield 25
Greeley Uses the 50-Year Drought Planning Standard 26
Computer Models Simulate Water System Yields and Operations.. 26
Current Greeley Firm Yield 27
Integrated Operation of the Water System 28
Determining the Raw Water Safety Factor 30
2000's Drought 31
Current Water Supplies Conclusion 32
Water Treatment Plants 32
Bellvue Water Treatment Plant 33
Boyd Lake Water Treatment Plant 33
Vulnerabilities of Existing Treatment Plants 33
Treated Water Transmission 34
Bellvue Plant Transmission 34
Boyd Lake Plant Transmission 35
Treated Water Storage and Distribution 35
Distribution System 35
Existing Transmission Conditions and Vulnerabilities 37
Non-potable Water System 38
Outside Service Customers 38
Peak Day Demand 39
Conclusion 41

Chapter 4. Future Demand 43

Unlimited Growth Potential 43
Annual Demand Projections 44
Water Use Trends 44
Water Use Factors 45
Future Land Use Scenarios 46
Land Use Scenario Results 47
Key Findings 48
Future Outside Contract Demands 49
Seasonal and Peak Day Demands 49
Greeley Climate 49
Peak Water Use Day 49
Obligated Demands 50
Pre-Paid Demands 51
Greeley-Loveland Irrigation System Obligations 51
Incentives for New Growth 51
Water Conservation and Demand Management 51
2000's Drought and Water Conservation 53
The Non-potable System 54
Advantages of Non-potable Water 54

Future Non-potable Needs 55
Peak Day Demand Projections 55
Conclusion 56

Chapter 5. New Supply Options 59

Adequacy of New Supplies to Meet 2020 Demands 60
Raw Water Alternatives Analysis and Screening 62
Options for the Future Water Account 62
Windy Gap Firming Project 63
Upper Poudre River Gravel Pit Storage 63
Lower Poudre River Gravel Pit Storage 64
Large Non-potable Development Projects 64
Blocks of Agricultural Water 64
Shares in Agricultural Ditch Companies 64
Other Projects and Water Supplies as They Become Available 64
Raw Water Safety Factor 65
Future Water Supplies to Meet Demands to 2050 65
Enlargement of Milton Seaman Reservoir 65
Proposed Glade Reservoir Project 66
South Platte Conservation Project 66
Other Regional Projects 66
Conclusion 67

Chapter 6. Treatment and Transmission Alternatives 69

Evaluating Treatment and Transmission Alternatives 69
Water Quality Implications 69
Upcoming Regulations 70
Potential Solutions to Existing Vulnerabilities 72
Evaluating Treatment Options 72
Evaluating Raw Water Quality 74
Matching Water Quality with Appropriate Treatment Options 74
Bellvue Water Treatment Plant Alternatives 76
Appropriate Bellvue Alternative: Membrane Treatment 76
Boyd Lake Water Treatment Plant Alternatives 77
Appropriate Boyd Lake Alternative: Combination of membranes and conventional treatment 78
New Water Treatment Plant Alternatives 78
Ultimate Capacities 79
Transmission System Vulnerabilities and Remedies 79
Assumptions for Evaluating Transmission Alternatives 80
Bellvue Transmission Alternatives 81
Preferred Bellvue Transmission Alternative 81
Preferred Boyd Lake Transmission Alternative 82

Finished Water Storage Needs....84
Peeking Storage....84
Emergency Use Storage....84
Overall Treatment and Transmission Plans....85
Ultimate Capacity of Alternatives....87
Cost Estimates for Alternatives....87
Lower Poudre Water Treatment Plant Clearly Most Expensive....88
Water Rights Do Not Affect Treatment Options in Short Term....88
Boyd Lake Expansion Lower Capacity and Higher Costs....88
Long-Term Costs for Bellvue Expansion and Gold Hill WTP....89
Analyzing Bellvue Expansion and Gold Hill WTP Alternatives....89
Risk Analysis of Bellvue Expansion and Gold Hill WTP Options....89
Bellvue Expansion Preferred Alternative....89
Conclusion....90

Chapter 7. Integrated Strategies....91

Raw Water Short-Term Strategy....91
2000's Drought Impact on Raw Water Strategy....91
Key Components of Greeley's Short-Term (to 2020) Raw Water Strategy 92
Maintain Current Safety Factor....92
Develop a Future Water Account....92
Value All New Supplies at 50-Year Drought Level....94
Use Water Portfolio Shifts to Increase Firm Yield....94
Raw Water Long-Term Strategy....95
Treatment and Transmission Short-Term Strategy....95
Aging Infrastructure and Regulations....95
Demand and Population Growth....95
Maximize Existing Treatment and Transmission Capacity....96
Add New Treatment and Transmission Capacity....96
Treatment and Transmission Long-Term Strategy....97
Additional Factors in the Integrated Strategy....97
Water Conservation....97
Non-potable Water Use....98
New Outside Service Contracts....98
Conclusion....98

Chapter 8. Financial Results....101

Fund Structure....101
Policy Premises....101
Capital Improvements Funding....102
Financial Analysis....102
Comparisons with Front Range Purveyors....104
Adjustments to Capital Improvements Plan....105
Conclusion....105

Chapter 9. Implementation and Future Updates 107

Raw Water Acquisition Plan 107
Annual Water Accounting 108
Regular Water Portfolio Audits 108
Treatment and Transmission Implementation Plan 108
Future Updates of the Water Master Plan 110
Annual Review 110
Revision of the Water Master Plan 111
Conclusion 111

Glossary of Terms 113

Appendix A. Maps 125

Map 1. Greeley Water Resources Map 127
Map 2. Greeley Non-potable Distribution System Map 128
Map 3. Northern Colorado Political and Water Service Boundaries Map129
Map 4. Existing and Future Greeley Land Use Map 130
Map 5. Greeley Future Water Supply Options Map 131
Map 6. Greeley Regionally Based Capital Improvements Projects Map132
Map 7. Greeley City Based Capital Improvements Projects Map 133

Appendix B. Assumptions and Policy Modifications 135

Assumptions 135
Raw Water 135
Treatment and Transmission 135
Demands 136
New Established Policies 136
Raw Water 136
Treatment and Transmission 137
Demands 137
Outside Service Customers 138
Additional Studies and Analysis 138
Shifts in Policy 139
Non-potable Water Dedication 139

Appendix C. 2003 – 2022 Capital Improvements Plan 141

Construction Fund – Raw Water Supply System 141
1. Northern Integrated Supply Project 141
2. Raw Water Telemetry 141
3. Boyd Water Treatment Plant Emergency Drought Project 141
4. Windy Gap Firming 142
5. Non-potable 142

6. 25th Avenue Gravel Pits 142
7. Parks Irrigation – SCADA 142
8. Security Projects 142
9. Pleasant Valley Pipeline 143
Construction Fund – Water Treatment 143
10. SCADA 143
11. Bellvue Raw Water Ponds Repair 143
12. Boyd Lake Water Treatment Plant Ultraviolet Light Treatment Addition 143
13. Boyd Lake Winterizing 143
14. Land Acquisition 144
15. Bellvue 10-mgd Addition 144
16. Bellvue 15-mgd Addition 144
17. Bellvue 10-mgd Addition 144
Construction Fund – Finished Water Transmission and Distribution 144
18. Finished Water Storage (15 mgd) 144
19. Finished Water Storage (22 mgd) 144
20. Chimney Park Transmission Main (60 Inch) 144
21. Chimney Park 30-mgd Pump Station 145
22. Zone 4 Improvements 145
23. Bellvue Transmission Line – Acquisition of Right of Way 145
24. Bellvue Transmission Program 145
25. Gold Hill Link Pipeline 145
26. Chlorine Scrubber 145
27. Line Extensions and Oversizing 145
28 & 29. New Construction Meters and Water Taps 145
30. Inspection Services 146
Replacement Fund – Raw Water Supply System 146
31. Comanche Rehabilitation 146
32. GLIC System Improvements 146
Replacement Fund – Water Treatment 146
33. Bellvue Rehabilitation Phase II 146
34. Bellvue Raw Ponds Repair 146
35. Bellvue Sludge Beds Rehabilitation 146
36. Transmission System Rehabilitation 146
37. Distribution Line Replacement 146
38 & 39. Valve Replacement and Fire Hydrant Replacement 147
40. Small Meter Replacement 147
41. Replacement Capital Outlay 147
42. 23rd Avenue Reservoir Cover Replacement 147
Acquisition Fund 147
43. Water Acquisition 147
20-Year Master List of Water and Sewer CIP Projects 148

List of Figures

Figure 1. Water Master Plan Process....8
Figure 2. Federally Regulated Drinking Water Contaminants Over Time....11
Figure 3. Greeley Water System Timeline....16
Figure 4. Modeled Reservoir Contents....28
Figure 5. Current Annual Potable Yield....29
Figure 6. Historical Demand and Raw Water Supply....29
Figure 7. Historical Perspective of 2000's Drought....32
Figure 8. Distribution System Pressure Zones Map....36
Figure 9. Facilities Elevation Profile....37
Figure 10. Historical Peak Day and Treatment and Transmission Capacity (1966 – 2001).40
Figure 11. In-City Potable Use by Land Use Type....45
Figure 12. Projected City of Greeley Population Growth and Water Demands....47
Figure 13. Historical Peak Day....50
Figure 14. Existing Capacity Vs. Projected Demand – Raw Water....57
Figure 15. Existing Capacity Vs. Projected Demand – Treatment and Transmission....57
Figure 16. Bellvue and Boyd Lake Transmission Alternatives Map....83
Figure 17. Treatment and Transmission Map....86
Figure 18. Future Greeley Water Supply....94
Figure 19. Project Capacity Vs. Projected Demand – Treatment and Transmission....97
Figure 20. Projected Water Bills and Annual Rate Increases....103
Figure 21. Projected Plant Investment Fees....103
Figure 22. Monthly Water Bills for Front Range Water Purveyors....104
Figure 23. Comparison of 2002 Water Tap Fees for Single-Family Tap....105

List of Tables

Table 1. Water Demand Projections....2
Table 2. Treatment and Transmission Alternatives....4
Table 3. Current Water Supply / Demand Summary....30
Table 4. Outside Service Contract Usage (Acre-Feet per Year)....39
Table 5. Greeley's Water System Summary....42
Table 6. Water Use Factors by Land Use Type....46
Table 7. Current and Future Water Demands....48
Table 8. Obligated Demand By Source (Acre-Feet)....50
Table 9. Conservation Measures for Greeley....53
Table 10. Alternative Supply Approaches Matrix....59
Table 11. 2020 Water Supply Demand Summary....61
Table 12. Regulations Timeline....71
Table 13. Plant Vulnerabilities and Potential Solutions....72
Table 14. Raw Water Quality Categories....74
Table 15. Raw Water Quality and Treatment Option Matches....75
Table 16. Bellvue Treatment Alternatives....76
Table 17. Boyd Lake Treatment Alternatives and Costs....77
Table 18. New Plant Location Alternatives....78
Table 19. Ultimate Capacities and Limiting Factors....79
Table 20. Transmission System Vulnerabilities and Remedies....79
Table 21. Zone Storage Needs....85
Table 22. Ultimate Plant Capacity for Alternatives....87
Table 23. Cost Estimates....88

Abbreviations

ac-ft	acre-feet
C-BT	Colorado-Big Thompson
cfs	cubic feet per second
CIP	Capital Improvements Program
ELCO	East Larimer County Water District
ENR	Engineering News Record
EPA	United States Environmental Protection Agency
FAR	Floor Area Ratio
Fe	Iron
GAC	Granular Activated Carbon
GLIC	Greeley-Loveland Irrigation Company
gmp	gallons per minute
mg	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
Mn	Manganese
NCWCD	Northern Colorado Water Conservancy District
NISP	Northern Integrated Supply Project
PIF	Plant Investment Fees
RO	Reverse Osmosis
SCADA	Supervisory Control And Data Acquisition
SDC	Strategic Development Corridor
SDWA	Safe Drinking Water Act
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
WTP	Water Treatment Plant

Executive Summary

"If a man does not know to what port he is steering, no wind is favorable to him."

Seneca (5 BC - 65 AD)

Driving Factors and Key Objectives

For the last century, Greeley has enjoyed a safe, good quality, plentiful water supply. As the 21st Century begins, the Greeley water system faces challenges of infrastructure age, population and economic growth, new regulations, and increasingly limited opportunities for new water supplies. The following questions cannot be answered in isolation, but rather must be answered in an integrated fashion due to the complexity and interdependency of Greeley's water system.

- Where should Greeley's additional raw water supplies come from?
- Where should additional treatment capacity be built?

This *Water Master Plan* defines specific steps to provide a reliable water supply for Greeley to the year 2020. More general plans are proposed through 2050.

Many components of Greeley's water system have been in use between 50 and 75 years and are nearing the end of their useful life. In the last 50 years, Greeley's water demand has increased almost fivefold, a sustained growth rate of 2.9 percent for over half a century. In that same time, population has tripled. In the next 50 years, Greeley can expect population to triple again with a corresponding increase in water demands. As growth continues along the Front Range, raw water options become increasingly scarce and the ability to construct a new transmission line becomes more difficult. At the same time, proposed regulations regarding contaminants such as cryptosporidium, total organic carbon, and trihalomethanes will require upgrades of both Greeley's existing water treatment plants.

Future Demand: Unlimited Growth Potential

The *Water Master Plan* follows Greeley's *Comprehensive Plan,* which forecasts a 2.5 percent population growth for the next 20 years, primarily to the west. The longer-term projection (2020-2050) assumed a more conservative annual growth rate of two percent. Even at these growth rates, Greeley is not expected to develop all land within the Urban Growth Boundary by 2050. Thus Greeley has no "ultimate"

water demand. Planning was arbitrarily limited to 50 years with the understanding that short-term options should not preclude long-term options.

Four land use development scenarios explored the sensitivity of Greeley's future water demand with different densities and patterns of growth. All four scenarios had essentially the same water demand, so the Comprehensive Plan scenario was selected, which produced the following water demand projections.

Table 1. Water Demand Projections

Water Demand (acre-feet)	Present	2020	2050
Greeley *	27,000	44,200	74,500
Windsor, Milliken, Evans	2,600	7,700	2,800 **
Total capacity needed	29,600	51,900	87,300

* Including non-potable demands. ** Outside service contracts expire around 2020.

Until at least 2020, Greeley will be supplying treatment and transmission services to Windsor, Milliken, and Evans. Greeley must include these demands in the planning for future treatment and transmission capacity. The future raw water demands of these entities are not included in future raw water planning by Greeley, as they are supplied by the individual entities.

Water conservation and demand management delay the need for treatment and transmission expansion, reduce pumping and treatment costs, and decrease the amount of wastewater produced. Significantly, construction of new large storage projects will require demonstration that existing supplies are being used efficiently. Greeley will expand water conservation efforts but because of the variability of conservation, Greeley will not use conservation as a firm water supply until it has been demonstrated.

New Supply Options

Greeley intends to maximize use of existing supplies in the short term, to 2020. The key components of Greeley's short-term raw water strategy are to:

- Maintain the current raw water safety factor.
- Develop a Future Water Account—revolving fund of 6,000 acre-feet for cash-in-lieu.
- Value all water supplies at the 50-year drought level.
- Use water portfolio shifts to increase firm yields.
- Maximize the use of lower cost non-potable supplies.

There will be some 17,200 acre-foot of new demand by 2020. See *Table 11. 2020 Water Supply Demand Summary* in Chapter 5 for details.

- 20 percent will be non-potable (3,400 acre-feet).
- 45 percent will come from pre-dedicated existing water supplies to satisfy obligated demands (7,900 acre-feet).
- 35 percent must be developed by Greeley (5,900 acre-feet).

Note that using pre-dedicated existing supplies will reduce Greeley's overall safety factor to 7,300 acre-feet by 2020. A safety factor gives Greeley a cushion in case of failure of Greeley's water system during a drought (e.g., forest fire in the Poudre River Basin which limits Greeley's Poudre water supplies).

Greeley's non-potable system provides irrigation water from ditches, the river or wells. The non-potable system reduces the need for filter plants and transmission lines, both by reducing the demand for potable water, and by shaving the peaks off the potable system. Non-potable systems are well placed to use wholly consumable wastewater treatment plant effluent or No. 3 Ditch water by exchange. As Greeley obtains additional transbasin supplies or firms Windy Gap, even more fully consumable non-potable water will become available. The *Non-potable Water Master Plan* is addressing the question of whether to build the infrastructure needed to use this supply, or to sell the excess non-potable water to purchase drinking water supplies.

Currently sufficient water supplies exist on lands annexed to Greeley to meet at least ten years of growth based on current market conditions. If these lands develop first, the water supplies currently available on the Northern Colorado market will not be available or affordable when development finally progresses to the drylands. Because the drought has focused attention on water supplies, Greeley cannot wait until growth consumes the existing surplus supplies before developing new supplies.

A list of 57 raw water options was developed. Each water supply option was ranked in three categories: implementation, cost, and yield. A short list of 16 was evaluated and the following options were selected.

- A large regional storage project for Windy Gap firming funded by exchanging some of Greeley's Windy Gap units for storage in the project (water portfolio shifting).
- Gravel pit storage on the Upper Poudre to both store existing City supplies and to make seasonal shifts of water. This can also be used for multi-year drought carryover storage.
- Gravel pit storage on the Lower Poudre to store reusable effluent.
- A "dirt pit" project to store excess non-potable water supplies during the winter.
- Purchase of agricultural rights, perhaps with interruptible supply contracts.
- Regional supply projects after 2020 include enlarging Milton Seaman Reservoir.

Treatment and Transmission Alternatives

Five treatment plant alternatives were evaluated:

- Adding finished water storage to meet the peak day demand.
- A new regional plant with Loveland, Windsor, Fort Collins, or others.
- A new Greeley-only plant near the city.
- An expansion at the Boyd Lake Plant.
- An expansion at the Bellvue Plant.

It was determined that adding sufficient finished water storage to meet peak day demands over a peak week would cost as much or more than constructing adequate treatment capacity. Too much finished water storage can lead to water quality problems, so this alternative was not considered further. At this time, there are not any project opportunities with neighboring utilities and thus, this alternative was set aside with the understanding that City staff will continue to discuss potential opportunities with neighbors.

Therefore, the remaining three options were evaluated in detail with respect to physical, technical, legal, institutional, political, regulatory, social, third party effects, economic, and environmental.

Raw water quality was a critical factor in the evaluations. Poor raw water quality implies greater treatment costs for both capital costs of facilities and operation and maintenance. Bellvue's raw water is generally higher quality than Boyd's. Water sources were characterized as: excellent (high mountain), good (Horsetooth), average (Boyd/Lake Loveland), and poor (Poudre River at Greeley). "Good" water source at Bellvue can be treated with either "loose membrane" microfiltration combined with activated carbon or conventional flocculation-sedimentation-filtration. "Average" water quality at Boyd needs "tight membrane" nanofiltration combined with activated carbon or conventional treatment combined with activated carbon. Two new plant locations were also considered: a plant at the Gold Hill Reservoir using raw water from the Greeley-Loveland Canal and a plant in Greeley with raw water from the Poudre River. Poor water quality from the lower Poudre makes that plant unfeasible.

All alternatives assumed the existing Bellvue and Boyd Lake transmission lines would be renovated with depreciation funds to maintain existing capacity throughout the planning period to at least 2050. The estimated ultimate plant sizes and cost estimates are shown in Table 2.

Table 2. Treatment and Transmission Alternatives

Alternative	Bellvue	Boyd Lake	Gold Hill	Poudre River Plant	Total Capacity	Capital Millions $	Operations Millions $
Expand Bellvue	120 mgd	38 mgd	0	0	158 mgd	$269	$112
Expand Boyd	20 mgd	120 mgd	0	0	140 mgd	$264	$192
Build at Gold Hill	20 mgd	38 mgd	100 mgd	0	158 mgd	$266	$150
Build Lower Poudre plant	20 mgd	38 mgd	0	100 mgd	158 mgd	$348	$428

The Lower Poudre Plant is clearly more expensive and also has serious concerns with disposal of treatment wastes (due to the poor raw water quality) and thus was removed from further evaluation. Expansion of Boyd has much greater operating costs and also does not result in as much total capacity and thus was also removed from further consideration.

The Bellvue Expansion and Gold Hill Water Treatment Plant, have similar capital costs. In the short term, the Bellvue alternative has a total cost about 65 percent more than Gold Hill due to the high cost of constructing a new transmission. By 2050, the Gold Hill option costs about 25 percent more than Bellvue due to higher capital, operation, and maintenance costs. Evaluations did not include lining the Greeley-Loveland Irrigation Company (GLIC) ditch. Delivery reliability is a serious problem with the Gold Hill alternative. The Bellvue alternative also is a better fit with the long-term raw water options. Water quality at Bellvue is less likely to experience temporary or permanent degradation compared to Boyd Lake. The cost of the Gold Hill option will increase significantly if water quality does not remain average.

Finally, the complexity of running three plants does not warrant the additional safety in multiple locations. Therefore, expanding Bellvue is considered the preferred alternative. Bellvue transmission capacity would first be improved with a 30-mgd pump station in Windsor and a five-mile section of pipe from Windsor to Gold Hill to obtain additional 10 mgd using existing lines. Bellvue Phase 2 would complete a

60-inch pipe from Bellvue to Gold Hill by 2020. Such a pipeline would have a 56-mgd capacity by gravity, 76 mgd when combined with the existing lines. Bellvue Phase 3 would expand the pump station at Windsor to pump 100 mgd to Gold Hill, 120 mgd total. Plant capacity at Bellvue will be increased in incremental stages as needed to meet demands.

Financial Results

Greeley's ten-year *Capital Improvements Plan* through 2012, expressed in current year dollars, is estimated at $247 million. Windy Gap firming will be self-funded by portfolio shift. Although a ten-year, $250-million capital improvement program may appear ambitious, continued growth makes the program both necessary and feasible. Greeley's water rates are well positioned, in comparison with other Front Range communities, to accept modest rate increases. While Greeley's combination of plant investment fees and raw water costs may make new development expensive in comparison to others, this is a direct result of the policy decision to make growth pay its own way. The *Raw Water Acquisition Plan* on page 107 is intended to reduce that cost of development while at the same time keeping Greeley's 50-year drought reserve intact.

Water rate increases of three percent a year for the next decade, combined with a growth of 2.5 percent and plant investment fee increases of about five percent annually after 2002, are adequate to fund the entire *Capital Improvements Plan*. An extra 1.5 percent water rate increase for six years will fund the $35-million Future Water Account. If growth slows, capital programs may be delayed to match the revenue. If growth accelerates, PIF revenue will also accelerate.

Implementation and Future Updates

As described by Harold Evans, the current Water & Sewer Board Chairman, this *Water Master Plan* is a roadmap, not a railroad. A roadmap can be used to look at where you have come from, which roads were taken and for which reasons. The roadmap can also be used to look ahead at the options (roads) that are now before you. The roadmap needs to be updated periodically to assure Greeley is aware of all the "roads" available.

In the short term, Greeley intends to:

- Participate in a large Windy Gap Firming Project by water portfolio shift.
- Create a 6,000 acre-foot Water Acquisition Fund, to supply water for growth on the drylands and eventually fund a large storage project after 2020.
- Purchase land for pump station in Windsor (complete).
- Construct transmission main from Windsor to the Poudre River (under design).
- Establish transmission main alignment to Bellvue and begin acquiring ROW.
- Winterize Boyd.
- Evaluate both Bellvue and Boyd for future regulatory compliance.
- Begin incremental improvements to Bellvue.

There will also be an annual accounting to establish the current safety factor, and the size of the Future Water Account, as well as an annual review of policies and options available to Greeley. The *Capital Improvements Plan* is updated annually for the budget. A triennial review of Greeley's water portfolio will re-establish firm yield estimates and the *Water Master Plan* should be formally updated and revised every five years.

Chapter 1. Introduction

Over the past four years, Greeley's Water & Sewer Department has undertaken a comprehensive planning process. The resulting *Water Master Plan* defines policy, develops and analyzes alternatives, and defines an implementation schedule for capital projects through the year 2020.

When the planning process began in the summer of 1998, Greeley anticipated significant capital improvements in all components of the Greeley water system from raw water supply and collection, to storage and conveyance, and treatment and treated water transmission and distribution. Greeley had to address emerging policy issues, system inefficiencies, and changing federal regulations in providing potable and non-potable water for an increasing customer base. Each potential capital project and institutional policy had multiple alternatives with unique advantages, costs and risks. All alternatives had to be evaluated as part of an interrelated system to assure the development of plan that can be implemented with consideration of funding limitations or significant impacts on water rates. In short, Greeley owned and operated an aging and complex water system that needed to be carefully and systematically upgraded to effectively and safely serve Greeley's future.

Greeley embarked on a four-year process of policy definition, technical analysis, alternatives development, and decision analysis. Specialized consultants provided comprehensive evaluations of the technical feasibility and cost of a myriad of alternatives. Greeley integrated input from Water & Sewer Department staff and Greeley's Planning Department to assure that the larger issues of compatibility with Greeley's *Comprehensive Growth Plan* were considered. Open houses provided a forum for seeking customer input on sensitive issues of growth, water rates, environmental compatibility and equity. And, throughout the process, Greeley maintained close communication with the Water & Sewer Board and City Council. The process is now complete and the result is a fully considered *Water Master Plan* that would have been impossible without the input of so many knowledgeable people so committed to Greeley's future.

The Water Master Plan Process

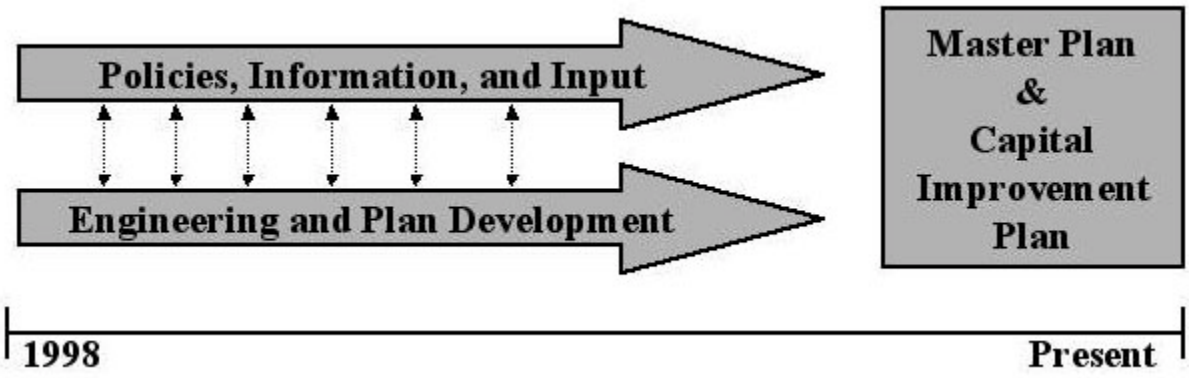
Master planning for water systems involves considerable art, science, and most importantly impeccable timing. It is difficult to forecast how much water a city will need as shown in this quote from a June 30, 1947 report by Crocker and Ryan, consulting engineers to Greeley's Mayor and Council.

> *"...The purchase of these facilities (high mountain reservoirs) in combination with the securing of Grand Lake water (C-BT) will insure the City of adequate water supply for all time. Such a purchase will eliminate any necessity for the installation of meters."*

In the last fifty years, Greeley's water supply has doubled, and the population has tripled. Not only are water meters now an important part of Greeley's demand-management program, new water supplies such as Windy Gap and the Greeley-Loveland System have been acquired. In the next fifty years many additional sources will be needed to meet the projected growth within Greeley.

The water master plan process was structured to answer dozens of questions while following two parallel tracks. One track regarded policy issues, public information, and the on-going input of the Water & Sewer Board and the City Council. The other more technical track involved engineering and cost analysis of many alternative plans and formulating the preferred alternatives. The results of these policy discussions were used in evaluating alternatives and plans so that this resulting *Water Master Plan* would be consistent with Board and Council directives.

Figure 1. Water Master Plan Process



Ultimately, Greeley used the water master plan process to define critical water policies, and to make changes in existing water policies. All policy discussions affected the technical evaluations and the range of potential solutions. The results provided for necessary improvement. Specific Capital Improvements Plans are provided for the short term (to 2020) for additional raw water supplies, treatment plant improvements, and transmission system improvements. General guidance was developed for the long term, through about 2050.

This *Water Master Plan* is not a static document, but rather an ongoing process of continuing to improve Greeley's water system to meet the needs of Greeley's citizens. It was realized early in the development of the *Water Master Plan* that change in this plan is inevitable due to the large number of variables affecting Greeley's water system. The enduring value of this plan will be a framework for evaluating

changes to key variables identified through the process and allowing Greeley to quickly and effectively respond to these changes.

Driving Factors and Key Objectives

For the last century, Greeley has enjoyed a safe, good quality, plentiful water supply. Major improvements over the years have built on the infrastructure originally constructed early in the 20th Century. As the 21st Century approached, a critical review of the overall system was needed before making decisions on where and how to make major investments. For each driving factor, key planning objectives were identified early in the process—objectives that related to water supply alternatives for Greeley's future.

Four driving factors were identified by the *Water Master Plan*.

- Population and Economic Growth
- Increasingly Limited Raw Water Opportunities
- State and Federal Regulations
- Aging Infrastructure

Population and Economic Growth

Greeley, like all Front Range communities, has experienced significant population and economic growth. In the 55 years since the Crocker and Ryan report quoted above, Greeley's water production has increased almost fivefold—a sustained growth rate of 2.9 percent for over 50 years. From 1997 to 2001, population growth, measured in water taps, has averaged just over three percent. Greeley has been able to manage such sustained growth with those water supplies described by the Crocker and Ryan report quoted above. However, Greeley is now nearing the capacity of existing treatment and transmission facilities and is reaching the end of its raw water surplus. The *Water Master Plan* seeks to answer the following questions.

- Where should additional raw water supplies come from?
- Where should additional treatment capacity be built?
- How will treated water be delivered to Greeley customers?

The above questions cannot be answered in isolation, but rather must be answered in an integrated fashion due to the inter-dependency of the various parts of Greeley's current and future water system.

Increasingly Limited Raw Water Opportunities

For over 100 years, Greeley has been forward looking in water planning. Developing water for today's needs and for future generations has always been a priority. The result is that Greeley enjoys a water supply that can supply existing customers in a 50-year drought, accommodate another ten years of growth, and provide a safety factor of 7,300 acre-feet. This present safety factor gives Greeley an opportunity, almost unique in Colorado, to plan and create new water supplies deliberately, without incurring the risks of hastily made decisions or the cost premiums associated with fast-track construction.

In the last 50 years, Greeley has "spent" the Colorado-Big Thompson (C-BT) supplies purchased in 1955 to supply growth, dropping Greeley's water supply surplus from 150 percent of the 1955 demand down to

20 percent of demand today. This cushion of water has allowed Greeley to triple in size, and to take advantage of opportunities as they arose (such as purchasing 40 percent of the Greeley-Loveland Irrigation Company and participating in the Windy Gap Project) without the need to "buy at any price," like many Front Range communities. The drought of 2000 has focused the public's attention on water supplies that will increase competition for the limited high quality, easily accessible supplies available. Many communities are paying 1,000 times more today, for the same types of water supplies that Greeley bought 50 years ago.

A key factor in the *Water Master Plan* is to continue this legacy of commitment to secure and plentiful future water supplies. The following are important criteria for any new water supply.

- **Plans must complement Greeley's existing system and water supply portfolio.** The existing system was reviewed in great detail to ensure that new supply options could be effectively incorporated with Greeley's existing water rights portfolio.
- **Plans for increasing firm yield must have a high probability of implementation.** Greeley currently has several supply options that are reasonable to implement. Therefore, it is not necessary for Greeley to pursue projects that would be difficult to implement and that have potentially costly consequences or lengthy regulatory approvals.
- **Specific plans will be developed to provide a reliable water supply for Greeley to the year 2020.** The ultimate objective for the raw water evaluation was to identify new projects/supplies that could provide sufficient supply to meet the demands projected for the year 2020. Additional projects or supplies that could meet water demands to the year 2050 would be identified.
- **Specific plans will be developed to provide developers with an alternative to dedicating Colorado-Big Thompson (C-BT) Project water when developing areas that have not historically been irrigated (dryland).** Historically, C-BT units were an affordable option for dedication to Greeley. Now that C-BT units are not as available and affordable, Greeley must develop other options for water dedication for dryland development. Once these new water supplies are developed, Greeley will allow developers to pay cash-in-lieu of raw water as an additional option to development beyond the traditional options of dedicating C-BT units or Greeley-Loveland Irrigation System water for historically irrigated lands.

State and Federal Regulations

State and federal regulations continue to affect all planning efforts. Environmental regulations affect raw water supplies, the construction of infrastructure, and the disposal of treatment wastes. The Safe Drinking Water Act controls the types of treatment required and, as additional regulations are promulgated, may drive modifications to treatment processes. City Staff sought to answer the following questions.

- What raw water options have the best chance of implementation with respect to environmental regulations?
- What kind of treatment technologies will be needed?
- How do treatment options interact with raw water quality, keeping in mind upcoming regulations?
- What treatment options give the greatest flexibility to meet future, unknown regulations?

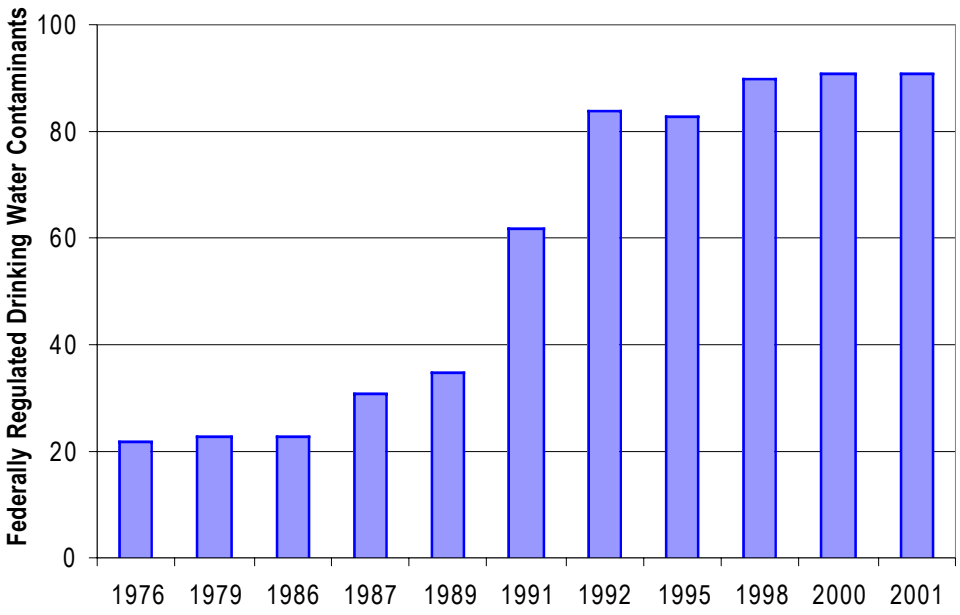
In 12 years, the number of federal regulations regarding drinking water (collectively promulgated under the Safe Drinking Water Act) has grown fourfold, as shown in the following figure. Although the growth in the absolute number of regulated contaminants has slowed in recent years, recent regulations and

proposed regulations are more difficult to meet than earlier regulations because they address more difficult problems. Proposed regulations regarding specific contaminants such as cryptosporidium, total organic carbon, and trihalomethanes will require upgrades or changes to the treatment provided at Greeley's two existing water treatment plants.

Regulations are becoming more sophisticated such that contaminants are no longer regulated by simply a maximum value but rather by the ability of a utility to actually remove the contaminant. Specific treatment techniques or combinations of treatment techniques are now listed in regulations. Therefore, it has become more difficult to operate, maintain and construct treatment plants that will meet future regulations.

In addition to meeting the regulations technically, the timeframes for most new regulations are such that there is generally just enough time for a utility to do preliminary design, final design, and construction on their normal contractual timeframes prior to the regulation being in effect. Recently, Greeley has constructed improvements to both plants. However, additional improvements may be needed to meet recently promulgated and proposed regulations. Future improvements to either plant need to be evaluated keeping in mind these recent and proposed regulations.

Figure 2. Federally Regulated Drinking Water Contaminants Over Time



In addition to regulations governing treatment, the regulations governing waste disposal must also be considered. Different treatment processes generate different types of waste and the ability to dispose of those wastes will vary.

Aging Infrastructure

Many components of Greeley's water system have been in use for 75 years or more and are nearing the end of their useful life. Specifically, a large portion of the Bellvue treatment and transmission system will need rehabilitation and replacement work even without any increases in capacity to the overall system.

A primary question of the planning process was whether to replace the Bellvue system or abandon it?

Major Policy Challenges

Policies directly influence decisions made by City Staff. As part of the water master plan process, the major policies regarding the Greeley water system were evaluated, and in many instances, the Board and Council modified them. Major issues that presented challenges include:

- How should Greeley handle its relatively unlimited growth potential?
- How can Greeley maintain the current level of service provided to its citizens into the future while minimizing the financial impacts to existing ratepayers and still provide water to new growth?
- How should Greeley minimize the burden to existing ratepayers with regards to financing system improvements and acquiring new water supplies related to new growth?
- What is the appropriate amount of raw water held in reserve (safety factor)?
- How does Greeley pay for infrastructure costs that accompany growth? If growth is to pay its own way, how does Greeley accomplish the financing?
- How aggressively should Greeley pursue alternatives that have a limited window of opportunity for implementation given the financial implications to existing ratepayers?
- Should Greeley pursue the acquisition of agricultural irrigation company shares on lands not being developed by Greeley? If so, which shares should be acquired?
- How can Greeley be responsive to opportunities for new raw water acquisitions and projects without putting undue risk on the existing ratepayers?
- How does the current drought within the State of Colorado affect Greeley's perspective on how water supplies should be developed for future growth?

The Water & Sewer Board and the City Council evaluated and discussed these issues and provided a clearer set of policies and direction to proceed with the *Water Master Plan*.

Guiding Principles and Policy Resolution

One of the primary goals of Greeley's *Water Mater Plan* was to provide information needed by the Board and Council to establish policies for Greeley's future water system. City Staff, consultants, citizens and policymakers were all involved in developing these policies. New polices and clarifications and modifications to existing policies were addressed. City Staff, consultants, and the Water & Sewer Board developed a comprehensive list of polices. A condensed version of the most important policies was taken to City Council for approval. These eight key policies, listed below, have far reaching impacts on both Greeley and the region as a whole. One original key policy, the water bank, has been changed to the Future Water Account, due to the current drought.

City of Greeley Adopted Water Policies

1. Growth shall pay its own way without unduly affecting existing ratepayers. Specifically:
   - **a**) Greeley will develop a "Future Water Account" of additional water supplies in advance of new growth. The near-term development of the additional supplies shall be limited to the projected growth expected to 2020 by Greeley's Comprehensive Growth Plan, or 6,000 acre-feet.
   - **b**) New dryland growth will pay cash-in-lieu of water rights as it occurs once new water supplies have been developed in the Future Water Account. Cash-in-lieu shall be priced at the full, actual cost of developing new water at a 50-year drought yield basis so as to completely replenish the water used from the Future Water Account.
   - **c**) System development charges (plant investment fees) for development shall be based on growth buying into the replacement cost of the existing asset base without deducting depreciation.
   - **d**) Waivers or reductions of raw water dedication or system development charges by City Council (e.g., for economic development incentives) shall be repaid by the General Fund to the Water Acquisition Fund.
2. Greeley will pursue agricultural water acquisitions from areas outside Greeley's growth boundaries.
3. Greeley will not enter into any additional open-ended outside service contracts.
4. During a severe drought, extended conservation and water restrictions will be imposed to reduce demand at least ten percent below the demand predicted for the population and climate conditions.
5. Greeley will develop non-potable systems where equal or less than the cost of potable sources, striving for 15 percent of new development to be served from non-potable sources.
6. Greeley will maintain a strong water conservation ethic and will invest in additional cost effective water conservation. The volume of savings from conservation will be analyzed periodically and Greeley shall only rely on this volume when those savings actually occur.
7. Construction of new treatment and transmission capacity shall begin when peak demands exceed 90 percent of existing capacity.
8. For the foreseeable future, Greeley will maintain the existing raw water safety factor of 7,300 acre-feet to protect against risks that may occur in meeting customer needs.

Conclusion

For the last century, Greeley has enjoyed a safe, good quality, plentiful water supply. Major improvements over the years have built on the infrastructure originally constructed early in the 20th Century. Many components of Greeley's system have been in use for 75 years or more and are nearing the end of their useful life.

For over 100 years, Greeley has been forward looking in water planning. The development of water for today's needs as well as the needs of future generations has always been a priority for Greeley. Greeley, like most Front Range communities, has experienced significant population and economic growth. And Greeley is nearing the capacity of existing facilities and water supplies to serve this growth.

New state, federal, and environmental regulations continue to impact raw water supplies, infrastructure construction, and the disposal of treatment wastes. And the timeframes for new regulations are tight. These and other driving factors set the stage for identifying and evaluating specific alternatives for raw water, water treatment, and water transmission components of Greeley's water system.

The results of this *Water Master Plan* include both public policy decisions and a plan of action for infrastructure improvements. These guiding policies will provide the focus for projects consistent with cost effective expansion of Greeley's water system.

The treatment and transmission options and the raw water options identified in this *Water Master Plan* are time sensitive. As growth continues along the Front Range, raw water options become increasingly scarce and the ability to construct items such as a long transmission line becomes more difficult. In some cases, the ability to economically purchase right-of-way may disappear altogether. If this *Water Master Plan* is not implemented promptly, Greeley may be forced into other options simply because opportunities will cease to exist. Those other options are likely to be more costly and not as closely matched to the public policies determined as part of this process.

Chapter 2.
Greeley's Water History

To fully comprehend the magnitude of a City's water supply challenges in an arid climate, one must have a sense of the effort undertaken by predecessors to create the water supply infrastructure that customers rely upon every day. Describing the history of Greeley's water system also gives an understanding of the nature of Greeley's current water system which is crucial to understanding which options should be considered when looking to the future. This chapter provides a brief overview of Greeley's water history highlighting those events, facilities, and agreements that shape or constrain Greeley's choices for the future.

Greeley's Early Water History (1886 – 1907)

Early in its history, Greeley's water supply leaders obtained the best quality raw water supplies reasonably available. In 1886, Greeley constructed its first water system consisting of a series of infiltration wells on the Poudre River with a steam-driven pump station to provide pressure to a standpipe south of 20th Street between 10th and 11th Avenues. The water quality of the well water degraded as nutrients from the surrounding agriculture flowed into the Poudre wells. The water continued to degrade and by 1900 Greeley began looking for a source with a better water quality.

In 1904, Greeley purchased farmland with very senior water rights (circa 1860s) at the mouth of the Poudre Canyon near the town of Bellvue, 35 miles northwest of Greeley. Greeley combined this senior water right with another senior water right and established a water supply that completely satisfied Greeley's needs for the next 40 years. These two senior water rights still form the base of Greeley's water system almost 100 years later. Furthermore, the Bellvue Water Treatment Plant constructed in 1907 is still one of two treatment plants providing water to Greeley's residents. The original 2.5 acres of slow sand filters and 36 miles of wooden pipe from Bellvue to Greeley have been enlarged and upgraded several times before being replaced by conventional filtration in 1946-1947.

Figure 3. Greeley Water System Timeline

Pre-1907	▪ Steam-driven pumps take Poudre water from infiltration wells.
1907	▪ Greeley acquires Whidbee water rights (7.5 cfs). ▪ Woodstave pipe from Bellvue constructed. ▪ Slow Sand Filters No. 1 and 2 Come On-line.
1913	▪ Bellvue slow sand filter No. 3 comes on-line.
1925	▪ Greeley buys Boyd and Freeman water rights (5 cfs). ▪ Concrete encasement of woodstave pipe joints completed.
1930	▪ Woodstave pipe is replaced with cast iron pipe.
1934	▪ Charlie Hansen of Greeley Tribune begins organizing the Colorado-Big Thompson Project.
1940 – 1943	▪ Milton Seaman Reservoir built.
1946	▪ New Filter Plant built at Bellvue with four rapid sand filters and flocculation/sedimentation basins are constructed.

Colorado-Big Thompson Project (1934 – 1957)

In 1934, Greeley was one of the first municipalities to participate in the Northern Colorado Water Users Association, founded by Charlie Hansen, publisher of the Greeley Tribune, to build the Colorado-Big Thompson (C-BT) Project. The C-BT Project was constructed from 1938 to 1957 and is the largest transbasin delivery project in Colorado. The C-BT Project delivers water from the headwaters of the Colorado River near Granby to the Big Thompson River near Estes Park via the Adams Tunnel beneath the continental divide and Rocky Mountain National Park. C-BT's extensive distribution facilities deliver water from Broomfield to Fort Collins and from Estes Park to Fort Morgan. The C-BT Project provides supplemental water supply to native East Slope water rights. Greeley can take C-BT water from numerous points for treatment or for the non-potable system.

The C-BT Project was designed to provide supplemental water supplies to native water rights in northeastern Colorado. The project consists of 310,000 acre-feet units, which historically yield between 0.5 and 1 acre-feet/unit per year. Due to the supplemental nature of the project, yields have historically been high (1 acre-feet per unit) in drought years when native yields are low and low (0.5 acre-feet per unit) in wet years when native yields are high. The C-BT Project, with over 800,000 acre-feet of active storage and a relatively senior water right on the Colorado River is very well suited to meet supplemental water needs in northeastern Colorado.

In addition to the importance of the C-BT Project as a supplemental water supply, the flexibility of C-BT supplies is also important to Greeley's water system. Greeley can take delivery of C-BT water at either of its two water treatment plants in whatever amount is needed during the irrigation season (April through October); and the Pleasant Valley Pipeline will soon allow winter deliveries of C-BT water to Greeley's Bellvue Water Treatment Plant.

Not only does the C-BT Project have flexibility in deliveries, the C-BT Project is also recognized internationally for its flexibility in adjusting to market conditions. C-BT allotments are continuously sold and purchased. Transactions in recent years are almost entirely from agricultural uses to municipal uses.

This condition is important to the *Water Master Plan* because of:

1. Greeley's key role in developing the C-BT Project.
2. Greeley's general desire to continue effective relationships with the agricultural sector.
3. Greeley's acceptance of C-BT allotments from developers dedicating water to Greeley.
4. Greeley's use of C-BT transactional prices to establish rates for developers paying cash in-lieu of water to Greeley.

Milton Seaman Reservoir Construction and High Mountain Reservoirs Purchase (1945 – 1947)

In 1945, Greeley finished construction of Milton Seaman Reservoir on the North Fork of the Poudre River upstream of Greeley's Bellvue Water Treatment Plant. This reservoir, in conjunction with the five mountain reservoirs in the upper Poudre River Basin that Greeley purchased in 1947, allows Greeley to capture spring runoff and release it in later summer months when Greeley's demand exceeds the yield of its two senior direct flow rights. The five mountain reservoirs purchased from the Mountain and Plains Irrigation Company are an example of an early agriculture-to-municipal water transaction.

The construction of the Milton Seaman Reservoir demonstrates the early recognition that multi-year water storage, in large quantities, is needed to assure adequate drought-year supplies from water stored in earlier, wetter years. Although the high mountain reservoirs were constructed almost 75 years ago, this was rather late within the Poudre River Basin where senior storage reservoirs were built circa 1900. The relatively junior nature of the reservoirs allow filling only when older reservoirs have completely filled, typically in wet years. For the reservoirs to provide water to Greeley in drought years, water must either be carried over from prior wet years or filled with Greeley's more senior (older) water rights through exchange.

Development of the Poudre system also demonstrated Greeley's need to act independently while also participating in regional water projects such as the C-BT Project discussed above and the Windy Gap Project discussed below.

Greeley Water System Timeline (con't)

1947	▪ Greeley Purchases Mountains and Plains Reservoir Company.
1953	▪ Four Additional Rapid Sand Filters are Installed at Bellvue WTP. ▪ Additional Transmission Line is Constructed.
1955	▪ Greeley Purchases Original 15,600 Units of C-BT.
1958	▪ Six Rapid Sand Filters are Installed at the Bellvue WTP.
1959	▪ Greeley Water Board is Established.
1961 – 1963	▪ Greeley-Loveland Operating Agreement is Negotiated.
1964	▪ Four Additional Filters Installed at the Bellvue WTP.
1968	▪ Original Boyd Lake WTP (#2) and Trans-mission Line Comes On-line. ▪ Mosier Hill Finished Water Reservoir Comes On-line.

Greeley Water System Timeline (con't)

1969	▪ Windy Gap Project Begins.
1976	▪ Current Boyd Lake WTP (#1) On-line.
1978	▪ Gold Hill Reservoir Constructed.
1985	▪ Windy Gap Project Comes On-line.
1986	▪ Boyd Lake Raw Water Intake and Pump House is Constructed.
1989	▪ Boyd Lake WTP is Converted to Conventional Treatment Plant with New Clearwell, High Service Pump Station.
1990 – 1998	▪ High Mountain Reservoir Rehabilitation (Comanche, Hourglass, Peterson, Barnes Meadow, Twin Lakes and Milton Seaman Reservoirs).
1991 – 1992	▪ Greeley-Loveland System Water Purchase Plan. $10 Million of Water is Purchased.

Greeley-Loveland Irrigation System (1961 – Present)

In 1961, Greeley began accepting shares in the Greeley-Loveland Irrigation System from developers. Three interrelated irrigation companies make up the system: Greeley-Loveland Irrigation Company (Boyd Lake), Loveland and Greeley Reservoir Company (Lake Loveland), and Seven Lakes Reservoir Company (Horseshoe Reservoir). Greeley uses the supplies within the Greeley-Loveland Irrigation System at the Boyd Lake Water Treatment Plant as a peaking source for Greeley during the irrigation season (April through October).

The Greeley-Loveland Irrigation System is characterized by junior water rights, large storage reservoirs (total of 70,000 acre-feet in three reservoirs), and large filler ditches designed to capture large flows during peak runoff in wet and average years when the junior water rights are in priority. During drought periods, the Greeley-Loveland Irrigation System must rely on water in storage from previous wet and average years to meet water demands.

Greeley's acquisition of these water supplies on the Big Thompson River has improved Greeley's water supply reliability and has added the complexity of operating two complementary but distinct water supply and treatment systems. Reliability has increased because water is supplied from physically separated river basins. Hydrologic or emergency conditions in one basin are less likely to occur simultaneously in adjacent basins. Two treatment and transmission systems, however, add day-to-day operational complexities, especially staffing.

In the late 1960's, the first Boyd Lake Water Treatment Plant and transmission line were built. During the late 1970's, the second, larger Boyd Lake Plant was built and titled Plant No. 1. As part of the continuous improvement of the Boyd Lake Plant, in 1986 the raw water intake and pump house on Boyd Lake were built, and in 1989 the plant was converted from direct filtration to conventional treatment.

In the early 1990's, Greeley purchased a large number of shares in Greeley-Loveland Irrigation System to secure Greeley's stake in the system from purchase by other municipal water providers. The City continues to allow shares within the system to satisfy the raw water obligation of lands that have been historically irrigated. The raw water credit given for many of shares being dedicated to Greeley were fixed as part of an operational agreement with the ditch company in early 1960's. There is a substantial difference between the drought or firm yield of the Greeley-Loveland Irrigation System and the credit given

for these shares by Greeley. This difference is described further under the discussion of obligated demands on page 50.

Windy Gap Project (1969 – 1985)

From 1969 to 1985, Greeley along with six other Front Range municipalities jointly developed the Windy Gap Project. The Windy Gap Project is a transbasin diversion project delivering water from the Colorado River to the East Slope using the C-BT System. The water rights associated with Windy Gap are junior rights within the Colorado River Basin and typically do not yield significantly in dry years. The limited dry-year yield of the Windy Gap Project is compounded by the dependency of the project on excess capacity within C-BT Project facilities for storage and conveyance. This dependency has led to a reduced yield in wet years when there is no excess capacity within the C-BT System to deliver or store Windy Gap supplies.

Windy Gap water rights are wholly consumable, allowing Greeley to reuse wastewater effluent from Windy Gap shares. Windy Gap's re-useable effluent helps Greeley satisfy return flow obligations in the South Platte and Cache La Poudre Rivers below Greeley's wastewater plant.

The Windy Gap Municipal Subdistrict of Northern Colorado Water Conservancy District (Subdistrict) distributes Windy Gap Project water to allottees now ranging from the Platte River Power Authority's Rawhide Power plant along I-25 near the Wyoming state line to Broomfield on the northern end of the Denver Metropolitan Area. As discussed in subsequent chapters, a group of nine participants, including Greeley, is evaluating enhancing the yield of the project during major droughts. This cooperative approach with other regional water suppliers, the Subdistrict, and the Bureau of Reclamation is consistent with, and extends, Greeley's historical role as a major regional water supply entity.

Conclusion

Early in Greeley's history, Greeley's water supply leaders obtained the best quality raw water supplies reasonably available. In 1886, Greeley constructed its first water system consisting of a series of infiltration wells on the Poudre. In 1904, Greeley established a water supply that completely satisfied Greeley's needs for the next 40 years.

In 1934, Greeley led the formation of the Colorado-Big Thompson (C-BT) project. In 1943, Greeley finished construction of Milton Seaman Reservoir on the North Fork of the Poudre River upstream of Greeley's Bellvue Water Treatment Plant and in 1947 purchased the high mountain reservoirs. In 1961, Greeley began accepting shares in the Greeley-Loveland Irrigation System from developers and purchased much of the company in the early 1990's. From 1969 to 1987, Greeley along with six other Front Range municipalities jointly developed the Windy Gap Project—a transbasin diversion project delivering water from the Colorado River to the East Slope.

During the last century, Greeley has proactively searched for and acted on opportunities to further develop and secure the Greeley water system. The combination of senior direct flow rights, supplemental C-BT water supplies, and junior native water rights (Greeley-Loveland Irrigation System, Poudre high mountain reservoirs, Windy Gap) has resulted in a balanced water yield for the City in a wide variety of hydrologic conditions (wet, average and dry years). As discussed in subsequent chapters, developing future water supplies that complement Greeley's existing water portfolio in various hydrologic conditions, especially in drought periods, is one of the primary goals of this *Water Master Plan*.

Chapter 3.
Greeley's Current System

This chapter describes Greeley's current water system and discusses the system's reliability and limitations. Water supplies owned by Greeley are used in one of two ways:

- Water supplies that are physically available upstream of one of the two treatment plants are generally delivered to those plants.
- Water supplies that are available near Greeley are used for non-potable water demands or to take care of obligations to downstream water users.

As described in the previous chapter, Greeley's water sources include direct river diversions, unit ownership in the C-BT and Windy Gap projects, high mountain reservoirs, and shares in several irrigation companies. Additionally, water rights owned by Kodak, Windsor, Evans, and Milliken are transferred to Greeley in exchange for Greeley supplying an equivalent amount of treated water. As part of the non-potable system, Greeley also owns and uses wells within Greeley for irrigation.

Greeley's water system includes many miles of treated water transmission pipes and major treated-water storage tanks. Expansion of Greeley's extensive water distribution system was not included in this *Water Master Plan* because distribution expansion does not affect the long-term direction for Greeley's water system. The general arrangement of Greeley's water system is shown in *Map 1. Greeley's Water Resources* in Appendix A. Summaries of each of the major components of the system are presented in the following sections.

When assessing the system's current performance, Greeley must consider all vulnerabilities of the system and each of its components, including performance during droughts and potential disruptions in service. The current drought gripping the State of Colorado is acting as a litmus test for the vulnerability of the various components of the Greeley water system during extreme drought conditions. In addition, Greeley is assessing vulnerability to threats from vandals, terrorists, or other criminal activity. This assessment will be in accordance with the recently passed Bioterrorism Bill.

Colorado's Water Supply and Water Law

Colorado's water supply is controlled by the orthographic effects of the Continental Divide, the seasonal patterns of the storm systems, and highly variable snowfall and rainfall from year to year. In fact, 80 percent of Colorado's precipitation and runoff fall west of the Continental Divide while more than 80 percent of Colorado's population live east of this dominant physical feature. Colorado's water law shows early recognition that these temporal and geographic variations play a huge part in water supply planning.

A description of Greeley's raw water system revolves around the yield of Greeley's water resources. Yield is the amount of water that the water rights produce under varying hydrologic conditions ranging from wet to average to dry years. To understand Greeley's water system yields, one needs a basic understanding of Colorado Water Law.

Water in Colorado is allocated using the Doctrine of Prior Appropriation. The basic rule in this mode of water allocation is "first in time, first in right." In other words, the oldest diversions or storage rights are fully satisfied before making water available to more recent diversions or storage rights. The priority of water rights is described by whether the water right is senior (very old) or junior (more recent). The older or more senior the water right, the better the reliability of the water right in all hydrologic conditions including drought, which is the most critical period for a raw water system. Conversely, junior water rights have less reliability in dry years when there is only enough water in rivers to satisfy the most senior water rights. Junior rights may be "firmed" by building storage for them. Then when the junior rights are in priority in wet years, their yield can be stored for use in dry years when the junior right is not in priority to take water from the river directly.

Raw Water Sources

Greeley's raw water sources are from three main river basins:

- The Cache La Poudre
- The Big Thompson
- The Upper Colorado

Having water supplies in more than one basin provides a greater level of reliability during dry years. These basins contain approximately 3,700 square miles and collectively cover land on both sides of the Continental Divide. During any given year, the hydrologic conditions can vary substantially between the three river basins because of the different weather patterns that affect each of the basins. This variability in hydrologic conditions increases the reliability of Greeley's water system.

Prior to looking at alternatives to add yield to Greeley's water supplies, one must understand the current yield of Greeley's water system. Below are descriptions of the water rights Greeley owns in each of the three river basins and the nature of these rights as they apply to the yield of Greeley's system.

Cache La Poudre River Basin Water Rights

Greeley has two types of water rights on the Cache La Poudre River (Poudre River): direct flow and storage rights. Greeley's direct flow rights form the cornerstone of Greeley's water rights portfolio. These rights have very senior river priorities and provide consistent yield to Greeley's Bellvue Water Treatment Plant in all types of hydrologic conditions including drought. These rights allow Greeley to divert water except when the river itself is dry.

Greeley's other Poudre River Basin water rights are six high mountain reservoirs: Barnes Meadow, Peterson, Comanche, Hourglass, Milton Seaman, and Twin Lakes. These reservoirs capture water at high elevations on tributaries to the Poudre River Basin. This high-elevation distributed storage avoids dams on the mainstream of the river, lessens evaporative losses compared to equivalent storage lower in the basin. High elevation storage also enhances flexibility to deliver water. These reservoirs have different water right priorities, but in general all of Greeley's mountain reservoirs are junior water rights and have low yields in droughts.

The ability of Greeley to carry water over from one year to the next is extremely important in drought when Greeley's junior water rights do not yield. On the Poudre, only Milton Seaman Reservoir is used for multi-year carryover storage. Located on the North Fork of the Poudre River, this large tributary has greater sediment loads than the mainstream. The Milton Seaman Reservoir has three benefits.

- Approximately 5,000 acre-feet of carry-over storage, which is the largest, single storage vessel owned by Greeley.
- Winter operation supplements native river flows.
- Enhanced clarity of water delivered to the mainstream and then to the Bellvue Water Treatment Plant because the sediment load is captured by the reservoir.

The distributed storage of the six high mountain reservoirs is complicated to operate and has required the negotiation of a Joint Operations Plan (JOP) with the United States Forest Service as a condition for Greeley to operate three of its reservoirs located on Forest Service Land. The JOP was selected as the preferred alternative by the Forest Service to meet the fish habitat standard when issuing easements for Greeley's reservoirs. The JOP requires Greeley to release seven cubic feet per second from the Barnes Meadow Reservoir during the winter months. The JOP is being contested by Trout Unlimited in federal court and a decision on the case is pending. If the JOP is overturned, it could result in a lower yield for Greeley's high mountain reservoirs.

Greeley owns shares in a number of irrigation companies in the lower portion of the Poudre River Basin, primarily the Greeley Irrigation Company, known as the Number 3 Ditch. These supplies are too far downstream to be delivered to the treatment plants and, therefore, are used for non-potable purposes (e.g., irrigation of parks within the City).

Big Thompson River Basin Water Rights

Greeley's water rights in the Big Thompson River Basin come from Greeley's ownership in the Greeley-Loveland Irrigation System. The Greeley-Loveland Irrigation System consists of three interrelated ditch companies that historically provided irrigation water to farmland between Loveland and Greeley.

As Greeley, Evans, and more recently Milliken have expanded onto the irrigated farmland under the Greeley-Loveland Irrigation System, shares in the three ditch companies have been exchanged for

potable water service. As of early 2002, Greeley and its outside service customers owned approximately half of the shares in the three companies comprising the Greeley-Loveland Irrigation System. All of the shares can be delivered to the Boyd Lake Water Treatment Plant using Lake Loveland and Boyd Lake.

The Greeley-Loveland Irrigation System consists primarily of junior water rights and approximately 70,000 acre-feet of storage. This storage allows the Greeley-Loveland Irrigation System to carry water over from wet years in which these water rights have high yields into dry years when the yields are very low. In addition to potable use of water within the Greeley-Loveland Irrigation System, Greeley also uses the Greeley-Loveland Irrigation System as a non-potable source available to large turf areas within Greeley via the historic canals.

Upper Colorado River Basin Water Rights

Greeley receives water from the Upper Colorado River Basin through two interrelated water projects: Colorado-Big Thompson (C-BT) and Windy Gap projects. These projects' transmountain diversions greatly enhance Greeley's water management flexibility and future options because water from these projects can be delivered to either treatment plant.

Colorado-Big Thompson Project

The C-BT Project was designed to provide supplemental water supplies to native water rights in northeastern Colorado. The project consists of 310,000 acre-feet units, which historically have yielded between 0.5 and 1 acre-feet/unit per year. Due to the supplemental nature of the project, yields have historically been high (1 acre-feet per unit) in drought years when native yields are low and low (0.5 acre-feet per unit) in wet years when native yields are high. The C-BT Project, with over 800,000 acre-feet of active storage and a relatively senior water right on the Colorado River, is well suited to meet supplemental water needs in northeastern Colorado.

Windy Gap Project

The Windy Gap Project was planned and constructed between 1969 and 1985. A municipal sub-district of the Northern Colorado Water Conservancy District was organized with the municipal participants (Greeley, Loveland, Fort Collins, Longmont, Boulder, Estes Park) to fund and oversee the operations of the project. The Windy Gap Project consists of a diversion dam forming a 450-acre-foot reservoir, a 600-cubic feet per second pump station, and pipeline to deliver water to Lake Granby. From Lake Granby, the water is delivered to customers on the Front Range of northeastern Colorado using the federally developed C-BT facilities. A "carriage" contract with United States Bureau of Reclamation (USBR) allows the Windy Gap water to be delivered when there is unused capacity in the C-BT reservoirs, pipelines, penstocks and canals.

The average annual yield of the Windy Gap Project was originally estimated to be 48,000 acre-feet per year. In dry years, more senior water rights in the Colorado River drainage limit Windy Gap diversions and, therefore, the project provides significantly less water in drought years than in average or wet years. There are also wet years in which the C-BT System does not have reservoir storage space to receive Windy Gap water in addition to C-BT System water. Therefore, Windy Gap yields are reduced both in dry years when water is not available at the diversion point and in wet years (and years following wet years) when there is no available storage within the C-BT Project. The limitations on yield led Windy Gap participants, including Greeley, to jointly study ways to increase the reliability of this project. The result from this study is the Windy Gap Firming Project described later in this document as a potential future supply option.

The Windy Gap Project gives flexibility to Greeley's day-to-day operations. Because Windy Gap water is imported to the South Platte River Basin from an entirely separate river basin, Colorado water law allows this water to be used to extinction. Therefore, Greeley is given credit for the amount of treated wastewater effluent that can be shown to have originated from the Windy Gap water brought into Greeley's municipal water treatment and distribution systems and used by Greeley's customers. Typically, for indoor uses, municipal customers consume about ten percent of the water leaving the water treatment plant and the remaining 90 percent is returned to the river as wastewater effluent or return flows. Greeley has the legal right to use this water again. It should be noted that C-BT water is also a transbasin supply, but in the original document governing the use of C-BT water, the water was explicitly defined as single use water with the return flows from the initial use of the water being made available to downstream water users within the Northern District Boundaries.

Non-potable Supplies

Greeley has several sources of non-potable water supply. Most of the following water rights divert water out of the Poudre River near Greeley and cannot be used by either Bellvue or Boyd water treatment plants. The primary non-potable water supplies are:

- Greeley Irrigation Company shares (Canal No. 3).
- 3/8th City interest of the Canal No. 3.
- Windy Gap units: re-useable effluent.
- Greeley-Loveland Irrigation System shares: re-useable effluent.
- Greeley-Loveland Irrigation System shares: lawn return flow credits.
- Ditch Company shares on the Lower Poudre River.

Greeley's non-potable supplies are currently used for Greeley-Loveland Irrigation System return flow obligations as required by Water Court in change-of-use proceedings, for non-potable irrigation, and for augmentation purposes in Greeley.

Greeley also uses the Greeley-Loveland Irrigation System shares either as a potable source of water (treatable at the Boyd Lake Water Treatment Plant), or as a non-potable source (useable through the Greeley-Loveland Canal and lateral ditches on the west side of Greeley). To deliver Greeley-Loveland Irrigation System water for non-potable purposes, water travels over 16 miles from Loveland to Greeley via the Greeley-Loveland Canal. Once in Greeley, the water is distributed using a series of lateral and farm ditches.

The only agricultural ditch shares currently accepted by Greeley for raw water dedication are Greeley-Loveland Irrigation System shares and Greeley Irrigation Company shares. Greeley is currently involved in a *Non-potable Water Master Plan* that will address what non-potable supplies Greeley will accept for dedication in the future and under what conditions.

Drought Planning and Yield

Greeley uses the "firm yield" of water supplies to assess the current water system and to compare new resources on an equivalent basis. Prior to exploring the raw water alternatives available to Greeley to meet its future water demands, one must have an understanding of how Greeley quantifies firm yield.

Greeley Uses the 50-Year Drought Planning Standard

The firm yield of the Greeley's current water system is the demand that can be met in a drought period without shortages. Greeley uses a 50-year drought as a planning standard. From a statistical standpoint, this is a six-year drought that has a one-in-50 chance of beginning each year. The severity of drought will vary during the six years and vary within the three basins from which Greeley receives water.

The 50-year drought standard was developed by generating stream flow values for each of the basins from which Greeley receives water. The stream flow values have the same statistical properties as the measured historical river flows over the last 50 years. The reason for generating the artificial stream flows is to evaluate potential drought events that are more severe than what has been recorded during the relatively short historical record of stream flow measurements. Greeley believes the 50-year drought is an appropriate planning standard and it is the same standard used by other regional water suppliers, including Fort Collins and Denver. If a drought more severe than a 50-year drought occurs, the firm yield of Greeley's water system will drop accordingly and could result in water shortages within Greeley if demand is not reduced.

Computer Models Simulate Water System Yields and Operations

To determine the reaction of Greeley's water system to a 50-year drought, Greeley uses a series of detailed computer models. These models simulate the components, operations, and yields of the Greeley water system. Greeley uses the MODSIM computer program to simulate water system yields and operations. This model was developed by Colorado State University and is used by a number of regional groups including Fort Collins, Loveland, and the Northern Colorado Water Conservancy District. The model allows the user to build a visual network of the simulated water system using nodes and links. The nodes represent reservoirs, treatment plants, and demands. Links represent rivers, irrigation ditches, and pipelines. The model uses an optimization program to allocate water within the system. This program is well suited to simulate rivers that use the prior appropriation doctrine for the administration of water rights. The model is run on a monthly time step, matching the level of accuracy of historical data, and it is of adequate accuracy for planning purposes. Greeley uses two types of models in the simulation of the water system: Basin Models and Greeley System Model.

- **Basin Models** simulate the water rights administration in the river basins from which Greeley receives water. The Basin Models are calibrated using historical river flows and administration. After the models are calibrated to historical river system operations, a simulated data set of stream flows containing the 50-year drought are applied to each of the Basin Models and the yield of Greeley's water rights are established. The yields from the Basin Models are then input into the Greeley System Model.
- **The Greeley System Model** simulates the overall Greeley water system. The model combines water right yields and storage with operational rules, system infrastructure (e.g., pipeline capacities) and demands (e.g., potable and non-potable demands and legal or contractual obligations).

These models predict the amount of Greeley's water demands that can be satisfied without shortages during the selected 50-year drought. This is the "firm yield" of Greeley's water system. Although the demand that can be satisfied is reported as a fixed number in acre-feet per year, the actual modeled demands vary from month to month, and year to year. In a normal year, water demand in a summer month exceeds demands in winter months by a factor of approximately three-to-one. The variation in annual demand can increase by as much as 15 percent in hot and dry years compared to cool and wet

years. These differences in monthly and annual demand values are primarily due to outdoor uses of water, most notably lawn irrigation.

The variations in monthly and annual demands are represented in Greeley's drought modeling. The one exception to this variation is in the last year of the 50-year drought. As part of the adopted water policies listed on page 13, Greeley will enact drought conservation measures in the last year of a 50-year drought to lower Greeley's annual demand by approximately ten percent in the last year of the drought. This level of conservation is included in Greeley drought modeling.

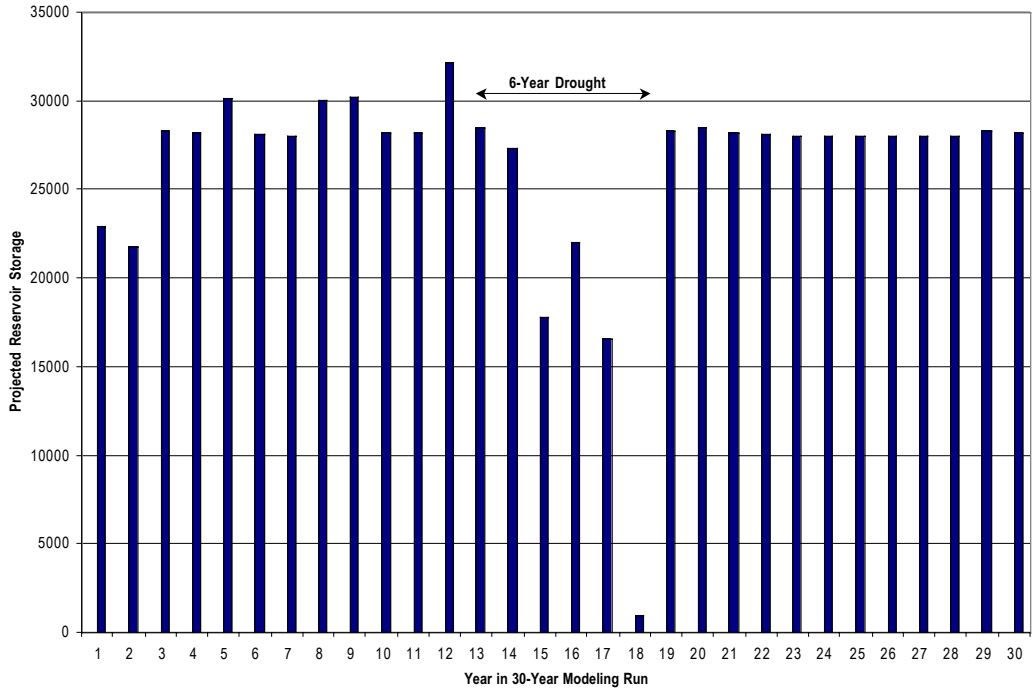
Current Greeley Firm Yield

To determine Greeley's current firm yield, the Greeley System Model is run with the 50-year drought data set and a trial level of water demands. If the model run ends with Greeley having no supply shortages, the demand numbers are increased and the model is re-run. If the model run results in supply shortages, the system demands are reduced and the model is re-run.

The balancing point between supply shortages and excess supplies is Greeley's **firm yield**. To meet Greeley's water demands in drought, Greeley supplements the annual yield of its water rights with carryover storage. The firm yield is the demand level where Greeley can meet all of its system demands, but does not have yield or available water in storage for additional demands. Shown in the following figure are the modeled end-of-year reservoir contents for the 30-year modeling run containing the 50-year drought sequence and applying a City potable demand of 42,500 acre-feet. This demand results in Greeley's reservoirs being completely emptied in the first few months of year 19, prior to the yield of Greeley's water rights in the spring and summer months. Therefore, the current Greeley water system can meet a potable demand of 42,500 acre-feet in the specific hydrologic conditions contained in the 50-year drought scenario modeled. If, however, a drought were more severe than the 50-year drought, the yield of Greeley's raw water system would be lower than the 42,500 acre-feet.

Firm yield is used as a measurement of the level of service Greeley can provide to its citizens during a defined drought period. It should be noted that from a practical standpoint, as the current drought is illustrating, water providers never know how much longer the drought may last and are unwilling to run out of storage. Water suppliers enact increasingly severe drought conservation measures as reservoirs drop during a drought, incrementally dropping the level of service to citizens and protecting the ability to provide essential services (drinking, sanitation, fire protection, etc.). The conservative nature of water systems will lead to an overestimate of the water that can be provided in drought periods if only looking at firm yield. The effect of the current drought on the Greeley's *Water Master Plan* is discussed in more detail later in this chapter.

Figure 4. Modeled Reservoir Contents



Integrated Operation of the Water System

When combined, Greeley's water supplies work very well in meeting water demands under a wide variety of hydrologic conditions. Greeley's senior direct flow rights available to the Bellvue Water Treatment Plant are the foundation of Greeley's supplies each and every year. The variable yield of Greeley's junior water rights is complemented by the supplemental nature of Greeley's C-BT ownership.

In wet years when native rights have high yields, the yield of Greeley's C-BT Project water is low. In years when native rights have low yields, the yield of Greeley's C-BT Project water is typically high. The only exception to this rule is in multi-year extreme drought situations when the C-BT System's storage and water rights are not sufficient to supply the need for supplemental water.

The following figure (*Figure 5. Annual Yield*) shows the current annual yield of Greeley's water system in various hydrologic conditions and the amount of the total yield attributed to the various Greeley water supplies. *Figure 6. Historical Demand and Raw Water Supply* illustrates how Greeley's raw water supplies have met demand over the years.

Figure 5. Current Annual Potable Yield

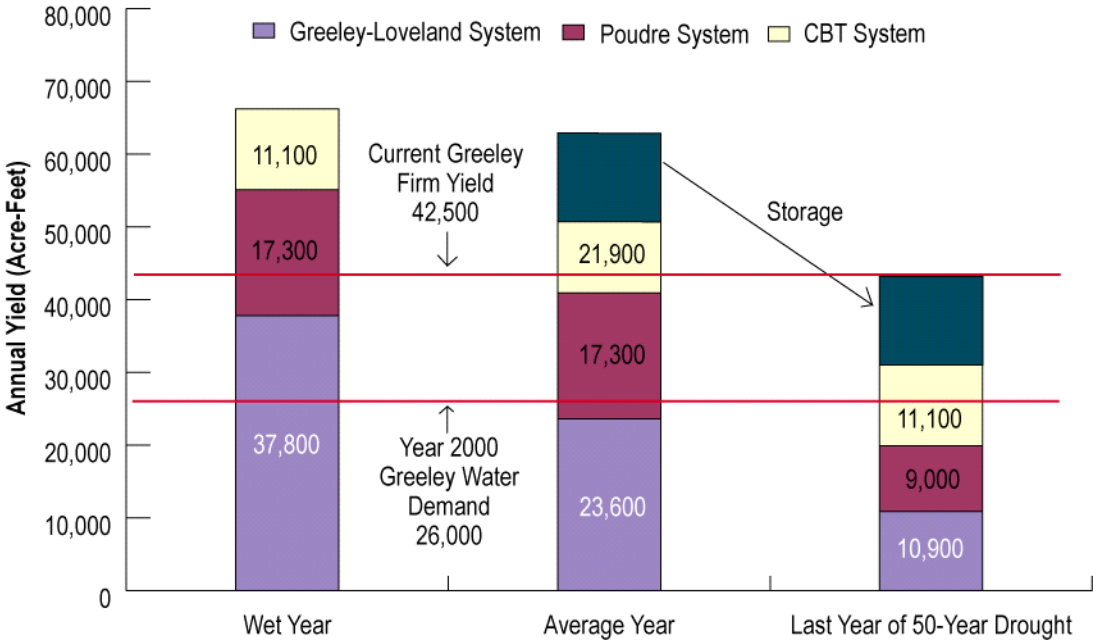
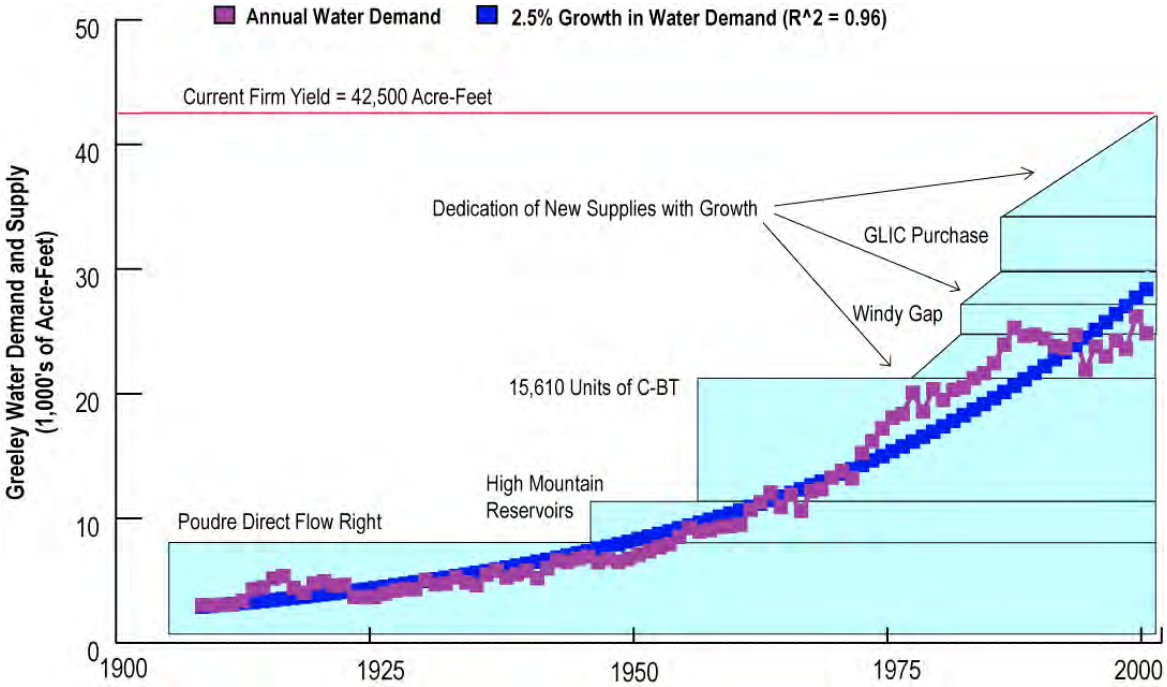


Figure 6. Historical Demand and Raw Water Supply



Determining the Raw Water Safety Factor

Before one can assess what kinds of improvements are needed to a water system, there must be a clear understanding of the current performance of that system. The system safety factor is the amount that current supplies exceed current demands. Greeley has a safety factor in a 50-year drought, even if one includes future demands from development that have already committed the necessary water supplies to Greeley. These **obligated demands** are discussed in more detail in *Chapter 4. Future Demand*.

In Greeley's drought modeling, all water supplies currently owned by Greeley are included in model runs. This includes water supplies that were dedicated to meet Greeley's raw water requirements, but where the development and associated water demands have yet to occur, which are known as **pre-paid or obligated demands**. In addition, Greeley has contractual obligations to accept some water supplies at a rate less than the firm yield of those supplies. If Greeley did not include obligated demands when calculating Greeley's safety factor, the safety factor would be overestimated. The following table shows a comparison of supplies and demands and calculation of Greeley's current safety factor of 7,300 acre-feet.

Table 3. Current Water Supply / Demand Summary

Demands		Supplies	
Existing Demands		**Existing Supplies**	
Potable Demand	25,000	Existing Potable Firm Yield	42,500
Non-potable Demand	2,000	Existing Non-potable	2,000
Total Existing Demands	**27,000**	**Total Existing Supplies**	**44,500**
Obligated Demands		**Supplies with Obligated Demands**	
New Obligated Demands by 2020	9,000	New Yield from Greeley-Loveland Shares (in City's 2020 growth path)	1,100
New Obligated Demands 2020-2050	3,700	New Yield from Greeley-Loveland Shares (in City's 2020-2050 growth path)	1,400
Total Demands	**39,700**	**Total Supplies**	**47,000**
Total Supplies minus Total Demands		7,300	
Raw Water Safety Factor		**7,300**	

Greeley calculates its raw water safety factor with an assumption that Greeley will implement drought conservation in the worst year of the 50-year drought. Greeley intends to reduce drought year water demands (hot and dry) down to a level of average year water demands (average temperature and average precipitation) by implementing Greeley's *Drought Emergency Plan*. This will result in a ten-percent reduction in water demand. Most communities calculate their raw water safety factor as the difference between their firm yield and their drought year water demand. If Greeley did not assume this reduction in demand, the safety factor would be approximately 3,000 acre-feet as opposed to the 7,300-acre-feet value used in the water master plan study. The drought conservation of ten percent was assumed because of the public awareness associated with a drought of this magnitude and the need to conserve given that during the drought the length and ultimate severity of the drought will be unknown.

2000's Drought

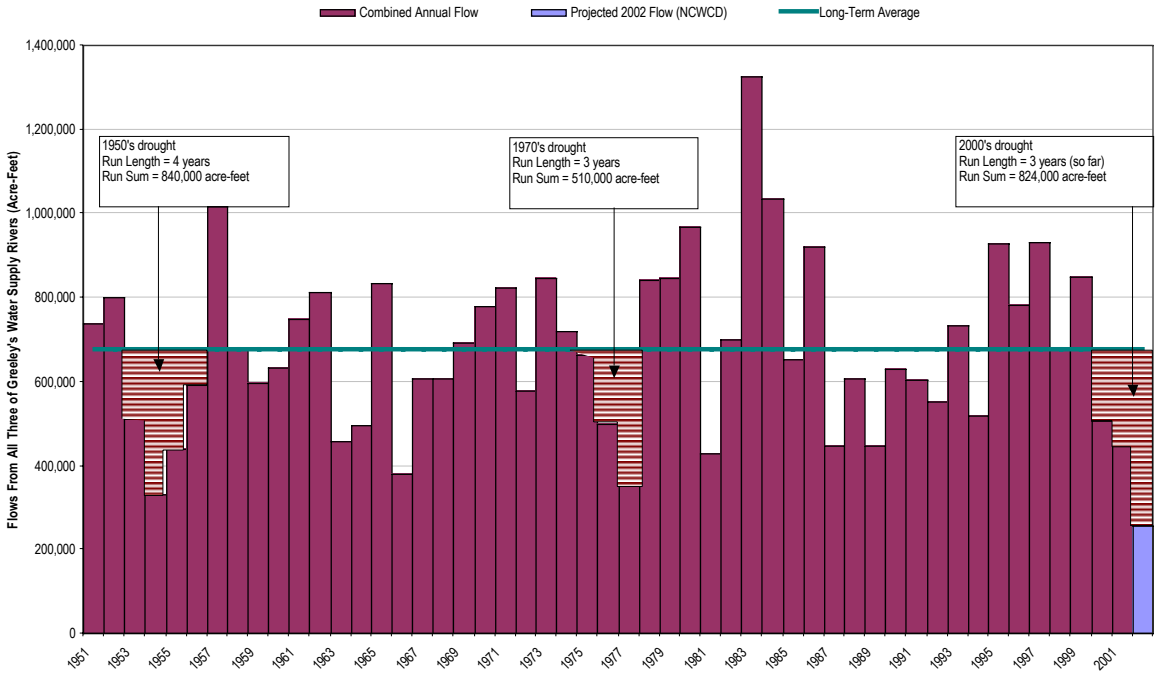
As of the spring of 2003, the State of Colorado appears to be headed into its fourth consecutive drought year. As shown in *Figure 7. Historical Perspective of 2000's Drought* below, in three years, the current drought has almost equaled the total deficit in river flows (within the three river basins from which Greeley receives water) experienced during the 1950's drought. The current drought also appears to be moving toward the level of drought last seen during the 1930's Dust Bowl drought, which lasted eight years. Year 2002 was the worst single drought year on record by far, and elevated the severity of the drought dramatically from 2001. The severity of the current multi-year drought will not be known until flows return to average. The uncertainty in the ultimate severity of the drought has led Greeley and other regional municipalities to implement increasing levels of conservation in an effort to slow the depletion of water supplies.

At the time this *Water Master Plan* was issued, it is unclear as to how long the drought will continue. Given the conditions, it is possible the current drought's impact on Greeley's water system will be worse in severity than the 1930's Dust Bowl drought. At the end of the current drought, Greeley and other regional water suppliers will likely be revisiting the level of service that should be provided by water systems. Issues that will have to be addressed as part of the discussion include the following.

- Do Greeley's water customers want to increase Greeley's drought protection above the 50-year drought level, given the potentially large rate increase necessary to provide this level of service?
- What permanent raw water options would be needed to increase drought protection? Can these raw water options be implemented at all, if the justification is a drought protection level greater than a 50-year drought?
- What level of drought conservation is acceptable in Greeley?
- What temporary options are available during a drought period to increase the water supply available to Greeley? What is the cost of these options? How long will these options be available for Greeley?

The current drought has already led to changes in how Greeley plans on implementing raw water options identified as part of this *Water Master Plan*. The impact on implementation of raw water options is discussed in *Chapter 7. Integrated Strategies*.

Figure 7. Historical Perspective of 2000's Drought



Current Water Supplies Conclusion

Greeley's current water supplies will provide 44,500 acre-feet versus an existing demand of 27,000 acre-feet (including both potable and non-potable demands). However, when Greeley's obligation to supply future demands (as defined in *Chapter 4. Future Demand*) is considered, Greeley has a current safety factor of 7,300 acre-feet in the 50-year drought chosen for planning purposes. This drought condition has been thoroughly evaluated, discussed and compared to many other water suppliers in the area. Greeley's drought standard was compared to other water suppliers to ensure that Greeley has a similar drought protection level as other regional entities and can provide a similar level of service in a drought. Once the final severity of the current drought is known, Greeley and other Front Range water suppliers will need to revisit the level of service provided to their citizens. However at this point, the current level of service appears to be appropriate and in-line with other regional water providers.

Water Treatment Plants

Greeley owns two water treatment plants: Bellvue and Boyd Lake, with a combined treatment capacity of 58 mgd. Both plants use conventional filtration and chemical treatment and have been upgraded to meet current regulatory requirements. Summaries of the plants and their vulnerabilities in meeting day-to-day and future requirements are presented below.

Bellvue Water Treatment Plant

The Bellvue Water Treatment Plant is located northwest of Fort Collins and is the older of the two plants. The Bellvue Plant was recently tested for capacity. The plant and transmission lines have a sustained capacity of about 20 mgd. This plant consists of raw water settling ponds, rapid mix, flocculation, sedimentation, filtration and disinfection. The Bellvue Plant is Greeley's base plant for meeting treated water demands and is operated year-round. Raw water quality into the Bellvue Plant is typically good with low turbidity (clear water) and low hardness (requires little soap).

The age of the existing Bellvue filters is of serious concern. Built between 1946 and 1964, the filters are approaching the end of their useful life. Although the plant is well maintained (e.g., all filter media was replaced in the last two years), much of the plant needs replacement or major overhaul, especially to meet new regulations. A detailed evaluation of the filter plant is underway and it may be that all 20 mgd of Bellvue filter capacity must be replaced because of age and to meet new regulations. Once replacement does occur, Greeley has an opportunity to choose between traditional mixed media filters and newer membrane technology. Membranes have the advantage of being a positive barrier to cryptosporidium and appear to be equal in cost for the relatively good water quality available at this treatment site.

Boyd Lake Water Treatment Plant

The Boyd Lake Plant is located east of Loveland. The plant has a capacity of about 38 mgd and is a conventional plant consisting of a raw water settling pond, rapid mix, flocculation, sedimentation, filtration, and disinfection. The Boyd Lake Plant is operated as a peaking plant to meet summer irrigation demands and it is typically operated from April through October. The sources for Lake Loveland and Boyd Lake are C-BT and Big Thompson River via irrigation ditches. The water sources for Boyd Lake and thus the Boyd Lake Water Treatment Plant are historically irrigation sources that were typically used from about April through October. Raw water quality from Boyd Lake is considered average quality with low turbidity but moderate hardness.

Vulnerabilities of Existing Treatment Plants

Water treatment plants are vulnerable in a number of ways, including physical limitations, natural disasters, source water quality deterioration, damage by vandals or others, and potential inability to meet future regulations. The Bellvue Plant has vulnerabilities in aging infrastructure, existing capacity limitations, lack of redundancy, potential contamination of the Poudre River or Hansen Canal, and potential inability to meet future regulations. The Boyd Lake Plant has vulnerabilities in contamination of the raw water supplies from manmade or natural sources, and potential inability to meet future regulations. Greeley has already taken steps to mitigate vulnerabilities at both plants by doing the following.

- **Developed a *Drinking Water Emergency Plan*** to provide guidelines for dealing with emergencies at either plant, including natural disasters, manmade disasters, and acute contamination of the raw water sources.
- **Participated in a watershed protection group for the Big Thompson basins** to improve, or at least maintain, the existing water quality in both basins.
- **Completed recent upgrades (2000) at the Boyd Lake Plant** that addressed specific vulnerabilities in the infrastructure of the plant.
- **Added chlorine dioxide to the Boyd Lake Plant** in 2002 that will increase the plant's ability to inactivate many microbes and also improve the taste and odor of the finished water.

- **Completed recent upgrades (2002) at the Bellvue Plant** to address specific vulnerabilities in the infrastructure of the plant, particularly with regards to the age of the infrastructure. These upgrades included the addition of chlorine dioxide, which increases the plant's ability to inactivate many microbes and mitigates the plant's vulnerability to specific chemical constituents in the Bellvue raw water sources.
- **Establishing a watershed protection system for the Poudre River Basin**.
- **Adding pumping facilities in 2003 to the Greeley-Loveland Canal** that will enable the Boyd Lake Plant to access water supplies within Boyd Lake and Lake Loveland below Greeley's intakes in these reservoirs.
- **Completing a Vulnerability Assessment** as required by the Bioterrorism Bill that assesses the threats to the entire water system and develops a mitigation plan for threats.

There are other vulnerabilities at each plant, including the following.

- **Microbial Contamination** – Every treatment plant has microbial contamination risk and the plant owner must mitigate the risk to at least the level required by regulations. The Bellvue Plant has historical data on microbes (Crytosporidium and Giardia) that may require more stringent treatment in the future. Although chlorine dioxide is one component to mitigating this risk, there may be additional methods for mitigation with future improvements and capacity increases. According to today's testing methods, the Boyd Lake Plant appears to have a lower risk with these microbes.
- **Filter Backwash Recycling** – Most plants in arid areas practice in-plant recycling to reduce raw water waste. Greeley practices filter backwash recycling at both plants. A risk with recycling is that microbes that may not have been inactivated are reintroduced into the treatment plant. Both plants meet current regulations with regards to recycling. However, there may be more stringent regulations in the future.
- **Future Regulations** – Who could anticipate in 1976, that 22 regulated contaminants would have expanded to 91 in only 25 years? Staying ahead of the regulations is an on-going process for all water treatment providers. However, some of the contaminants regulated today were not known in 1976 and new contaminants are likely to be regulated in 2020.

Treated Water Transmission

Bellvue Plant Transmission

The two transmission lines from the Bellvue Water Treatment Plant operate by gravity and have an approximate combined capacity of 20 mgd.

- The first transmission line is predominantly 27-inch diameter, and then splits into two 20-inch lines at about I-25.
- The second transmission line is 38-inch, 30-inch, and predominantly 27-inch diameters all the way to Greeley.

A number of customers are served directly from these transmission lines. Currently, all flow from the Bellvue Plant is gravity into Greeley.

The age of the transmission mains is also of concern. The newest transmission line from Bellvue was constructed in 1952, the oldest in 1923. While the steel lines have been cathodically protected and some pipes have been lined with a polyethylene liner, continued maintenance and replacement is anticipated.

Boyd Lake Plant Transmission

There are two transmission lines from Boyd Lake. One is a 27-inch line. The other is a 34-inch line. A test performed in spring of 2002 determined that the combined capacity of the lines is approximately 40 mgd. The Boyd Lake Plant is at a lower elevation than the first zone it serves and thus all water is pumped from the Boyd Lake Plant. As with the Bellvue transmission lines, a number of customers are served directly from the transmission line.

Treated Water Storage and Distribution

Greeley currently has four sites of existing treated-water storage as shown in the following figure.

- 23rd Avenue — Four reservoirs with a total of 37 mg.
- Mosier — A two-celled reservoir with a total of 15 mg.
- Gold Hill — A single reservoir with 15 mg.
- Zone 4 — Two million gallon elevated storage tank completed in 2003.

Distribution System

The distribution system has four pressure zones. The highest pressure zone is located to the west and the lowest pressure zone is located to the east. The pressure zones are interconnected via pump stations and pressure-reducing valves.

Greeley has three pump stations in the distribution system: two pump stations at the Mosier site and one at Zone 4.

In general, water from the Bellvue Water Treatment Plant is primarily delivered to Zone 1 by gravity. Bellvue water may also be delivered to Zones 2 and 3 via the Mosier Pump Station.

Water from the Boyd Lake Water Treatment Plant is primarily delivered to the Gold Hill Reservoir serving Zone 3. Boyd Lake water also serves Zones 1 and 2 by flowing through Zone 3 and pressure-reducing valves. Zone 4 is supplied by pumping from Zone 3.

Figure 8. Distribution System Pressure Zones Map

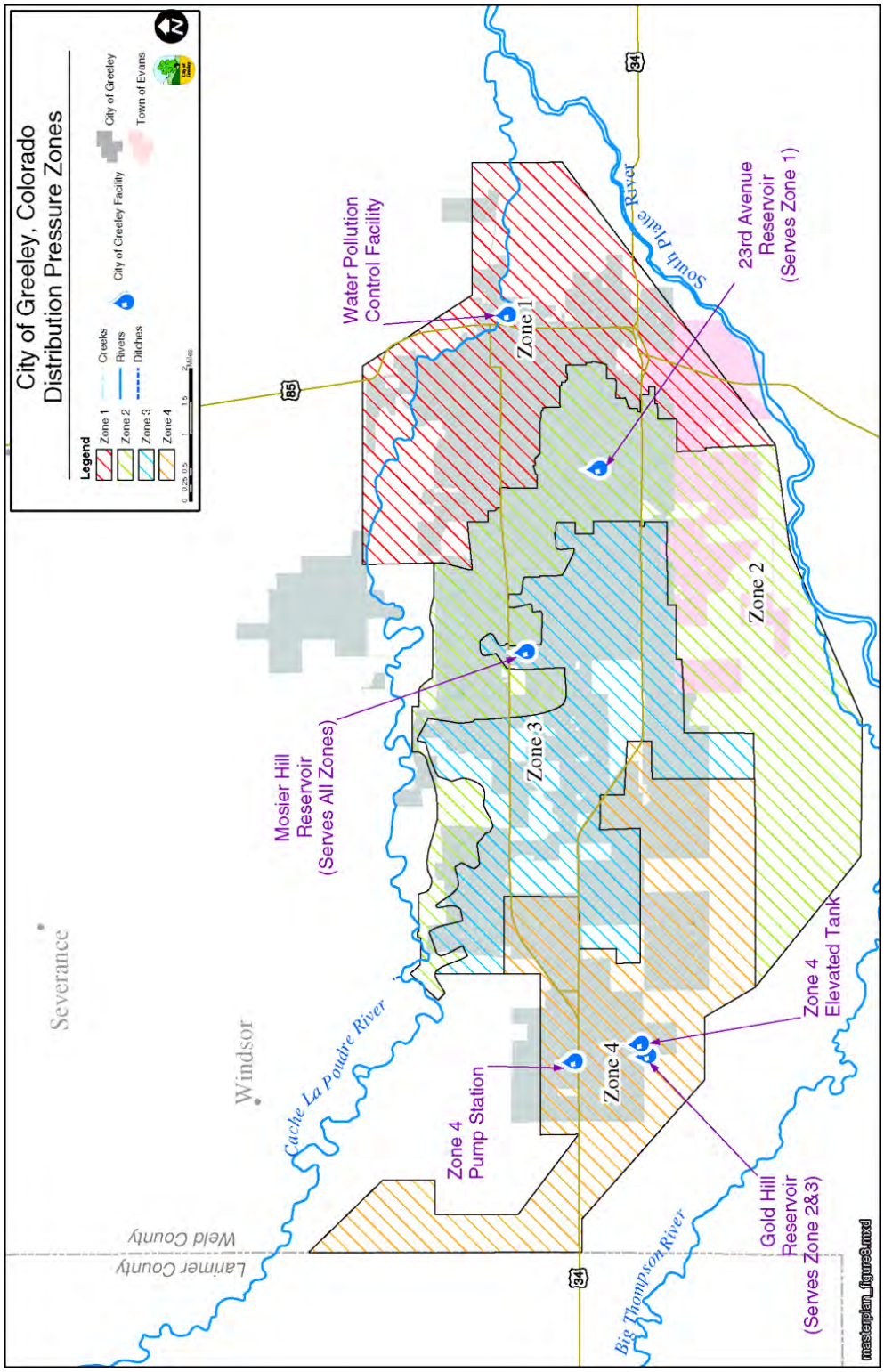
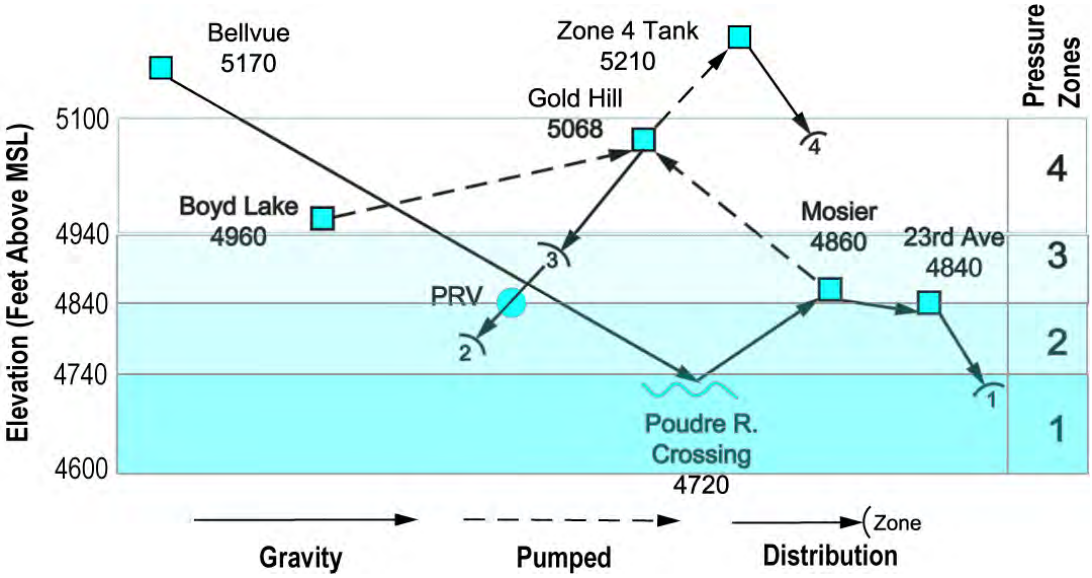


Figure 9. Facilities Elevation Profile



Existing Transmission Conditions and Vulnerabilities

Existing conditions and vulnerabilities were defined before looking at transmission alternatives. Transmission piping vulnerabilities are primarily physical—susceptible to breaks and capacity limitations. Although pipe lining can affect water quality, in this case, the effect is negligible.

Transmission capacity should match capacity of the treatment plant to avoid unusable capacity in either system and to avoid the capital expenditure to build that capacity. A computer model was developed to assess two critical capacities under both existing and future conditions.

- Peak production using both the Bellvue and Boyd Lake Plants (summer).
- Peak conditions with just the Bellvue Plant operating (spring).

Modeling results show that the existing system operates as follows to meet existing demands.

- With both plants operating near capacity, current peak demands can be met throughout the service area.
- Transferring water from the Bellvue system into the higher pressure zones is limited. The Mosier Pump Station is a bottleneck. The capacity limitations at Mosier are the trigger for turning on the Boyd Lake Plant in the spring to meet demands in the higher pressure zones even when the total system demand is less than the Bellvue capacity.
- The Boyd Lake Plant can serve the lowest pressure zone by gravity via pressure reducing valves (PRV) from the higher pressure zones.
- Both transmission systems have more than one pipe, providing partial redundancy and mitigating the effects of a pipe break.

Vulnerabilities in the existing system include the following.

- Bellvue lines are aging and are susceptible to leaks and breaking.
- Boyd Lake's 27-inch pipeline has joints that may need repair or replacement.
- Providing water to the higher pressure zones under emergency conditions using just the Bellvue Plant could be problematic in the summer due to the difficulties in transferring water into those zones from the Bellvue pipes.
- Water quality may degrade in the Gold Hill tank because the inlet/outlet pipe configuration of this large tank does not mix the water well.
- Taking the Gold Hill reservoir out of service for maintenance creates operations difficulties because it is the only reservoir in the higher pressure zones.

Non-potable Water System

Greeley's non-potable supplies are used to maintain historical return flow obligations associated with the Greeley-Loveland Irrigation System shares, for non-potable irrigation, and for augmentation. The non-potable system of irrigation canals and alluvial groundwater wells supply some of Greeley's irrigation demand in the summer, reducing the peak demands for treated water.

The backbone of the non-potable system consists of two major canal systems: the Greeley-Loveland canal system on the west side of town and Canal No. 3 on north side of town. The Greeley-Loveland canal system includes several major laterals that can provide water to a significant portion of west Greeley. The typical non-potable system consists of a pump station off a canal and non-potable distribution system, although in some cases, a pond is constructed to provide three days storage.

Greeley also uses several wells along the Poudre River for non-potable irrigation. Greeley non-potable supplies replace water to the Poudre River equal to effects of well pumping. This is known as augmentation. *Map 2. Non-potable Distribution System Map* in Appendix A shows the location of the canals used by Greeley to deliver non-potable water for irrigation.

Greeley currently is meeting approximately 2,000 acre-feet of irrigation demands with non-potable water from the Greeley-Loveland canal, Canal No. 3 and from wells. Non-potable use of 2,000 acre-feet water represents approximately 7.5 percent of Greeley's total annual demand. It is estimated that another 1,500 acre-feet of non-potable demands are supplied by privately owned non-potable supplies. This includes such entities as the University of Northern Colorado, Aims Community College, and the Greeley Country Club. When these demands are added to the 2,000 acre-feet of non-potable demands being met by Greeley, it equates to over 12 percent of the total annual demands within Greeley.

Outside Service Customers

Larger municipalities often provide water and wastewater services to others because of the economies of scale and the difficulty of small entities with limited staff and financial resources to comply with evolving state and federal regulations.

In addition to supplying treated water to Greeley citizens, Greeley also provides treatment and transmission services via separate contracts for Evans, Windsor, Milliken, and Kodak. Each municipality turns water over to Greeley each year for treatment and transmission through the Greeley water system.

These entities pay Greeley the cost of treating and transmitting the water plus ten percent return on investment and also pay plant investment fees for the addition of treatment and transmission capacity.

Greeley also provides Eastman Kodak's industrial facilities near Windsor with treatment and transmission services. In contrast to the municipal outside service contracts, Kodak has transferred water supplies into Greeley's system for use on a permanent basis instead of the annual transfer that occurs with the municipal contracts. The quantity of use of the outside service contact holders for the last six years is listed in the table below.

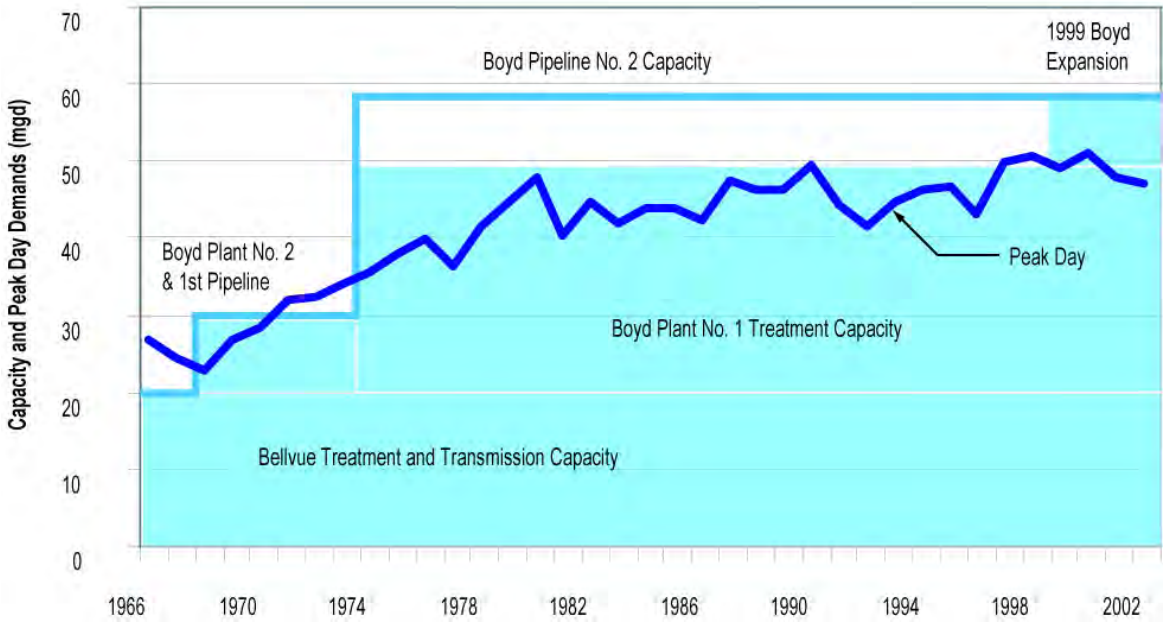
Table 4. Outside Service Contract Usage (Acre-Feet per Year)

	Evans	Milliken	Windsor	Kodak	Total
1997	1,715	0	341	1,448	3,504
1998	2,004	0	420	1,398	3,822
1999	1,900	0	412	1,454	3,766
2000	2,275	249	573	1,355	4,452
2001	2,344	174	525	1,265	4,308
2002	2,449	270	574	1,431	4,724

Peak Day Demand

Until the 1999 expansion, the Boyd transmission capacity exceeded the plant's treatment capacity. Today, the total treatment and transmission capacity for both plants is about 58 million gallons per day (mgd). Peak day demand had been around 50 mgd for three of the last six years, about 86 percent of maximum capacity. In-town storage of finished water provides an additional buffer against peak demands. Growth in peak day demand has been slower in the last two decades than population growth due to a variety of factors, including universal metering.

Figure 10. Historical Peak Day and Treatment and Transmission Capacity (1966 – 2001)



Conclusion

In comparison with systems of other similarly sized cities, Greeley's water system is a robust, moderately complex. However, as the system grows, the existing facilities will be strained to meet the needs of customers. The strengths of Greeley's current system include:

- Multiple raw water sources from three major river basins.
- Two treatment plants located in different river basins.
- Multiple transmission lines from each plant.
- Gravity transmission of water from one of the plants.
- Adequate treated water storage in Greeley, near water customers.
- Good water quality at one treatment plant and average water quality at the other plant.

Despite these strengths, Greeley's water system requires:

- Expansion of all aspects of the system to provide for growth in water demand.
- Replacement of components that have reached the end of their lifespan.
- Vulnerabilities to be addressed.

Greeley's *Water Master Plan* identifies or defines:

- Future water demands.
- Future raw water sources.
- Treatment capacity requirements.
- Location and general type of treatment associated with future raw water sources.
- Future treatment.
- Existing transmission capacity that will need upgrades or replacement.
- Future transmission needs (in conjunction with treatment location) and means.
- Future finished water storage needs.

When implementation of this *Water Master Plan* is complete, the new system must assure adequate:

- Water (quantity and quality) is available even during defined levels of drought to meet forecasted needs.
- Treatment capacity is available and tailored to specific water quality issues associated with the mix of raw sources available to the plants.
- Treated water transmission and storage to meet peak requirements.

Greeley's water system can be summarized as follows.

Table 5. Greeley's Water System Summary

	Capacity	Comments
Raw Water	42,500 acre-feet 50-year drought	7,300 acre-feet safety factor above current and obligated demand level.
Bellvue Water Treatment Plant	20-mgd peak capacity	Most of the plant requires replacement before 2010.
Boyd Lake Water Treatment Plant	38-mgd peak capacity	Plant was recently upgraded and expanded.
Bellvue Transmission	20-mgd maximum capacity	Lines are between 51 and 80 years old (constructed 1923 to 1952).
Boyd Lake Transmission	40-mgd maximum capacity	Lines are between 30 and 36 years old (constructed 1967 to 1973).

Chapter 4. Future Demand

This chapter presents the water demand forecasts that underlie the entire *Water Master Plan*. In the short term to 2020, water demands are based on 2.5 percent population growth as forecasted in Greeley's *Comprehensive Plan*.

Unlimited Growth Potential

A city's growth potential is dependent on geography, transportation, historical industries, potential industries, and proximity to other entities. Greeley is located in an agricultural area and is surrounded on three sides by rural areas. The area around Greeley within service areas of other water providers is relatively small. Additionally, Greeley's Urban Growth Boundary includes extensive undeveloped lands. Based on historical growth rate, Greeley is not expected to develop all land within the Urban Growth Boundary by 2050.

The combination of these factors makes Greeley fairly unique on the Front Range with respect to growth potential. Growth in water demand for the majority of entities on the Front Range is typically limited by adjacent municipalities, other water providers, or un-developable land (such as mountains, federally-owned installations, and national forests). The Greeley Council-defined Urban Growth Boundary, shown in *Map 4. Existing and Future Land Use Map* in Appendix A, is essentially the only limit to Greeley's growth potential. Therefore, the *Water Master Plan* must anticipate long-term implementation of water supplies to 2050 and beyond.

The consequences of unlimited growth potential are:

- The difficulty defining water demand for the next 20 years and beyond without a sense of the pace at which an ultimate demand is approached.
- A large number of raw water sources must be considered that can be developed far into the future.
- A wider variety in the location of potential treatment plants, the size of treatment plants, and the size and location of finished water transmission.

Annual Demand Projections

The Water & Sewer Department undertook a comprehensive forecast future water demand. Rather than using a more traditional, static approach of forecasting future use based solely on per capita consumption rates and population statistics, the analysis was based on a model of future land use changes. Four land use forecasts were developed based on transportation analysis zones, environmental constraints, planning documents, and proposed developments. Coordination among City departments was essential in developing the four land use scenarios. A series of workshops and review meetings were held among consultants, Greeley's Water & Sewer Department, and Community Development Department's staff over a two-year period to take input on local development trends, demographic forecasts, and interpretation of planning documents such as the recent *Comprehensive Plan*. A list of the key steps used in the demand forecasting process is provided below.

1. **Review water use trends and derive annual water use factors** for existing and anticipated land uses within Greeley.
2. **Develop future land use scenarios** for the year 2020 using a variety of sources including population and employment forecasts developed by the North Front Range Transportation and Air Quality Planning Council, Greeley's recent *Comprehensive Plan*, and other variants described below. A longer-term land use scenario (to 2050) was also developed, comparing long-term projected growth to the Urban Growth Boundary.
3. **Forecast future water demand**. To compute the future water demand for each land use scenario, Greeley multiplied the estimated quantity of each land use by the specific water use factor for each land use and then totaled the results.

Key findings from each of these steps are summarized below.

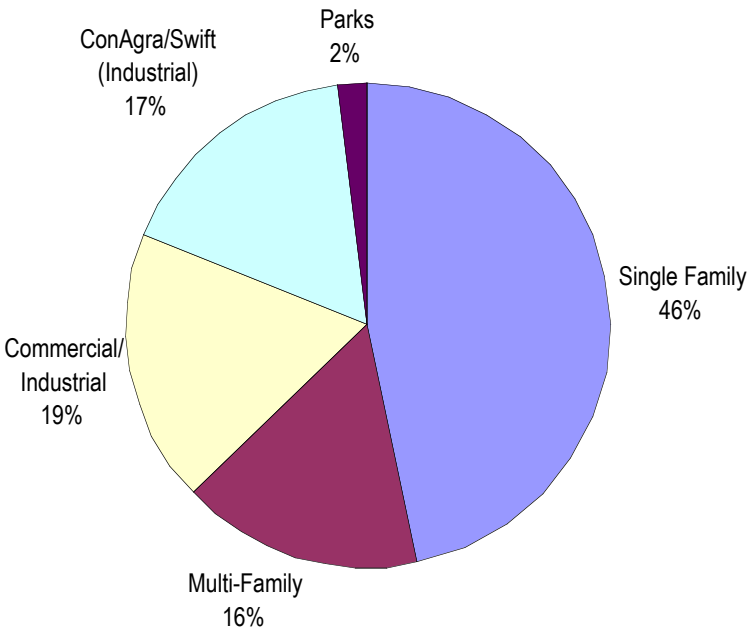
Water Use Trends

Water demand has grown substantially over the past few decades. In 1975, Greeley's total annual water production was approximately 17,000 acre-feet. By 1990, total annual water production had increased to nearly 25,000 acre-feet, an average annual increase of three percent. This rate of growth was above Greeley's population growth rate during this period, which was less than two percent per year. As Greeley's residential metering program was implemented in the late 1980's, growth in per capita water use flattened as customers began to realize the benefits of water conservation. By 1999, total annual water production had increased to 25,880 acre-feet.

Of the total water demand Greeley currently serves, approximately 85 percent is used within Greeley and the remainder is associated with customers located outside of Greeley.

In-city uses are depicted in the following figure. Residential uses account for approximately 62 percent of total water use within Greeley; the remainder is comprised of commercial, industrial, and park or golf course uses. Between 50 to 70 percent of residential use occurs outside the home in landscaping. Thus residential use shows a strong seasonal variation, with nearly 75 percent of total City annual use occurring between May and October.

Figure 11. In-City Potable Use by Land Use Type



Water Use Factors

To convert future land uses into a water demand, the current water use by the various land use types within Greeley was analyzed using data from actual metered accounts where available. The following land use types were analyzed.

- Single Family Residential
- Multi-family Residential
- Commercial
- Employment District
- Industrial
- Developed Parks

The results of this analysis are shown in the following table. For those land uses for which metered data was not available, usage was estimated through other means, such as reviewing data from other communities.

Table 6. Water Use Factors by Land Use Type

Land Use	Water Use (acre-feet/acre/year)	Comments
High Density Residential (average of 18 units per acre)	4.0	This includes only apartment type housing. (Townhomes/condos with landscaped areas have similar use as low density residential.)
Low Density Residential (average of 3.5 units per acre)	2.4	Use factor reflects slight increase from historical demand level for low density residential resulting from inclusion of higher use factor for moderate density.
Commercial	2.3	Average of three typical accounts contains high variability.
Employment District (office park)	2.3	Based on a FAR* of 0.4 and 20% of area landscaped with 32 inches of annual irrigation applied.
Developed Parks	2.1	Based on application of 32 inches of irrigation and a 3:1 area ratio of community to neighborhood park. Also assumes 75% irrigated area for community park and 92% for neighborhood park.
Industrial	1.6	Includes a mix of warehouse, light manufacturing and other non-water intensive uses.

*FAR = Floor Area Ratio, which is a ratio that results from dividing gross building area by the area of the site.

Future Land Use Scenarios

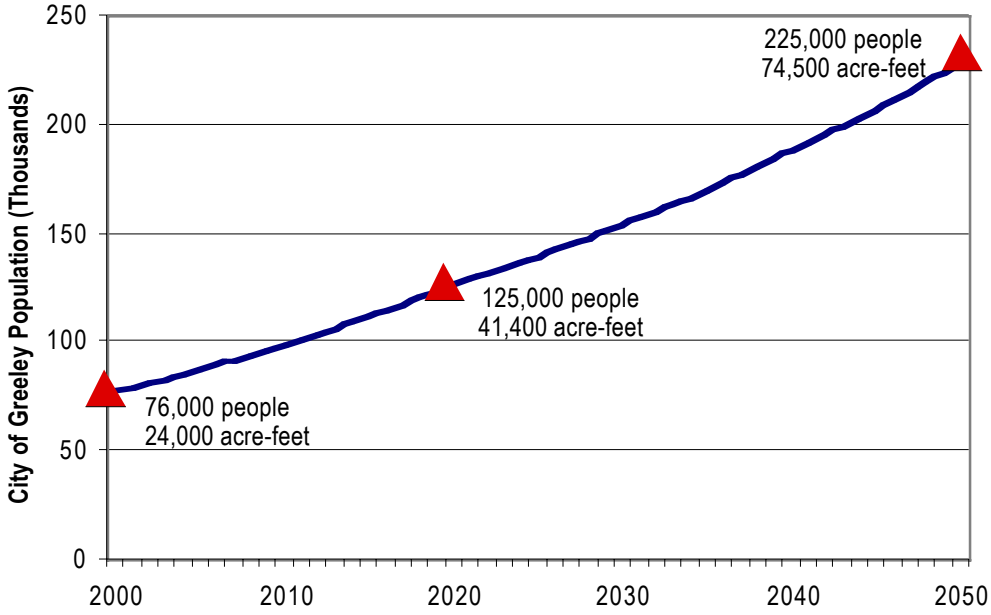
In order to illustrate a range of future development patterns, four development scenarios were defined. The scenarios explore the sensitivity of Greeley's future water demand and raw water system with different densities and patterns of growth. General land use scenarios are shown in *Map 4. Existing and Future Land Use Map* in Appendix A.

- **Comprehensive Plan**. Interprets the land use policies contained in Greeley's recent *Comprehensive Plan*. The *Comprehensive Plan* proposes growth to the west and higher residential densities (6 units per acre) than those found in historical land use patterns.
- **Historical**. A forecast based on a continuation of historical development patterns, growth to the west, and densities of 3.5 units per acre.
- **Follow-The-Water**. A forecast that places increased importance on water availability in the "fertile crescent" of irrigated Greeley and Loveland irrigated farms to the south.
- **Dryland**. A hybrid forecast that allocates more development to the Anheuser-Busch annexation area to the north of Greeley and the Two Rivers Parkway to the south and west.

A more detailed description and map of each scenario is provided in the report, *City of Greeley Water Demand Study*, February 2002, which describes the detailed land use patterns associated with each of the four forecast scenarios.

Population trends are presented in the following figure. Until 2020, growth is 2.5 percent annually — the rate of growth projected by Greeley's *Comprehensive Plan*. Between 2020 and 2050 (long term) growth is assumed to slow to 2.0 percent, which is lower than Greeley's actual 30-year average annual growth rate of 2.4 percent.

Figure 12. Projected City of Greeley Population Growth and Water Demands



Land Use Scenario Results

The various scenarios do not vary substantially in population. The resulting water demands for each scenario were within five percent of each other. Instead, the key variable is the geographic distribution of land use, and in one case, the density of residential development. Therefore, only the results of the scenario that followed Greeley's *Comprehensive Plan* are shown in the following table.

Table 7. Current and Future Water Demands

	Comprehensive Plan—Land Use Scenario		
	Present (acre-feet)	2020 (acre-feet)	2050 (acre-feet)
Greeley	25,200	41,400	74,500
Evans	2,000	4,700	7,000
Milliken*	200	2,600	5,500
Windsor[1]	500	600	600
Total	**27,900**	**49,300**	**87,600**

*Milliken provided its data. Neither Staff nor consultants projected Milliken data.

[1]Windsor has signed an agreement with another regional water provider for long-term treatment and transmission services. This is the reason for no increase in Windsor demand from Greeley to 2020 and 2050

Note: All numbers are in acre-feet and represent finished water production, which is five percent higher than metered demand.

Johnstown has a projected demand of 2,400 acre-feet in land located near the intersection of I-25 and Highway 34 that was recently annexed by Johnstown. This area is in the vicinity of Greeley's existing Boyd Lake Transmission lines and therefore could be served by these lines in the future. Greeley does not have any existing agreements with Johnstown or Little Thompson Water District (the entity currently providing water service to this area) to provide water service. Because Greeley does not have any agreement to provide potable service to this area, these demands were not included in projected treatment and transmission demands. If Greeley does reach an agreement in the future to provide water service to this area, the treatment and transmission projections will need to be revised accordingly.

Key Findings

- **Two scenarios, *Follow-The-Water* and *Dryland*, changed the location of future demand**. In addition, these two scenarios vary substantially in the amount and type of raw water that could be brought in by a developer under historical City policies.
- **Common to all four scenarios is a need to serve new development along the U.S. 34 corridor, an area referred to as the Strategic Employment Corridor**. Greeley's Planning Department and Council intend to provide incentives for industries and businesses to locate in this area. A preliminary market analysis from the U.S. 34 Corridor Study projects approximately 570 acres of new campus-like business areas and 250 acres of new commercial development can be expected to occur in the general U.S. 34 area by the year 2020. The study area excludes property adjacent to I-25. A competing employment center, approximately 847 acres, is the Johnstown Annexation near I-25, which could be served by Greeley water, but is not included in Greeley's projections of treatment and transmission demands.
- **The long-term forecast to 2050 predicts water demand will be three times the water demand today**. By 2050 Greeley will see almost 60,000 acre-feet of new demand, resulting in a total annual use of almost 90,000 acre-feet even at the lowest forecast.

Future Outside Contract Demands

Each of Greeley's existing outside contracts with Windsor, Milliken, and Evans has approximately 20 years left (see *Outside Service Customers* on page 38). Therefore, Greeley must include these demands in the planning for short-term treatment and transmission capacity (to 2020). Each of the entities own and provide raw water supplies to Greeley for treatment, so their future raw water demands are not included in future raw water planning by Greeley. Greeley has defined when Greeley would lease additional water to outside users during drought. Greeley intends to initiate further discussions with the existing outside contract holders to address this issue and to explore under what circumstances Greeley would provide leased water.

Seasonal and Peak Day Demands

The quantity of water a city uses can be described in an annual use, a seasonal use, a daily use, or an hourly use. Historical data was used to predict the ratios among these factors.

- **Annual use** is used to determine water rights needs and the size of reservoirs that provide storage over multi-year periods.
- **Seasonal use** determines storage needed to re-time irrigation water rights yielding in the spring and early summer to match year-round municipal demands.
- **Peak daily use** determines treatment and transmission capacity.
- **Peak hourly use** determines sizes of storage tanks in the distribution system and the pipe sizes in the distribution system. Because the distribution system does not affect the long-term direction of Greeley's water system, hourly use is not considered.

Greeley Climate

Greeley's climate and that of the watersheds affect both the seasonal demand and supply. Greeley receives an average of 14 inches of rainfall per year, while most landscaping (turf) requires 35 inches per year or more of water. Consequently, Greeley's biggest demand is irrigation.

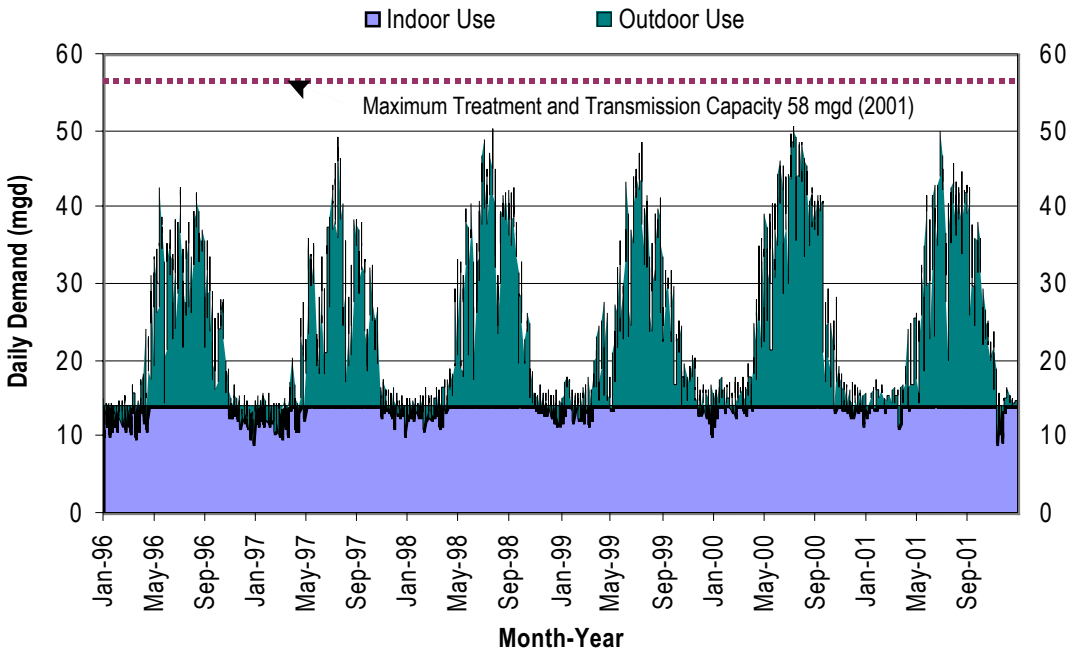
In addition, in hot weather, people tend to take more showers, do more laundry, and use greater amounts of water for other outdoors uses (such as pools). Hence, the season with the greatest water demand is summer, while the season with the greatest supply is spring, during snowmelt runoff. Therefore, storage is essential to balance the supply and demand on a seasonal basis. For seasonal storage, Greeley uses Hourglass, Peterson, Comanche, Twin, Barnes Meadow, Horseshoe, and C-BT. For multi-year storage, Greeley uses Milton Seaman, Boyd, Lake Loveland, and C-BT.

Peak Water Use Day

The peak day of water use for each year typically occurs during the early part of July. The overall water system, including treatment, transmission and distribution, must be able to meet the peak day of use.

Using the last 20 years of historical data, the peak day to annual demand ratio can be calculated. The historical peak day as well as the treatment and transmission capacity of the system is shown in the following figure.

Figure 13. Historical Peak Day



Obligated Demands

A large portion of Greeley's short-term development will be done by developers who have either pre-paid their raw water obligation or have a contract with Greeley that limits the amount of water they must dedicate to Greeley to meet raw water dedication requirements. City Council will also likely provide some economic incentive to industrial development. These are all defined as **obligated demands**.

Table 8. Obligated Demand By Source (Acre-Feet)

Type of Obligated Demand	Total New Demand (C1)	Total New Supply (C2)	Net Obligated Demand (C1 – C2)
Pre-Paid Demands (e.g., Hewlett-Packard)	5,100	0	5,100
Greeley-Loveland Irrigation System	6,800	2,500	4,300
New Growth Incentives (assumed figure)	800	0	800
Totals	**12,700**	**2,500**	**10,200**

Pre-Paid Demands

As the name implies, this is demand from lands for which developers have already dedicated raw water supplies to Greeley, but the development has yet to occur. When the pre-paid lands develop, Greeley's overall water demand will increase, but Greeley's water supply remains constant. A prime example is the Hewlett-Packard site that dedicated water to Greeley in 1982.

Greeley-Loveland Irrigation System Obligations

Greeley has entered into a number of contracts with farmers under the Greeley-Loveland Irrigation System, that explicitly define how much credit per share Greeley must give when these shares are dedicated to Greeley for water service. Greeley must accept these shares at the contractual level (e.g., 33 acre-foot per GLIC share) even if the share yields less in drought (e.g., 9 acre-foot per GLIC share). To account for these obligated demands, the estimated yield of the water rights on the farms in Greeley's growth path was subtracted from the demands that will come onto Greeley's water system when those farms develop. This calculation determines the net reduction in Greeley's current water surplus.

Incentives for New Growth

Where the Board and Council believe a development is advantageous to Greeley as a whole, Greeley can make exceptions to its raw water dedication requirements. Typically, these exceptions would allow an industrial development with high paying jobs to pay cash-in-lieu of water at a rate below the true cost of developing the new supplies sufficient to offset the new demands. Greeley can also make pre-purchased supplies, such as the Monfort C-BT purchase at $2,200 per unit, available on a first-in-first-out basis.

To account for past incentives given for new growth as an obligated demand, Greeley calculated the ratio of the dollar amount paid by the new development by the estimated cost of developing new supplies and multiplied the ratio by the total water demand to determine the amount of supplies that could be developed with the cash-in-lieu paid. The supplies that could be developed with the cash-in-lieu paid are then subtracted from the total new water demand to get the obligated demand.

Water Conservation and Demand Management

The demand projections do not include conservation measures above and beyond current efforts. As part of the *Water Master Plan*, Greeley took a closer look at the existing conservation efforts and evaluated a variety of additional measures. A comprehensive water conservation program provides significant benefits including:

- Reducing demands especially peaks.
- Making current supplies go further.
- Providing energy savings by reducing pumping and treatment.
- Decreasing the amount of wastewater produced.
- Reducing treatment and transmission costs.
- Delaying water treatment plant and transmission line expansions.

- Deferring or eliminating capital projects that would have been necessary in the absence of conservation.
- Providing savings in operation and maintenance costs.

The primary goals of Greeley's water conservation program are to:

- Reduce end-user demands and future operating costs.
- Enhance public relations and education.
- Satisfy current and future regulations.

Conservation programs are typically considered two-pronged: 1) standard conservation measures that are normal operations, and 2) drought response measures. Conservation is a two-edged sword: if you achieve conservation in the short term, easy savings are not available when needed in a drought emergency. This *Water Master Plan* addresses standard conservation measures and touches on drought conservation measures. Drought response measures are frequently voluntary measures during normal times that become mandatory during severe droughts. The drought conservation measures are reserved for those rare occasions when water yields are less than the 50-year drought yield and demands must be reduced. As part of the *Water Master Plan*, the Water & Sewer Board has planned for a ten percent reduction in demand by conservation measures in the 50-year drought. The specific conservation measures are addressed in Greeley's *Drought Emergency Plan* (June, 1998).

The following shows the wide range of potential standard conservation activities that could be included in a water conservation program for Greeley.

- Leak Detection – City Water Distribution Systems
- Leak Detection – End Users and Retail
- Residential and Commercial Landscape Ordinances
- Public Education/Demonstration Projects
- Uniform and Inclining Block Rates
- Seasonal or Other Innovative Rate Structures
- Rain/Wind Sensors on Irrigation Systems
- Xeriscape Gardens
- Irrigation Watering Restrictions
- Toilet Exchange
- Retrofit Indoor Plumbing
- Plumbing Code
- Home Water Audits
- Policy Enforcement
- Irrigation Audits
- Metering
- Seasonal or inclining block rates
- Monthly billing

Each of these measures has numerous components and each component was evaluated according to the low, medium or high water savings they could offer. The Board and Council reached a consensus to implement the following conservation measures.

Table 9. Conservation Measures for Greeley

Measure	Component	Estimated Savings (%)*
Metering	Require separate irrigation meters for new multi-family units. Requires new ordinance. Do not allow new multi-family units to have common pipes between residences.	0 – 1
Billing	Read and bill meters monthly. Requires changes in Finance Department. Completed April 2002.	0 – 1
City Parks Irrigation	Establish central irrigation control system with rain sensors. Use Water Funds for conservation.	Less than 1
Plumbing Code	Encourage plumbing retrofits for homeowners and City properties. Requires public education.	2 – 3
Leak Detection	Identify leaks both within the distribution system and for property owners. Increase funding.	0 – 1
Watering Restrictions	Water every third day. Requires education and new ordinance if mandatory.	0 – 1
Xeriscape Demonstration Gardens	Continue with existing xeriscape gardens and require xeriscaping at City parks, golf courses and commercial and industrial sites. Requires additional funding for parks.	Minimal
Inclining Block Rate Structure	Implement a multi-tiered structure with lower block at current rate and other blocks at multiples of current rate.	1.5 – 3

*Of Total City Use

The estimated savings from the above programs is four to nine percent of total use or about eight to 17 gallons per capita per day from existing per capita use.

2000's Drought and Water Conservation

As previously described, in 2002 Colorado had the lowest single year streamflows in recorded history. Greeley and other Front Range communities in Colorado scrambled to develop drought conservation plans or to re-write existing plans that were not designed to handle such an extreme drought year as 2002. Since the end of the 2002 irrigation season, water conservation specialists have been working collaboratively with the "green" industry (landscape professionals, sod growers, etc.) to develop conservation plans that balance conserving water with minimizing the impact on landscapes within cities. The drought has been an opportunity for Greeley's Water & Sewer Department to implement a number of the conservation measures identified by the *Water Master Plan* as long-term options, including:

- **Increase Efficiency of Greeley Parks Irrigation.** The Water & Sewer Department is working with Greeley Parks Department to increase the efficiency of turf irrigation on City facilities by

purchasing a central control system for improved water management and lining of ponds used to store irrigation water.

- **Additional Water Restrictions.** In 2002, Greeley changed from its long-term practice of restricting irrigation every other day to requiring every third day irrigation. Greeley prohibited irrigation between 10 a.m. and 6 p.m. in an effort to reduce the evaporation from lawn watering. Looking to 2003, Greeley has developed three levels of conservation based on the severity of drought. When lawn irrigation is allowed, it will be limited to once or twice per week irrigation depending on the time of year. Under more severe drought levels, lawn irrigation will be banned during July or August or both.
- **Inclining Block Rates.** Inclining block rates were identified as a long-term conservation measure and drought response. Inclining block rates provide two important services during drought. First, inclining block rates promote efficient use of water by sending a price signal to customers to conserve. Second, inclining block rates offset revenue shortfalls caused by a decrease in water use. Considering Greeley may require between 15 to 40 percent savings in water use depending on the level of drought, at some point higher rates will be necessary to offset budgetary shortfalls created by the lack of water sales.

  In early 2003, the Board and Council decided against imposing inclining block rates without applying a water budget to the customer. In the water budget approach, each customer would receive a unique water budget based on efficient irrigation of his individual turf area. Consumption within the budget would pay normal water rates. Excessive, wasteful consumption over the budget would be charged at a much higher penalty rate. While this approach is fair, it requires extensive documentation beyond present department capacities.

When Colorado emerges from the current drought, Greeley could to maintain a number of drought conservation measures on a permanent basis, including water budgeting. The conservation realized during this drought predicts the conservation that can be realized with various combinations of conservation measures. The current drought has also raised Greeley citizens' awareness of the need to conserve water resources. This awareness should re-enforce Greeley's conservation ethic and make the permanent implementation of conservation measures more acceptable if the measures are adopted within a reasonable time after the drought has subsided.

The Non-potable System

Greeley's non-potable system provides irrigation water from ditches, the river, or wells that is not treated to drinking water quality. Sources of non-potable water include treated wastewater although Greeley does not intend to create a traditional reuse system which uses treated wastewater directly for irrigation. Rather, wastewater will be used by exchange. Non-potable customers typically include: large irrigators; industrial uses that are not for food production; other outdoor uses such as ornamental fountains, created wetlands, car washes, cooling water; and any other uses where a raw water supply is typically used.

Advantages of Non-potable Water

Using non-potable water has the following advantages.

- Reducing the size of finished water treatment plants and transmission lines.
- Realizing cost savings on treatment and transmission.

- Efficiently using Greeley's water rights on the Poudre system that cannot be used at the existing treatment plant.
- Using Greeley-Loveland rights without treatment and without constructing conveyance facilities.
- Efficiently using wholly consumable wastewater treatment plant effluent.

A non-potable system reduces the size of treatment and transmission both by reducing the overall average demand for potable water, and by shaving the peaks off of the potable system. In Greeley's arid climate, peak days occur during the summer months due to irrigation. If some of the irrigation demand is removed from the potable system, the peak day is reduced, reducing treatment and transmission needs.

Reducing the size of treatment plants and transmission lines postpones the need for capital improvements, providing cost savings. Additionally, reducing the overall potable demand reduces the cost of operation and maintenance of treatment plant and transmission lines, including chemical and pumping power costs.

Using existing non-potable water supplies also increases the efficiency of Greeley's raw water system by freeing up potable water supplies that can be used for indoor water uses. Although the potential benefits of utilizing non-potable water are numerous, the actual benefits must be determined on a case-by-case basis due to the unique costs and site-specific situations of each non-potable project. In some cases the cost of non-potable service will be greater than providing potable water for irrigation. Greeley is currently developing a *Non-potable Master Plan* that will define a framework to evaluate the costs and benefits of non-potable development.

Future Non-potable Needs

Greeley owns water rights in Canal No. 3 and in the lower portion of the Poudre River Basin near Greeley that cannot be reasonably delivered to the treatment plants. Without a non-potable use for these rights, these rights would not be used in Greeley. Greeley owns water rights that are wholly consumable, meaning the water can be used more than once and does not have to be returned to the river. The water becomes available for second use at the wastewater treatment plant. This water could either be reused directly (after treatment which is currently practiced only at the wastewater treatment plant site) or can be used as an exchange for other raw water in the stream. Either way provides water for non-potable use without obtaining a new water right. A third option, explored in the *Non-potable Master Plan*, is to sell surplus non-potable supplies and buy potable supplies which can be delivered to the treatment plants.

Greeley intends to develop non-potable irrigation for City lands such as parks and for new privately developed large turf areas, especially greenbelts. During the water master plan process, Greeley set a goal to reduce new potable demand by 15 percent by developing non-potable irrigation systems. As shown on *Table 7. Current and Future Finished Water Demands* on page 48, 16,200 acre-feet of new demand will come on line by 2020. About 2,400 acre-feet (15%) will be served by non-potable supplies. (See *Table 11. 2020 Water Supply Demand Summary* in the next chapter.)

Peak Day Demand Projections

With some notable exceptions, growth in annual water demand has been steady in Greeley (see *Figure 14. Existing Capacity Vs. Projected Demand – Raw Water* below). Projecting peak day demands is much more uncertain. Between 1966 and 1978, peak day demand was rising at around six percent a year, even though population was growing at only 2.5 percent annually (see *Figure 15. Existing Capacity Vs.*

Project Demand – Treatment and Transmission below). For the last 25 years, however, peak demands have grown at only about 0.75 percent annually. This dramatic change from peak days growing faster than population to slower than population may have several explanations.

- During the early eighties, a statewide recession slowed construction and Greeley's overall water consumption slowed considerably (see *Figure 14. Existing Capacity Vs. Projected Demand – Raw Water* below).
- Then in the late eighties and early nineties, universal metering in Greeley flattened the growth in overall water consumption (see *Figure 14. Existing Capacity Vs. Projected Demand – Raw Water* below). It is likely that universal metering flattened the growth of peak day demand as well.
- Most recently, in the late nineties, water conservation has begun to play an ever more prominent role, and the construction of the non-potable system has shaved at least 5 mgd of peak day demand off the potable system.

The *Water Master Plan* anticipates that growth in peak day demand will accelerate to match the population growth rate of 2.5 percent. This assumes continued population growth and continued, but moderate, non-potable system expansion. Continued residential growth will tend to increase peak day demands because most new residential development has extensive landscaping which is the cause of peak day demands. Greeley's existing peak day demands are moderated by constant industrial demands from ConAgra and Kodak, which tend to flatten peaks.

Regardless of whether peak day demand begins to match population growth or maintains the more moderate growth of the last several years, the rate of peak day demand does not determine answers to the fundamental decisions in the *Water Master Plan*. The growth of peak day demand does not determine the location of plant expansion nor does it even determine the timing of pipeline installation. Plant location is driven by water rights and water quality and treatment cost considerations. Construction timing for the pipeline is driven by the need to install the pipeline before development in Northern Colorado makes any pipeline route expensive or impossible. Even the size of the pipeline is driven more by ultimate capacity rather than whether that capacity will be needed in ten or 20 years.

Peak day demands do drive the need and timing of treatment plant expansion. Over the last six years, peak days have three times come within fifteen percent of Greeley's delivery capacity. A 10-mgd expansion at Bellvue is warranted soon. Staff is evaluating whether an addition is necessary or whether additional capacity can be obtained through various plant improvements. Future expansions will await the trigger of peak day demands. If watering restrictions continue to flatten the growth of peak day demands, the timing shown in *Appendix C. 2003-2022 Capital Improvements Plan*, will be delayed.

Conclusion

Projecting future water demands is a dynamic process that must be updated and revised to match Greeley's growth philosophy and the Council and Planning Department's efforts to manage and direct growth. Because of the inherent uncertainties in projecting future conditions, flexibility is desirable. However, the costly nature of water supply infrastructure and the long lead times involved in planning, design, and construction dictate decisions be made so that capital plans can be pursued.

Figure 14. Existing Capacity Vs. Projected Demand – Raw Water

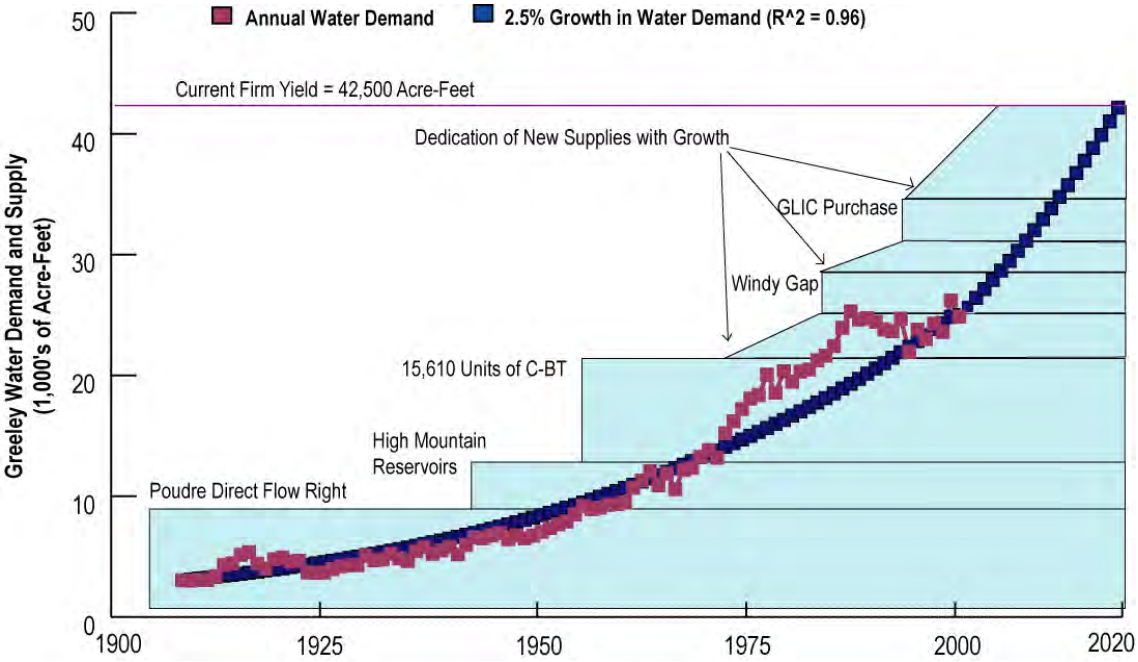
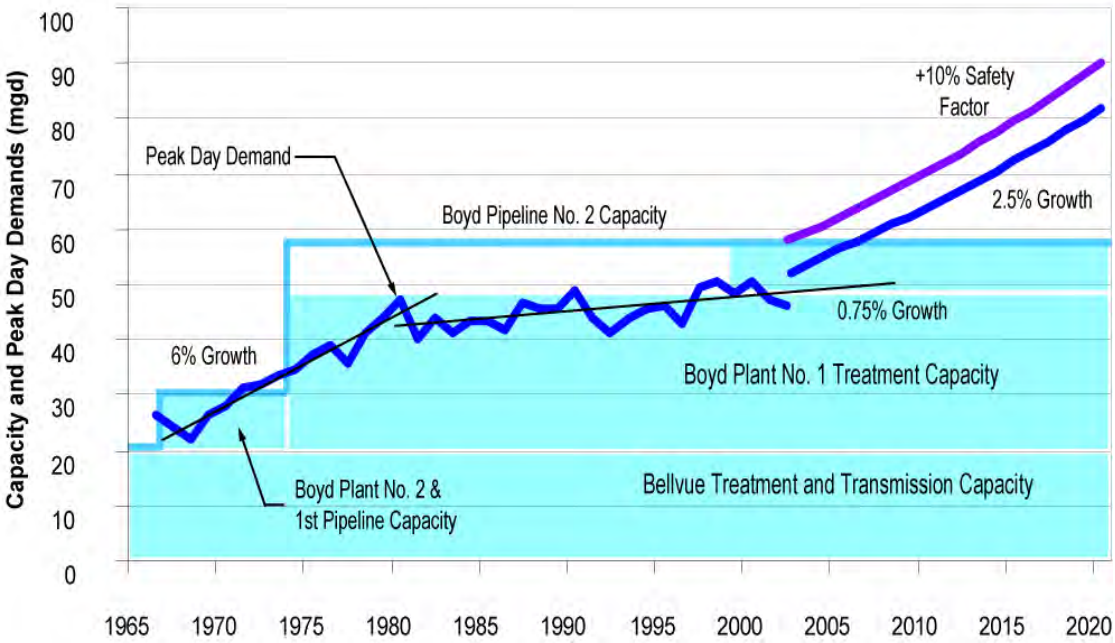


Figure 15. Existing Capacity Vs. Projected Demand – Treatment and Transmission



Chapter 5.
New Supply Options

Once Greeley's existing system and water rights portfolio were reviewed, a simple matrix of generic alternatives for increasing firm yield was developed. Using six categories clarifies the dozens of raw water alternatives developed during brainstorming and provides focus for raw water strategies and projects.

Table 10. Alternative Supply Approaches Matrix

Construct No New Storage Build Infrastructure to Use Existing Supplies	Construct No New Storage Purchase New Senior Supplies	Construct No New Storage Purchase New Junior Supplies
Construct New Storage Use Existing Supplies	Construct New Storage Purchase New Senior Supplies	Construct New Storage Purchase New Junior Supplies

It is extremely important to Greeley's planning approach that raw water projects have a high probability of implementation. In addition, it is essential that options complement Greeley's existing system. These two major goals focused attention on raw water plans that involve:

- Using existing supplies that do not require the construction of new storage (e.g., building structures to use existing non-potable water supplies to serve new non-potable demands).
- Purchasing new senior supplies that complement Greeley's system and do not require new storage (e.g., purchase senior agricultural water rights with existing storage).
- Purchasing new junior supplies that complement Greeley's system without requiring new storage (e.g., increased ownership of the Greeley-Loveland Irrigation System with its 70,000 acre-feet of existing storage).
- Constructing new storage projects that use existing supplies and that are relatively easy to implement (e.g., purchase or construction of gravel lake storage).

Developing new storage focused on projects that could fit within Greeley's existing system and supplies. Greeley currently has junior water supplies that yield in wet and average years and could benefit from additional storage. Therefore, new storage should maximize existing rights rather than depend on new, even more junior supplies. Of high priority was identifying new storage projects that would be reasonably easy to implement. Options that could deliver water to alternative treatment plant locations (in-town or Poudre River) or to non-potable sites were also examined.

Adequacy of New Supplies to Meet 2020 Demands

By 2020, Greeley expects 17,200 acre-feet of new demand (see the following table). As illustrated in *Table 7. Current and Future Finished Water Demands* on page 48, 16,200 acre-feet of new demands will come on-line by 2020, which includes a mixture of potable and non-portable demands. The balance, 1,000 acre-feet, is a non-potable demand required by ConAgra augmentation.

- Some 3,400 acre-feet, or 20 percent of the new demand can be met from non-potable supplies, much of it existing surplus non-potable, which is presently unusable.
- Because of obligated demands, only 1,100 acre-feet of new supplies will come on-line with 9,000 acre-feet of new demand, leaving 7,900 acre-feet, about 45 percent of the new demand, to be taken from Greeley's pre-paid or existing water supplies.
- The remainder of the new demand, 5,900 acre-feet or about 35 percent of the new 2020 demand, must be satisfied by developing new water supplies in a Future Water Account.

Of the 5,900 acre-feet of new potable supplies needing to be developed, about 1,100 acre-feet of firm yield will be supplied by the dedication of shares in the Greeley-Loveland Irrigation System that are within the 2020 Urban Growth Boundary. Due to uncertainty in future growth patterns, Greeley may not obtain the full 1,100 acre-feet of firm yield by 2020 from Greeley-Loveland Irrigation System dedications. Therefore, the Future Water Account should be populated with the full 5,900 acre-feet of projected water demands to 2020.

Greeley will develop a Future Water Account of 5,900 acre-feet and as needed, take cash-in-lieu for this water as new dryland development comes to Greeley. With the cash-in-lieu of water rights, Greeley will immediately develop additional water supplies to offset the amount obligated by the new development.

The Master Plan raw water alternatives analysis determined that Greeley has sufficient raw water alternatives to develop the 5,900 acre-feet needed for the Future Water Account.

The 3,400 acre-feet of new non-potable demands can be met from either Greeley's existing non-potable supplies or non-potable supplies committed to Greeley by developers. Greeley currently has non-potable supplies in excess of the non-potable demands in a 50-year drought. Greeley's non-potable supplies will continue to exceed non-potable demands out to 2020 as Greeley participates in the Windy Gap Firming Project and obtains other wholly consumable transbasin supplies on the Poudre River. Consequently, Greeley will have more than adequate supplies to meet the 1,700 acre-feet of new non-potable demands needed by 2020. Unfortunately, Greeley's non-potable supplies are frequently a considerable distance from the non-potable uses. Greeley is currently working on a *Non-potable Water Master Plan* looking at alternatives available for putting existing and future non-potable water supplies to use.

Table 11. 2020 Water Supply Demand Summary

Demands		Supplies	
Existing Demands		**Existing Supplies**	
Potable Demand	25,000	Existing Potable Firm Yield	42,500
Non-potable Demand	2,000	Existing Usable Non-potable	2,000
Total	**27,000**	**Total**	**44,500**
New Demands 2000 to 2020		**New Supplies 2000 to 2020**	
Potable		**Potable**	
Obligated Demands[2] (Growth with limited or no raw water dedication)	9,000	New Yield from Greeley-Loveland Shares (shares located on lands being developed)	1,100
Growth Paying Cash-In-Lieu of Water Dedication	4,800	New Yield from Future Water Account for Cash-In-Lieu Payments	4,800
Subtotal	***13,800***	***Subtotal***	***5,900***
Non-potable		**Non-potable**	
City Parks in 2020 Growth Plan	700	Existing City Non-potable Supplies[1]	700
ConAgra Augmentation	1,000	Existing City Non-potable Supplies[1]	1,000
Growth	1,700	Non-potable Dedication to the City	1,700
Subtotal	***3,400***	***Subtotal***	***3,400***
Total	**17,200**	**Total**	**9,300**
Total Demands in 2020	**44,200**	**Total Supplies in 2020**	**53,800**

Obligated Demands 2020 to 2050		**New Supplies with Obligated Demands 2020 to 2050**	
Obligated Demands[2] (Growth with limited or no raw water dedication)	3,700	New Yield from Greeley-Loveland (Shares located on lands being developed)	1,400
Total Demands	**47,900**	**Total Supplies**	**55,200**
Total Supplies Less Total Demand (55,200 – 47,900)		7,300	
Raw Water Safety Factor		**7,300**	

[1] Existing Greeley non-potable supplies are only included in the water supply column as the non-potable demands come on-line. This is done in the table to not over estimate the true raw water safety factor for Greeley. Prior to non-potable demands coming on-line, Greeley's unused non-potable supplies do not have an impact on the raw water safety factor because they cannot be delivered to Greeley's treatment plants.

[2] Obligated demands are: 1) water demands that will come on-line in future years but without a full supply to meet those demands; or 2) water demands on lands that have already satisfied raw water requirements but the demands have not been developed (water has been dedicated to Greeley and is therefore included in the current supply totals but is not included in the current demand totals). See *Chapter 4. Future Demand* for a more detail description of Greeley's obligated demands.

Raw Water Alternatives Analysis and Screening

Greeley's investment in three river basins (Cache La Poudre, Big Thompson, and Colorado) presents multiple opportunities for future water supplies and projects. A multi-level screening process was necessary to narrow down the numerous water supply alternatives.

All possible water supply ideas were organized using the matrix discussed above. A list of 57 options addressed both re-operation of existing water supplies and acquisition of new supplies or storage. The list included newly identified projects as well as projects Greeley has been considering for many years. Consequently, the feasibility of some water supply options was fairly well developed whereas assessments of newly identified projects had to be based on more preliminary information. These 57 options were presented to the Water & Sewer Board for review.

To narrow the list, each water supply option was ranked in three categories: implementation, cost, and yield. The process was intended to identify which projects should be analyzed in more detail (high priority projects) and which projects should be set aside until the higher priority projects have been evaluated to determine their resulting firm yield supply.

The screening identified 16 raw water supply options for further research. The 16 options can be further grouped into the following six general categories.

- Opportunities to increase Greeley's yield in the Greeley-Loveland Irrigation System through additional ownership in this system.
- Modification to company operations to increase the yield of Greeley's ownership in the Greeley-Loveland Irrigation System.
- New storage options that increase the efficiency of Greeley's existing raw water portfolio.
- Options to increase Greeley's yield of its C-BT Project ownership.
- Purchase of agricultural water rights that complement Greeley's system.
- Extensive development of non-potable water.

Each option was further researched and evaluated. Some options, including certain Greeley-Loveland Irrigation System and Colorado-Big Thompson options, were set aside because those options were not feasible or the firm yields were too small to be considered at a water master plan level. The remaining raw water options all meet the planning objectives of complementing Greeley's existing water supplies and have a high probability of implementation. These options are discussed below.

Options for the Future Water Account

Prior to the current drought, the *Water Master Plan* proposed a policy, called the Water Bank, which required new development to bring in agricultural supplies, similar to existing practice but with an expanded scope. This was intended to keep existing ratepayers from funding development of water supplies for new growth. Greeley has water supplies for perhaps ten years of growth without adding any new supplies. The current drought brings into question whether water supplies that fit well into Greeley's water portfolio will be available for new growth once development finally begins to occur on drylands.

If Greeley does not acquire the new supplies in the short term, existing Greeley ratepayers will have to share water resources with new dryland growth until new water supplies can be developed. This potential

of reducing the level of service to existing customers led the *Water Master Plan* to continue the historical practice of being proactive in developing new water supplies prior to new demands coming on-line. To limit the impact to existing ratepayers, Greeley will develop the water for the Future Water Account incrementally. By spreading out the development of the new supplies, the rate increases necessary to fund the development of the Future Water Account will be smaller and spread over a number of years.

In addition to the Future Water Account, Greeley will continue to allow dedication of Colorado-Big Thompson (C-BT) units for new dryland growth, unless prevented by Northern Colorado Water Conservancy District policies. Given the current scarcity (70% of C-BT units are already in industrial or municipal use) and cost (C-BT units cost $17,000 per ac-ft at a yield of 0.7 ac-ft per unit), the lower-cost water in the Future Water Account should be appealing to developers of dryland in Greeley.

The Future Water Account will develop about 5,900 acre-feet, as discussed earlier. The alternatives for incremental development of the Future Water Account include:

- Windy Gap Firming Project
- Upper Poudre River Gravel Pit Storage
- Lower Poudre River Gravel Pit Storage
- Large Non-potable Development Projects
- Blocks of Agricultural Water
- Shares in Agricultural Ditch Companies
- Other Projects and Water Supplies (as they become available)

Refer to *Map 5. Future Water Supply Options Map* in Appendix A for project locations.

Windy Gap Firming Project

Greeley owns 64 units of the Windy Gap Firming Project's 480 units. Each unit of Windy Gap represents 100 acre-feet of delivery. However, to obtain the 100 acre-feet of delivery in drought, additional storage (a firming project) is necessary. Greeley, together with other municipalities that own Windy Gap units are proposing to build new storage project(s) in order to carry over Windy Gap water from average and wet years into drought years. One of the primary sites considered is the Chimney Hollow Storage Project shown on *Map 5. Future Water Supply Options Map* in Appendix A. To minimize the financial impact of firming these units on existing ratepayers and to diversify the options that will be looked to for future water supplies, Greeley will not firm all Windy Gap units and will pursue an exchange some of the remaining units in the firming project with other water providers for storage in the Windy Gap Firming Project. The exchange of Windy Gap units for storage in the firming project will increase the drought year yield Greeley will receive from its Windy Gap units over historical levels.

Upper Poudre River Gravel Pit Storage

Gravel lake storage utilize the end product of sand and gravel mining (for concrete and asphalt production), to provide incremental storage additions to Greeley's water system. The gravel lakes must be lined to be used for storage. The incremental nature of gravel mining results in incremental additions (and cost) of new storage to Greeley's system reducing the financial burden to Greeley's existing ratepayers. Storage on the upper portions of the Poudre River can deliver water to the Bellvue Water Treatment Plant. New gravel pit storage can store existing City supplies and make seasonal shifts of water. Alternatively, Greeley could use the Upper Poudre gravel pit storage for drought carryover storage.

Lower Poudre River Gravel Pit Storage

Water storage on the Lower Poudre could be used in conjunction with Greeley's non-potable supplies, much of which is reusable effluent from the wastewater treatment plant. Greeley could use lower storage to shift water seasonally to match monthly supplies with monthly demands. Storage could also be used to provide a firm supply of non-potable supplies over a multiple-year drought.

Large Non-potable Development Projects

Greeley is exploring large non-potable project alternatives to expand the use of excess existing and future non-potable supplies. The large-scale development of non-potable supplies has the potential to free up a significant amount of potable water currently serving non-potable irrigation.

The largest non-potable development project being considered by Greeley is the "Dirt Pit" project near Windsor (see *Map 5. Future Water Supply Options Map* in Appendix A). Also known as Raindance Ridge, the Dirt Pit project, could store excess non-potable water supplies during the winter months in reservoirs near Windsor for delivery to the Greeley-Loveland Canal during the following irrigation season. By serving non-potable water demands under the Greeley-Loveland Irrigation System with non-potable water supplies, potable water in the Greeley-Loveland Irrigation System can be used to meet potable water demands at the Boyd Lake Water Treatment Plant, increasing the efficiency and firm yield of Greeley's water system by matching excess non-potable supplies with non-potable demands.

Blocks of Agricultural Water

Periodically Greeley has the opportunity to purchase large blocks of agricultural water supplies that are not sold on the market on a share-by-share basis. As these blocks of water become available in the future, Greeley will evaluate the potential purchase of these supplies.

Shares in Agricultural Ditch Companies

In contrast to the purchase of blocks of agricultural water supplies, Greeley also has the opportunity to purchase individual shares in agricultural ditch systems, adding yield on an incremental basis. Greeley will evaluate these ditch shares as they become available.

Greeley has had a long history of supporting the surrounding agricultural community in practical ways such as low priced water leases to supplement irrigation company supplies. Supporting the agricultural community continues to be a goal of the Greeley Water & Sewer Department while still providing a proper level of service to the Greeley's water customers.

One way that agriculture could be supported into the future would be through the use of interruptible supply contracts. Greeley would obtain ownership of the water but lease water back to the landowner for farming in years when Greeley has excess water supplies. In years when Greeley does not have adequate supplies, such as drought years, the water would be transferred to municipal uses. Even if the interruptible supply concept is determined to be not feasible, Greeley intends to leave water purchased from agriculture on the farms for as long as possible before transferring the water to municipal use.

Other Projects and Water Supplies as They Become Available

When projects and water supplies other than those listed above may become available, they will need to be compared to these alternatives as they arise. The new options must meet the basic planning criteria of being compatible with Greeley's water system and supplies and have high probability of implementation.

The funding of these new supplies and new projects would be paid for by the cash-in-lieu sale of water from the Future Water Account discussed in detail in *Chapter 7. Integrated Strategies*.

Raw Water Safety Factor

While it may be tempting to use the raw water safety factor for growth instead of developing water for the Future Water Account, this is unwise. The *Water Master Plan* intends the raw water safety factor will be maintained at 7,300 acre-feet and will neither be reduced nor increased in the future. Consequently, Greeley should allow development to provide cash-in-lieu of water only as water supplies are added to the Future Water Account. Before water is developed for the Future Water Account, existing raw water policies, requiring new growth to bring water rights or C-BT units as they develop, shall apply.

Future Water Supplies to Meet Demands to 2050

The *Water Master Plan* describes specific plans for new water supplies to meet demands out to the year 2020 and identifies general approaches for supplies out to 2050. By 2020, Greeley will have fully populated the Future Water Account and will have taken cash-in-lieu of the 5,900 acre-feet developed. This funding will lower bonding costs for future regional supply projects. The water to be developed within the Future Water Account by 2020 (5,900 acre-feet) will meet a small portion of the 2050 demand. It is fully anticipated that Greeley will need to develop large supply projects (either regional or Greeley-only) to meet demands out to the year 2050, which are projected to be 75,000 acre-feet.

Map 5. Future Water Supply Options Map in Appendix A, identifies the future regional water supply projects being explored in greater detail by Greeley and other water providers in the region. These include:

- Enlarging Milton Seaman Reservoir (either as a smaller Greeley-only project or as part of a regional project).
- Glade Reservoir Project (Northern Colorado Water Conservancy District NIPS project).
- South Platte Conservation Project (Northern Colorado Water Conservancy District NISP project).
- Other regional projects.

Enlargement of Milton Seaman Reservoir

Over the last 20 years, Greeley has studied expanding the Milton Seaman Reservoir. This strategy would move surplus supplies in average and wet years into Milton Seaman for long-term drought storage by exchange. The exchange potential is limited to the amount of water flowing into Milton Seaman Reservoir from the North Fork of the Poudre River unless a pumping facility or tunnel were built to deliver water from the main stem of the Poudre River. This project is being explored as two distinct options for Greeley:

- **Northern Integrated Supply Project (NISP).** The Northern Colorado Water Conservancy District (NCWCD) is researching storage options within the Poudre River Basin for twelve municipal water providers. One of the options being explored is an expansion of the Milton Seaman Reservoir to store a conditional water right held by NCWCD and to provide additional storage for entities such as Greeley who want to store existing water rights in a new reservoir. The NISP project could include expanding the Milton Seaman Reservoir up to 200,000 acre-feet.

Milton Seaman Reservoir currently holds 5,000 acre-feet. This project would require the construction of a new dam just above the confluence with the main stem and the complete inundation of the existing Milton Seaman Reservoir.

- **Greeley-Only Enlargement of Milton Seaman.** In contrast to the regional NISP Project, Greeley is considering enlarging the Milton Seaman Reservoir as a Greeley-only project. Greeley's enlargement would increase the height of the existing dam at the Milton Seaman Reservoir. The maximum size of reservoir currently contemplated under the Greeley-only option is about 40,000 acre-feet.

Permitting requirements, timing of need among NISP participants, cost, and ability of the projects to integrate with Greeley's existing water system will all factor into the decision as to which option is best for Greeley.

Proposed Glade Reservoir Project

Another NISP project being considered is Glade Reservoir, an off-channel reservoir located near the intersection of Highways 14 and 287 near Ted's Place, northwest of Fort Collins. For Greeley, this storage option would be similar to the enlargement of the Milton Seaman Reservoir by allowing storage of excess existing water rights during wet and average years for use in drought. Water would be diverted off the main stem of the Poudre River to this storage facility.

South Platte Conservation Project

Another NISP alternative, the South Platte Conservation Project, would exchange existing low quality water supplies available on the South Platte River below Greeley, to supply the lower sections of area ditch companies in exchange for higher quality water supplies available at the ditch headgates. Several large ditch systems to the north of Greeley have headgates in the upper Poudre near Fort Collins. Under certain conditions, the water available at the ditch's headgate could be exchanged into upstream storage such as an enlarged Milton Seaman Reservoir or Glade Reservoir.

Other Regional Projects

Greeley has been and will continue to diligently pursue these and other regional projects, fully aware that Greeley cannot meet anticipated 2050 demands without participation in one or more of these projects or projects of similar nature.

Perhaps the most significant finding of the *Water Master Plan* is that the majority of the future water supplies for Greeley (2050 and beyond) will be physically located along the Poudre River. Note that all proposed regional supply projects are in the Poudre River Basin. Additionally, most of the remaining irrigated land not in municipal growth paths is located along the Poudre River. The extensive irrigated lands that lie to the north of the Poudre River represent water that can be used directly, delivered into new regional storage, or used by exchange through a project such as the South Platte Conservation Project.

In the analysis of long-term water treatment and transmission alternatives, the location of the long-term future water supplies became a significant factor in the final selection of expanding the Bellvue Water Treatment Plant to accommodate growth to 2050. See *Chapter 6. Treatment and Transmission Alternatives* for more discussion on the treatment and transmission alternative analysis and selection.

Conclusion

The goals of the *Water Master Plan* water supply analysis were as follows:

- Identify as many raw water options as possible that are available to Greeley on a short- and long-term basis, given the large growth potential of the City.
- Narrow the large list of raw water options to projects that have the best chance of implementation in the short term and long term, highlighting options that will increase the efficiency of Greeley's existing water system.
- Consider remaining native water supplies within Greeley's growth path, and the potential timing of growth of both the historically irrigated lands and drylands.
- Consider the potential impact of the current drought on Greeley's ability to implement short- and long-term water supply options.

The short-term supply options that Greeley will pursue have a high probability of implementation and will increase the efficiency of Greeley's existing water system. The projects identified for short-term supplies include small storage projects and the acquisition of agricultural water rights that fit well within Greeley's existing water system.

The variability in growth patterns and the potential for increased competition for limited water resources due to the current drought has led Greeley staff and policymakers to question the availability of short-term water supply options if Greeley does not take an active role in securing these supplies. The uncertainty of short-term water supplies led Greeley to begin securing available water supplies in the short term (next 10 years) in what is known as the Future Water Account. The role of this account is discussed further in *Chapter 7. Integrated Strategies*.

The long-term (after 2020) supply options for Greeley are all large water projects within the Poudre River Basin. These long-term projects could include a regional project or a Greeley-only project. The decision on which long-term supply options to pursue will be primarily based on ability to implement, cost, and timing.

Chapter 6. Treatment and Transmission Alternatives

The first step in determining treatment and transmission alternatives involved analyzing the age and condition of current facilities, water quality implications (both raw water quality and desired finished water quality), required plant modifications to meet upcoming regulations, and resolving plant vulnerabilities.

Evaluating Treatment and Transmission Alternatives

Defining treatment and transmission alternatives had to account for both replacement and repair of the many of the Bellvue facilities. The treatment plant and transmission lines at Bellvue are between about 30 and 90 years old. Many are reaching the end of their useful life. In the spring of 2002, Greeley completed a $14-million rehabilitation on the Bellvue Plant. This rehabilitation addressed aging infrastructure, capacity limitations, and lack of redundancy. It also mitigated microbial contamination of the raw water source. This phase of the rehabilitation was designed to be compatible with additional upgrades or replacement of the remaining facilities in the future phases.

The Boyd Lake facilities range in age from recent (1999) to about 30 years old. The Boyd Lake Water Treatment Plant was recently upgraded and expanded and is generally in good condition. Therefore, the existing Boyd Lake facilities do not need replacement in the short term but may require modifications to meet future regulations and/or expansion to satisfy future treatment needs.

Water Quality Implications

Water quality involves both raw water quality and desired finished water quality. Poorer raw water quality necessitates greater treatment costs in both capital and operation and maintenance. Additionally, better quality water generally reduces risks to public health at a lower cost for treatment. Finished water quality needs to meet current and future regulations and aesthetics should be acceptable to the customer within economic limits.

The raw water currently supplied to Bellvue Water Treatment Plant is generally of higher quality compared to raw water currently supplied to Boyd Lake Water Treatment Plant. However, certain microbial risks like Giardia and cryptosporidium are higher at Bellvue and may require more stringent treatment compared to Boyd Lake.

In general, the finished water currently provided by Greeley is acceptable to customers. There are occasional aesthetic complaints (primarily hardness) about the Boyd Lake finished water quality. However, treatment to resolve this aesthetic complaint would be expensive and would also cause a large increase in wastes from the plant that would be difficult to dispose. Therefore, for the analysis of alternatives, it was assumed that matching the current water quality being produced at Boyd Lake is sufficient.

Upcoming Regulations

Upcoming regulations will likely require modifications at both plants. Regulatory requirements are becoming more complex as the need for protection from microbial contaminants competes with the need to protect water consumers from long-term health effects from chemicals used to treat water and reduce microbial risk. Both plants produce water that meets current regulations. The following table lists recent, proposed, and upcoming regulations and how each affects Greeley's treatment facilities.

Table 12. Regulations Timeline

Rule	Proposed Date	Promulgated Date	Effective Date	How It Affects Greeley
Arsenic Rule		Jan. 22, 2001	Jan. 23, 2006	Not Applicable. Arsenic levels are less than regulated levels.
Radon Rule	Nov. 1999	Late 2003	Late 2006	Not Applicable. Radon levels are less than regulated levels.
Radionuclides Rule	July 1991	Dec. 7, 2000	Dec. 8, 2003	N/A. Radionuclides levels are less than regulated levels.
Stage 2 Disinfection/ Disinfection By Products Rule	Summer 2003	Summer 2004	Summer 2007	May need changes at Boyd Lake Plant to reduce TTHMs. May need changes at both plants to reduce TOC. Changes could include change in disinfectant, change in primary process, or practice enhanced coagulation.
Long-Term 2 Enhanced Surface Water Treatment Rule	Summer 2003	Summer 2004	Summer 2007	Additional monitoring for crypto will be required. May need to add or change treatment processes depending on the results of monitoring. Bellvue is at greater risk of needing modifications than Boyd Lake based on historical monitoring.
Ground Water Rule	May 2003	Fall 2003	Fall 2006	N/A. No ground water sources are used for drinking water.
Endocrine Disruptors	Unknown	Unknown	Unknown	This issue is currently under study. Greeley is at less risk than many utilities due to high quality water sources that are also high in the watershed. Regulations are probably 10 years or more away.
Terrorist Agents	Unknown	Unknown	Unknown	This issue is currently under consideration. Normal common-sense precautions are warranted (such as fencing, lighting and locks). Note that a vulnerability assessment was completed by March 2003.

Potential Solutions to Existing Vulnerabilities

Both regulations and treatment processes are continually evolving. The treatment options were evaluated with respect to known regulations, whether existing or proposed, and consideration given to future treatment processes.

The following table presents potential solutions to the vulnerabilities of the existing facilities included in *Chapter 3. Greeley's Current System.*

Table 13. Plant Vulnerabilities and Potential Solutions

Vulnerability	Bellvue	Boyd Lake
Aging Infrastructure	Upgrade consistent with any expansion plans considered to meet future needs.	Not Applicable
Capacity Limitations	Expand as appropriate to meet future needs.	Expand as appropriate to meet future needs.
Lack of Redundancy	Incorporate new systems.	Not Applicable
Acute Contamination of Raw Water Sources	Update *Emergency Operating Plan*.	Update *Emergency Operating Plan*.
Chronic Microbial Contamination of Raw Water Sources	Future treatment should meet the proposed Long-Term rule for removal of microbial contaminants.	Based on historical levels of microbial contamination, the Boyd Lake Plant currently meets the draft Long-Term rule.
Filter Backwash Recycling	Treatment may be needed in the future. Allow physical space and hydraulic capacity for future treatment process.	Add filter-to-waste piping with next improvement or expansion. Treatment may be needed in the future. Allow physical space and hydraulic capacity for future treatment process.
Future Regulations	Allow physical space and hydraulic capacity for future treatment processes.	Allow physical space and hydraulic capacity for future treatment processes.

Evaluating Treatment Options

Treatment options need to meet two basic criteria.

- Provide **adequate capacity** to meet projected demands.
- Provide **adequate treatment** to meet health, safety and aesthetic standards.

Expansions in treatment capacity should match the timing of water demand increases; however, the larger the expansion, the greater the economics of scale. Therefore, the treatment options were developed in 40-mgd units (with four 10-mgd increments in each). This increment approach allows for staging of capacity increases and mixing and matching of different options. A brainstorm list of potential

treatment systems included both plant locations and treatment types. The treatment alternatives were evaluated and compared using predefined criteria (developed prior to identifying alternatives) that include the following categories.

- Physical, Technical
- Legal, Institutional, Political, Regulatory
- Social, Third Party
- Economic
- Environmental

The brainstorm list of treatment alternatives included the following.

- "Virtual capacity" by building large volumes of in-town finished water storage (discussed below).
- New regional plants with one or more water providers at Fort Collins, Soldier Canyon, Loveland, Windsor, and/or Johnstown.
- New plant owned and operated solely by Greeley in a different location from Boyd Lake or Bellvue.
- Boyd Lake Plant expansion considering conventional treatment and membranes.
- Bellvue Plant expansion considering variations on conventional treatment and membranes.

For "Virtual Capacity" a system can be configured to meet the peak demand either by:

- Constructing adequate treatment and transmission capacity to meet the peak demand, or by
- Constructing finished water storage that acts as "virtual" treatment capacity.

The first option is to build treatment plants and transmission lines capable of conveying the peak day demand on a 24-hour basis. For example, if the peak day demand were 55 mgd, the treatment plants and transmission pipes would flow 55 million gallons over the entire day, or a steady 38,000 gallons per minute. Hourly fluctuations in demand are handled by moderate sized in-town finished water storage.

The second option is to build treatment and transmission capacity sufficient to meet the peak week demand and rely on in-town finished water storage to meet the peak day demand, which is greater than the peak week demand. This is sometimes referred to as virtual treatment capacity. For example, if treatment and transmission capacity are designed for a peak week of 50 mgd, in-town finished water storage would be built to handle the peak day, which can easily be 20 percent higher.

Evaluation of historical water use data determined that 5 mgd of virtual treatment capacity requires about 13 million gallons of additional storage, and the costs are similar. Unfortunately, that ratio escalates rapidly and soon is not cost effective. In addition, water quality degrades when water is stored too long which could occur with too much finished water storage capacity. Therefore, construction of virtual capacity is not as feasible as constructing adequate treatment and transmission capacity to meet the peak day demands.

Partnering with a nearby water provider for treatment capacity was also investigated. Based on discussions with other entities considering plant upgrades, there are no definite treatment plant projects that would provide partnering opportunities for Greeley at this time. However, Greeley plans to continue communications with nearby water providers to identify future projects that may be advantageous to all parties involved.

Evaluating Raw Water Quality

Each water source requires a treatment scheme matched to the water quality. Alternative water sources were characterized in four raw water quality categories: excellent, good, average and poor. These broad categories and associated treatment schemes allowed Greeley to match treatment options to various raw water sources and to make cost estimates accurate enough for water master plan decisions. These water quality categories are defined in the following table.

Table 14. Raw Water Quality Categories

Raw Water Quality Category	Type Concentrations	Examples
Excellent	Hardness less than 80. Turbidity less than 10. TOC less than 2. TDS less than 100. No parameters requiring treatment beyond standard conventional or microfiltration.	High mountain source such as the Poudre River at Bellvue during normal flows.
Good	Hardness less than 100. Turbidity less than 10. TDS less than 250. One or two parameters of concern that are easily treated (e.g., Fe and Mn or TOC removal via conventional treatment).	Horsetooth Reservoir Bellvue source water – if water quality throughout the year is considered.
Average	Hardness less than 200. Turbidity less than 20. TDS less than 500. Possibly parameters moderately difficult to treat, such as algal blooms or high TOC.	Boyd Lake, Lake Loveland, or blended water from these reservoirs.
Poor	Hardness greater than 250. Turbidity greater than 20. TDS greater than 500. Parameters difficult to treat, such as sulfates or nitrates that require advanced treatment such as electro dialysis (ED) or reverse osmosis (RO).	Poudre River in Greeley.

Both of Greeley's filter plants, Boyd Lake and Bellvue, have multiple raw water sources. The most probable source water was estimated to be of the following qualities.

- The existing raw water quality for Bellvue is good. The most probable future raw water sources for Bellvue were of excellent or good quality.
- The existing raw water quality for Boyd Lake is average. The most probable raw water sources for Boyd Lake were of all water qualities, including poor.

The existing sources for both plants are in watersheds that will require protection to maintain water quality. Greeley is part of a coalition that works collectively to protect the watershed of the Big Thompson River. A watershed protection group does not exist for the Poudre River.

Matching Water Quality with Appropriate Treatment Options

Raw water quality categories were paired with the appropriate treatment technology as shown in the following table.

Table 15. Raw Water Quality and Treatment Option Matches

Raw Water Quality Category	Appropriate Membrane Treatment	Appropriate Conventional Treatment
Excellent	Microfiltration (Loose Membrane)	Flocculation/sedimentation/filtration
Good	Microfiltration with Granular Activated Carbon filter* (Loose Membrane)	Flocculation/sedimentation/filtration
Average	Nanofiltration or reverse osmosis (Tight Membrane) Granular Activated Carbon filter on any blended streams*	Flocculation/sedimentation/filtration followed by Granular Activated Carbon filter*
Poor	Nanofiltration or reverse osmosis (Tight Membrane) If surface water, pretreatment with conventional or microfiltration will be needed. Granular Activated Carbon on any blended streams	Conventional Treatment is Not Adequate[1]

*Other processes may be needed depending on water source characteristics. Granular Activated Carbon (GAC) used in the *Water Master Plan* to provide a level of cost estimates and a level of operational complexity.

[1]Conventional treatment with lime softening, or conventional treatment with multiple additional treatment processes, may be adequate for some poor quality waters. However, waters with high TDS or concern with a specific or multiple ionic species will require membrane treatment. At the water master plan level, the costs for either are similar. Because membranes will treat any contaminant of concern and conventional treatment cannot, only membranes are evaluated in the *Water Master Plan* for poor water quality.

In general, conventional treatment consists of chemical addition, slow mixing to form particles, sedimentation of the particles, and filtration through sand or sand-like media to remove any remaining particles. Membrane processes may or may not use chemical addition and provide filtration via “fibers” that resemble straws or large sheets. Membranes have the ability to remove much smaller particles than conventional filters. Some membranes have the ability to remove chemical constituents in the water. Conventional filtration generally relies on gravity while membrane filters rely on pumps or vacuum.

Note both Bellvue and Boyd alternatives were evaluated to deliver around 100 mgd to Greeley. In the Bellvue alternative, Boyd is kept at 38 mgd and Bellvue is expanded to 60 mgd. In the Boyd alternative, Boyd is expanded to 80 mgd and Bellvue is kept at 20 mgd.

Bellvue Water Treatment Plant Alternatives

Probable water sources for the Bellvue Water Treatment Plant are of excellent or good quality due to the relatively pristine nature of the lands upstream of Greeley's intake off of the Poudre River. Bellvue treatment alternatives had to consider replacing or upgrading the existing treatment plant with conventional treatment or loose membranes. The alternatives evaluated for Bellvue are shown in the following table.

Table 16. Bellvue Treatment Alternatives

Treatment Alternative	Source Water Quality	Estimated Capital Cost for Total of 60 mgd ($ million)*	Estimated Operation & Maintenance Cost ($/mg)*
Conventional Treatment	Excellent	$70.0	$100
Conventional Treatment	Good	$70.0	$121
Conventional and Loose Membrane[1,2]	Excellent	$55.8	$95
Loose Membrane[2]	Excellent	$50.1	$92
Conventional and Loose Membrane[1]	Good	$63.8	$115
Loose Membrane[2]	Good	$62.1	$112

*ENR Construction Index = 6201 (April 2000).

[1]Conventional treatment for the existing 20 mgd and membranes for the additional 40 mgd.

[2]Loose membrane = Microfiltration or ultrafiltration.

Appropriate Bellvue Alternative: Membrane Treatment

- The Bellvue alternatives provide a total capacity of 60 mgd comprised of replacing 20 mgd of existing capacity and adding 40 mgd of new capacity.
- If raw water quality were **excellent**, membrane treatment for both new and existing capacity is the preferred alternative at the Bellvue Plant. Costs are slightly lower compared to conventional treatment. Membrane treatment is rated slightly better and membranes are easier to operate and require less land for the equivalent amount of capacity.
- If raw water were **good**, membrane treatment for both new and existing capacity is again the preferred alternative.

Boyd Lake Water Treatment Plant Alternatives

The Boyd Lake Water Treatment Plant could potentially receive any raw water quality. Both urban and rural growth in the watersheds supplying the Boyd Lake Plant could degrade the supply to poor. On the other hand, if the watershed protection group were successful, water quality could remain at average quality. There are other sources that if direct piped to the treatment plant, would be considered good or excellent water quality. Treatment alternatives for all water qualities were evaluated.

- For **excellent** or **good** raw water quality, the existing plant would require few modifications.
- For **average** raw water quality, the existing plant would need some additional treatment process. Granular Activated Carbon was used in the *Water Master Plan* to represent the level of cost required.
- For **poor** raw water quality, membrane treatment was evaluated.

For poor water quality, Boyd Lake's existing conventional plant could be used for pretreatment prior to the tighter membrane processes for the first 38 mgd of capacity. Because Boyd Lake's existing conventional plant was recently upgraded and is in good condition, Boyd Lake's existing capacity need not be replaced or upgraded for excellent, good, or average water quality. However, for average water quality, an additional treatment process is recommended. Boyd Lake alternatives are shown in the following table.

Table 17. Boyd Lake Treatment Alternatives and Costs

Treatment Alternative	Source Water Quality	Estimated Capital Cost for Total of 80 mgd ($ million)*	Estimated Operation & Maintenance Cost ($/mg)*
Conventional Treatment	Excellent	$48.6	$136
Conventional Treatment	Good	$48.6	$163
Conventional Treatment	Average	$64.6	$192
Conventional and Loose Membrane[1,2]	Excellent	$33.6	$124
Conventional and Loose Membrane[1,2]	Good	$41.6	$148
Conventional and Tight Membrane[1,3]	Average	$71.6	$264
Tight Membrane[3]	Poor	$158.1	$536

*ENR Construction Index = 6201 (April 2000).

[1]Conventional treatment for the existing 40 mgd and membrane treatment for the additional 40 mgd.

[2]Loose membrane = Microfiltration or ultrafiltration.

[3]Tight membrane = Reverse osmosis or nanofiltration.

Appropriate Boyd Lake Alternative: Combination of membranes and conventional treatment

- The Boyd Lake alternatives provide a total capacity of 80 mgd (38 mgd of existing capacity plus 42 mgd of additional capacity).
- For **excellent** and **good** raw water quality, the preferred alternatives are conventional treatment for existing capacity and membrane treatment for new capacity.
- For **average** raw water quality, the preferred alternative is conventional treatment for all capacity.
- For **poor** raw water quality, the preferred alternative is membrane treatment.

New Water Treatment Plant Alternatives

Two new plant locations were considered.

- A plant in Greeley with raw water from the Poudre River.
- A plant adjacent to the Gold Hill Reservoir using raw water from the Greeley-Loveland Canal.

Raw water from the Poudre River in Greeley was classified as poor quality (current quality) for the purposes of this *Water Master Plan* and a tight membrane plant was evaluated. Raw water from the Greeley-Loveland Canal was considered average quality, similar to Boyd Lake. However, please note that only one water quality data point from the canal was available and water quality could be worse at a different time. A conventional plant for average quality was evaluated for the Gold Hill option.

Table 18. New Plant Location Alternatives

New Plant Location Alternative Treatment Alternative	Source Water Quality	Estimated Capital Cost for Total of 40 mgd ($ million)*	Estimated Operation & Maintenance Cost ($/mg)*
Conventional Treatment	Excellent	$52.6	$100
Conventional Treatment	Good	$52.6	$121
Conventional Treatment	Average	$60.6	$150
Loose Membrane Treatment[1]	Excellent	$33.6	$113
Loose Membrane Treatment	Good	$41.6	$133
Tight Membrane Treatment[2]	Average	$63.6	$336
Tight Membrane Treatment	Poor	$95.7	$428

*ENR Construction Index = 6201 (April 2000).

[1]Loose membrane = Microfiltration or ultrafiltration.

[2]Tight membrane = Reverse osmosis or nanofiltration.

Ultimate Capacities

The ultimate capacity possible at the Bellvue and Boyd Lake plants is somewhat limited by the amount of land owned by Greeley and the manner in which existing facilities occupy the space.

Table 19. Ultimate Capacities and Limiting Factors

Plant	Ultimate Capacity	Limiting Factors
Bellvue	120 mgd using loose membrane treatment	Raw water settling ponds/pretreatment
Boyd Lake	120 mgd using conventional treatment	Raw water storage/pretreatment

To reach 120 mgd of capacity at the Boyd Plant mechanical treatment of residuals (sludge) is required. Beyond 120 mgd, the Boyd Lake Plant would also require mechanical pre-treatment of raw water. Recently acquired property next to the Boyd Lake Plant could be used to provide area for these additional processes.

Transmission System Vulnerabilities and Remedies

The vulnerabilities of the various components and potential remedies are shown in the following table.

Table 20. Transmission System Vulnerabilities and Remedies

Transmission System Component	Vulnerability	Operational or Capital Modification
Bellvue Pipes	Aging lines.	Monitor condition of lines. Replace as needed with new lines or by upsizing lines constructed for additional capacity.
Boyd Lake Pipes	Joint deficiencies.	City Staff to repair pipe joints.
Gold Hill Reservoir	Difficult to take out of service for maintenance.	When additional storage is added in Zones 2 and 3, construct piping such that reservoirs can easily be taken out of service. The recently constructed Zone 4 storage tank will help alleviate this problem.
Gold Hill Reservoir	Potential water quality problems due to long residence time.	Construct separate inlet and outlet pipes and baffles after additional storage is constructed in Zones 2 and 3.
Mosier Pump Station	Cannot supply all Zones 2 and 3 demand from the Bellvue system.	Provide for direct transmission from the Bellvue system to the Gold Hill Reservoir, and thus Zones 2 and 3.

Assumptions for Evaluating Transmission Alternatives

Transmission alternatives were developed to match the ultimate capacity at both the Bellvue and Boyd Lake plants: 120 million gallons per day peak capacity. Transmission alternatives for all scenarios assumed that the existing Bellvue and Boyd Lake lines would be maintained or replaced so that existing capacity would be available throughout the planning period or roughly to 2050.

Transmission alternatives for the Gold Hill plant and in-town alternatives were not needed because both of these treatment alternatives could provide water directly to the distribution system. The Gold Hill plant could deliver water to the existing finished water storage at Gold Hill and the new plant could tie into the distribution grid at the plant site.

The expected lifespan of a pipe is between 75 and100 years. Portions of the Bellvue lines are nearing this lifespan with the oldest lines at 80 years old. To carry existing capacity and new capacity, three transmission alternatives were considered for the Bellvue lines: direct replacement, direct installation, and upsizing new lines.

- **Replacement in place** would be removal of existing pipe and replacement with new pipe large enough to handle the total new capacity desired.
- **Parallel installation** means installing new pipe near existing pipe and interconnecting old and new pipelines.
- **Replace and abandon** means constructing one new line large enough for total new capacity and then abandoning existing lines.

The advantages to **Replacement in Place** are:

- Costs can be phased over many years as small portions of the pipe are replaced on an annual basis.
- Multiple pipelines provide redundancy in the event that there is a break or other problem with one of the pipes.

The advantages of **Parallel Installation** are:

- Costs can be phased over many years by incremental installation of new pipelines and interconnecting to existing lines.
- Redundancy is maintained through the use of multiple pipelines.

The advantages of **Replace and Abandon** are:

- The unit cost per acre-feet of water delivered can be lower due to economies of scale and only digging one trench.
- Less complexity in the system makes the system easier to maintain.

Selected Method: Due to the ability to spread out costs and the redundancy provided, the *Water Master Plan* recommends that there will be **parallel installation** utilizing both new and existing pipes.

Bellvue Transmission Alternatives

A transmission main from Bellvue could deliver water to Gold Hill, Mosier, or the 23rd Avenue Reservoirs. As discussed in *Chapter 4. Future Demand*, the majority of new demand will be on the west side of Greeley in the higher pressure zones served by Gold Hill. As discussed in *Chapter 3. Greeley's Current System*, the primary vulnerability of the transmission system is the difficulty of delivering water from the Bellvue side to Gold Hill. Therefore, the Bellvue alternatives were designed to deliver water directly to Gold Hill. Because delivery to Gold Hill will require greater pressures than the existing transmission lines, new pipelines will be operated separately from existing pipelines (see the following *Figure 16. Bellvue and Boyd Lake Transmission Alternatives Map*). The Bellvue transmission alternatives included:

- **Partial Route: from Kodak toward US Highway 85 and then south (O Street Alternative)**. This alternative did not include any new pipe from the Bellvue Water Treatment Plant to Kodak. Analysis showed this alternative provides little additional capacity and cannot deliver the ultimate capacity of the Bellvue Plant. This alternative also delivers water to the eastern portion of Greeley away from the projected areas of growth to the west of Greeley.
- **Partial Route: east along Colorado Highway 14 and south along US Highway 85**. This alternative attempted to avoid adding pipe in the congested area between I-25 and the Bellvue Plant. The additional capacity obtained by this new pipe was not sufficient and the line was not evaluated in detail. A rough cost estimate indicated such a route would cost about one-third more compared to constructing a line parallel to the existing pipes. This alternative also delivers water to the eastern portion of Greeley away from the projected areas of growth to the west of Greeley.
- **Existing lines with pump station near Windsor**. With a pump station at Windsor pumping to either Gold Hill or Mosier, the existing transmission lines could provide approximately 30 mgd in capacity – 10 mgd greater than existing capacity. This pump station could be part of phasing of the above parallel alternatives.
- **Parallel lines: gravity from Bellvue to Gold Hill**. This line would parallel the existing pipe from the Bellvue Plant to Windsor and then south to the Gold Hill Reservoir. To deliver the ultimate capacity by gravity, this line would have to be 78-inch diameter. A pump station at Windsor could allow phased construction of the pipe.
- **Parallel lines: gravity from Bellvue to Windsor then pumped to Gold Hill.** This alternative is similar to the parallel gravity line alternative but assumes that the ultimate capacity is pumped from Windsor to Gold Hill. This line would be a 60-inch pipe. The gravity capacity of this alternative is expected to be about 56 mgd of additional flow over existing flows.

Preferred Bellvue Transmission Alternative

A 60--inch line parallel to the existing route with a pump station at Windsor is the preferred Bellvue transmission alternative. This alternative allows phasing to reach the ultimate capacity, minimizing capital expenditures. If the ultimate capacity at Bellvue is never built for any reason (such as growth does not occur or future raw water sources unexpectedly come from outside the Poudre River Basin), Greeley will not have overbuilt the transmission system and wasted capital. This alternative can be phased as follows.

Phase 1 **Build pump station at Windsor and construct half of the 60-inch pipe from Windsor to Gold Hill (Chimney Park Pipeline)**. This initial phase would add 10 mgd through existing lines. The pump station would pump 20 mgd to Mosier and 23rd Avenue and pump 10 mgd to Gold Hill. Total flow from Bellvue is 30 mgd.

Phase 2 **Construct a 60-inch pipe from Bellvue to Windsor and remaining pipe from Windsor to Gold Hill.** This phase would decommission the pump station and would have a total gravity flow capacity of 76 mgd including existing Bellvue transmission lines. Although the 60-inch pipe can be constructed in phases, well over half the pipeline must be constructed before capacity increases significantly.

Phase 3 **Rebuild a larger pump station at Windsor to pump a total of 100 mgd to Gold Hill**. Total flow from Bellvue is 120 mgd with 20 mgd going to Greeley by gravity. The pump station expansion could be incremental.

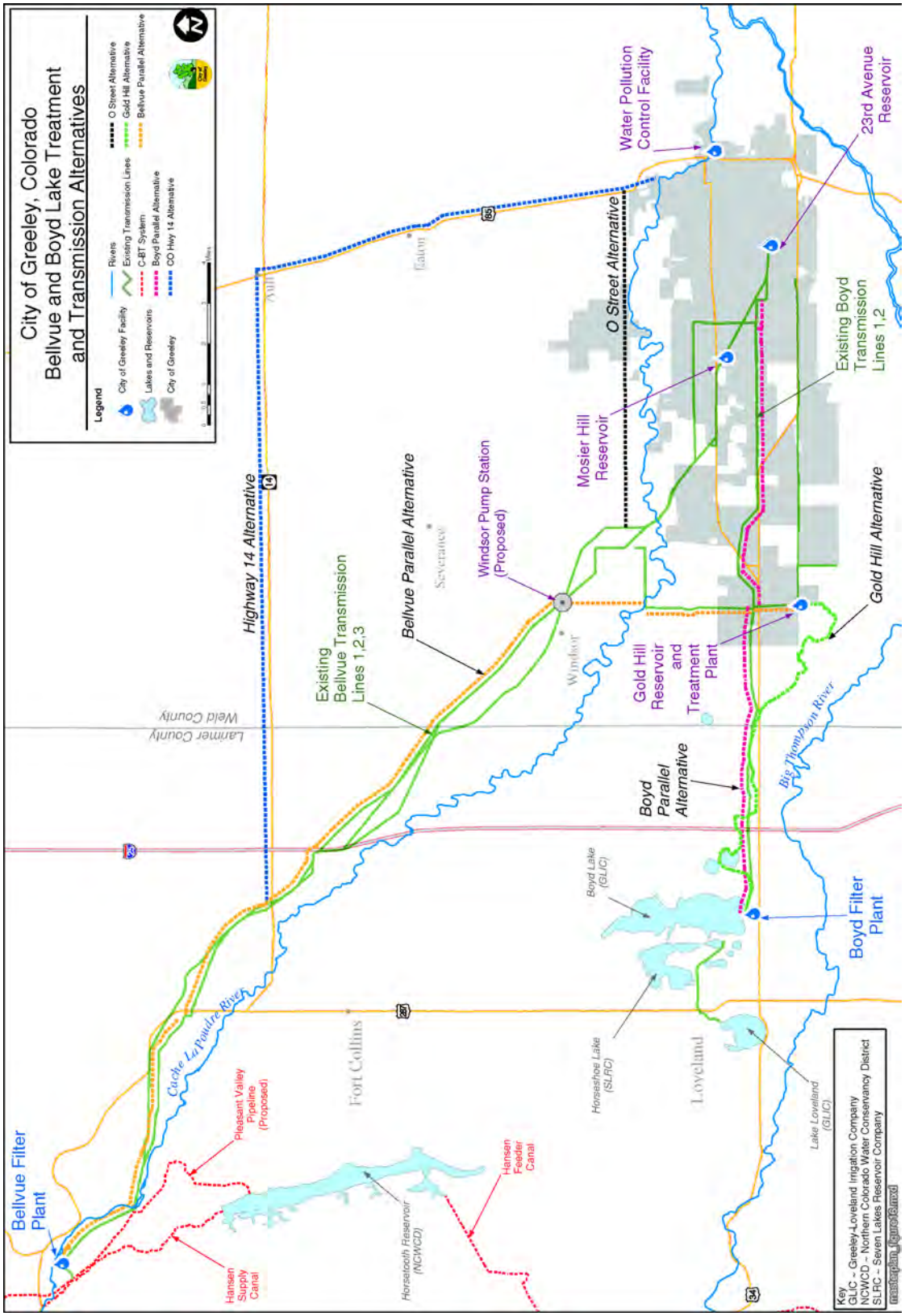
Preferred Boyd Lake Transmission Alternative

The Boyd Lake transmission alternatives convey water from the Boyd Lake Water Treatment Plant to Gold Hill. Because the Boyd Lake Plant is lower in elevation than Gold Hill, all the alternatives involve pumping. Two parallel 48-inch lines, would each have a 40 mgd capacity. This alternative can be phased and thus reduces short-term capital costs.

Phase 1 **Construct a 48-inch pipe from the Boyd Lake Water Treatment Plant to Gold Hill**. Expand the finished water pumping capacity at Boyd. This provides 80 mgd in total capacity from Boyd Lake.

Phase 2 **Construct a second 48-inch pipe from Boyd Lake Water Treatment Plant to Gold Hill**. Expand the finished water pumping capacity at Boyd again. This provides 120 mgd in total capacity from Boyd Lake.

Figure 16. Bellvue and Boyd Lake Transmission Alternatives Map



Finished Water Storage Needs

Evaluating finished water storage alternatives involved:

- Determining the required storage for each treatment plant alternative.
- Estimating the storage needed for each zone under ultimate build-out of a plant.

Greeley evaluated storage volumes needed to meet fire fighting, system peaking, and emergency use. Fire volume is based on a fire flow demand of 3,500 gallons per minute with a duration of three hours, for a total of about 0.6 mg—a negligible amount.

Peeking Storage

The needed peaking storage was evaluated by analyzing the diurnal (24-hour) flows from the maximum days for 1995, 1998 and 1999. The diurnal data indicated that, the overall distribution system (all zones), has two periods of below average use and two periods of above average use. This means that there are two periods every day from which storage is drawn and two periods in which storage is filled. The calculations also showed that the maximum storage needed for the drawing periods is approximately 0.04 mg per mgd of demand. There was not data available to determine the diurnal curve for each zone. Therefore, for the zones that are primarily residential, based on percentage of total use in winter versus summer, a multiplier of two for entire system results is used, resulting in 0.1 mg of storage per 1 mgd of demand. Note that this is a low peaking storage number compared with other municipal water systems and is influenced greatly by the two filling periods. Should the Greeley change watering restrictions or use other measures to change when water is used, this peaking storage factor would no longer apply, and would likely increase. However, the peaking storage is within the total emergency storage volume required as described below Thus, even with an increase in required peaking storage, the total storage needed by zone and for the entire system will not increase.

Emergency Use Storage

The greatest storage needed is for emergency use. Emergency storage needed is subjective and ranges from one day (the minimum required by CDPHE) to three days (the length of time estimated by Greeley staff to repair most problems). Applying this range to the needed plant capacity of the largest plant results in emergency storage of 110 to 330 mg. For this study, ratios of existing storage versus different parameters were also evaluated to develop a recommended emergency storage volume. The ratio of storage volume to maximum plant capacity today is 2.2. This ratio was used to develop the recommended storage volume. Greeley has long transmission lines compared with other municipal water providers and has a corresponding higher potential for transmission line breaks and resulting dependence on finished water storage. The largest plant under build-out conditions will be Bellvue, at 120 mgd, with 10 mgd as a safety factor. Thus, the recommended storage is 2.2 times 110 mgd, or 240 mgd.

The storage needs for each zone are shown in the following table and illustrated in *Figure 8. Distribution System Pressure Zones Map*.

Table 21. Zone Storage Needs

Zone	Existing Storage (mg)	Total Storage Required at Plant Build Out (mg)	Additional Storage Needed
1	52*	40	0
2 and 3	15[1]	150	135
4	2	40	38

*Assumes both Mosier and 23rd Avenue. Future treatment capacity at Bellvue or Boyd Lake will be delivered directly to Gold Hill and the Mosier Pump Station would be used only in emergencies.

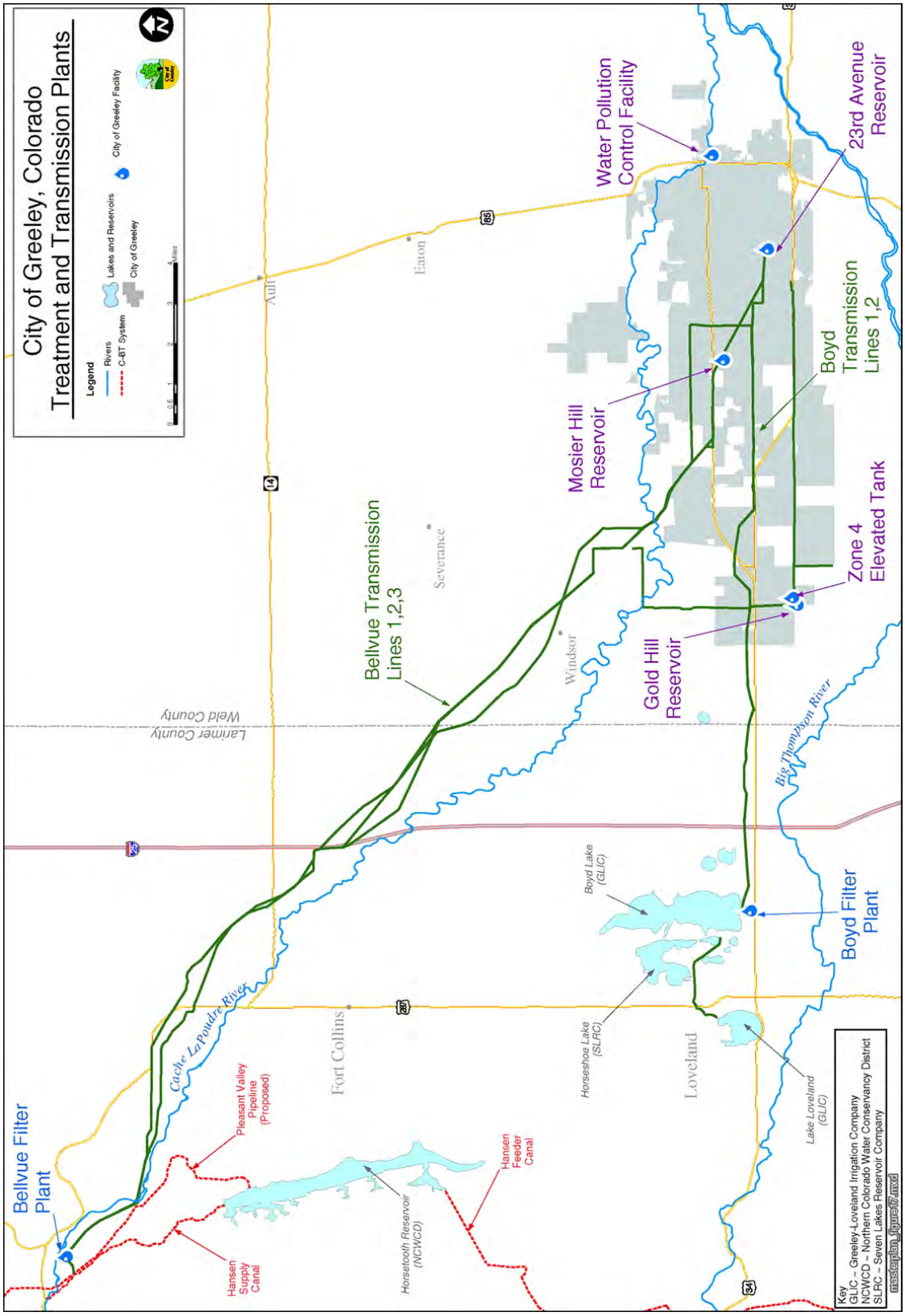
[1]Assumes Mosier storage is dedicated to Zones 1.

[2]Minimum additional elevated storage would be provided, instead pumping from groundwater storage would be provided to match demand.

Overall Treatment and Transmission Plans

There were four options remaining after the preliminary analysis. These four options were evaluated over both the short term and long term to determine the preferred direction for increasing treatment and transmission capacity. This evaluation included the repairs and upgrades needed at the existing plants, particularly the need to replace most of the Bellvue Plant.

Figure 17. Treatment and Transmission Map



Ultimate Capacity of Alternatives

Using the preferred alternatives for each of the treatment sites and the preferred alternatives for transmission from the treatment sites, the following specific alternatives were evaluated to achieve ultimate capacity at each site.

Bellvue Expansion – Construct additional capacity at Bellvue, up to the site capacity of 120 mgd. Expansion is 100 mgd. Maximum treatment capacity using both Bellvue and Boyd is 158 mgd.

Boyd Lake Expansion – Construct additional capacity at Boyd Lake, up to the site capacity of 120 mgd. Expansion is 80 mgd. Total treatment capacity using both plants is 140 mgd.

Gold Hill Water Treatment Plant – Construct a new treatment plant at the Gold Hill site for up to 100 mgd. Total treatment capacity at three plants is 158 mgd.

Lower Poudre Water Treatment Plant – Construct a new treatment plant in Greeley using water from the Poudre River. Treatment plant capacity would be up to 100 mgd. Total treatment capacity at three plants is 158 mgd.

Table 22. Ultimate Plant Capacity for Alternatives

Alternative Scenario	Ultimate Plant Capacity (mgd)				
	Bellvue	Boyd Lake	Gold Hill	Poudre Plant	Total
Bellvue Expansion	120	38	0	0	158
Boyd Lake Expansion	20	120	0	0	140
Gold Hill WTP	20	38	100	0	158
Lower Poudre WTP	20	38	0	100	158

Cost Estimates for Alternatives

Cost estimates were prepared for each alternative as follows.

- Capital costs for the initial 10 mgd of additional capacity.
- Capital costs for ultimate capacity.
- Operation and maintenance costs.

The capital costs for the initial 10 mgd for each alternative were estimated for the following reasons.

- There are significant costs to rehabilitate the existing system and maintain existing capacity.
- There are additional significant costs to increase the capacity of the system.
- The timing and methods for rehabilitating the existing system vary somewhat under each alternative.
- Capacity increases are needed in the near future.
- The timing and costs are interrelated. Greater costs in the near future will significantly impact rate increases while delaying costs will not impact rates as significantly.

Table 23. Cost Estimates

Alternative Scenario	Ultimate System Capacity (mgd)	Capital Costs Initial 10 mgd ($ Million)*	Capital Costs Ultimate Capacity ($ Million)	Operation & Maintenance Costs ($/mgd)**
Bellvue Expansion	158	$56	$269	$112
Boyd Lake Expansion* **	140	$67	$264	$192
Gold Hill WTP	158	$63	$266	$150
Lower Poudre WTP	158	$71	$348	$428

*Costs include upgrade of Boyd Lake to meet regulations, replacement/rehabilitation of Bellvue, additional 10 mgd of treatment and transmission improvements.

** Present value of annual operations and maintenance costs: 30 years at 5 percent.

***The Ultimate System Capacity for the Boyd Lake Expansion listed is prior to the City's acquisition of 25 acres adjacent to the current Boyd Lake Treatment Plant, which allows the ultimate system capacity to be increased to at least 158 mgd utilizing expansion at Boyd Lake. Because the cost estimate for this scenario is not favorable to the other options at a lower ultimate system capacity, a cost analysis for the Boyd Lake Expansion with an ultimate system capacity of 158 mgd was not performed.

Lower Poudre Water Treatment Plant Clearly Most Expensive

The Lower Poudre Water Treatment Plant alternative is clearly most expensive for both capital costs and ongoing operation and maintenance costs. The Lower Poudre alternative would need to be a reverse osmosis plant due to poor raw water quality. This type of treatment produces a brine waste that can be very difficult to dispose. There is no defined alternative for disposing of the waste in or near Greeley. Potential disposal methods all have high costs or significant regulatory obstacles, or both. Additionally, the Lower Poudre alternative results in higher conveyance losses of existing Greeley potable water rights to the lower Poudre River. Therefore, this alternative of constructing a plant in Greeley near the Poudre River was not considered further.

Water Rights Do Not Affect Treatment Options in Short Term

In the short term, water rights have little impact on the three remaining option as Greeley expects to be able to make deliveries of C-BT water at all three remaining treatment alternative sites. However, in the long term, Greeley's best raw water alternatives are in the Poudre River Basin and can be used at the Bellvue Plant location but not the Boyd Lake or Gold Hill locations. Effects of water rights were set aside for the next step of analysis and then were considered in the final selection of a preferred alternative.

Boyd Lake Expansion Lower Capacity and Higher Costs

The Boyd Lake Expansion alternative has similar capital costs as the other two alternatives, but the ultimate capacity is less due to space restrictions at the Boyd Lake site. Additionally, the operation and maintenance costs are significantly higher than the other two options. Therefore, the Boyd Lake Expansion alternative was also not considered in any further detail.

Long-Term Costs for Bellvue Expansion and Gold Hill WTP

The remaining two options, the Bellvue Expansion and the Gold Hill Water Treatment Plant, have similar capital costs, for both the initial 10 mgd and ultimate capacity. However, operation and maintenance costs are greater for the Gold Hill alternative because of poorer water quality from the Boyd Lake system. To evaluate the impact of the operation and maintenance costs on a long-term basis, a projection of costs to year 2050 was estimated. The results are:

- The Bellvue Expansion has a total cost that is about 65 percent more in 2020 compared to Gold Hill due to the high cost of constructing a new transmission line from Bellvue to Gold Hill Reservoir, although the annual operating cost in 2020 is projected to be within four percent of each other.
- By 2050, the Gold Hill option had a total cost that is about 25 percent more compared to Bellvue due to higher treatment, capital, operation, and maintenance costs. Also, Bellvue has a projected annual operating cost of about 50 percent of the Gold Hill option.

Analyzing Bellvue Expansion and Gold Hill WTP Alternatives

As shown above, cost issues do not result in a clearly preferred alternative since the Gold Hill location is preferred in the short term but the Bellvue Plant is preferred in the long term. The alternatives analysis also looked at the interaction of the treatment location with the preferred raw water sources and a risk analysis of the two locations.

Greeley's preferred short- and long-term raw water sources are located in the Poudre River Basin. If treatment capacity is built at the Bellvue Plant: 1) treatment can take delivery of the future raw water supplies, and 2) Greeley could maintain its existing flexibility to treat C-BT water at either plant and maintain the Boyd Lake Plant operation. Therefore, from a raw water perspective, the Bellvue Plant Expansion is preferred in the long term.

Risk Analysis of Bellvue Expansion and Gold Hill WTP Options

In addition to cost issues and raw water sources, a risk analysis was used to determine the preferred option. Some key points to the risk analysis include:

- Water quality at Bellvue is excellent to good while water quality at Gold Hill is average to poor.
- Water quality at Bellvue is less likely to experience temporary or permanent degradation because of Bellvue's higher location in the watershed and remoteness from wastewater and stormwater discharges and agricultural runoff.
- The Gold Hill option may increase significantly in cost if water quality is not average. Multiple water quality data points were not available and there is significant risk in assuming water quality over a seasonal basis and an annual basis without long-term data.

Although three plants (Boyd Lake, Bellvue and Gold Hill) provide more points of treatment, it is more difficult to operate three plants. City Staff have indicated that the complexity of running three plants does not warrant the additional safety in multiple locations. Two plants will provide the necessary redundancy.

Bellvue Expansion Preferred Alternative

The Bellvue location is preferred for the following reasons. The Bellvue Expansion option:

- Matches well with long-term preferred raw water sources.

- Has less risk than the Gold Hill site with regards to raw water quality and costs.
- Results in less system complexity.
- Has lower costs in the long-term compared to Gold Hill.

Conclusion

Numerous raw water options were presented in the previous chapter, and in this chapter, treatment options and transmission options were identified and evaluated in relation to the raw water options. The most likely raw water options can be delivered to the Bellvue Water Treatment Plant, and use existing conveyance facilities (pipelines, canals, and streambeds).

Greeley's preferred raw water options in the short term are Greeley-Loveland Irrigation Company shares and C-BT units, with many of the irrigation company shares coming from the Poudre River Basin. The C-BT units can be treated at either the Boyd Lake or Bellvue Water Treatment Plants. Note that the Boyd Lake Plant has sufficient capacity to treat Greeley-Loveland irrigation shares currently owned by Greeley.

The preferred treatment and transmission option to expand the Bellvue Water Treatment Plant, which:

- Matches well with the future raw water supplies.
- Reduces risk associated with meeting future regulations.
- Offers lower long-term costs.
- Provides continued high quality water production for water customers.

These preferred raw water and treatment and transmission options are explored in more detail in the following chapters, including the specific impacts to water rates charged to Greeley's customers and short- and long-term strategies.

Chapter 7. Integrated Strategies

This chapter of Greeley's *Water Master Plan* develops integrated strategies by overlaying various options with key policies and driving factors affecting Greeley's water system.

- The Greeley's water system has multiple raw water options, various treatment and transmission options, and many opportunities for system efficiency improvements such as non-potable water use and water conservation.
- The driving factors affecting Greeley's water system include drinking water regulations, growth, system age, and the current drought.
- The water master plan policy decisions include defining the level of service to be provided to Greeley citizens and how costs for this service should be shared between existing ratepayers and new growth.

The outcome of the *Water Master Plan* are integrated short- and long-term strategies for developing Greeley's water system to 2020 and 2050.

In this chapter, strategies for Greeley's raw water system, treatment and transmission system, water conservation, non-potable water use, and Greeley's involvement in outside service contracts are described independently. Although described independently, these strategies have been developed as an integrated whole because of the inter-related nature of each component and how each relates to meeting projected demands.

Raw Water Short-Term Strategy

2000's Drought Impact on Raw Water Strategy

The current drought gripping Colorado has made water providers in Colorado aware of the shortcomings of their raw water systems and, no doubt, will sharpen their focus on new water supplies. Many of the water providers along the Front Range of Colorado have the same water supply opportunities as Greeley. Before the drought, Greeley intended to have dryland growth bring in agricultural water supplies as they develop and thereby minimize the financial burden on existing ratepayers. The potential for increased competition and the resulting lack of future supply options has made this policy questionable.

Currently, there are sufficient lands annexed into Greeley with existing water supplies to meet approximately ten years of the City's growth. If development occurs only on lands that already have a water supply for the next ten years, the other water supplies currently available on the market will not be available or affordable when development finally progresses to the drylands. If growth were then to continue, existing ratepayers would have to share water resources with that growth until the cash-in-lieu paid by new development could be turned into new water for Greeley. That could take years.

This potential has led Greeley policymakers to continue Greeley's historical practice of proactive development of water supplies prior to growth occurring. Examples of Greeley's historical practice abound and include:

- The purchase of the Poudre High Mountain Reservoirs in 1940's.
- The acquisition of over 15,000 units of C-BT water in the 1950's.
- Involvement in the Windy Gap Project in the 1980's.
- The purchase of numerous shares within the Greeley-Loveland Irrigation System during the 1990's.

The amount of water to be proactively developed under this *Water Master Plan* is limited to the projected growth to 2020. By beginning development of the water supplies needed for dryland growth immediately, Greeley can minimize the potential for having to reduce the level of drought protection provided to existing ratepayers.

Key Components of Greeley's Short-Term (to 2020) Raw Water Strategy

The key components of Greeley's short-term raw water strategy are:

- Maintain the current raw water safety factor.
- Develop a Future Water Account.
- Value all water supplies at the 50-year drought level.
- Use water portfolio shifts to increase firm yield.

Maintain Current Safety Factor

Greeley has a raw water 50-year drought safety factor of 7,300 acre-feet (more supply than demand) even after all obligated demands are met. The *Water Master Plan* intends to maintain the existing level of drought protection into the future including the existing safety factor. A safety factor is important for several reasons:

- A safety factor provides water if a portion of Greeley's water system were not functional during a drought (e.g., a forest fire in the Poudre River Basin could limit Greeley's Poudre supplies).
- A safety factor provides water if the drought goes beyond a 50-year drought severity.
- A safety factor provides water while Greeley converts agricultural water supplies, dedicated by growth, from agricultural to municipal use, a process, which can take many years.

Develop a Future Water Account

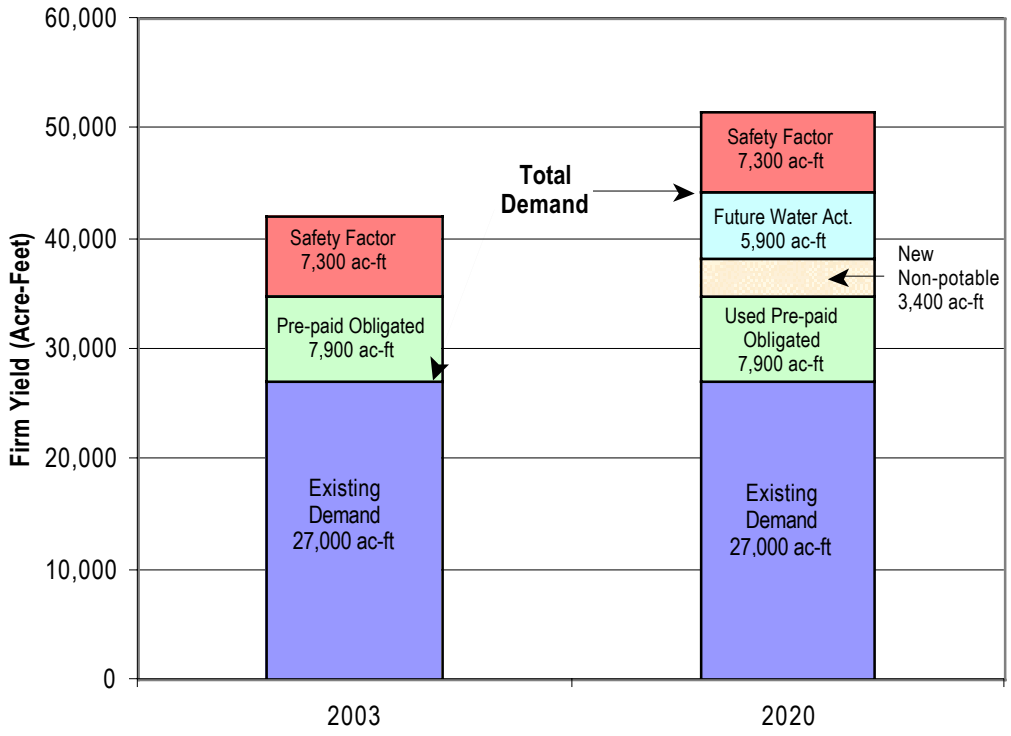
For the short-term, Greeley will proactively develop new water storage and raw water supplies to assure continuation of the current level of drought protection. Greeley will develop new water storage and supplies incrementally over the next ten years to minimize the financial impact to Greeley ratepayers. The

new storage and supplies will be placed in what is known as the "Future Water Account," which is similar to a revolving fund. While developing the Future Water Account, Greeley will try to minimize the burden on existing ratepayers by taking the following steps.

- **Greeley will increase the efficiency of the raw water system**. Examples include using existing excess non-potable supplies to free up potable supplies, and reducing potable water demands through water conservation.
- **Greeley will use the currently budgeted Water Acquisition Fund to help fund the Future Water Account**.
- **Greeley will allow new development to pay cash-in-lieu of water rights only when water supplies have been developed within the Future Water Account.** Until new water supplies have been developed within the Future Water Account and their cost is known, Greeley's Water & Sewer Board is unwilling to allow development to pay cash-in-lieu of water rights. This policy can minimize the risk of taking in cash and not being able to develop new supplies and leaving existing ratepayers to make up the difference. The historical practice of accepting Colorado-Big Thompson dedication for dryland development and Greeley-Loveland Irrigation System dedication for historically irrigated lands will still apply.
- **As cash-in-lieu is paid for water in the Future Water Account, Greeley will quickly convert the cash-in-lieu into raw water storage or supplies to replenish the Future Water Account**. This action will minimize the risk that existing ratepayers will have to share existing water supplies with new growth and will also delay the need for a large storage project. Once incremental water storage and supply options have been exhausted, Greeley will need to build a large storage project. Maintaining as high a balance of water in the Future Water Account as possible will allow Greeley the years necessary to implement a large storage project.
- **Greeley will evaluate water portfolio shifts** on a case-by-case basis as a way to increase Greeley's firm supply without additional costs to Greeley ratepayers.

As the graph below shows, the Future Water Account will be a part of Greeley's future water supply, combined with new non-potable supplies and the existing pre-dedicated supplies. Greeley's safety factor floats on top of these three new supplies. The Future Water Account will be available for new dryland development on a cash-in-lieu basis. To the extent that there is water within this account at any one time, this water will act as an additional safety factor for existing ratepayers should the need arise (e.g., in case of fire, contamination, severe drought). Note that the pre-paid obligated demands provide the function of an extra safety factor today.

Figure 18. Future Greeley Water Supply



Value All New Supplies at 50-Year Drought Level

To assure that the level of service currently provided to Greeley water customers can be maintained into the future, Greeley will value all new water supplies at their 50-year drought yield. When new dryland growth comes to Greeley and must pay cash-in-lieu of water rights for water in the Future Water Account, the cash-in-lieu price will be based on the cost of developing new supplies with a 50-year drought firm yield. This will minimize the need for Greeley ratepayers to either lower their drought reserve or to develop new water for growth after the Future Water Account has been established.

Use Water Portfolio Shifts to Increase Firm Yield

To minimize the financial burden of developing new water supplies, Greeley could exchange high-priced water supplies for other supplies or projects that are less cost to Greeley—a water portfolio shift. Using the capital from the sale of high market value water, Greeley could purchase or develop a greater amount of water at a lower market value.

A primary example is the firming of Greeley's Windy Gap units. Greeley is soliciting offers to exchange a portion of Greeley's current Windy Gap water supplies for storage in the proposed Windy Gap Firming Project. For a detailed description of the Windy Gap Project, see page 63. The result of this exchange will be an increase in firm yield to Greeley at no cost to Greeley ratepayers.

Greeley must carefully implement future water portfolio shifts. The Water & Sewer Board has been reluctant to sell existing higher value water supplies before having secured the lower priced water supplies. To protect against this in the Windy Gap water portfolio shift, Greeley will make the exchange contingent upon the firming project receiving the necessary federal permits to assure that the firming project will be constructed.

Raw Water Long-Term Strategy

The long-term (beyond 2020) raw water strategy is to have new growth pay its own way as growth occurs. This strategy has two components:

- **Minimize the long-term impacts of new growth on existing ratepayers** by making new growth pay cash-in-lieu at the true cost of developing new supplies at a 50-year drought level.
- **Use the cash-in-lieu of water rights paid by new development to replenish the Future Water Account** ahead of new growth; thereby assuring that Greeley can maintain the current level of service over the long term with minimum impacts to existing ratepayers.

Storage and supply options available for incremental development (such as increases in efficiency, gravel lake storage, agricultural water rights) are adequate to meet projected demands to 2020 if implemented over the next ten years. Once the projects that can be implemented incrementally are gone, Greeley will be looking toward large water projects (e.g., large storage projects). As mentioned above, the current direction is to have new growth pay cash-in-lieu of water rights for water in the Future Water Account that would in turn be used to fund future raw water projects. The sale of water in the Future Water Account will minimize the cost of these large water projects to existing ratepayers. As the large water projects come on-line, this new yield will be added back to the Future Water Account and once again be available for sale on a cash-in-lieu basis to new dryland growth.

Treatment and Transmission Short-Term Strategy

Greeley's treatment and transmission short-term strategy is affected by three driving factors: aging infrastructure, regulations, and growth of demand and population.

Aging Infrastructure and Regulations

Even with extensive and on-going efforts to maintain the water system, the age of Greeley's system has increased the system's vulnerability. Since 1999, Greeley has updated its treatment facilities by modernizing both the Boyd Lake and Bellvue Water Treatment Plants but additional work is required. The age of the system and increased stringency in drinking water standards requires Greeley to update its facilities prior to or in conjunction with adding any capacity.

Demand and Population Growth

The recent large capital projects at the Bellvue and Boyd Lake Water Treatment Plants combat the age of the facilities and help to meet recently promulgated drinking water standards. However, the $14 million Bellvue improvements did not add capacity to Greeley's water system. If Greeley's population continues to grow at historical rates, Greeley's population will double in about 30 years. Although historically the increase in peak water demand has not exactly matched the rate of increase in population, overall, increase in peak capacity will undoubtedly increase with population.

The key policies of Greeley's short-term strategy for treatment and transmission capacity are:

- Minimize the rate impacts on existing ratepayers associated with adding capacity for new growth.
- Maintain the ability to implement Greeley's long-term treatment and transmission strategy.
- Maximize the use of existing infrastructure prior to constructing new facilities and add system capacity incrementally to the Bellvue treatment and transmission systems to minimize the rate impacts.

Maximize Existing Treatment and Transmission Capacity

Over the next five years, Greeley intends to maximize use of the existing treatment and transmission infrastructure. Doing so, temporarily postpones construction of new transmission lines to Greeley, which is the bulk of the proposed capital expenditures over the next 20 years. Maximizing existing infrastructure includes:

- Constructing a pump station at Windsor to increase the capacity of existing transmission piping in stages.
- Constructing new transmission lines parallel to existing lines in stages.

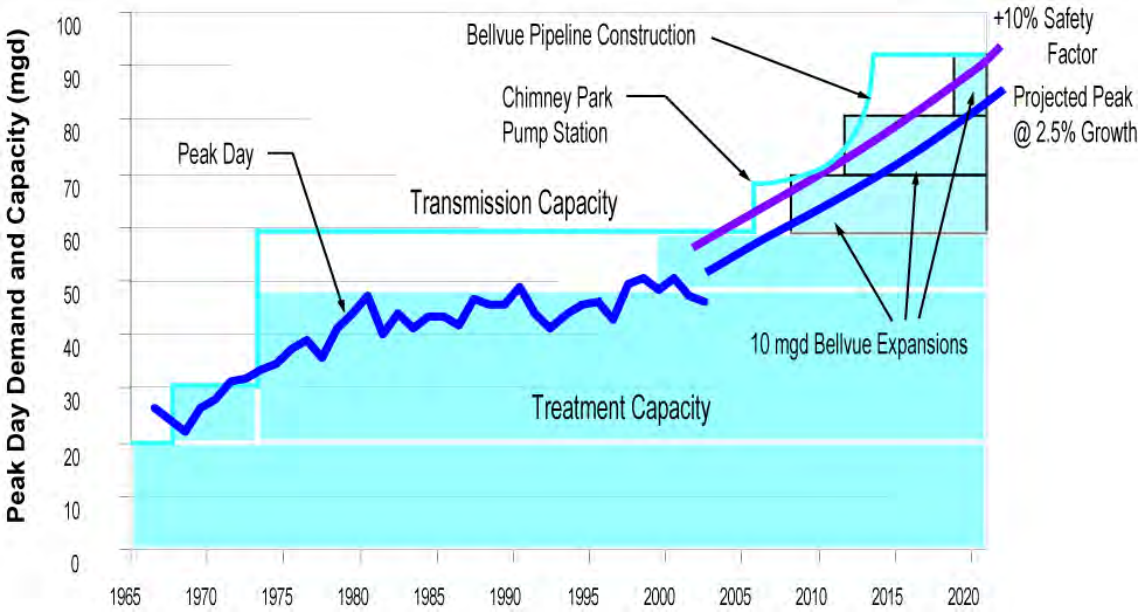
Because Greeley's long-term raw water sources are in the Poudre River Basin, the current Bellvue water treatment and transmission facilities must eventually be expanded. To protect this long-term strategy, Greeley must immediately start acquiring right-of-way and installing segments of a new Bellvue transmission line before development occurs in the transmission corridor. Most new demands are to the west of Greeley so new treatment and transmission capacity will supply Greeley's Gold Hill Reservoir.

Add New Treatment and Transmission Capacity

After maximizing the efficiency of existing treatment and transmission system, Greeley's short-term strategy adds new treatment and transmission capacity in 10 mgd increments, minimizing the financial impacts to ratepayers by offsetting as much of the cost of adding capacity as possible with revenue generated through the plant investment fees paid to Greeley by new development.

The primary cost in adding treatment and transmission capacity will be constructing the 27-mile pipeline from Bellvue to Gold Hill finished water reservoir west of Greeley. To delay this expense as long as possible, Greeley will continue to use the existing transmission lines and build a pump station in Windsor to increase capacity from the existing 20 mgd by gravity up to 30 mgd by pumping. Although new transmission lines can be added incrementally, hydraulic analysis shows at least half the new larger line must be complete before the next 10 mgd increase in capacity can be realized to 40 mgd. If Greeley grows at the rates projected in the *Comprehensive Plan*, and if peak demands follow growth, the entire new Bellvue transmission line would need to be completed by 2020. The pump station could then be retired for a number of years and flow from Bellvue would again be by gravity.

Figure 19. Project Capacity Vs. Projected Demand – Treatment and Transmission



Treatment and Transmission Long-Term Strategy

The long-term treatment and transmission strategy adds incremental capacity to the Bellvue treatment and transmission system, up to the 2050 maximum demand of 120 mgd. The new 60-inch Bellvue transmission line is sized to meet the ultimate capacity of the Bellvue Water Treatment Plant. The complete new Bellvue transmission line could operate under gravity flow, meeting demands until approximately 2035, based on historical growth rates. Beyond that, Greeley would re-commission the Windsor pump station and pressurize the pipelines to Mosier and Gold Hill to increase capacity.

The financial impacts to ratepayers due to the long-term strategy appear to be minimal in that plant investment fee charges cover a large portion of the cost of new treatment and transmission capacity.

Additional Factors in the Integrated Strategy

Water conservation and non-potable use will reduce the need for potable water supplies and the resulting treatment and transmission demands. Greeley's outside service contracts also affect the timing and ultimate need for treatment and transmission services.

Water Conservation

A major theme driving Greeley's *Water Master Plan* is to increase the efficiency of Greeley's water system. One key component of increasing the efficiency is water conservation. Water restrictions and conservation methods have been in place for decades in Greeley. Particularly, universal metering in the 1990's had a major effect in reducing water consumption. Greeley plans to build on this history of water conservation while maintaining the quality of life that Greeley citizens have come to enjoy. *Water Conservation and Demand Management* on page 51 provides a detailed discussion of the conservation

methods that will be implemented in the short term. As part of the *Water Master Plan*, Greeley has reviewed considerable literature on conservation methods available and the effectiveness of each. The water savings realized with a conservation measure can vary widely depending upon a number of variables including climate, other conservation measures already in place, and the state of drought. Due to the variability in water savings associated with different conservation measures, Greeley will not incorporate these savings into its future planning until these savings can be documented.

Non-potable Water Use

Greeley will use non-potable water sources where cost effective and strive for 15 percent of new demand to be served by non-potable water. Greeley has a long history of non-potable irrigation within Greeley, beginning in 1870, when Greeley began using Canal No. 3 to irrigate the parks and gardens within the City. Where cost effective, Greeley wants to continue this historical practice and in the process both delay construction of new treatment and transmission capacity and maximize the efficient use of Greeley's raw water portfolio.

New Outside Service Contracts

Greeley will not enter into any new open-ended outside service contracts. Historically these contracts have been limited to providing treatment and transmission services to the surrounding municipalities of Evans, Windsor, and Milliken. These cities' high variability in growth rates and their ability to take delivery of water supplies from multiple suppliers and sources has made planning for future demands difficult. Such small water systems typically have limited water management staff, putting a disproportionate administrative burden on Greeley staff to coordinate operations and project water use. The level of drought protection provided by these entities to their customers is also a concern. If these cities are not actively managing their water supplies and are not implementing adequate drought conservation methods, these cities may not have adequate water supplies in a drought.

The cumulative affect of these problems is to discourage any more open-ended outside service contracts. Well-defined outside service contracts could still be considered if they address the issues listed above.

Conclusion

Greeley's *Water Master Plan*, with guidance from the Water & Sewer Board and City Council, has developed policies to guide the Water & Sewer Department staff in a single, coordinated direction. The key policies address issues such as:

- Level of service Greeley should provide to its citizens in a 50-year drought, and the associated safety factor.
- Allocation of the cost of this service between existing customers and new growth.
- Use of non-potable water and conservation to increase efficiency of existing supplies.
- Development of a Future Water Account to provide water for dryland growth in the short term and cash for a large storage project in the long term.
- Limitation of outside service contracts.

The integrated strategies in this chapter combine these key policies with the current driving factors affecting Greeley's water system and overlay the whole onto the treatment and transmission and water supply options available to come up with the direction for Greeley's future water system.

Recent capital projects at the Bellvue and Boyd Lake Water Treatment Plants combat the age of the facilities and help to meet new drinking water standards. However, the Bellvue project did not add capacity, the Boyd Lake project added only 12 mgd of treatment capacity, and neither addressed compliance with future regulations.

Key considerations for adding treatment and transmission capacity are:

- Minimize rate impacts on existing ratepayers when adding capacity for new growth.
- Maintain the ability to implement Greeley's long-term treatment and transmission strategy, which is tied to Poudre River Basin water supplies.
- Maximize existing infrastructure prior to constructing new facilities and add system capacity incrementally.
- Maintain the flexibility in Greeley's water system to take C-BT water at either plant, which provides flexibility in managing raw water supplies. Future projects should not lock this raw water capacity into one plant.

Maximizing the efficiency of existing infrastructure includes:

- Constructing a pump station in Windsor in the short-term to increase the capacity of existing transmission piping.
- Constructing new transmission lines incrementally and parallel to existing lines.
- Delivering all new capacity to Greeley's existing Gold Hill Reservoir to meet new demands west of Greeley.

Greeley also needs to take immediate steps (in the next five years) to protect the ability to implement the long-term strategy for transmission that matches long-term raw water sources in the Poudre River Basin with long-term treatment and transmission capacity at the Bellvue Water Treatment Plant. To protect this long-term strategy, Greeley must immediately start acquiring right-of-way and installing segments of a new Bellvue transmission line prior to development occurring. Pipeline construction after development can increase cost fourfold.

The short-term raw water strategy includes:

- Maintaining the existing 50-year drought protection level with a 7,300-acre-foot safety factor.
- Developing storage and water supplies to be placed in the Future Water Account. Water supplies within this account will be available to new growth for cash-in-lieu of water.
- Valuing the cash-in-lieu rate for water within the Future Water Account at the rate necessary to develop new firm yield at the 50-year drought level.
- Implementing a water portfolio shift exchanging Windy Gap units for storage in the Windy Gap Firming Project.

The long-term raw water strategy is to use the cash-in-lieu developed in the Future Water Account to build a regional storage project. Using the cash-in-lieu minimizes the burden on ratepayers to develop new water for growth.

Chapter 8. Financial Results

This chapter addresses financing of Greeley's substantial construction and acquisition needs identified in the 20-year *Capital Improvements Plan* (CIP) in Appendix C.

Fund Structure

Greeley has three distinct capital improvements sub-funds, each designated for a specific purpose.

1. **Construction Fund** — for growth related needs, funded by plant investment fees.
2. **Replacement Fund** — for major replacement and rehabilitation projects, funded by water rates through the depreciation reserve.
3. **Water Acquisition Fund** — for the purchase or acquisition of water rights, funded by cash-in-lieu income, rentals of surplus water, and partially through water rates.

Policy Premises

When revenues or fund balances are insufficient to meet immediate needs, revenue bonds may be issued. Greeley has established the policy of paying for bond debt service from the fund that issues the bonds. As a rule, in the construction fund, the debt service will not exceed 50 percent of the plant investment fee (PIF) income. This policy minimizes the risk that the operating fund would have to pay new construction debt service if there is a slowdown in growth, which would reduce PIF income.

Greeley computes PIF on a “buy- in” of equity basis. That is, the total system replacement cost divided by the total customer base is the “buy-in equity.” The current (2003) PIF, $8,400 per 3/4-inch tap, is a significant increase from the $2,920 per 3/4-inch tap prevailing in 1999, which was calculated on total system replacement cost less depreciation.

The Greeley City Council desired to have growth pay more of the cost for adding capacity to Greeley’s treatment and transmission system and requested the Water & Sewer Board to increase plant investment fees accordingly. The intent is to have growth bear its fair share of growth-related costs. By using only

PIF income for new construction and paying any bond debt service for new construction from the Construction Fund, the city is assured that growth is paying its own way.

Depreciation funds replacement projects. In the long term, using only depreciation to fund replacement projects may be inadequate as depreciation is calculated on replacement cost, which may be insufficient to replace plant in kind to modern standards. However, for the foreseeable future, replacement projects are fully funded by depreciation.

Water rights are the other major policy issue governing the 20-year *Capital Improvements Plan* financing. In January 2003, the City Council adopted the first of six planned 1.5 percent rate increases above the rates needed for operation, maintenance, debt service, and depreciation. This extra revenue is intended to raise $35 million to be used to purchase about 6,000 acre-feet of new water over the next ten years. This $35 million is in addition to $3 million already allocated for the acquisition and rental of specific water supplies. Greeley developers needing raw water will be able to pay cash-in-lieu of raw water once this water is available. The cash-in-lieu revenue would then be used to fund future raw water projects.

Capital Improvements Funding

The ten-year *Capital Improvements Plan* through 2012, expressed in current year dollars, is estimated at $247 million dollars. This includes:

- $144 million for growth related construction.
- $23 million for replacement and rehabilitation.
- $42 million for Windy Gap firming.
- $38 million for water acquisition above developer dedications of rights.

Revenue sources funding the next ten years of capital improvements are:

- $92 million in plant investment fee revenues.
- $55 million from funded depreciation and miscellaneous sources.
- $78 million from revenue bonds.
- $37 million from sale of a portion of Greeley's Windy Gap portfolio.

Revenue bonds may be issued starting 2004, but capitalized interest techniques will be used to postpone payment until 2008, when two existing General Obligation bonds will be paid in full.

Financial Analysis

Greeley's water rate model, developed by Black & Veatch, was used to determine the rate impact of the *Capital Improvements Plan* identified above. Numerous runs were used to identify the options resulting in the lowest rates and fees. Water rate increases of three percent a year (to 2010) combined with a growth of 2.5 percent and plant investment fee increases of about five percent annually after 2002 are adequate to fund the entire *Capital Improvements Plan*. An extra 1.5 percent for six years will fund the Water Acquisition Fund. This of course, assumes that developers will pay their own way with respect to raw water development as policy dictates. If growth slows, capital programs may be delayed to match the revenue.

Monthly bills for a typical single-family homeowner using 16,000 gallons per month are shown below in *Figure 20. Projected Water Bills and Annual Rate Increases.* Over the ten-year period of rate increases, the average homeowner's monthly water bill will increase about $13 a month. This is contrasted with plant investment fees, currently at $8,400 in 2003, rising to $12,410 in 2011 (as shown in *Figure 21. Projected Plant Investment Fees*).

Figure 20. Projected Water Bills and Annual Rate Increases

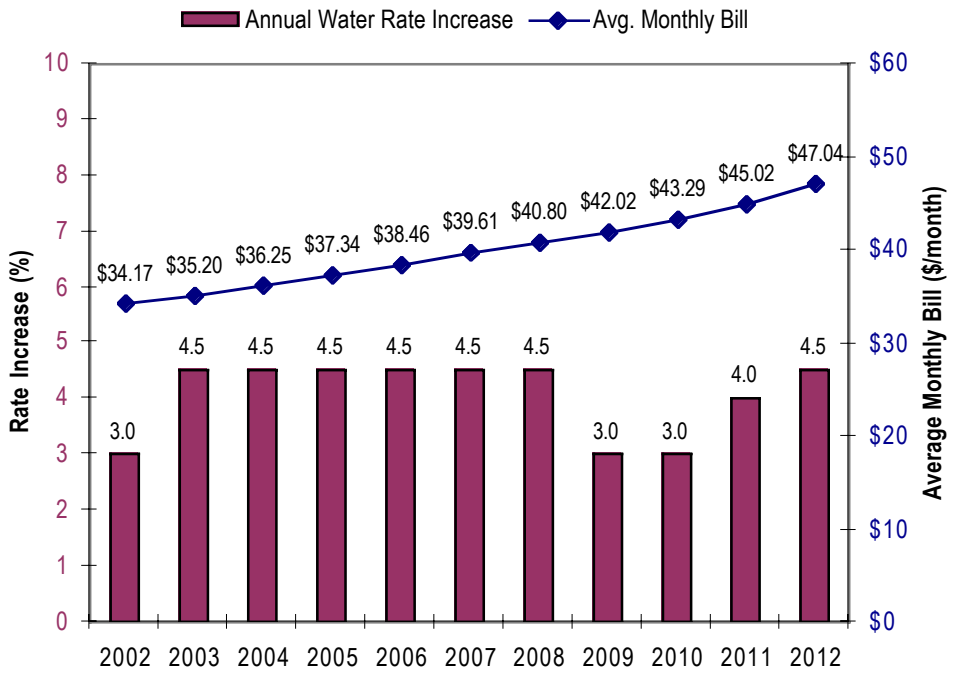
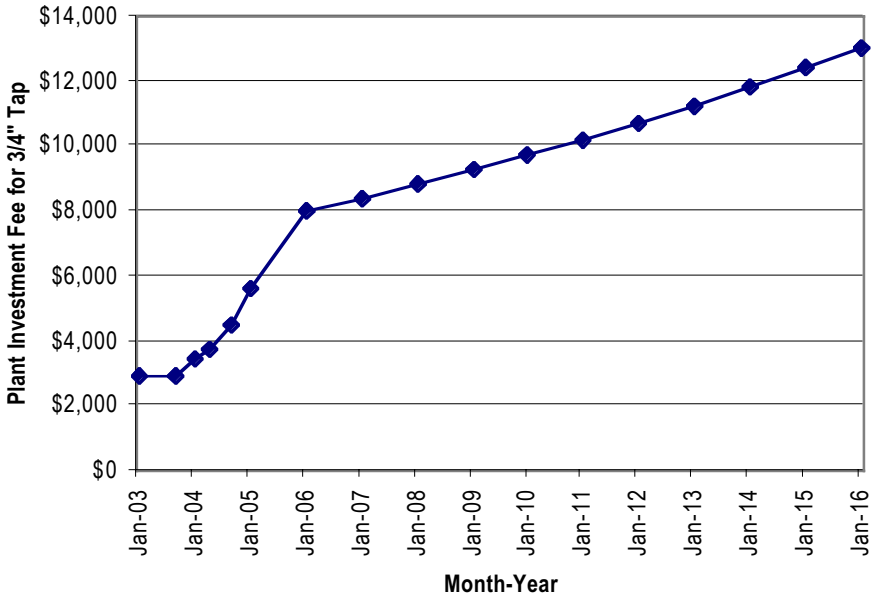


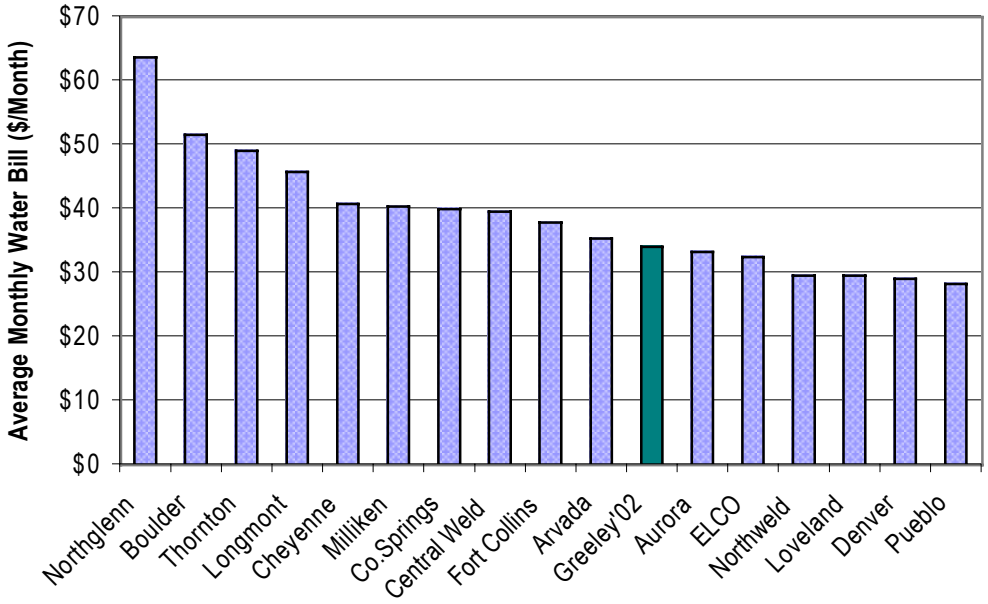
Figure 21. Projected Plant Investment Fees



Comparisons with Front Range Purveyors

The following chart compares monthly water bills for 2002 for Front Range single-family residences, assuming the customer uses 15,000 gallons per month. Note that most of the systems used for comparison do not have as complex water system as Greeley and frequently they are closer to the mountains, their source of supply. Compared to Front Range communities surveyed, Greeley's 2002 water rates are in the lower third. Compared to Greeley's northern Colorado neighbors, Greeley's rates are between Loveland and Fort Collins rates.

Figure 22. Monthly Water Bills for Front Range Water Purveyors

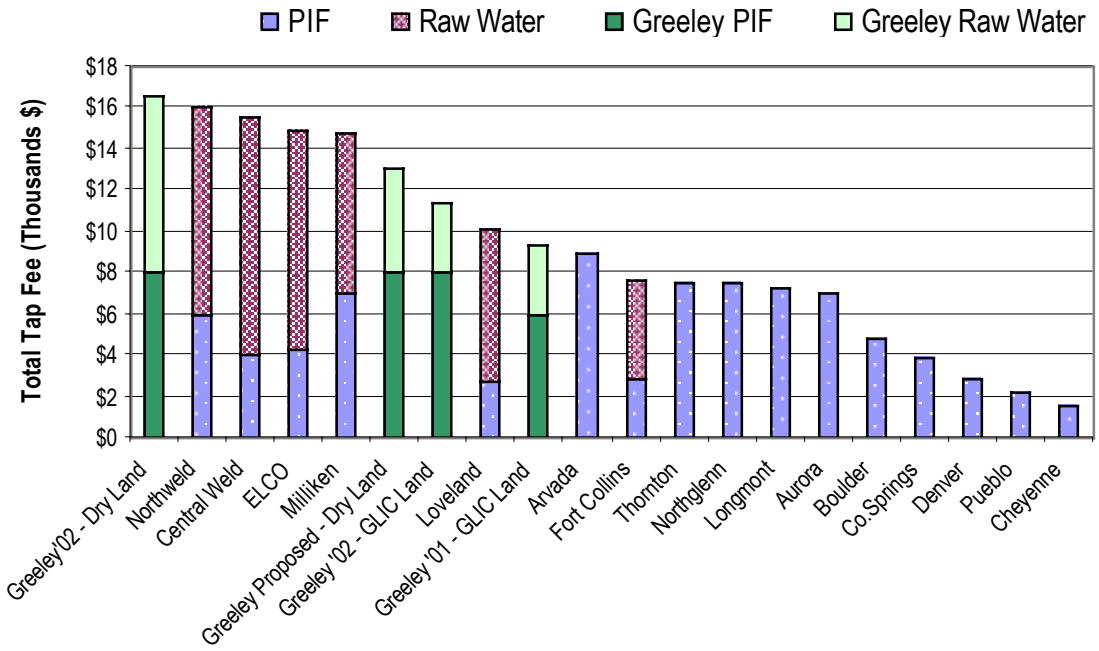


Assumes average use of 15,000 gallons per month for all cities and does not include drought rates.

The *Water Financial Plan* requires annual 4.5 percent rate increase over the foreseeable future, including development of the Future Water Account. It is anticipated that Greeley will continue to enjoy lower rates compared to other Front Range communities who will most likely have higher annual increases.

When comparing cost of development (Plant Investment Fees and water rights dedications), the situation is more complex. Greeley has higher cost of development fees if raw water contributions are valued at present cash-in-lieu levels ($17,000 per acre-foot based on the price of Colorado-Big Thompson units) — a situation applicable to dryland development, which comprises the bulk of Greeley's potential development. However, the *Water Master Plan* anticipates that Greeley will develop new Future Water Account supplies for cash-in-lieu at a considerable discount to the current cash-in-lieu rate based on prices of C-BT. Consequently, the raw water cost of development in Greeley may become lower than neighboring communities that still require C-BT for dedication.

Figure 23. Comparison of 2002 Water Tap Fees for Single-Family Tap



Adjustments to Capital Improvements Plan

The rates and Plant Investment Fees shown above are designed for a particular, specifically identified, optimal 20-year *Capital Improvements Plan*. If adjustments are needed to the *Capital Improvements Plan*, the financial results will also need adjusting.

Of primary importance, the analysis is keyed to a 2.5 percent population growth and consequent 2.5 percent growth in annual water demands. A more rapid growth in water demand would mean acceleration of the *Capital Improvements Plan* schedule. With more rapid growth, say five percent, analysis shows the higher plant investment fee revenues combined with capitalized interest bonding techniques would result in water rates and plant investment fees very similar to those identified for the base case of 2.5 percent growth. A slower growth rate is less critical than the high growth rate because Greeley would be able to delay the construction of treatment and transmission capacity to coincide with the income generated from plant investment fees.

Conclusion

Although a ten-year, $250-million capital improvement program may appear ambitious, continued growth makes the program both necessary and feasible. Greeley's water rates are well positioned, in comparison with other Front Range communities, to accept modest rate increases. While Greeley's combination of plant investment fees and raw water costs may make new development expensive in comparison to others, this is a direct result of the policy decision to make growth pay its own way. The *Raw Water Acquisition Plan* on page 107 is intended to reduce that cost of development while at the same time keeping Greeley's 50-year drought reserve intact.

Chapter 9. Implementation and Future Updates

As described in *Chapter 7. Integrated Strategies*, the driving factors affecting Greeley's water system and the key policies derived with Greeley policymakers were overlaid onto the various options available to meet Greeley's future water demands to establish an integrated strategy for Greeley water. As with all planning efforts, the strategy will be dynamic as driving factors change or new driving factors become evident, as Greeley changes key policies or implements new ones, or as new options for meeting Greeley water demands are made available. Even though there will be changes in Greeley's *Water Master Plan*, the value of the plan is undiminished for two reasons.

- First, Greeley must make immediate decisions regarding the future of the water system. A number of the options must be implemented in the short-term or the options will either not be available or be much more expensive. This plan has an integrated strategy that allows Greeley to go in the best direction currently available.
- Second, the *Water Master Plan* explicitly describes the factors affecting the integrated strategy. Any changes to these factors (driving factors, key policies, options available to meet future demands) can be monitored and Greeley can change its future direction accordingly.

As described by Harold Evans, the current Water & Sewer Board Chairman, the *Water Master Plan* is a roadmap for Greeley's water system, not a railroad. A roadmap can be used to see where you have come from, which roads were taken and for which reasons. The roadmap can also be used to look ahead at the options (roads) that are now before you. Like all maps, this roadmap must be updated periodically to assure Greeley is aware of all the "roads" available.

Raw Water Acquisition Plan

As described in *Chapter 7. Integrated Strategies*, Greeley will continue the historical practice of developing water in advance of new water demands. The new water that will be developed by Greeley will be limited to the projected new demand for growth on dryland to 2020. In a change from historical

practices, Greeley will develop new water incrementally in order to keep the financial burden off existing ratepayers. The following steps in the *Raw Water Acquisition Plan* need to occur in the next few years.

- Proceed with the incremental development of 6,000 acre-feet of new water storage and supplies needed for projected dryland growth to 2020 (Future Water Account).
- Once the new storage and water supplies are available, the firm yield of these new sources will be available to new dryland development. The cash-in-lieu of raw water that these developments pay, will develop additional firm yield for Greeley's water system as part of the Future Water Account.
- Continue with the Windy Gap water portfolio shift to exchange Greeley Windy Gap units for storage in the Windy Gap Firming Project.
- Continue evaluating other long-term water options for Greeley. Many of these options could take many years to implement (e.g., a large new reservoir). To the extent possible, Greeley needs to pursue only the options with the best chance for implementation.

Annual Water Accounting

As Greeley develops water for the Future Water Account and takes cash-in-lieu of water for dryland development, Water & Sewer Department staff will need to account for these transactions. An annual water accounting will be prepared each year to identify the quantity of water in the Safety Factor Account and the Future Water Account.

This accounting will also identify the Water & Sewer Department's budget earmarked for new water acquisitions and any General Fund debt. For example, if the City Council waived raw water dedication for economic reasons, the Future Water Account or Safety Factor Account (depending on the balance of the Future Water Account) would be reduced temporarily and the accounting would show: 1) the reduced balance in the account the water is taken from; and 2) the money transferred from the General Fund to the Water Acquisition Fund. This accounting will keep Greeley officials up-to-date on the status of Greeley's raw water accounts and the proposed raw water acquisition activities planned for the next year.

Regular Water Portfolio Audits

In addition to the annual water accounting, the Water & Sewer Department also intends to do an audit of Greeley's water portfolio every three years to capture any changes to the firm yield estimates. These changes could result from more accurate firm yield modeling, increased firm yield from conservation efforts, increased utilization of City non-potable supplies, or other events resulting in a loss or gain of firm supply.

Treatment and Transmission Implementation Plan

As described in *Chapter 7. Integrated Strategies*, expanding the Bellvue system is the preferred alternative for additional treatment and transmission capacity.

With that decision made, Greeley will:

- Begin design when demand is at 80 percent of capacity.
- Begin construction when demand is at 90 percent of capacity.

The current capacity of the treatment and transmission system is approximately 58 mgd. The historical maximum day demand is about 51 mgd, or 89 percent of capacity. Although water restrictions are temporarily reducing the peak, design to increase capacity of the treatment and transmission system should begin soon. The following steps are needed within the next two to three years.

- Determine the type of treatment for a Bellvue Water Treatment Plant expansion. Although the *Water Master Plan* recommends membranes, the analysis was done on a broad scale. A study should be done in much greater detail, perhaps including pilot plant work, to confirm that membranes are the proper choice for the Bellvue Plant.
- Evaluate treatment at Bellvue with regard to recently promulgated, proposed and, expected regulations.
- Purchase land for a pump station near Windsor (completed in 2002).
- Design and construct the pump station planned for Windsor.
- Design and construct new transmission from Windsor to the existing "Kodak" pipeline (under construction in fall of 2003).
- Determine the preferred alignment for a new 60-inch pipeline from Bellvue. Begin to obtain right-of-way for pipeline alignment.
- Winterize the facilities at Boyd Lake to increase system flexibility and redundancy.

Additional steps for 2004 and beyond include:

- Design and construct additional treatment capacity at the Bellvue Water Treatment Plant including upgrades and/or replacement at Bellvue as identified in earlier studies.
- Evaluate the Boyd Lake Water Treatment Plant with regards to recently promulgated, proposed and expected regulations to determine if granulated activated carbon is appropriate or another treatment technique is needed.
- Perform a study on increasing flow through existing Bellvue transmission lines from 20 mgd to 30 mgd.
- Construct the pump station planned for Windsor.
- Continue acquiring right-of-way for pipeline from Bellvue to Windsor to Gold Hill.
- Develop an implementation schedule for pipeline from Bellvue to the pump station and the remainder of pipeline to Gold Hill and begin design.

Some specific additional steps are recommended.

- Establish a water quality monitoring system for the Boyd Lake Water Treatment Plant supplies; the Bellvue Water Treatment Plant supplies; the Poudre River above and below the wastewater plant; Canal No. 3; the Greeley-Loveland Canal near Boyd Lake, near Gold Hill, and in town; the South Platte River; and the Big-Thompson River. This water quality monitoring program would provide an on-going database for decision making with regards to treatment needs and options, non-potable uses, and wastewater discharges.
- Monitor the progress of the conservation program on an annual basis. As savings are realized, adjust demand projections accordingly. The *Drought Emergency Plan* must be adjusted as

conservation savings become permanent and are no longer available in droughts. Conservation savings will also affect revenues.

- Review drinking water and environmental regulations on an annual basis and evaluate how they may change the *Water Master Plan* implementation. Regulations should be monitored on an on-going basis for their potential effect on existing treatment plant operations.

Future Updates of the Water Master Plan

Public involvement, which started with a Water & Sewer Department open house at the beginning, has been an on-going part of the water master plan process. City Council and the Water & Sewer Board were involved throughout the process, with annual developments of Capital Improvements budgets, and culminating in the joint *Guiding Principles and Policy Resolution* discussed on page 12. As Greeley moves forward with the *Water Master Plan*, all parties must continue to provide input for updates based on changing circumstances.

Annual Review

On an annual basis, City Staff and the Water & Sewer Board should review a number of the key areas of the *Water Master Plan* to assure these areas reflect the current situation. These areas include:

- **Key policies.** On an annual basis there can be considerable turnover in the policymakers. It should be confirmed on an annual basis that the key policies, that guide the future of the Greeley water system, reflect the current goals of Greeley. The policies are listed under *City of Greeley Adopted Water Policies* on page 13.
- **Driving factors.** As the 2000's drought has illustrated, new driving factors can emerge, changing the how Greeley may implement the *Water Master Plan*. Changes in drinking water standards or federal environmental policies are other driving factors that could impact the strategies resulting from Greeley's *Water Master Plan*. Greeley should monitor the driving factors described in *Chapter 1. Introduction*.
- **Changes to options available to meet water demands.** The emergence of new options or loss of existing options needs to be monitored and compared to the current direction of Greeley's water system. New treatment processes, new raw water options, or new conservation methods will be available to Greeley in the future. The purchase of a raw water option by another water provider would eliminate an existing option.
- **Review of integrated strategies.** The strategies described in *Chapter 7. Integrated Strategies* should be reviewed regularly to determine if these still reflect the best direction for Greeley's water system taking into account changes in key policies, driving factors, and options available.
- **Update of Greeley's Capital Improvements Plan (CIP).** On an annual basis Greeley will update Greeley's CIP and determine specific action steps for implementation. The CIP update needs to be tied to a broader review of the water master plan direction.

The purpose of the annual review is to assure the integrated strategies of Greeley's water system are consistent with goals of Greeley policymakers for the water system, taking into account any changes to the driving factors affecting Greeley's water system and any changes to the options available to the Greeley water system that have emerged in the last year. The result from this annual review will be a specific CIP for the short-term changes to the Greeley water system that is consistent with the long-term

direction for the City. The annual review contemplated as part of the *Water Master Plan* will be an opportunity for City Staff and policymakers to take a holistic view of where the Greeley water system should be headed given the most current information available.

Revision of the Water Master Plan

Every five years, the *Water Master Plan* will be formally revised and re-distributed.

Conclusion

Greeley's water system is at a critical juncture. Greeley needs to replace or rehabilitate portions of a century old system while also accommodating growth. This water master plan process has determine the best way for Greeley to maintain an adequate supply of good quality drinking water at reasonable cost as City customers have enjoyed for decades. For this water master plan process to continue to be of benefit, the broad approach identified must be developed into a specific, task-oriented implementation plan that includes deadlines. In addition, City Council and the Water & Sewer Board need to provide continued input to reflect the desires of Greeley's citizens.

The *Water Master Plan* is just the first step from this critical juncture. Periodic follow-up is needed including:

- Annual monitoring of the raw water system taking into account the impact of new growth.
- Annual review of the water master plan direction including:
    - Key policies
    - Driving factors
    - Changes to options available to meet water demands
    - *Capital Improvements Plan*

This *Water Master Plan* represents the best direction for Greeley's water system given the current goals for the Greeley water system, current driving factors affecting Greeley's water system, and the various options available to meet Greeley's mission of providing water to its citizens. The periodic follow-up listed above is designed to assure that Greeley continues to go in the best direction as conditions change.

This is an exciting period in the history of Greeley's water system. Just as City leaders had the foresight to provide water supplies that lasted through the last century, today's City leaders have the opportunity to maintain those water supplies and improve them so that Greeley's water system will lead Greeley through this century and beyond.

Glossary of Terms

Acre
A measure of area; equivalent to 43,560 square feet.

Acre-foot
A volume of water that covers one acre to a depth of one foot, or 43,560 cubic feet (about 326,000 gallons). An acre-foot of water can supply the water needs of a typical family of four for about one year.

Activated Carbon
Adsorptive particles or granules of carbon usually obtained by heating carbon (such as wood). These particles or granules have a high capacity to selectively remove certain trace and soluble material from water.

Appropriation
The volume or flow of water that is legally allocated to an individual, municipality, corporation, or government entity for an identified beneficial use.

Augmentation
Enlarging or increasing the quantity of an item such as increasing the flow of a stream or river or replacement of out-of-priority diversions from a new or separate source of water.

Augmentation plan
A requirement of the 1969 Water Right Determination and Administration Act covering tributary ground water. An augmentation plan allows each well owner to provide replacement (augmentation) water to the stream at times when a senior right would be “calling out” his well. Now also applied to out-of-priority surface water diversions.

Basin
The drainage or catchment area of a stream or lake.

Beneficial use
The use of the amount of water that is reasonable and appropriate under reasonable efficient practices to accomplish, without waste, the purpose for which the diversion is lawfully made and without limiting the generality of the foregoing, shall include impoundment of water for recreational purposes, including fishery or wildlife.

Brackish
Mixed fresh and salt waters.

Chlorination
The application of chlorine to water, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results (aiding coagulation and controlling tastes and odors).

Clarifier
A large circular or rectangular tank or basin in which water is held for a period of time, during which the heavier suspended solids settles to the bottom. Clarifiers are also called *settling basins* and *sedimentation basins*.

Clearwell
A reservoir for the storage of filtered water of sufficient capacity to prevent the need to vary the filtration rate with variations in demand. Also used to provide chlorine contact time for disinfection.

Coagulation
The clumping together of very fine particles into larger particles caused by the use of chemicals (coagulants). The chemicals neutralize the electrical charges of the fine particles and cause destabilization of the particles. This clumping together makes it easier to separate the solids from the water by settling, skimming, draining or filtering.

Coliform
A group of bacteria in the intestines of warm-blooded animals (including humans) also in plants, soil, air and water. Fecal coliforms are a specific class of bacteria that only inhibit the intestines of warm-blooded animals. The presence of coliform is an indication that the water is polluted and may contain pathogenic organisms.

Complete treatment
A method of treating water that consists of the addition of coagulant chemical, flash mixing, coagulation, sedimentation and filtration. Also called *conventional filtration*.

Conduit
A channel or pipe for conveying water or fluid.

Consumptive use
The amount of water consumed during use of the water and no longer available to the stream system. For irrigation, consumptive use is water used by crops in transpiration and building of plant tissue.

Contaminant
Anything found in water (including microorganisms, minerals, chemicals, radionuclides, etc.) that may be harmful to human health.

Conventional filtration
A method of treating water to remove particulates. The method consists of the addition of coagulant chemicals, flash mixing, coagulation, flocculation, sedimentation and filtration. Also called *complete treatment*. Also see *direct filtration* and *in-line filtration*.

Conventional treatment
See *conventional filtration*. Also called *complete treatment*.

Conveyance
The act of transporting (e.g., water is conveyed in a pipeline, penstock canal, aqueduct or tunnel).

Conveyance loss
The loss of water from a conduit or open channel due to leakage, seepage, evaporation or evapotranspiration.

Corrosion
The gradual decomposition or destruction of a material by chemical action, often due to an electrochemical reaction. Corrosion may be caused by: 1) stray current electrolysis, 2) galvanic corrosion caused by dissimilar metals, or 3) differential concentration cells. Corrosion starts at the surface of a material and moves inward.

Cryptosporidium
A microorganism commonly found in lakes and rivers, which is highly resistant to disinfection. Cryptosporidium has caused several large outbreaks of gastrointestinal illness, with symptoms that include diarrhea, nausea, and/or stomach cramps. People with severely weakened immune systems (that is, severely immuno-compromised) are likely to have more severe and more persistent symptoms than healthy individuals.

Cubic feet per second (cfs)
A measure of a moving volume of water at the flow rate of water equal to 724 acre-feet per year or 449 gallons per minute.

Depletion
Net rate or quantity of water taken from a stream or ground water aquifer and consumed by beneficial and non-beneficial uses. For irrigation or municipal uses, the depletion is the headgate or wellhead diversion less return flow to the same stream or ground water aquifer.

Direct diversion
The diversion of water from a natural flowing stream.

Direct filtration
A filtration method of treating water, which consists of the addition of coagulant chemicals, flash mixing, coagulation, minimal flocculation, and filtration. The flocculation facilities may be omitted, but the physical-chemical reaction will occur to some extent. The sedimentation process is omitted. Also see *conventional filtration* and *in-line filtration*.

Direct flow right
A right defined in terms of discharge and which must be put to use more or less promptly following diversion from the source.

Discharge, or rate of flow
The volume of water passing a particular point in a unit of time. Units of discharge commonly used include cubic feet per second (cfs) and gallons per minute (gpm).

Disinfectant
Any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines and ozone, which is added to water in any part of the treatment or distribution process and is intended to kill or inactivate pathogenic microorganisms. Can also be a physical process such as ultraviolet light.

Disinfection
The process designed to kill most microorganisms in water, including essentially all pathogenic (disease-causing) bacteria. There are several ways to disinfect, with chlorine being most frequently used in water treatment.

Disinfection by-product
A compound formed by the reaction of a disinfectant such as chlorine with organic material in the water supply.

Distribution system
A network of pipes leading from a treatment plant to customers' plumbing systems.

Ditch (or canal)
A trench cut into the surface of the ground to transport water from a stream to a point of use away from the stream.

Diversion
1) Use of part of a stream flow as a water supply. 2) A structural conveyance (or ditch) used to divert water to some convenient discharge point.

Diversion dam
A barrier across a stream built to turn all or some of the water into a diversion channel or conduit.

Divert
To remove water from its natural course or location, or to control water in its natural course or location, by means of a ditch, canal, flume, reservoir, bypass, pipeline, conduit, well, pump, or other structure or device.

Drainage area
The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide. It is expressed in acres, square miles or other units of area.

Drainage basin
A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Drought
There is no universally accepted quantitative definition of drought. Generally, each investigator establishes a definition. Drought is usually defined as a year or series of consecutive years with below average runoff.

Dryland farming
Growing of crops without the aid of additional water through irrigation.

Eastern slope
That portion of Colorado lying east of the Continental Divide.

Effluent
Water or some other liquid-raw, partially or completely treated, flowing from a reservoir, basin, treatment process or treatment plant.

Environment
All the conditions, circumstances, and influences surrounding and affecting the development of an organism or group of organisms.

Environmental analysis
An analysis of alternative actions and their predictable short- and long-term environmental effects.

Exchange
A formal or informal agreement between owners of water rights to allow flexibility in the use of water. An example would be releasing reservoir storage water to a calling ditch, rather than decreasing the upstream diversion. There are many methods that have been devised by water users to exchange water rights.

Feasibility study
An investigation performed to formulate a project and definitively assess its desirability for implementation.

Filtration
A process for removing particulate matter from water by passage through porous media.

Finished water
Water that has been treated and is read to be delivered to customers.

Firm water supply (or yield)
An assured minimum supply of water (or yield) under the defined adverse water year supply conditions.

Flocculation
The gathering together of fine particles in water by gentle mixing after the addition of coagulant chemicals to form larger particles.

Fresh water
Water that generally contains less than 1,000 milligrams per liter of dissolved solids.

General obligation bond
Project funding, repayment for which is made from sources not limited to those revenues generated by project output, such as water or power sales. “GO” bonds typically involve the pledging of future tax proceeds.

Giardia lamblia
A microorganism frequently found in rivers and lakes, which if not treated properly, may cause diarrhea, fatigue, and cramps after ingestion.

Ground water
For administrative purposes, ground water is usually defined as any water not visible on the surface of the ground under natural conditions.

Ground water outflow
The part of the discharge from a drainage basin that occurs through the ground water. The term “under-flow” is often used to describe the ground-water outflow that takes place in valley alluvium (instead of the surface channel) and thus is not measured at a gauging station.

Ground water recharge
Inflow to a ground water reservoir.

Ground water reservoir
An aquifer or aquifer system in which groundwater is stored. The water may be placed in the aquifer by either artificial or natural means.

Hardness, water
A characteristic of water caused mainly by the salts of calcium and magnesium, such as bicarbonate, carbonate, sulfate, chloride and nitrate. Excessive hardness in water is undesirable because it causes the formation of soap cures, increased use of soap, deposition of scales in boilers, damage in some industrial processes, and sometimes causes objectionable tastes in drinking water.

Headgate
A physical structure on a stream through which water is diverted into a ditch.

Head losses
Reductions to the gross difference in elevation between water surfaces upstream and downstream from a hydroelectric power plant due to friction of the flow of water through a penstock or conduit and changes in direction or velocity of the flow.

Headwaters
Source of water in a stream.

Headworks
Structure at the head of a channel or conduit for diverting water into the channel. Also the initial treatment processes at a water or wastewater treatment plant.

Historic use
The documented diversion and use of water by a water right holder over a period of years.

Hydraulic grade line
The surface or profile of water flowing of hydraulic gradient. The slope of the hydraulic grade line is under pressure, the hydraulic grade line is at the level water would rise to in a small vertical tube connected to the pipe.

Hydrology
The science dealing with water on the land, its properties, laws, and geographic distribution.

Hydrologic study period
A period of time specified for the selection of data for analysis. The base period should be sufficiently long to contain data representative of the averages and deviations of the averages that must be expected in other periods of similar and greater length. For ground water studies, the base period should begin and also end at the conclusion of a dry trend so that the difference between the amounts of water in transit in the soil at the ends of the base period is minimal.

In-line filtration
The addition of chemical coagulants directly to the filter inlet pipe. The chemicals are mixed by the flowing water. Flocculation and sedimentation facilities are eliminated. This pretreatment method is commonly used in pressure filter installations.

Instream flows
A prescribed level(s) of streamflow, usually expressed as a stipulation in a permit authorizing a dam or water diversion, which can be met with bypass flows.

Irrigable land
Arable land for which a water supply is available.

Irrigation
The application of water to crops, lawns, and gardens by artificial means to supplement natural precipitation. Water can be applied by spreading over the ground with or without furrows, by sprinkling, dripping or other methods.

Irrigation return flow
Applied water that is not consumptively used and returns to a surface water or ground water supply. In water right litigation, the definition may be restricted to measurable water returning to the stream from which it was derived.

Lateral
A minor ditch headgating off the main ditch used to direct water onto the land. A ditch may have many laterals depending on the amount of acreage irrigated, the slope of the land, and the rate of seepage losses.

Loss
In water conveyance, the difference between the amount of water that is actually placed on the land and the amount of water that was physically diverted to the headgate. Losses usually are from seepage and evaporation.

Milligrams per liter (mg/L)
A measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water. For practical purposes, this unit is equal to parts per million (ppm) since one liter of water is equal in weight to one million milligrams. Thus a liter of water containing ten milligrams of calcium has ten parts of calcium per one million parts of water, or ten parts per million.

Non-consumptive use
A use of water that does not reduce the supply, such as for fishing, boating, water-skiing, and swimming.

Non-potable
Water that may contain objectionable pollution, contamination, minerals, or infective agents and is considered unsafe and/or unpalatable for drinking, but may be of acceptable quality for other uses such as irrigation or cooling.

Non-tributary ground water
Water that is not part of a natural stream as established through geologic and hydrologic facts. The determination of “non-tributary” usually involves the length of time the impact of withdrawal would take to reach the stream and the amount of impact relative to the total volume of surface flow impacted.

Osmosis
The passage of a liquid from a weak solution to a more concentrated solution across a semi-permeable membrane. The membrane allows the passage of the solvent (water) but not the dissolved solids (solutes). This process tends to equalize the conditions on either side of the membrane.

Out-of-priority storage option
The ability to store water before one has the right according to his court decree to do so.

Peaking capacity
That part of a system’s capacity that is operating during the hours of highest demand within the system.

pH
pH is an expression of the intensity of the basic or acid condition of a liquid. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion concentration [H+]. pH=Log (1/[H+]). The pH may range from 0 to 14, where 0 is most acid, and 14 most basic, and 7 neutral. Natural water usually has a pH between 6.5 and 8.5.

Potable water
Water that is safe and satisfactory for drinking and cooking.

Priority
The relative seniority of a water right as determined by its adjudication date and appropriation date. In some cases, other factors are also involved in determining priority. The priority of a water right determines its ability to divert in relation to other rights in periods of limited supply.

Raw water
1) Water in its natural state, prior to any treatment. 2) Usually the water entering the first treatment process of a water treatment plant.

Reservoir
A pond, lake, or basin, either natural or artificial, used for the storage, regulation, and control of water.

Return flow
Unconsumed water which returns to its source or some other water body after its diversion as surface water or its extraction from the ground.

Return period
In statistical analysis of hydrologic data. Assuming that observations are equally spaced in time, and, choosing the interval between two successive observations as unit of time, return period is the reciprocal of one minus the probability of a value equal to or less than a certain value. Where the interval between observations is a year, a return period of 100 years for example means that, on the average, in the long run, not more often than once in 100 years is an event of this magnitude, or greater, expected to occur.

Reuse
Subsequent use of a water supply for the same user. An example would be the treatment of sewage water for use in potable or non-potable water use in the municipal water system or area.

Revenue bond
Project funding, repayment for which is strictly dependent on the income from the project to meet the interest and principal payments.

Reverse osmosis
The application of pressure to a concentrated solution, which causes the passage of a liquid from the concentrated solution to a weaker solution across a semi-permeable membrane. The membrane allows the passage of the solvent (water) but not the dissolved solids (solutes). The liquid produced is demineralized water. Also see *osmosis*.

Safe Drinking Water Act (SDWA)
Commonly referred to as SDWA. An act passed by the U.S. Congress in 1974 and the subsequent updates and modifications SDWA establishes a cooperative program among local, state and federal agencies to insure safe drinking water for consumers.

Sedimentation
A water treatment process in which solid particles settle out of the water being treated in a large clarifier or sedimentation basin.

Soft water
Water having a low concentration of calcium and magnesium ions. According to U.S. Geological Survey guidelines, soft water is water having a hardness of 60 milligrams per liter or less.

Source water
Water in its natural state, prior to any treatment for drinking.

Stinky water
1) Water containing some malodorous material such as hydrogen sulfide. 2) Water stock which would be difficult to change in water court; that is, water stock unacceptable to Greeley.

Storage decree
A decree of the court allowing the storage of water, usually in a reservoir.

Storage right
A right defined in terms of the volume of the water, which may be diverted from the flow of the stream and stored in a reservoir or lake to be released and used at a later time either within the same year or a subsequent year.

Surface water
The water that systems pump and treat from sources open to the atmosphere, such as rivers, lakes, and reservoirs.

Topographic
Of, relating to, or concerned with the configuration of the earth's surface including its relief and the position of its natural and manmade features.

Topography
The physical features of a district or region, especially the relief and contour of the land.

Total consumptive use
The amount of water, regardless of its source, used by the crops during the growing season. It is the amount of water that is physically removed from the stream's system and is not available for other users on the stream.

Total Dissolved Solids (TDS)
All of the dissolved solids in a water. TDS is measured on a sample of water that has passed through a very fine mesh filter to remove suspended solids. The water passing through the filter is evaporated and the residue represents the dissolved solids.

Total Trihalomethanes (TTHM)
The sum of the concentration, in milligrams per liter, of the trihalomethane compounds (trichloromethane [chloroform], dibromochloromethane, bromodichloromethane and tribromomethane [bromoform]), rounded to two significant figures.

Transbasin diversion
The removal of the water of a natural stream from its natural basin into the natural basin of another stream.

Transfer
The process of moving a water right originally decreed to one ditch, to another ditch, by court decree. A transferred water right generally retains its priority in the stream system and may or may not retain its right to divert its entire decreed amount.

Transmission lines
Pipelines that transport raw water from its source to a water treatment plant. After treatment, water is usually pumped or fed by gravity into pipelines (transmission lines) that are connected to a distribution grid system.

Transmountain
The crossing or extending over or through a mountain.

Tributary
Any stream that contributes water to another stream.

Trihalomethane
(THM) One of a family of organic compounds named as derivatives of methane. THMs are generally the by-product from chlorination of drinking water that contains organic material. The resulting compounds (THMs) are suspected of causing cancer.

Turbidity
The cloudy appearance of water caused by the presence of suspended and colloidal matter. In the waterworks field, a turbidity measurement is used to indicate the clarity of water. Technically, turbidity is an optical property of the water based on the amount of light reflected by suspended particles. Turbidity cannot be directly equated to suspended solids because white particles reflect more light than dark-colored particles and many small particles will reflect more light than an equivalent large particle. High levels of turbidity may interfere with proper water treatment and monitoring.

Vulnerability assessment
An evaluation of drinking water source quality and its vulnerability to contaminant by pathogens and toxic chemicals.

Water development
The process of building diversion, storage, pumping and/or conveyance facilities to apply water to beneficial use.

Water right
A right to use, in accordance with its priority, a certain portion of the waters of the State by reason of the appropriation of the same.

Water supply, basin
That quantity of surface and ground water that could be made available for all users in the basin. This quantity would include transbasin diversions, natural flow, ground water, and the reuse of these waters.

Water year
The 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes nine of the 12 months. Thus, the year ending September 30, 1959, is the “1959 water year.”

Watershed

The land area that drains into a stream. An area of land that contributes runoff to one specific delivery point; large watersheds may be composed of several smaller “subsheds,” each of which contributes runoff to different locations that ultimately combine at a common delivery point.

Western slope

That portion of Colorado lying west of the Continental Divide.

Appendix A. Maps

Map 1. Greeley Water Resources Map

Map 2. Greeley Non-potable Distribution System Map

Map 3. Northern Colorado Political and Water Service Boundaries Map

Map 4. Existing and Future Greeley Land Use Map

Map 5. Future Water Supply Options Map

Map 6. Greeley Regionally Based Capital Improvements Projects Map

Map 7. Greeley City Based Capital Improvements Projects Map

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Map 7. Greeley City Based Capital Improvements Projects Map

Appendix B. Assumptions and Policy Modifications

Listed below is a comprehensive list of the major assumptions, new policies and shifts in policies made by Greeley as an outcome of the *Water Master Plan*.

Assumptions

Raw Water

All Greeley supplies are accounted for in the supply modeling. Greeley owns certain water rights that are not currently being used by Greeley and have not been adjudicated through water court, such as Greeley-Loveland shares that are owned by Greeley but leased back to farmers. These shares along with all Greeley water are included in the water supply estimates.

Colorado-Big Thompson Units. In the drought modeling of the Colorado-Big Thompson (C-BT) units owned by Greeley, it was assumed that the yield was 0.5 acre-feet in the worst year of the 6-year long drought.

Treatment and Transmission

Age of existing treatment facilities will require replacement of existing capacity. The existing Bellvue Water Treatment Plant will require replacement in approximately five years.

Upcoming regulations will require upgrades at Greeley treatment plants. New regulations will require a higher level of treatment at Greeley's treatment plants. To help meet impending second round of microbial and disinfectant byproduct regulations as well as future regulations, Greeley will implement new technology as needed such as membrane treatment or granular activated carbon where cost effective. The recent addition at each plant of chlorine dioxide may reduce or eliminate the need for new treatment processes. City Staff are currently evaluating this.

Water quality available to future treatment plants. For cost comparison of capital costs and operation and maintenance costs at the various treatment and transmission options studied, it is assumed that existing water quality levels will be maintained. This is a safe assumption on the Bellvue side of Greeley's

system, but there is the potential for significant degradation of the water going to the Boyd Lake or Gold Hill options if measures are not taken to maintain the watershed (i.e., participation in the Big Thompson Watershed Protection Group).

Treated Water Storage. Greeley will develop 1.5 million gallons of finished water storage for every one million gallons per day of treatment and transmission capacity added to the system.

Demands

Projected population, land use, and water demand. Population growth within Greeley will be similar to historical growth rates. The projected land use and corresponding water demand in 2020 is based upon the policies adopted in Greeley's *Comprehensive Growth Plan* adopted in 2000. Population growth is projected at 2.5 percent per year until 2020. Demands for outside service contract holders (Evans, Milliken and Windsor) are based upon existing comprehensive plans and figures supplied by these Cities.

Strategic Development Corridor (SDC). Growth in water demand within the SDC is assumed to be over and above the historical growth in water use by Greeley. The projected SDC growth will add an additional 5,400 acre-feet of demand by 2050.

Projected non-potable water use. The total amount of projected new demand to be served with non-potable supplies is 15 percent of new demands. Greeley will continue to develop non-potable projects to serve parks and large turf areas. Presumably, a portion of the new residential and commercial demands will use non-potable water for irrigation. This level of non-potable usage was also assumed for the outside service contract holders.

New Established Policies

Raw Water

To provide adequate water for emergency supplies, 7,300 acre-feet of Greeley's yield is reserved for a raw water safety factor. The raw water safety factor will ensure that Greeley has sufficient supplies in the event of facility failures, contamination, and other major losses of supply. This safety factor is also required due to the time delay between taking water in for development and the time that is required to bring the water on-line for use by Greeley. The 7,300 acre-feet safety factor assumes that Greeley can lower potable water demands by ten percent in the worst year of a 50-year drought. If Greeley is not able to realize ten percent conservation savings in the worst year of the drought, a corresponding reduction in the safety factor will occur.

Develop a Future Water Account. Greeley will develop a Future Water Account of 5,900 acre-feet and as developed, sell this water to new dryland development coming to Greeley. As water is sold to dryland development for cash-in-lieu of water rights, Greeley will immediately pursue the development of additional water supplies to offset the amount sold. Greeley will fund the initial development of this account through small rate increases to existing ratepayers spread over a number of years.

Ensure that growth pays its own way. Except where precluded by contract, all new development shall provide sufficient water or cash-in-lieu of water (through purchases of water in the Future Water Account) to meet the 50-year drought firm yield requirements of three acre-feet per acre of development.

Do not develop a Raw Water Economic Incentive Account. Greeley will not develop an account of water to be used for attracting businesses. If City officials wish to use raw water for economic incentives, water will be borrowed from Greeley's existing safety factor with Greeley's General Fund compensating

the Water & Sewer Department for development of water to offset the amount taken from the safety factor.

Provide alternatives to C-BT. Currently Greeley only allows Colorado-Big Thompson (C-BT) units and a limited amount of cash-in-lieu for water dedications for land not irrigated under the Greeley-Loveland Irrigation System. Presently, only about 30 percent of all C-BT units are still in agricultural ownership and the number of C-BT units on the market is shrinking. Alternatives other than C-BT are needed for lands not irrigated by the Greeley-Loveland Irrigation System.

Greeley will pursue the acquisition of agricultural water rights. Previously, Greeley has only accepted irrigation shares for water dedication that has historically been used to irrigate the land that is being developed. Greeley will now actively pursue the acquisition of agricultural water rights that complement Greeley's water system including water supplies on lands outside of Greeley's growth path. While Greeley explores future acquisition of these supplies, it will also explore options that leave the land in agriculture for as long as possible, and ensure that the re-vegetation of the land is done properly. Greeley will explore the ability to enter into interruptible supply agreements with farmers. These agreements would allow Greeley to lease the water purchased back to the farmers and only pull into municipal use in times of drought.

Greeley-Loveland Irrigation System Shares - Value of shares without development of historically irrigated land. The full contract yield (33 acre-feet per share) will only be given for those Greeley-Loveland Irrigation System shares (e.g., Lake Loveland, Seven Lakes, and Greeley-Loveland Irrigation Company) that have been historically used on the land being developed. Greeley-Loveland Irrigation System shares purchased by Greeley that are not tied to the land being developed would receive only firm yield credit, estimated at nine acre-feet per share. Greeley will not give value for floating shares or shares used on expanded acreage within the Greeley-Loveland Irrigation System.

Treatment and Transmission

Calculation of Plant Investment Fees (PIF) on a replacement cost basis. Historically Greeley has had new development buy into Greeley's system on a replacement cost less depreciation basis. In 2000, Greeley's City Council requested that the PIF calculation be on a replacement cost basis to make growth pay more of the cost related to new capacity additions due to increased demands. PIF will be on a replacement cost basis from 2002 on. PIF increases will take affect 90 days after the Water & Sewer Board has approved the PIF increase.

Improvements to future taste and odor of Greeley drinking water. Greeley is planning on only addressing taste and odor issues through improvements necessary to meet future treated water regulations. Hardness of water from Boyd Lake will not be reduced due to cost.

Treatment and transmission capacity. Greeley will begin designing of additional treatment and transmission capacity when Greeley's current demand is within 80 percent of Greeley treatment and transmission capacity and will start construction of additional capacity when Greeley's demand is within 90 percent of existing capacity.

Installation of transmission piping prior to development occurring. Greeley will attempt to acquire land and install transmission piping prior to development occurring on rights-of-way to minimize cost.

Demands

Greeley will reduce water demands up to ten percent in the 50-year drought. Annual water demand in the driest year of a drought would be approximately ten percent higher than the average annual water

demand. Presumably, Greeley will reduce water demands up to ten percent in the 50-year drought so that all drought year demands are no more than average year demands.

Greeley will not replace obligated demands. Obligated demands include land that has pre-paid water demands or by contract are allowed to dedicate water supplies below the projected demand that will come on-line (Greeley-Loveland Shareholder's Agreement). Greeley will not acquire new supplies to offset the obligated demands, but will use existing supplies to satisfy new demand.

On-going conservation efforts will be credited to demand reduction only when clearly documented. Greeley will continue implementing on-going water conservation efforts approved by Water & Sewer Board and City Council to reduce water demands. Based on the current list of conservation measures, the projected savings is expected to be low. Currently, these projected water savings have not been factored into the raw water safety factor or future treatment and transmission needs. These savings will be included in future planning only when reduced demands by water conservation efforts can be clearly documented.

Provide a way for developers to use their non-potable supplies where cost effective. Greeley would like to encourage non-potable development where it is cost effective and in turn save on treatment and transmission costs.

Outside Service Customers

Greeley will not contract with additional outside service customers. Greeley's planning is limited to providing service to existing outside service customers (Evans, Milliken, Kodak, and Windsor). Greeley is not planning on having any additional large outside service contracts in the future. Small outside service contracts that provide Greeley with economic benefits may be considered in the future. However, these demands will not have major impacts on the long-term treatment and transmission needs for Greeley.

Lease of excess Greeley supplies in drought periods. In 2003, Greeley will evaluate a policy of not leasing excess supplies to outside service customers in drought conditions except to help meet absolute minimum demands such as indoor water usage.

Additional Studies and Analysis

Greeley will re-evaluate potential to be long-term water supplier to outside service customers. Greeley's current outside service customers have 20 to 25 year contracts with Greeley to provide treatment and transmission services for the customer's supplies. By 2004, staff will look at the impacts on Greeley's water system of being the long-term water provider for existing outside service contracts.

Greeley-Loveland Irrigation System Shares - Value of non-shareholder agreement shares with development of historically irrigated land. In the current planning, Greeley will provide full contract yield credit for all shares on lands developing to Greeley, both to those with shareholders agreements and those without shareholder agreements. If Greeley provides full credit for these shares, each share dedicated will bring with it a greater demand than supply. This is a conservative assumption because Greeley may have the right to provide only firm yield credit for Greeley-Loveland shares without shareholder agreements. Greeley will address this issue by 2004.

Shifts in Policy

Water supply planning is based on 50-year drought modeling. Prior to the *Water Master Plan*, Greeley used a 100-year drought as a planning standard. Greeley changed this standard to a 50-year drought to be consistent with the level of service provided other regional water suppliers including Fort Collins. The modeling estimates Greeley's water system yields during a 6-year long drought. The 50-year drought modeling uses synthetic hydrologic data.

Use of the Water Acquisition Fund. Greeley has historically allocated one million dollars for the acquisition of new water supplies. The purpose of this fund is to facilitate the acquisition of water if an opportunity becomes available that benefits the Greeley water system. Prior to the *Water Master Plan* the yield of the water supplies purchased using the water acquisition fund was to add to Greeley's safety factor. Currently, the firm yield developed through the use of these funds will be placed in the Future Water Account.

Non-potable Water Dedication

The policies listed below were designed to make the non-potable water dedication policies consistent with the new potable dedication policies. Non-potable policies will be re-visited as part of Greeley's *Non-potable Water Master Plan* update to be finished in 2003.

Growth will pay its own way. Credit given by Greeley for non-potable water dedication will be based on the same firm yield requirements as for potable supplies (annual yield in the worst year of a 50-year drought).

City will develop a list of acceptable non-potable water rights for non-potable dedication. Greeley will develop a list of acceptable non-potable water supplies that can be dedicated to Greeley for developments that will use non-potable systems. The non-potable supplies on the acceptable list must 1) have a firm yield in the 50-year drought, 2) be a supply that has both legal and physical certainty into the foreseeable future, and 3) will be obtained in a large enough quantities to warrant the cost of staff time to administrate a new supply and to take the supplies through the water court process. This position on acceptable water rights supports the major objective of this *Water Master Plan* of not putting the ratepayers at risk of funding water supplies for new development.

Non-potable systems design and maintenance. Although Greeley would like to encourage non-potable use, non-potable systems must be constructed and maintained properly so Greeley does not have to re-build the system in the future with ratepayer's money.

Appendix C. 2003 – 2022 Capital Improvements Plan

This appendix provides an overview of the various projects that comprise Greeley's *Capital Improvements Plan* for the next 20 years.

Construction Fund – Raw Water Supply System

1. Northern Integrated Supply Project

This Northern Colorado Water Conservancy District (NCWCD) managed project to plan for future water demands within District boundaries has just commenced. Greeley is a participant along with numerous municipalities and districts. One contemplated reservoir project is the expanding Greeley's Milton Seaman Reservoir. Funding has been set aside for initial feasibility level studies. Greeley looks at this project as a source of future supply, perhaps some 20 to 35 years hence.

2. Raw Water Telemetry

Raw water telemetering permits the monitoring of reservoir levels, flow, gage heights, and piezometer readings from a remote location via satellites, telephones etc. The plan is to initially orient the project around reservoir safety indicators. Three of Greeley's six high mountain reservoirs are being telemetered in 2002. The remaining will be completed in 2004.

3. Boyd Water Treatment Plant Emergency Drought Project

Greeley's intakes to the Boyd Lake Water Treatment Plant from Lake Loveland and Boyd Lake do not take water from the bottom of these reservoirs. During extreme drought situations when the reservoirs are at very low levels, there is the possibility that Greeley would not be able to access approximately 13,000 acre-feet of storage within the system. In contrast to Greeley facilities, the Greeley-Loveland Irrigation Company does have outlets within the system that allow for access of nearly all water supplies in the reservoirs to the Greeley-Loveland Canal. Greeley completed construction of a 20-mgd emergency intake and pump station from the Greeley-Loveland Canal to the raw water ponds at the Boyd Lake Water Treatment Plant in May 2003. In addition to allowing delivery of water below Greeley's intake during

drought situations, this project will also provide additional redundancy should one of Greeley's existing intakes within the Greeley-Loveland Irrigation System fail.

4. Windy Gap Firming

The Windy Gap Project does not currently yield water in the drought years when water is most needed. To remedy this inadequacy, a storage reservoir or series of reservoirs, of about 110,000-acre-feet capacity, which will "firm" drought year yields is being proposed. Greeley is one participant in this NCWCD Municipal Sub-District project, currently at 11 percent of total costs. Feasibility studies have been completed and NEPA assessments have just started. Current schedule has construction commencing in 2007. Greeley is pursuing the sale of a portion of the 40 units it has within the firming project to pay for firming storage for the remaining Windy Gap units owned by Greeley in the firming project.

5. Non-potable

This program, underway since 1996, is aimed at shaving peak summer demand by utilizing ditch water for the summer irrigation of selected customers with large lawns. Several projects will have been completed including: E. Memorial School and Park, Youth Sports Complex and offshoots, Luther Park, Northridge School, Boomerang Golf Course, Centennial Park, Saddle Club, Mosier Hill and Peakview Park, Monfort School and Park, and the Promontory complex. The *Water Master Plan* counts on 15 percent of new demand being provided through non-potable, through either direct building of projects by Greeley or through projects built by private parties for which Greeley may provide incentives. Three-quarters of a million dollars a year has been generally set aside for this project. Additionally, in 2002, a McCloskey Project was started to provide non-potable irrigation to 200 acres of a new City Park. The cost will be $1.5 million.

6. 25th Avenue Gravel Pits

With the permitting and construction of major large storage projects increasingly difficult, small storage projects are being looked at as a source of relatively quick, relatively certain and relatively inexpensive supply. In November 2002, Greeley completed the construction of a slurry wall surrounding two existing gravel pits. The inlet and pump station (outlet) will be constructed in 2003. The local storage will be used to manage return flows and raw water for non-potable projects, as well as provide augmentation services to ConAgra.

7. Parks Irrigation – SCADA

The sprinkler systems and controls for many parks within Greeley were installed decades ago. The large number of sprinkler zones and old systems make it difficult to maximize the efficiency of irrigation of Greeley facilities. As a measure to increase the efficiency of irrigation of City parks and turf areas, the Water & Sewer Department is funding the construction of a Parks Department Central Control SCADA system to give the Greeley Parks Department the ability to manage water use at City facilities more effectively.

8. Security Projects

In the wake of the September 11th, 2001 terrorist attacks, Congress passed legislation requiring local governments to do vulnerability assessments of water facilities. As an outcome of Greeley's vulnerability assessment, funding for various security projects have been added to the City's CIP. Projects may

include alarms notifying Greeley staff of unauthorized entrance to City water facilities (treatment plants, finished water reservoirs, etc.).

9. Pleasant Valley Pipeline

Work on this pipeline project, which would enable Greeley's Bellvue Water Treatment Plant to receive C-BT water from Horsetooth Reservoir in the winter, has been continuing. Construction on this project began in early 2003 and is projected to continue until early 2004. Greeley's share represents about 13 percent of the overall project, in which the Tri-Districts and Fort Collins are also participants. The Northern Colorado Water Conservancy District manages the project.

Construction Fund – Water Treatment

10. SCADA

SCADA is a Supervisory Control and Data Acquisition System. SCADA enables remote monitoring and remote operations of plants and other facilities. This continuing program is budgeted at about $75,000 a year. To date, 23rd Avenue reservoir, Boyd Lake Water Treatment Plant and a section of Bellvue Water Treatment Plant have been put on SCADA systems. Plans for the future include sensors for the remote monitoring of system pressure and chlorine levels at strategic sites.

11. Bellvue Raw Water Ponds Repair

During the modernization of the Bellvue Water Treatment Plant completed in 2002, the outlet works from the raw water ponds to the treatment plant were replaced. After the new outlet works were installed, additional seepage from the ponds was noticed. It was determined that improvements to the pond were needed in 2003 to reduce seepage and reduce the risk of a catastrophic failure of the dikes surrounding the ponds.

12. Boyd Lake Water Treatment Plant Ultraviolet Light Treatment Addition

As part of the water master plan process, it was projected that additional treatment processes would be needed at the Boyd Lake Water Treatment Plant to meet upcoming changes in drinking water regulations by 2010. During the water master plan process, Granular Activated Carbon (GAC) was used as a surrogate treatment process to estimate the potential cost for treatment upgrades to meet regulations until more detail analysis of water quality and potential options to meet future regulations could be started. After more analysis, it has been determined that the additional of ultraviolet light to the treatment processes at Boyd Lake would be the most cost effective way of meeting future regulations. The addition of ultraviolet light to the treatment process is projected to be on-line by 2009 to meet upcoming regulations.

13. Boyd Lake Winterizing

This project generally will provide for an enclosure over the flocculation and sedimentation basins at the Boyd Lake Water Treatment Plant. The building would include heating, lighting and ventilation. This enclosure is necessary for winter operations, provides for redundancy of the Bellvue Water Treatment Plant, and is scheduled to be on-line by 2004.

14. Land Acquisition

Monies for land acquisition are set aside annually to purchase non-project-specific parcels of land. This included the 2003 purchase of the Berquist property adjacent to Boyd Lake Water Treatment Plant, to be used for additional treatment processes that may be required in the future. Further acquisitions of property adjacent to other major facilities are possible. Greeley does not always own the land on which Greeley's facilities rest, and prudent acquisitions ease operations and maintenance issues.

15. Bellvue 10-mgd Addition

Projected treated water demand levels indicate the need for additional treatment capacity by 2008. A 10-mgd addition to the Bellvue Water Treatment Plant will provide this supply. A decision between a conventional treatment plant and a membrane plant to fulfill this demand will be decided upon in the future. The relatively small incremental additions of capacity at the Bellvue Water Treatment Plant are designed to reduce the financial burden placed on Greeley ratepayers compared with constructing very large increases in plant capacity.

16. Bellvue 15-mgd Addition

Based on current projections, an additional 15-mgd treatment capacity will be needed by 2012. This increment will also be added on at the Bellvue Water Treatment Plant. The relatively small incremental additions of capacity at the Bellvue Water Treatment Plant are designed to reduce the financial burden placed on Greeley ratepayers compared to constructing very large increases in plant capacity.

17. Bellvue 10-mgd Addition

Based on current projections an additional 10-mgd treatment capacity will be needed by 2019. This increment will also be added on at the Bellvue Water Treatment Plant. The relatively small incremental additions of capacity at the Bellvue Water Treatment Plant are designed to reduce the financial burden placed on Greeley water ratepayers compared to constructing very large increases in plant capacity.

Construction Fund – Finished Water Transmission and Distribution

18. Finished Water Storage (15 mgd)

Greeley currently possesses some 67 mg of treated water storage. Additional storage capacity is needed in step with increases in treatment capacity. In 2010, 15 mg will be added.

19. Finished Water Storage (22 mgd)

An additional 22 mgd of storage capacity will be added by 2011.

20. Chimney Park Transmission Main (60 Inch)

This is a two-mile 60-inch transmission main that is the first portion of the new 60-inch Bellvue transmission line (30 miles total). Work will be completed by early 2004.

21. Chimney Park 30-mgd Pump Station

The existing Bellvue transmission line is at maximum capacity at 21 mgd. Studies associated with the *Water Master Plan* indicated that the optimal means of adding short-term pipeline capacity was with a 30-mgd pump station on the Bellvue line near Windsor. The pump station will be completed by 2006.

22. Zone 4 Improvements

Completion of improvements to the Zone 4 pressure zone near the Promontory development in west Greeley including putting into service a two-million gallon elevated finished water storage tank in June, 2003.

23. Bellvue Transmission Line – Acquisition of Right of Way

Transmission capacity will need to be incrementally increased to match additional capacity added to Greeley's Bellvue Water Treatment Plant. Prior to construction of sections of transmission line, Greeley will need to secure sufficient right-of-way. As with the addition of treatment and transmission capacity, it is anticipated that the acquisition of right-of-way will be done incrementally. Greeley will focus the initial acquisition of right-of-way and construction of transmission lines on areas that are developing in the short term in order to reduce the overall cost to Greeley ratepayers.

24. Bellvue Transmission Program

Due to future treatment capacity being added at the Bellvue Water Treatment Plant, a 60-inch transmission line from Bellvue to the Windsor area must be installed. As with the acquisition of right-of-way, construction of the new 60-inch pipeline in areas that are in the process of being developed will proceed prior to areas that are open fields. By constructing the 60-inch line prior to the development of areas, the overall cost to Greeley can be kept to a minimum.

25. Gold Hill Link Pipeline

This long-term project (2010) consists of 6,000 feet of 60-inch mains to connect the Boyd Lake transmission lines to Gold Hill reservoir. The pipe would create an additional means of supplying water to Gold Hill, and eliminate the problem of deteriorating chlorine residuals at Gold Hill because of stagnant water.

26. Chlorine Scrubber

Currently, chlorine gas is stored at all three reservoir sites. Safety practices dictate that scrubbing units (which decontaminate chlorine in case of a leak) be installed at such sites. Scrubbers have now been installed at 23rd Avenue Reservoir and Mosier Hill Reservoir.

27. Line Extensions and Oversizing

This is an annual provision, at about a quarter million dollars, for reimbursement to developers for the labor and materials cost of oversizing developer-installed mains. This is an economical means of building for future capacity increases and for Greeley's geographical expansion.

28 & 29. New Construction Meters and Water Taps

Monies for the tapping of mains and installation of new meters at development sites are budgeted annually. The costs are offset through an associated revenue item.

30. Inspection Services

Monies for these services are budgeted for enhanced inspections of new developments, over and beyond that provided by Code Enforcement.

Replacement Fund – Raw Water Supply System

31. Comanche Rehabilitation

Comanche rehabilitation includes repairing toe drains at Comanche Reservoir that are crushed in two places; as well as replacing and realigning gate stems.

32. GLIC System Improvements

Greeley currently owns 45 percent of the shares of the Greeley-Loveland Irrigation Company (GLIC) system. This system has many rehabilitation needs; consequently a budget item has been established to address some repairs.

Replacement Fund – Water Treatment

33. Bellvue Rehabilitation Phase II

The first phase of the rehabilitation of the Bellvue Water Treatment Plant, completed in 2002, remedied hydraulic inadequacies, added a two-million-gallon clearwell, a backwash pump station, a modern chemical building, and modernized inlet outlet structures. Phase II continues with a new floc-sed unit and a new filter/administration building. Phase II will coincide with the addition of 10 mgd of new capacity identified in Construction Fund above, and is scheduled for completion by 2008. The rehabbed/enlarged plant will have 30 mgd of filter capacity. Whether filters or membranes will be used has not been determined yet.

34. Bellvue Raw Ponds Repair

The dikes surrounding the two raw water ponds at the inlet to the Bellvue Water Treatment Plant are almost 100 years old and are leaking. The repair of these dikes is urgently needed to stop the leakage and resulting loss of Greeley's raw water supplies and to prevent the catastrophic failure of the dikes.

35. Bellvue Sludge Beds Rehabilitation

Funds are budgeted for rehabilitating existing sludge beds at the Bellvue Water Treatment Plant. This project will commence in 2003.

36. Transmission System Rehabilitation

Repairs planned are for the placement of protective caps around exposed pipe in rivers, as well as for the upgrade of existing cast iron mains through swage lining or replacement.

37. Distribution Line Replacement

Money is budgeted on an annual basis to replace and rehabilitate distribution lines. Currently, ten miles of lines are over 70 years old, so there is a regular program of rehabilitating lines based on age, corrosion and leak history. Techniques used for the rehabilitation of lines include plastic lining, cement mortar

lining, and pipe bursting. These techniques permit the extension of the useful life of lines without the major disruption that digging up streets to replace them would entail.

38 & 39. Valve Replacement and Fire Hydrant Replacement

Exercising valves and replacing inoperable valves is a strongly recommended practice in the industry, as is the replacement of substandard hydrants discovered during flow tests.

40. Small Meter Replacement

Radio trace meters were gradually phased in starting in 1993. Battery and transponder replacements have started coming due. Varying amounts have been set aside annually for expected replacements.

41. Replacement Capital Outlay

Funds are budgeted for items of equipment that are to be replaced.

42. 23rd Avenue Reservoir Cover Replacement

Funds are budgeted for replacing existing Hypalon covers over three treated water reservoirs. The existing covers are close to the end of their 20-year useful lives.

Acquisition Fund

43. Water Acquisition

Greeley has decided to continue its historical practice of being proactive in the development of new water supplies prior to water demands from new growth coming on-line. Greeley will use the money allocated within this fund to acquire water prior to growth occurring and then sell this water to new growth on a cash-in-lieu basis at the cost of developing additional new firm yield to Greeley's system.

20-Year Master List of Water and Sewer CIP Projects

City of Greeley, Colorado Water Resources

Legend

- City of Greeley Facility
- Other Water Supply Lakes/Reservoirs
- City of Greeley Supply Lakes/Reservoirs
- C-BT System *
- Creeks
- Rivers
- Ditches
- Ditch Systems
- City of Greeley
- Continental Divide

Note: * - The C-BT System depicts infrastructure pertinent to the City of Greeley treated water.

0 1.5 3 6 9 12 Miles

POUDRE BASIN

BIG THOMPSON BASIN

COLORADO RIVER BASIN

Rocky Mountain National Park

Pawnee National Grasslands

Larimer County
Jackson County
Weld County
Grand County
Boulder County

Laramie River
North Fork Cache La Poudre River
Cache La Poudre River
South Fork Cache La Poudre River
Big Thompson River
Colorado River
South Platte River
Sand Creek
Sheep Creek
Lone Pine Creek
Roaring Creek
Nunn Creek
Willow Creek

Red Feather
Wellington
Ted's Place
Rockwell Ranch
Fort Collins
Nunn
Pierce
Ault
Eaton
Severance
Windsor
Loveland
Greeley
Kersey
Evans
Johnstown
Milliken
Gilcrest
Berthoud
Lyons
Mead
Platteville
Longmont
Frederick
Estes Park
Granby

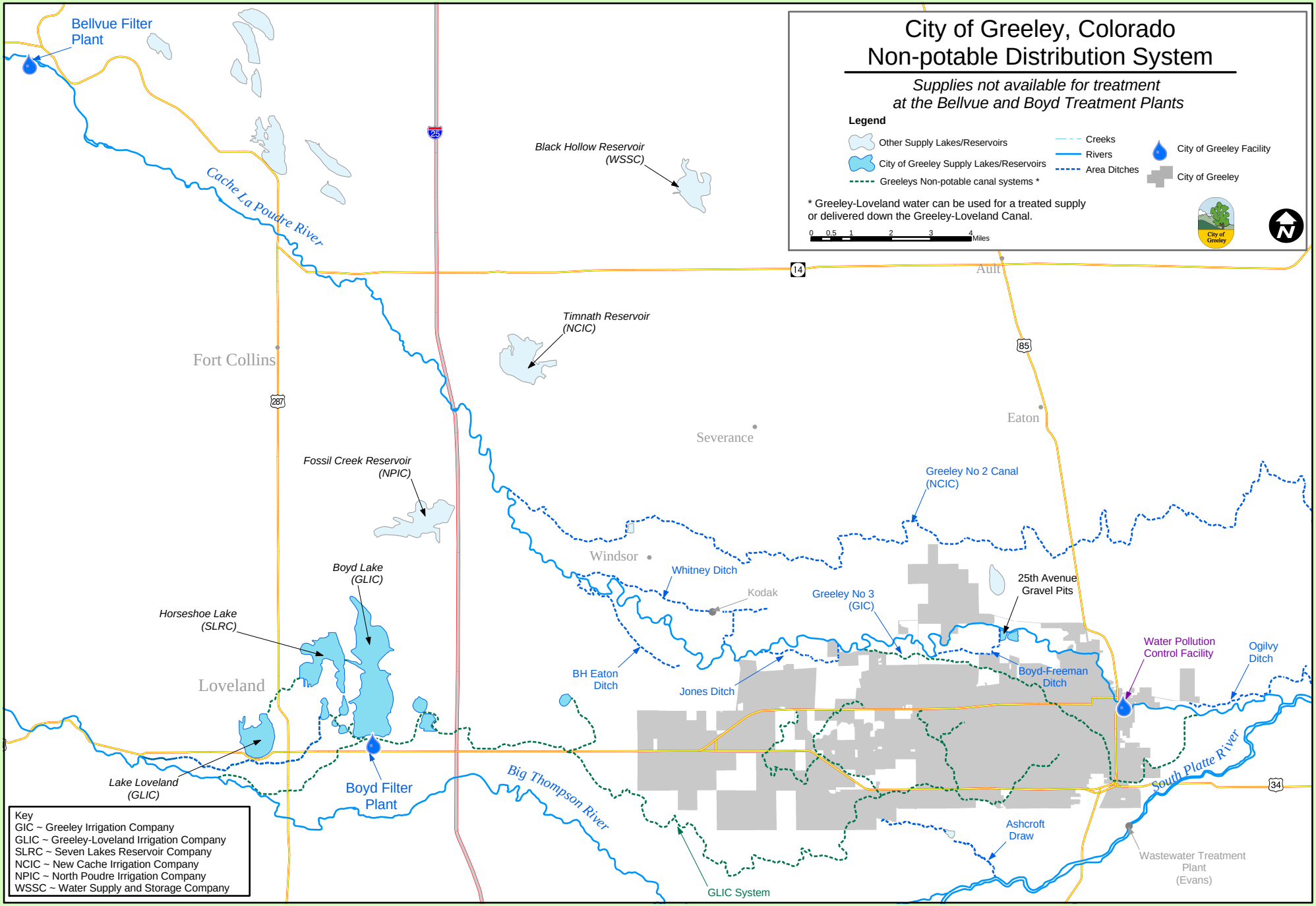
Bob Creek Diversion
Milton Seaman Reservoir (City of Greeley)
North Poudre Diversion Tunnel
Bellvue Filter Plant
Hansen Supply Canal
Pleasant Valley Pipeline (Proposed)
Barnes Meadow Reservoir (City of Greeley)
Comanche Reservoir (City of Greeley)
Hourglass Reservoir (City of Greeley)
Peterson Lake Reservoir (City of Greeley)
Twin Lake Reservoir (City of Greeley)
Horsetooth Reservoir (NCWCD)
Bellvue Transmission Lines 1,2,3
25th Avenue Gravel Pits
Greeley No. 3 (GIC)
Mosier Hill Reservoir
Water Pollution Control Facility
Horseshoe Lake (SLRC)
Boyd Lake (GLIC)
Raw Water Line
Hansen Feeder Canal
Lake Estes (NCWCD)
Olympus Tunnel
Flatiron Reservoir (NCWCD)
Pinewood Lake (NCWCD)
Marys Lake (NCWCD)
Lake Loveland (GLIC)
Boyd Filter Plant
Boyd Transmission Line 1,2
Gold Hill Reservoir
23rd Avenue Reservoir
Wastewater Treatment Plant (Evans)
Ashcroft Draw
Greeley-Loveland Irrigation Canal (GLIC)
Carter Lake Reservoir (NCWCD)
Alva B. Adams Tunnel
Continental Divide
Shadow Mountain Lake (NCWCD)
Grand Lake (NCWCD)
Willow Creek Reservoir (NCWCD)
Windy Gap Pipeline
Windy Gap Reservoir (NCWCD)
Lake Granby (NCWCD)

Key
GIC ~ Greeley Irrigation Company
GLIC ~ Greeley-Loveland Irrigation Company
NCWCD ~ Northern Colorado Water Conservancy District
SLRC ~ Seven Lakes Reservoir Company

MAP 1

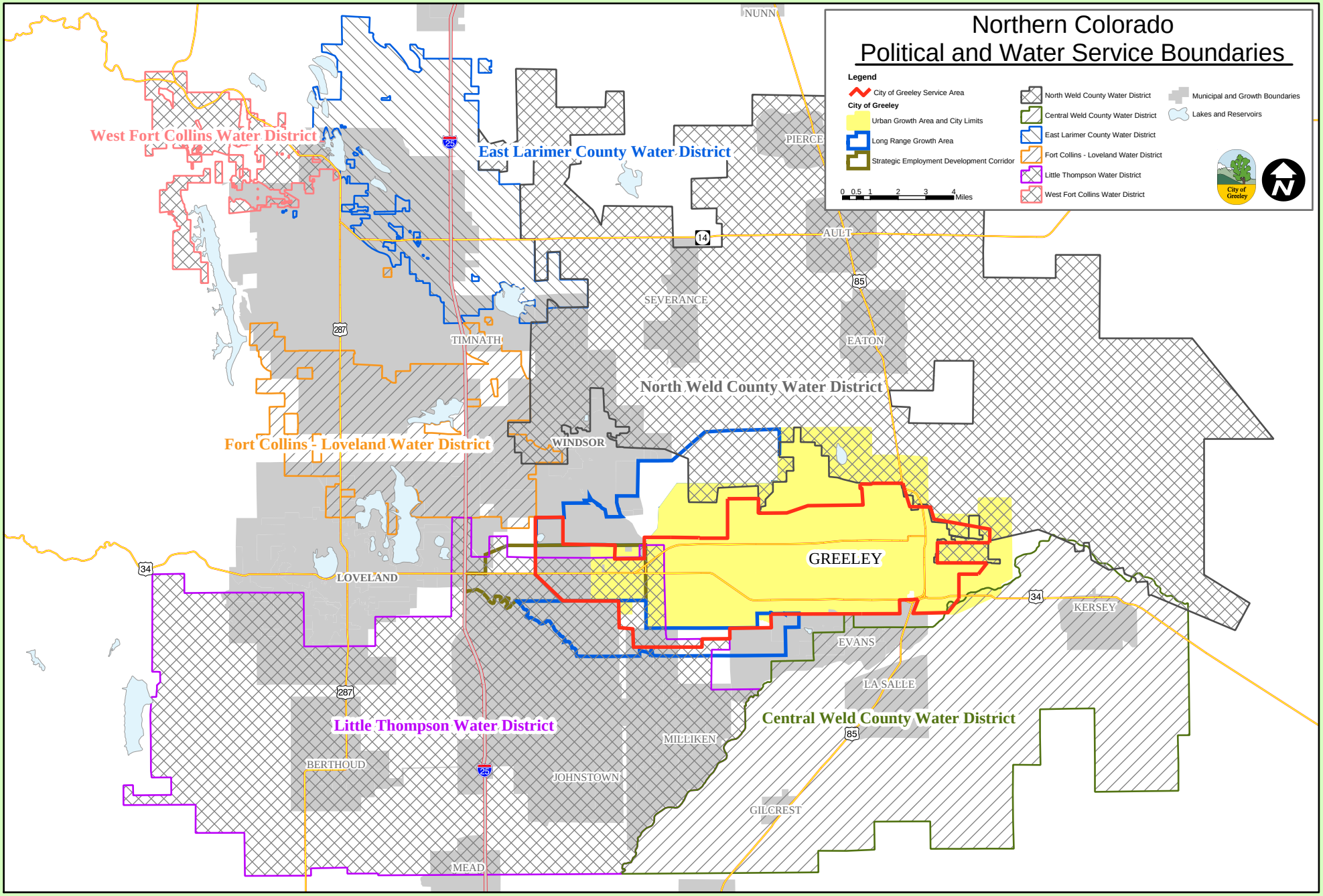
masterplan_map1.mxd

masterplan_map2.mxd



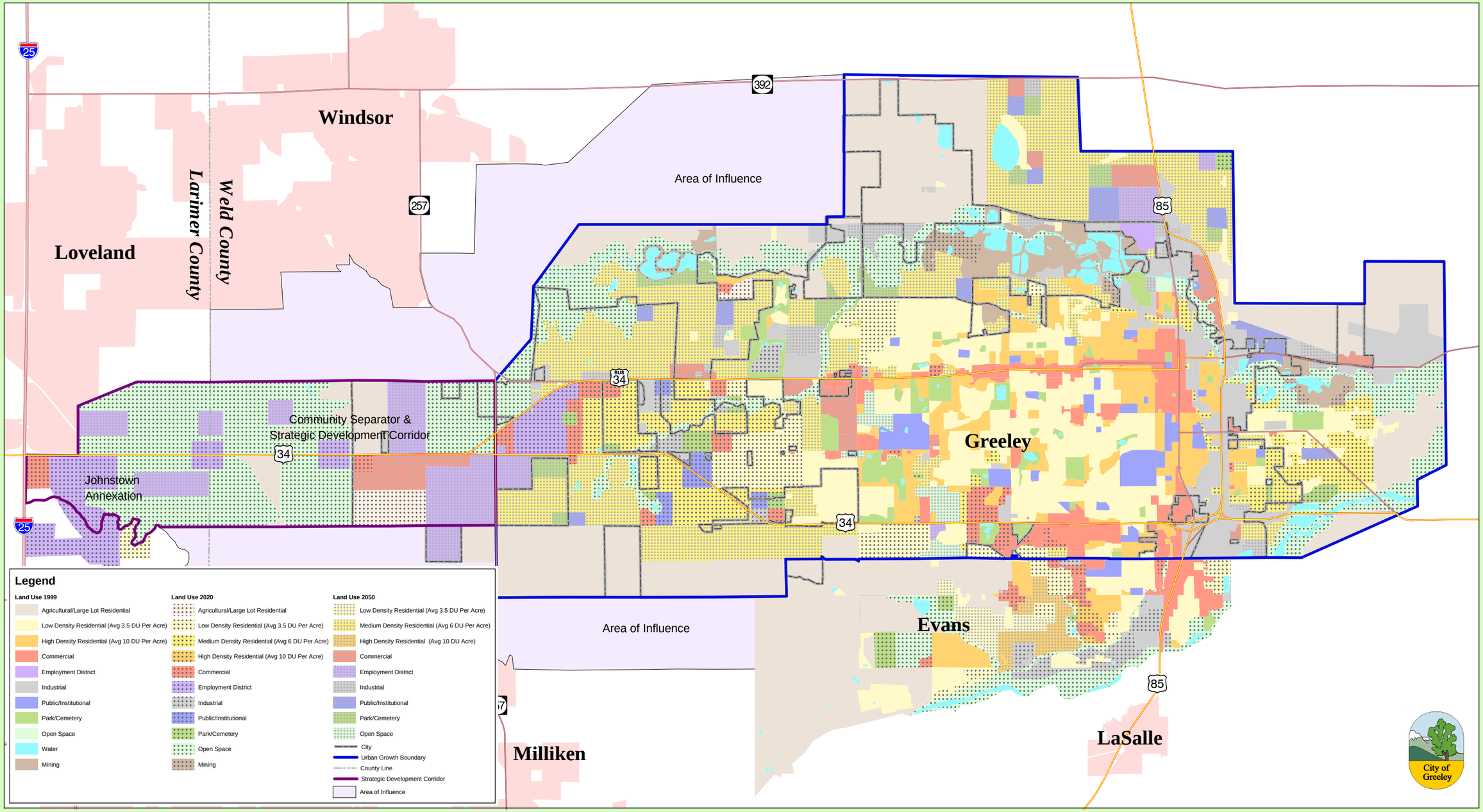
MAP 2

masterplan_map3.mxd



MAP 3

GREELEY WATER DEMAND STUDY
EXISTING AND FUTURE LAND USE



Comprehensive Plan Development Pattern

This map is used for water master planning purposes only and represents only one of many possible land use patterns which may develop in the future. The map should not be interpreted as a land-use master plan and does not constitute a defin

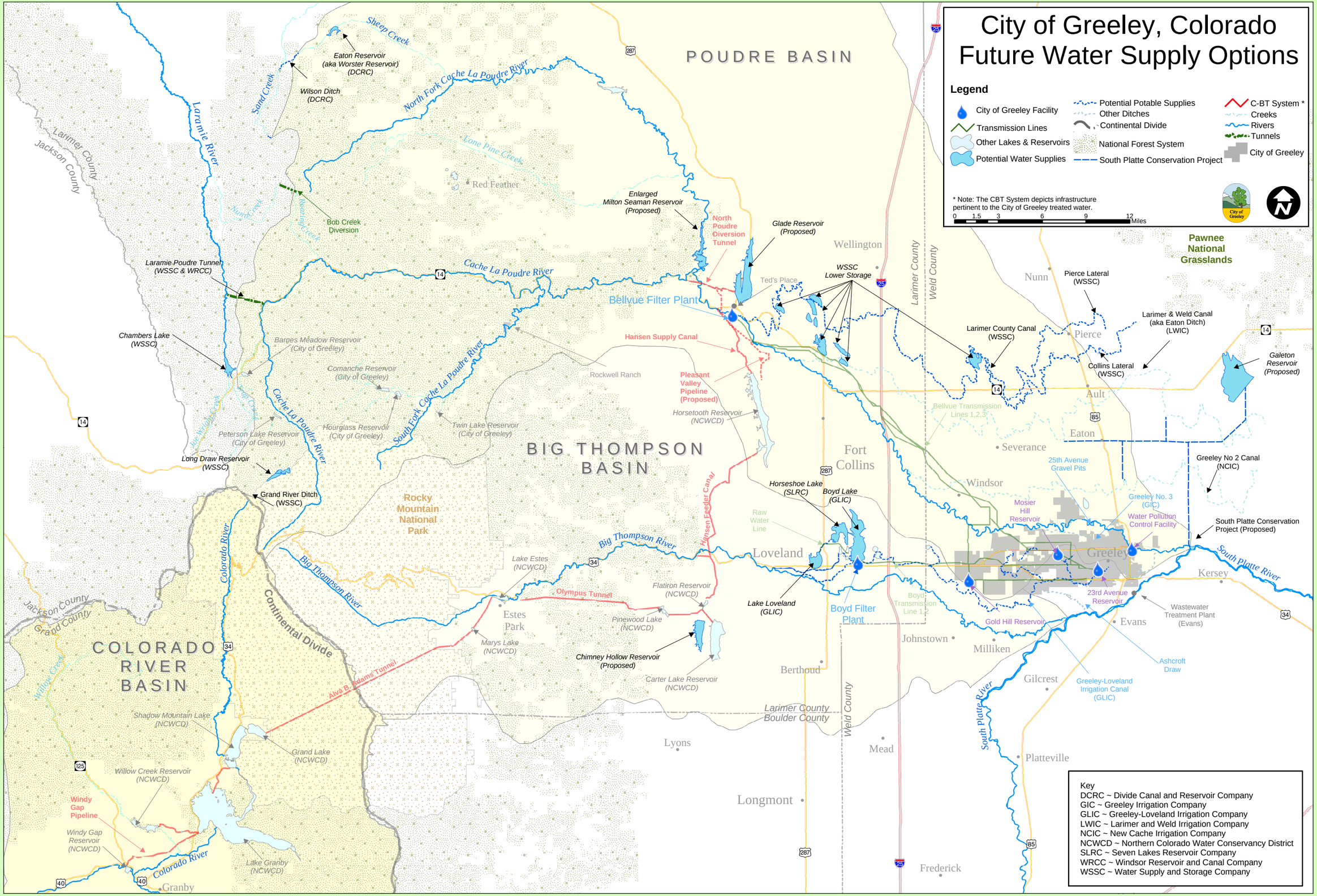
Febuary 2001

1 0.5 0 1 2 Miles

The following analysis represents one potential development scenario. It is based on planning documents, transportation/ population figures, zoning and development plans.

MAP 4

City of Greeley, Colorado
Future Water Supply Options



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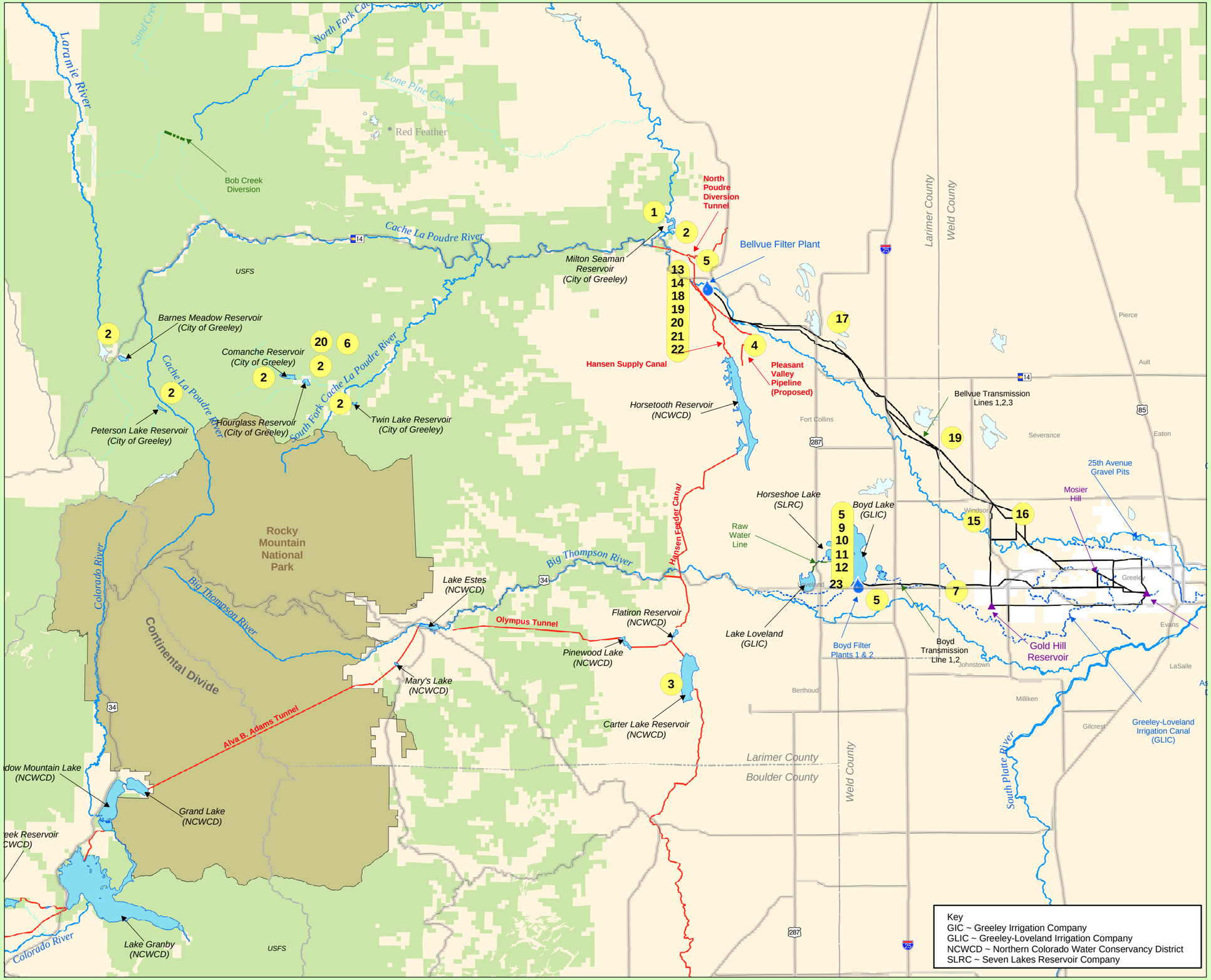
MAP 5

City of Greeley, Colorado
Capital Improvements Projects
Regionally Based Projects 2003-2012



Legend

- City of Greeley Facility
- C-BT System
- Projects

Note: * - The C-BT System depicts infrastructure pertinent to the City of Greeley treated water.

0 1.25 2.5 5 7.5 10 Miles

Water and Sewer G.I.S

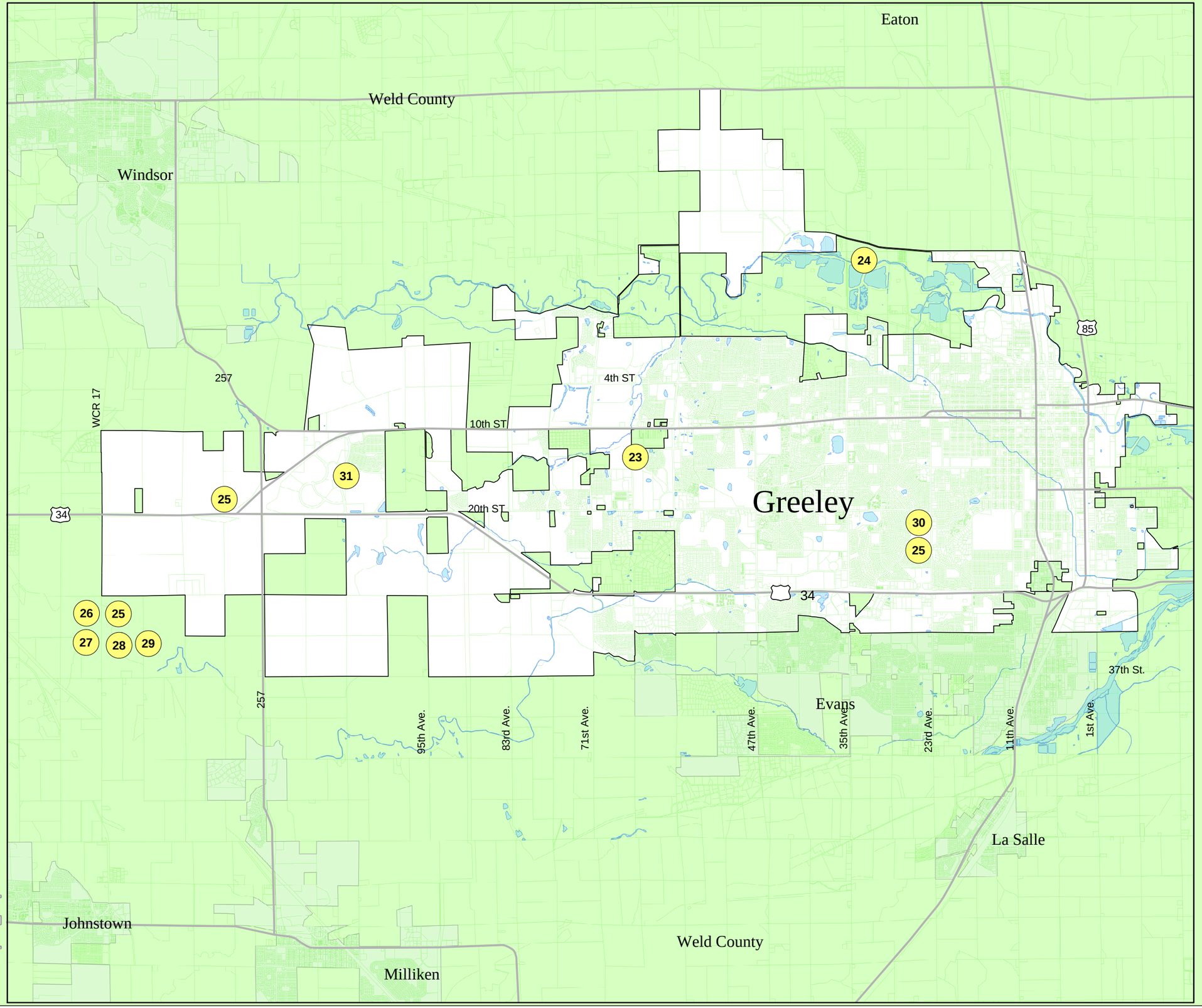
	Regionally Based Projects	2003-2012
01	Northern Colorado Integrated Storage	550,000
02	Raw Water Telemetry	133,000
03	Windy Gap Firming *	48,062,000
04	Pleasant Valley Pipeline	4,000,000
05	Land Acquisition	2,450,000
06	Comanche Improvements	110,000
07	Ancillary System Improvements	3,000,000
08	Transmission System Rehab **	874,000
09	Boyd Sludge Beds	484,000
10	Boyd Lake UV to meet regs	5,000,000
11	Boyd Winterizing	1,600,000
12	Boyd Emergency Drought Project	1,000,000
13	Bellvue 10mgd Addition (2008)	14,000,000
14	Bellvue 15mgd Addition (2012)	21,000,000
15	Chimney Park Transmission Main	4,000,000
16	Chimney Park 30mgd Pump Station	3,100,000
17	Bellvue Transmission Program	38,400,000
18	Bellvue-UV to meet regs	4,000,000
19	Bellvue ROW Improvements	3,500,000
20	Bellvue Rehab (20mgd) Phase II	3,500,000
21	Bellvue Rawwater Ponds Repair	1,100,000
22	Bellvue Sludge Beds Rehab	800,000
23	Security Projects	236,000

* Note: Greeley is currently planning on selling enough Windy Gap units to firm the City's remaining units and therefore wouldn't have a capital cost associated with firming.

** Not Specifically Located

MAP 6

City of Greeley, Colorado
Capital Improvement Projects
City Based Projects 2003-2012



Legend

Projects

0 0.25 0.5 1 1.5 2 Miles

Water Projects Located Within City 2003-2012

22	Non-Potable	7,621,000
23	Non-Potable McCloskey	1,500,000
24	Gravel Pits	1,650,000
25	SCADA (includes parks)	1,060,000
26	15mg Finished Water Storage (Gold Hill)	7,500,000
27	22mg Finished Water Storage (Gold Hill)	11,000,000
28	Chlorine Scrubber (Gold Hill)	250,000
29	Gold Hill Link	1,800,000
30	23rd Ave. Cover Replacement	1,050,000
31	Zone 4 Improvements	700,000

City Wide Water Projects

Line Extension & Oversizing	2,600,000
New Construction Meters	1,870,000
Water Taps	669,000
Distribution Line Replacement (CML)	8,000,000
Valve Replacement	858,000
FIre Hydrant Replacement	338,000
Small Meter Replacement	1,900,000
Inspection Services	800,000
Security Projects	235,000

MAP 7

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