City of Greeley Colorado

FINAL

Greeley Non-Potable Water Master Plan

June 2021

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Acronyms and Abbreviations

$/LF	dollars per linear foot
AF	acre-feet
AFY	acre-feet per year
BBC report	City of Greeley Population and Water Demand Projections
cfs	cubic feet per second
CMMS	computerized maintenance management system
C-H	commercial high intensity
C-L	commercial low intensity
CIP	capital improvement plan or program
City's Specifications	City of Greeley Design Criteria and Construction Specifications
Dev	development
EDR	engineering development review
EPS	extended period simulation
ENR-CCI	Engineering News Record Cost Construction Index
fps	feet per second
ft	feet
GIS	Geographic Information System
gpm	gallons per minute
gpm/acre	gallons per minute per acre
gpd/acre	gallons per day per acre
GPS	Global Positioning System
GLIC	Greeley-Loveland Irrigation Company
GIC	Greeley Irrigation Company
HOA	homeowners association
HDD	horizontal direct drilling
in	inches
I-L	industrial low intensity
I-M	industrial medium intensity
I-H	industrial high intensity
LREGA	long-range expected growth area
MG	million gallons
MGD	million gallons per day
NPMP	Non-Potable Water System Master Plan
NP	non-potable
OPCC	opinion of probable construction cost
O&M	operations and maintenance
psi	pounds per square inch
Poudre Ponds	Poudre Ponds Complex Project
PLC	Programmable Logic Controller
RTU	Radio Telemetry Unit
R-E	residential estate
R-H	residential high density
R-L	residential low density

R-M	residential medium density
SA	Service Area
SSMP	Sanitary Sewer Master Plan
SCADA	supervisory control and data acquisition
VFD	Variable Frequency Drive
W/S	City of Greeley Water and Sewer Department
WTDMP	Water Transmission and Distribution Master Plan

Definitions

Adoption rate - an estimate of the amount of land that could potentially be irrigated that is expected to use NP irrigation; this value is based on customer type and should only be used for planning level estimates, not design

Buildout - the theoretical point in time where the City has experienced complete development within the LREGA, expected to be sometime after year 2090

Bulk area - the total area of a parcel, including both the irrigated area and the impermeable area (such as buildings and parking lots)

Capital improvement - a recommended construction project to improve or expand the water system, summarized in the capital improvement plan

Conversion area - a previously developed parcel that is currently irrigated by potable water, but may consider switching to NP irrigation in the future; the amount of irrigated area for this type of customer is typically known

Diurnal curve - a pattern of peaking factors applied to a base demand (the typical demand for an area) that shows how demands vary by pattern throughout the day; the diurnal curve typically includes the peak hour

Extended period simulation - a hydraulic modeling methodology that shows how the system performs over a set timescale, during which demands and operating conditions can vary

Flow factor - value used to estimate the water demand that a given amount of land will produce once it's developed, depending on its land use

Hub-and-spoke - methodology for NP infrastructure design where a future pond and pump station (usually located at a park) is not connected to other pump stations and becomes an individual system with distribution piping extending out from it

Irrigated area - the portion of a parcel that requires irrigation (i.e. only permeable area)

Long range expected growth area - the limits of the City's expected growth and where it plans to provide water and wastewater services

Non-potable water - raw (untreated) water from agricultural ditches used to irrigate certain areas within the City

North of the River - the geographic area north of the Poudre River and within the City's LREGA

Opinion of probable construction cost - the costs borne by the contractor to construct a capital project

Peak day demand - the maximum demand anticipated to occur during a one-day period expressed as the daily average

Peak hour demand - the average demand anticipated during a maximum one-hour period for a typical year; this is considered to be a conservative value for infrastructure sizing

Peak month demand - the average demand anticipated during a maximum one-month period for a typical year, typically experienced during July

Planning horizon - a timeframe used to estimate expected demands and infrastructure needs; for this master plan, the three planning horizons are 5-year (2025), 20-year (2040) and buildout

Service area - the general geographic area that is served by or expected to be served by an individual NP system

Shoulder month/season - the periods in early spring and late fall where NP customers begin to require some irrigation water, but the agricultural ditches are not yet operational, occasionally resulting in the NP system being supplied by potable water

Shoulder tap - locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months

Summer water use - the amount of water used in summer months, defined as July and August

Tier 1, 2 or 3 - tier of information used to distribute future flow parameters to currently undeveloped areas or areas of redevelopment

Undeveloped land - land that does not currently have development, but may be eligible for NP irrigation when construction is completed in the future; the amount of irrigated area for this type of customer is unknown and therefore estimated.

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Executive Summary

The City of Greeley, Colorado (the City) is in Weld County approximately 60 miles northeast of Denver, east of Fort Collins and Loveland. The City is the twelfth largest city in Colorado and has developed into a cultural and academic hub, hosting educational institutions such as the University of Northern Colorado and Aims Community College. The City offers an affordable cost of living with many options for housing and economic growth. The City's population grew from 20,354 in 1950 to an estimated population of 108,175 in 2019. The City continues to experience strong growth in population through both infill and also through an expansion of residential, industrial, and commercial development within the City's defined service area.

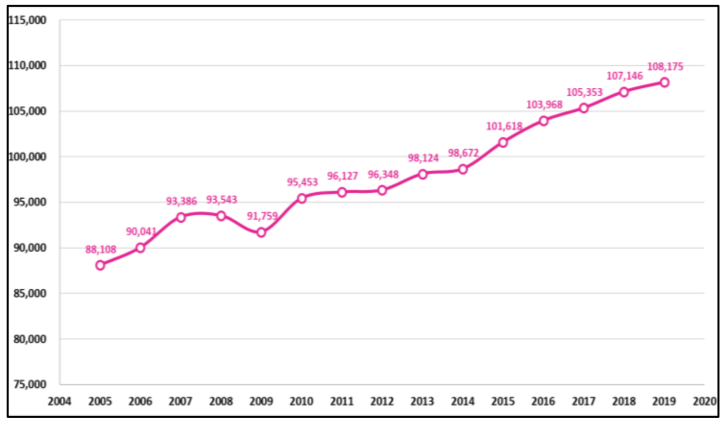


Figure ES-1 Historical Population for the City of Greeley

The 2020 Non-Potable Water System Master Plan (NPMP) is intended to plan for infrastructure growth and develop a capital improvement plan (CIP) for the City's non-potable (NP) irrigation system. The CIP plan will help the City plan for future development and costs both in the short-term and long-term. Continuing to grow and improve the NP system works in tandem with other water conservation efforts to decrease the total potable demand of the City as it experiences ongoing growth through buildout in a semi-arid environment.

ES.1 Greeley Master Plan Integration

To address existing and future system needs, the City developed their 2004 Non-Potable Water Master Plan to forecast water resources and infrastructure needs. The NPMP update occurred concurrently with updates to both the City's Sanitary Sewer Master Plan (SSMP) and the City's Water Transmission and Distribution Master Plan (WTDMP). This provided an ability to use consistent data for population and growth, common planning horizons and an integrated planning approach to CIP development. This approach to integrated master planning provides the City with a defensible and coordinated CIP and allows for the scheduling of CIP projects in ways that minimize the impacts to citizens.

Figure ES-2 illustrates the critical points of coordination between the three master plans.

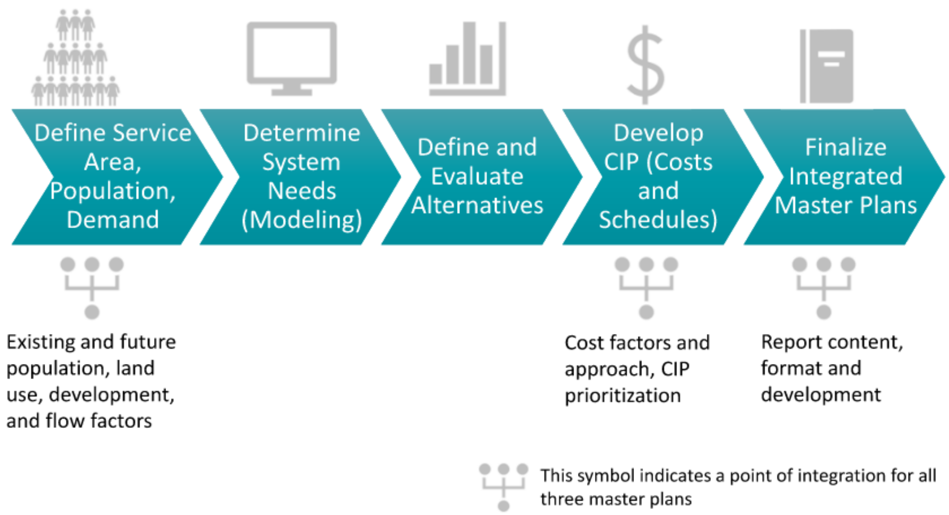


Figure ES-2 Master Plan Approach and Integration with Other Master Plans

ES.2 Existing System Information and Data Collection

The City's NP irrigation system is unique and advanced, particularly for raw water suppliers. In the current system, raw (untreated) water is supplied throughout the City via a system of agricultural ditches and gravity-fed pipes. The water typically flows from these ditches into an intermediate pond before entering a pumped distribution system, which includes 37 disconnected pump stations. This type of system is sometimes referred to as a hub-and-spoke layout. Through this system, the City is able to serve over 100 customers. Growing the NP system and offsetting more potable demands with NP irrigation water is a key goal for the City's water and sewer department.

City-provided data, including mapping, asset information, planning data, development plans, draft policy, and historic records, were used to inform the development of the NPMP. Additionally, a field inventory was conducted to supplement the City's existing geographic information system (GIS) database by geolocating key NP infrastructure, such as pumps, ponds, and valves. All of this information was compiled into a hydraulic model that accurately reflects the existing system. Existing demands were based on billing data and pumping records from July and August in 2018 and 2019 and were calibrated to available supervisory control and data acquisition (SCADA) data.

ES.3 Administrative Considerations

In addition to infrastructure construction and expansion efforts, certain administrative improvements can help the City continue to grow its NP system and act as a leader in potable water conservation and sustainable irrigation practices along the Front Range. The most significant change the City could make to promote NP irrigation would be implement and enforce the revised NP policy, included in **Appendix K**.

Historically, comprehensive data collection has been difficult for NP systems nationwide. Additional studies or data collection, along with more standardized record keeping practices, can help the City keep track of the overall system. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regular updates to the GIS database, and/or implementing a computerized maintenance management system (CMMS) for NP infrastructure. Installing SCADA systems at new or rebuilt pump stations can also help with data collection and control.

ES.4 Service Area, Population, and Demand Projections

The City's Long-Range Expected Growth Area (LREGA) is the area where it plans to provide water and sewer services. The future population, and resulting demands, that were distributed over the LREGA for each planning horizon used the "middle" projection from the *City of Greeley Population and Water Demand Projections* (BBC Research & Consulting 2018), referred to as the BBC report, as shown in **Figure ES-3**. Because the 2075 projection does not represent the buildout year for the City within the LREGA boundary, a buildout population was extrapolated using planning data and factors.

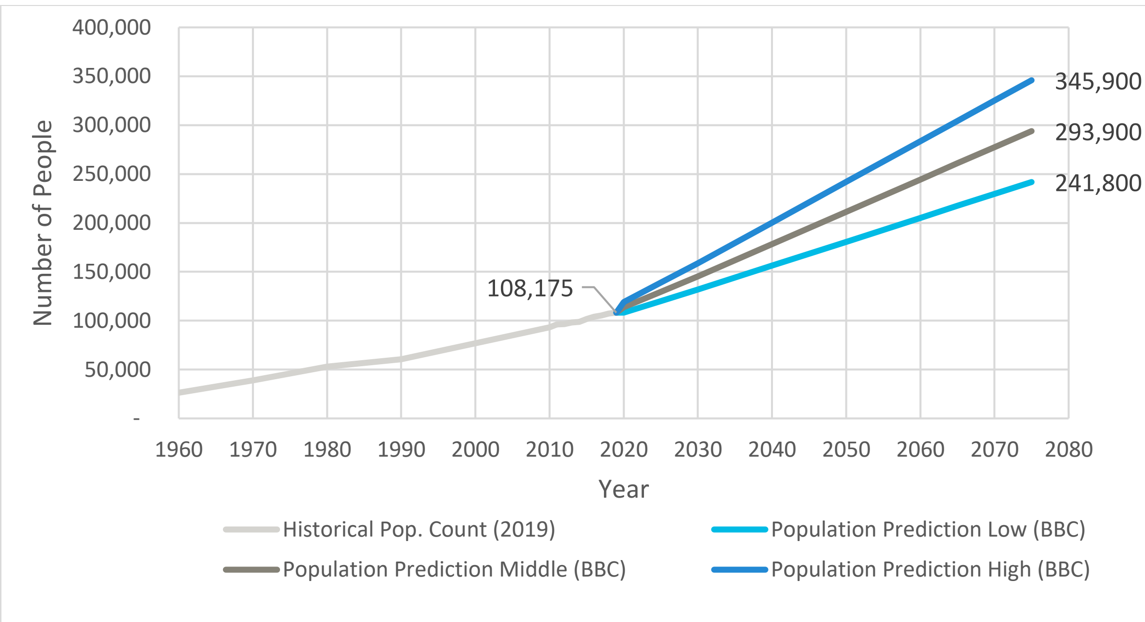


Figure ES-3 Historical and Projected Population

Future NP demand comes from two places: 1) undeveloped land that will use NP irrigation when it develops, and 2) existing areas that may switch from potable to NP irrigation, which are referred to as "conversion areas." Undeveloped land was identified and categorized by land use as part of the WTDMP and SSMP; these land use designations were used to predict NP demand in these areas. Conversion areas were based on the City's knowledge of potential customers; conversion areas are only potential areas that may benefit from NP irrigation but are currently not required to convert.

A set of flow factors were developed that show the expected demand per acre of a certain land use category, or customer type. There are flow factors for irrigated land (defined as the actual acreage of land that is irrigated on a given lot) and bulk land (defined as the total acreage of a given parcel, including impervious areas). However, just because an area could use NP irrigation, it does not guarantee that it will. To account for this, an adoption rate was applied to each flow factor, which designated the amount of that land that is expected to actually use NP irrigation. The adoption rates were coordinated with the BBC report. It is therefore recommended to use this NPMP for infrastructure planning, and the BBC report for all water resources planning. The total demand projected for both the potable and NP water systems is shown by planning horizon in **Table ES-1**.

Table ES-1 Peak Month Demand by Planning Horizon

Planning Horizon	Total Water Demand (MGD)	Potable Water Demand (MGD)	Non-Potable Water Demand (MGD)
Existing	47.3	46.0	1.3
2025	51.8	49.4	2.4
2040	61.0	56.9	4.1
Buildout	106.3	93.5	12.8

While the NPMP is primarily focused on planning for infrastructure needs based on peak summer demands, it is also important for the City to plan for the total annual water demands through buildout. Water conservation methods, such as improved landscaping practices and the encouragement and adoption of NP water for irrigation, may help reduce the City's annual water demands. The BBC report focused on developing three alternative scenarios for annual water demands. The total annual demands developed for the WTDMP under the NP offsets demand scenario at buildout are captured in **Table ES-2**.

Table ES-2 NPMP Annual Demand Projections at Buildout

Demand	Total Water Demand (AFY)[2]	Potable Water Demand (AFY)	NP Water Demand (AFY)
Existing	30,500	28,600	1,900
Future Demands	33,500	28,300	5,200
New I-H Users (6)	10,300	10,300	0
Total	74,300	67,200	7,100

[1] Potable demand shown in this table is for the NP offsets demand scenario.

[2] AFY = acre-feet per year

ES.5 Model Evaluation and Infrastructure Planning

The existing and future NP system was analyzed using both a hydraulic model (InfoWater) and various desktop analyses that used existing and projected future demands against the system requirements, as outlined in the City's Design Criteria and Construction Specifications, 2008 (City's Specifications). These requirements are summarized in **Table ES-3**.

Table ES-3 System Evaluation Criteria

Metric	Evaluation Criteria	Comments
Piping		
Pressure	70-100 pounds per square inch (psi)	
Velocity	< 5 feet per second (fps)	
Headloss	< 10 ft / 1,000 ft	
Minimum Main Size	8 inches	Not specified in the City's Specifications, City preference for future.
Maximum Inlet Pipe Headloss	6 inches	Not specified in the City's Specifications, but generally considered to be good practice.
Pumping		
Pumping Capacity	120% of peak hour	
Irrigation Window Assumed	10 hours / day	Not specified in the City's Specifications. For irrigation-only pumps, does not apply to transfer pumps.
Pump Station Layout	No standby pump, however low flow pump required	
Ponds		
Storage Volume	4 times peak day + losses	
Demands		
Daily Irrigation Application Rate	24 gallons per minute per acre (gpm/acre)	Peak season metric used in the design of irrigation systems per the City's Specifications. This value is appropriate for areas where the exact irrigated acreage is known but is not appropriate for planning-level estimates of bulk undeveloped land.

Table ES-4 summarizes the existing infrastructure and identified deficiencies by buildout. Typical deficiencies include a pump station being undersized by buildout, undersized inlet or outlet piping, or undersized taps.

Table ES-4 Summary of Existing System Analysis

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Balsam Park	N/A	290	51	51	No deficiencies were identified for this pump station.
Bella Romero Elementary	N/A	330	109	109	No deficiencies were identified for this pump station.
Bittersweet Park	N/A	1,000	854	**1,160**	Small diameter pipes may be producing high headloss; limited data is available on pipe sizes. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Boomerang	Boomerang North	1,500	769	769	No deficiencies were identified for this pump station.
	Boomerang South	1,500	694	0	This system is being replaced by the Boomerang Regional Pump Station.
	Boomerang Transfer	1,800	951	621	Some of the Boomerang transfer lines are undersized; this issue will be resolved by the construction of the Boomerang Regional Pump Station.
	Boomerang Regional Pump Station	*3,260*	*N/A*	*2,716*	*This new pump station is part of a larger redevelopment project and will replace the existing Boomerang South pump station. This pump station is identified as a CIP project.*
	North Ridge Transfer	1,800	936	936	No deficiencies were identified for this pump station.
	North Ridge School	2,700	1,205	1,752	No deficiencies were identified for this pump station.
	Poudre River Ranch	175	**205**	**205**	The lines to Poudre River Ranch and the pump station do not meet hydraulic design criteria but do not appear to hinder system performance. While there are no recommended changes, additional demand should not be added to this area without upsizing.
Cottonwood Park	N/A	115	69	69	No deficiencies were identified for this pump station.
Delta Park	N/A	95	52	52	No deficiencies were identified for this pump station.
East Memorial	N/A	319	314	**440**	Bringing on all potential undeveloped and conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
Glenmere Park	N/A	180	135	**304**	The inlet may be undersized; inlet pipe size data was not available for this system. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Greeley West Park[1]	N/A	2,000	72	861	No deficiencies were identified for this pump station.
Highland Hills Golf	N/A	2,001	1,792	1,792	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Island Grove and Saddle Club	Island Grove West	600	605	605	No deficiencies were identified for this pump station.
	Island Grove East	700	401	401	No deficiencies were identified for this pump station.
	Saddle Club	300	72	138	No deficiencies were identified for this pump station.
Jackson Field Sports	N/A	400	258	317	No deficiencies were identified for this pump station.
Josephine Jones Park	N/A	115	106	**161**	Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Linn Grove Cemetery	N/A	350	95	122	No deficiencies were identified for this pump station.
Luther Park	N/A	530	492	498	The small pipe diameter (4”) at the outlet does not meet hydraulic design criteria; while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Madison Elementary and Houston Gardens	Houston Gardens	125	**310**	**310**	While this system appears to be operating over the pump design capacity, it does not hinder system performance, as this system is designed for low pressures.
	Madison Elementary	500	90	93	No deficiencies were identified for this pump station.
Monfort	N/A	2,400	1,423	1,745	The inlet is slightly undersized (10” diameter); while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Peakview Park	Mosier Hill	800	681	681	The pipes at Peakview Park have a small diameter (as low as 4”) and do not meet hydraulic design criteria. Although this does not appear to significantly hinder system performance, the City may consider upsizing if other work is already being done in this area.
Promontory Park	Main	2,100	1,270	1,866	No deficiencies were identified for this pump station.
	Transfer	1,600	**1,651**	**1,651**	While this pump station sometimes operates over its design flowrate, it is not significant enough to warrant upsizing. If additional demands in this area increase transfer station operations, expanding the length of time the transfer station operates each day will likely maintain an acceptable flowrate.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Ramseier	N/A	450	**734**	**739**	Additional evaluation of this site is needed as outlet pipe size and SCADA data were not available. While current modeling shows that the system is operating over the design head, the peaking factor may be lower than the system-wide diurnal curve, resulting in lower peak demands.
Sanborn Park	N/A	500	268	289	Small diameter lines may be causing high headloss; limited data is available on pipe sizes.
St. Michaels	N/A	1,120	**1,121**	**1,167**	This pump station may be undersized. Additional evaluation should be conducted to determine if demand management is effective and whether the pumps can be upsized without replacing the entire station.
Tech Center	N/A	N/A	N/A	N/A	This area is currently only served by a shoulder tap. A pump station is necessary to transition it to NP irrigation (future service area SA-14).
Youth Sports Center	Youth Sports	1,200	941	941	The inlet line does not meet hydraulic design criteria but does not appear to hinder system performance. This line should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
	Twin Rivers Park	4,200	1,314	1,692	No deficiencies were identified for this pump station.

1 Greeley West Park is planned for replacement before 2025. The values shown in the table represent the design for the new pump station.

Table ES-5 summarizes anticipated future infrastructure through buildout. It is important to note that the majority of future infrastructure will be built by development as the City grows. Future infrastructure is expected to continue using a hub-and-spoke methodology, where future parks are equipped with ponds and pump stations to serve as the hubs of future NP systems.

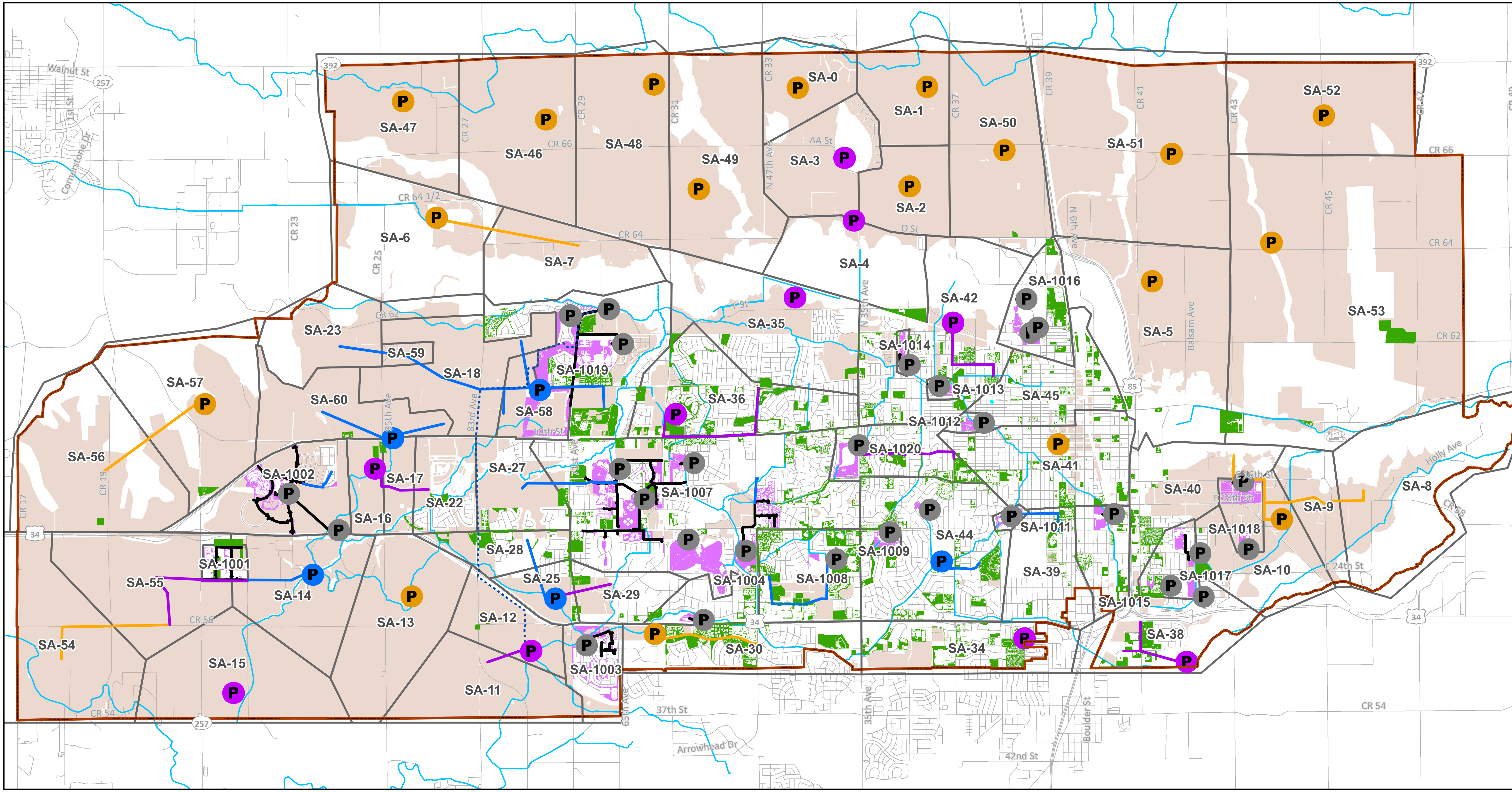
Table ES-5 Proposed Infrastructure by Planning Horizon

Planning Horizon	Pump Stations[1]	Storage in Ponds (AF)[2]	New Pipeline (ft) by Diameter					
			8-inch	10-inch	12-inch	16-inch	30-inch	Total
Existing	*37*	*Unknown*	*23,100*	*17,600*	*12,200*	*3,400 > 12"*		*90,000*
2025	5	35.1	21,800	18,500	0	19,000	26,700	86,000
2040	10	28.1	26,900	11,500	0	8,200	0	46,600
Buildout	18	75.7	28,300	1,000	200	14,800	0	44,300
Total New	33	139.0	77,000	31,000	200	42,000	26,700	150,200

1 All new pump stations are expected to have a pond.

2 AF = acre-feet

Figure ES-4 shows both the existing and future system by planning horizon. Pump station locations and pipeline alignments are approximate and schematic.



Legend

LREGA
Existing NP Irrigated Areas
Future NP Demand Parcels
Greeley Ditch
Existing Pump Station
2025 Pump Station
2040 Pump Station
Buildout Pump Station
Existing NP Pipes
2025 Proposed NP Pipes
2040 Proposed NP Pipes
Buildout Proposed NP Pipes
Upper Equalizer Project
Conversion Areas
Service Areas

N

0 0.5 1 2
Miles

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May 17, 2021

NP System by Planning Horizon

Figure ES-4

Greeley Non-Potable Water System Master Plan

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ES.6 Capital Improvement Plan Projects and Schedule

The opinion of probable construction cost (OPCC) is the anticipated bid cost of a capital project. The project CIP costs include the OPCC and project implementation costs, such as planning and design, administration, and construction management. Assumptions made during CIP development can add to the variability of final bid project costs when compared to the planning level costs. The assumptions are necessary to capture the costs for project elements that cannot be defined at a planning level. Project costs were developed using modeled pipeline quantity estimates and data, then multiplied by unit cost estimates. During design development, the more specific data will be used to inform the design and the resulting project cost estimate. **Table ES-6** provides a breakdown of the different costing factor assumptions used for project implementation and contingency.

Table ES-6 Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention[1]	2%
	Mobilization and Demobilization[1]	5%
	Contingency[2]	35%
Project Implementation[3]	Feasibility and Site Studies	9% for OPCC ≤ $1 million 6% for OPCC of $1 million to $10 million 5% for OPCC > $10 million
	Preliminary and Final Design	9% for OPCC ≤ $1 million6% for OPCC of $1M to $10 million5% for OPCC > $10 million
	Engineering Services During Construction	5%
Additional Project-Related Costs[3]	Outside Construction Management - not used if OPCC is < $1M	5%
	Outside Project Management - not used if OPCC value is < $1M	3%

[1] Construction costing factors for erosion control/stormwater pollution prevention, mobilization, and demobilization are added to the subtotal of unit cost items.

[2] Contingency is 35% of the subtotal of the unit cost items and contractor born costs determined by costing factors.

[3] Project implementation and additional project-related cost categories are determined as a percentage of the construction cost and part of the total CIP project costs.

ES.6.1 Identified CIP Projects

Table ES-7 summarizes the anticipated capital projects through the 5-year and 20-year planning horizons. Costs for some projects are shared proportionally across the City's water and sewer department, the City's parks department, and with development entities. The split shown in **Table ES-7** has been calculated from the anticipated total demands at buildout that each of these parties is responsible for. For each project these costs and splits will need to be refined during the development plan review process.

Table ES-7 Summary of CIP Projects

Projects	Funding Source[1]	Planning Start Year[2]	Design Start Year[2]	Construction Start Year[2]	Total Cost[3]	City of Greeley Water/Sewer	City of Greeley Parks	Development
5-Year Planning Horizon								
SA-44 Centennial Park	Service Expansion	W/S, Parks, Dev	2021	2022	$5,030,000	$3,488,100	$1,379,300	$162,600
Boomerang Regional Pump Station	Service Expansion	W/S, Parks, Dev	2021	2022	$6,920,000	$221,300	$694,000	$6,004,700
Boomerang Regional Phase 2	Service Expansion	W/S, Parks, Dev	2021	2022	$2,390,000	$76,400	$239,700	$2,073,900
Greeley West PS Replace	Service Expansion	W/S, Dev	2022	2023	$7,470,000	$6,161,400	-	$1,308,600
Upper Equalizer Project	Shoulder Season Extension	W/S	2023	2024	$25,620,000	$25,620,000	-	-
SA-14 Tech Center Supply	Service Expansion	W/S, Dev	2025	2026	$5,930,000	$17,100	-	$5,912,900
Promontory Park Expansion	Service Expansion	Development	2025	2026	$720,000	-	-	$720,000
Monfort Expansion	Service Expansion	W/S, Parks, Dev	2025	2026	$500,000	$245,300	$76,000	$178,700
Twin Rivers Expansion	Service Expansion	W/S, Parks, Dev	2025	2026	$2,390,000	$1,172,400	$363,300	$854,300
SA-38 1st Ave Pond	Service Expansion	W/S, Dev	2025	2026	$3,590,000	$2,881,600	-	$708,400
SA-25 Westgate Regional Pump Station	Service Expansion	W/S, Parks	2026	2027	$2,670,000	$2,038,415	$631,585	-
SA-25 Westgate Regional Phase 1	Service Expansion	Dev	2026	2027	$1,160,000	-	-	$1,160,000
SA-60 Lake Bluffs	Service Expansion	W/S, Dev	2026	2027	$6,050,000	$57,000	-	$5,993,000
				5-Year Subtotal	**$70,440,000**	**$41,979,015**	**$3,383,885**	**$25,077,100**
20-Year Planning Horizon								
SA-34 30th St/17th Ave	Service Expansion	W/S, Parks, Dev	2028	2029	$2,880,000	$1,932,500	$281,200	$666,300
Boomerang Regional Phase 3	Service Expansion	W/S, Parks, Dev	2029	2030	$8,000,000	$255,900	$802,300	$6,941,800
SA-4 35th Ave/O St	Service Expansion	W/S, Dev	2029	2030	$1,170,000	$262,400	-	$907,600
SA-3 35th Ave/AA St	Service Expansion	Development	2030	2031	$2,190,000	-	-	$2,190,000
Bittersweet Park Expansion	Service Expansion	W/S, Parks, Dev	2030	2031	$3,160,000	$2,475,181	$684,819	-
SA-35 44th Ave/F St	Service Expansion	W/S, Parks, Dev	2031	2032	$2,580,000	$166,000	$658,300	$1,755,700
SA-36 59th Ave/10th St	Service Expansion	W/S, Parks, Dev	2032	2033	$8,190,000	$3,810,800	$2,569,500	$1,809,700
SA-16 95th Ave/16th St	Service Expansion	W/S, Dev	2035	2036	$5,260,000	$205,300	$610,300	$4,444,400
SA-14 Tech Center Expansion	Service Expansion	W/S, Parks, Dev	2036	2037	$3,460,000	$10,000	-	$3,450,000

Projects	Funding Source[1]	Planning Start Year[2]	Design Start Year[2]	Construction Start Year[2]	Total Cost[3]	City of Greeley Water/Sewer	City of Greeley Parks	Development
SA-15 37th St/SH-257 Pump Station	Service Expansion	W/S, Dev	2037	2038	$3,880,000	-	-	$3,880,000
SA-12 Cobblestone Regional	Service Expansion	Development	2038	2039	$4,260,000	$48,500	-	$4,211,500
Glenmere Park Expansion	Service Expansion	W/S, Parks, Dev	2038	2039	$2,200,000	$1,427,916	$603,228	$168,856
SA-25 Westgate Regional Phase 2	Service Expansion	W/S, Dev	2039	2040	$1,220,000	$857,400	-	$362,600
SA-42 23rd Ave/NW C St	Service Expansion	W/S, Parks, Dev	2040	2041	$6,030,000	$2,513,300	$1,421,100	$2,095,600
				20-Year Subtotal	**$54,480,000**	**$13,965,198**	**$7,630,746**	**$32,884,056**
				Total	**$124,920,000**	**$55,944,212**	**$11,014,631**	**$57,961,156**

August 2020 dollars as adjusted by Engineering News Record Cost Construction Index (ENR-CCI) were used for project OPCCs, total costs, and project fund allocations

[1] W/S: City of Greeley Water and Sewer Department, Parks: City of Greeley Parks Department, Dev: Development

[2] Project planning, design, and construction years are subject to change pending future project updates, development of projects, and/or schedule changes.

[3] OPCC and total costs per project are subject to change pending future project updates, development of projects, and/or schedule changes.

ES.6.2 CIP Implementation Schedule

The CIP schedule implementation process considered several factors that influence a project schedule in addition to the hydraulic evaluation. The City provided the Water and Sewer 10-year CIP, public works CIP, and parks CIP to integrate with projects identified in the WTDMP for developing CIP implementation schedules.

The growth-driven projects will be funded by either the City or developer (or combination), depending on the project driver. Based on the 5- and 20-year CIP schedule, annual funding requirements for City NP projects from 2021 through 2040 are shown in **Figure ES-5**.

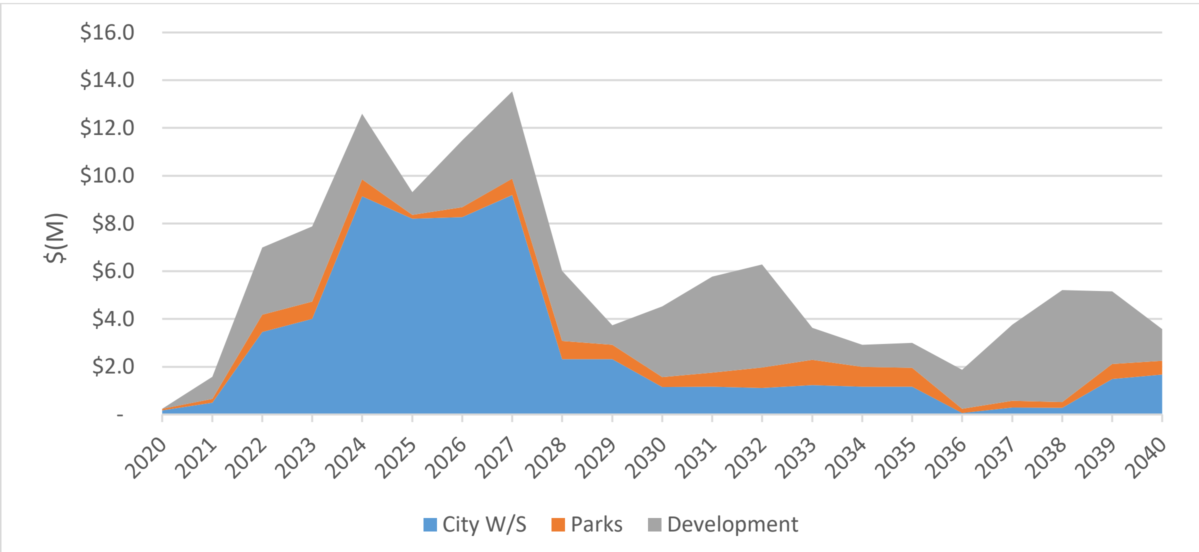

Figure ES-5 Annual NP Funding Projections by Fund

CIP costs are August 2020 dollars from ENR-CCI.

ES.7 Conservatism and Uncertainty in Planning

During master plan development, assumptions were made for existing and future conditions. These included population distribution and flow factors to develop water demand projections for growth and development under future conditions, along with considerations for extreme seasonal conditions that would emphasize higher demands while considering future water conservation planning to help reduce these impacts. The master planning assumptions trended toward conservative values to ensure the potable system was not undersized, which may result in the predicted demands being higher than actual. This NPMP analyzes the existing system and defines future needs, which should be validated by the City as new data becomes available.

The NP water system model, in conjunction with its potable water system companion model, is a tool for analyzing the existing system and defining future capacity needs. Detailed planning and timing of development will inevitably vary from the best planning projections and will result in the need to review areas where the model indicates system deficiencies.

Additional uncertainty can occur during the development of the CIP and, as a result, conservative planning assumptions are used. Planning level cost development considers the major categories of capital projects but does not include the additional detail available during the preliminary and final design stages of projects. The CIP was developed based on anticipated growth, modeling results, and planning information and is subject to change if the planning information and forecasts shift over time. Prior to COVID-19, a global pandemic, cost inflation tools provided high confidence for predicting unit prices within a given year. However, during and after COVID-19, these cost inflation tools may not be as accurate.

ES.8 Key Findings and Recommendations

The findings and recommendations summarized in this section have been drawn from the planning and evaluation sections of this NPMP. The recommendations identify system needs, actions, and capital improvements through the buildout planning horizon; however, the actual implementation time frame will depend on actual growth rates, order of development, and the level of available capital funding. Additionally, the actual scope and implementation of these recommendations may vary with detailed planning and design.

ES.8.1 Key Findings

Key findings identified as part of the NPMP include the following:

- Discussions with other Front Range stakeholders showed that the City has a unique and advanced NP irrigation system, particularly for raw water suppliers.
- Historically, comprehensive data collection has been difficult for the NP system. Additional studies or data collection, along with more standardized record keeping practices, can help the City keep track of the overall system. Record keeping practices could include recording ditch laterals in GIS, updating and enforcing construction drawing standards, creating a system for regularly updating the NP GIS database, and/or installing SCADA systems.
- Review of historical demands showed that NP usage varied significantly on an annual basis. In particular, demand dropped significantly when parks began the transition process to improved control systems. Future NP demands are expected to come from two sources: 1) undeveloped lands that will use NP irrigation when they develop, and 2) existing areas that will convert to NP irrigation, defined as conversion areas. NP peak season demands are expected to increase by 1.1 million gallons per day (MGD) by 2025, 2.8 MGD by 2040, and 11.5 MGD by buildout. NP adoption is strongly influenced by policy, which is a key step for promoting conservation.
- Some of the existing systems were identified as needing improvement, but no critical deficiencies were identified. These include areas that are expected to have undersized inlet lines, pipes, taps, or pumps by buildout.
- New recommended CIP projects were identified. These primarily consist of new pump stations or expansions of existing pipe systems to serve new areas and customers. New pump stations will be primarily constructed by developers. It is estimated that the system will need 4 new pump stations by 2025, 12 new pump stations between 2025 and 2040, and 19 new pump stations between 2040 and buildout.

ES.8.2 Recommendations

The recommendations for the NPMP include the following:

- Implement and enforce an NP policy to promote and expand NP irrigation practices. It is recommended for this policy to mandate that new developments and redevelopments use NP irrigation and for the policy to generally encourage the growth of the NP system.

- Implement improved operational practices at existing pump stations as it becomes necessary. Also implement improved operational practices during other construction, such as rehabilitating a park irrigation system. Improved operational practices can include items such as increasing the watering window to reduce peak hour demands by decreasing the size of irrigation zones and implementing SCADA where not currently installed. It is recommended for customers to use a watering window of 10 hours a day, where possible, and to use the best landscaping practices included in **Appendix F**.

- Create new standards for data collection and record keeping. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regularly updating the GIS database, and/or implementing a CMMS for NP infrastructure. It is also recommended that the City conducts a study of ditches and laterals throughout the LREGA and requires developers to include this data in their plans.

- Implement and enforce requirements for the installation of SCADA systems at new or rebuilt pump stations. The City may consider including SCADA requirements in the City's Specifications.

- Continue monitoring and recording demands and pump station flows to identify major changes in operations that may impact system performance.

- Evaluate the St. Michaels pump station to determine whether additional construction is needed at this site to meet higher demands. This evaluation should determine whether demand management could be an effective solution, and whether the pumps can be upsized without replacing the entire pump station.

- Continue maintenance of the InfoWater model. This can include adding new pipes, deleting abandoned pipes, tracking open and closed valves, and reflecting operational changes as the system continues to expand.

- Coordinate this NPMP with other relevant planning documents, such as the WTDMP, SSMP, *Imagine Greeley Comprehensive Plan*, and BBC report. It is recommended to use this NPMP as a guide for infrastructure planning, and to use the BBC report as a guide for water resources planning.

- Continue building the NP system through a hub-and-spoke methodology, as defined earlier. Consider looping or connecting systems where systems are on similar hydraulic grade lines, as looping would improve operational flexibility.

- In areas with limited or interim development, require the construction of NP infrastructure, such as a piped irrigation system, even if a pump station will not be constructed until a later time.
- New pipe and pump station layouts are conceptual in nature and are primarily intended to show hydraulic feasibility for master planning purposes. Conduct a detailed evaluation of pipe alignment and size as well as pump station location and sizing as projects move into design and implementation stages when there is more certainty of development and design criteria. The InfoWater model, if regularly maintained, can be used as a tool to support future planning decisions.
- Complete the capital improvements recommended in **Section 6**, prioritizing the 5-year CIP recommended projects. Coordinate closely with the City's parks department, other utilities, and developers to regularly update the scheduling of these projects. The City should consider using the InfoWater model as a tool to inform developer plans while coordinating with them.
- Update the NPMP every 5 years, including reevaluating demand and population projections every 5 to 10 years. Planning assumptions made for the NP system in the next 20 years and beyond are subject to change with time.

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Section 1

Background Information and Project Purpose

Reliance on NP irrigation and improved irrigation practices is a key part of the City's water conservation plan. The NPMP covered in this report will help the City provide untreated irrigation water to large turf areas, which will help preserve potable water for other uses, reduce treatment costs for the City's water and sewer department, and lower irrigation costs for customers. This master plan update documents the approach and assumptions used to evaluate the system while defining the capital improvements needed for the long-range CIP for the NP system through the year 2040. To plan for the future NP needs of the City, background information was first collected on the historic and current NP water system and is described further below.

1.1 Master Planning Process and Organization

The NPMP was developed in conjunction with the City's SSMP and WTDMP. The City integrated the three master plans, creating a consistent approach to determining existing and future population and water demands and to defining capital projects and costs. A schematic of the City's integrated water system for water, wastewater, and non-potable water is shown in **Figure 1-1**.

Figure 1-1 Greeley's Integrated Water System

The future population projections and associated water demand, planning horizons, and approach to capital and project cost development are consistent between the three master plans, as shown in **Figure 1-2**. This figure also shows the critical points of coordination between the three master plans.

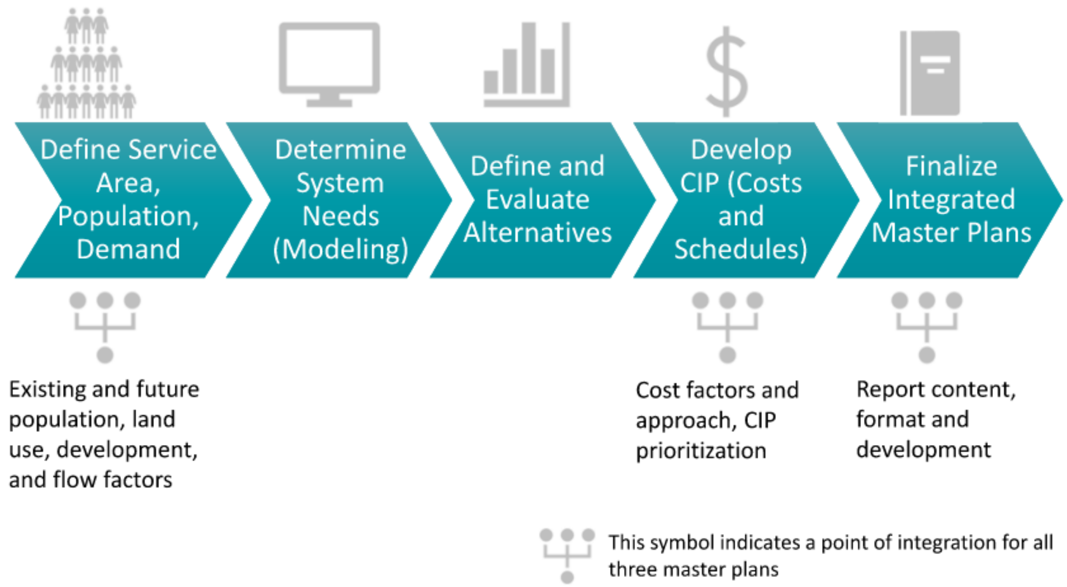

Figure 1-2 Master Plan Approach and Integration with other Master Plans

1.1.1 Report Organization

The NPMP is organized into the following sections:

- Section 1 – Background Information and Project Purpose
- Section 2 – Administrative Considerations
- Section 3 – Demand and Economics
- Section 4 – Development of the Non-Potable System Model
- Section 5 – Existing and Future System Model Evaluation
- Section 6 – Capital Improvement Plan
- Section 7 – Findings and Recommendations

1.2 Review of Existing Data and System

Before any other data gathering was initiated, information on the existing system was collected from the City files. This information primarily came from the two former NPMPs (dated 2002 and 2004), which provided overarching views of the City's goals, strategies, and specific plans for the NP system. These plans analyzed the then current and potential sources of supply and demand, established design and costing criteria for future projects, and examined options for the use of surplus NP water.

Part of the review of the existing system involved examining the records of existing infrastructure and construction projects. This data was checked by field visits and incorporated into the GIS. A new NP tagging and naming convention based on the City's standard naming scheme was established and will be used to describe the existing and future infrastructure. This naming system is included in **Appendix B**.

In general, the City's NP system operates using a "hub-and-spoke" approach, where a pump station (the hub) serves the irrigated areas (the spokes) without any connections to other pump stations or NP systems. Each of the individual systems has a unique setup, as described in **Section 4.1**. A typical NP system is shown in **Figure 1-3**. However, each individual system may differ in whether it pulls from a ditch or well, whether there is an intermediary pond, and how many pumps it has. Detailed descriptions of each system are included in **Table 4-1** and a map of all pump stations is included in **Figure 1-4**.

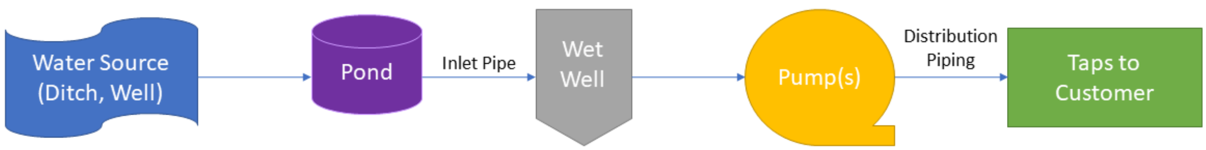

Figure 1-3 Typical NP System Schematic

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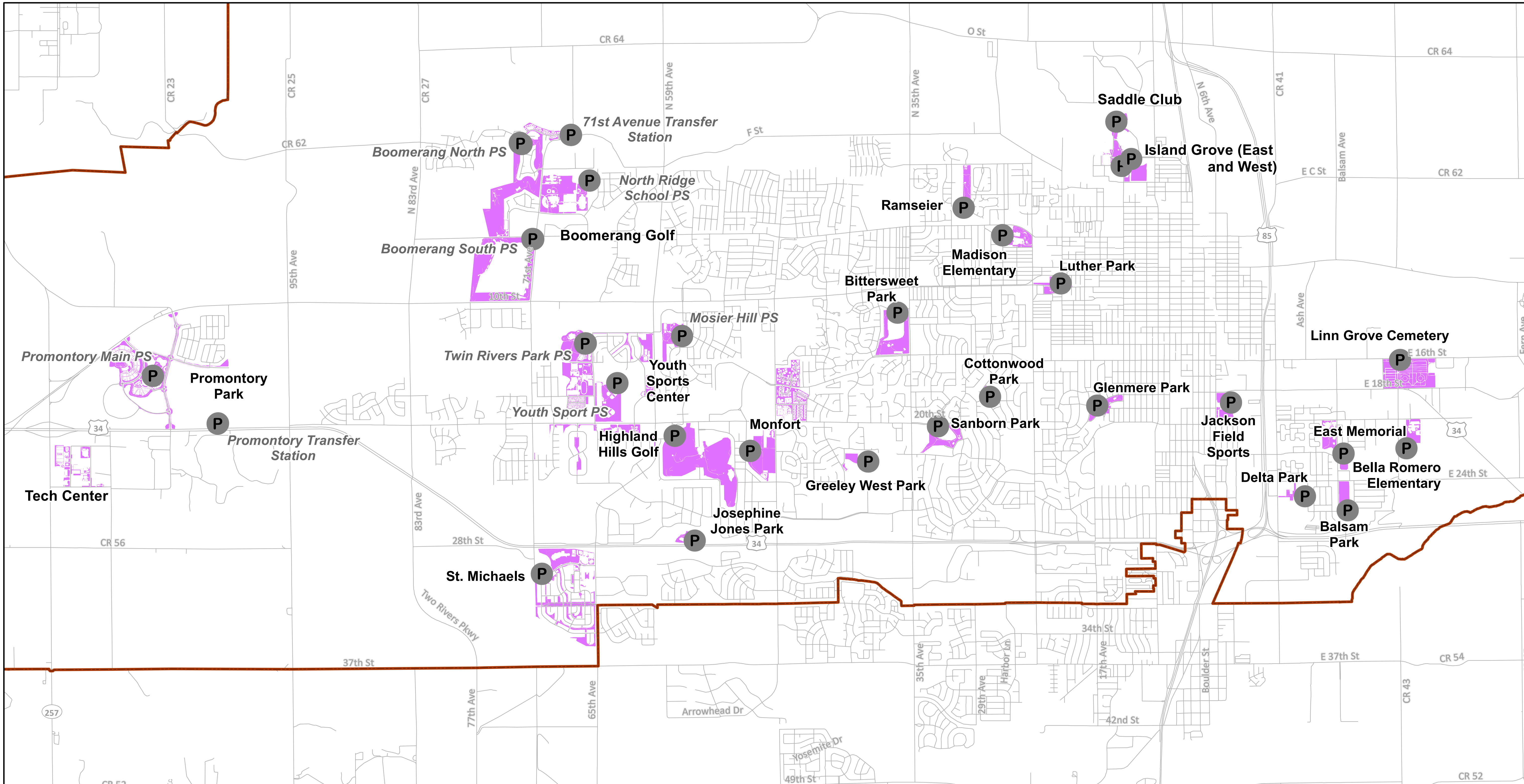

Legend

- LREGA
- P Pump Station
- Existing NP Irrigated Areas

N

0 0.5 1 2
Miles

May 17, 2021

Existing Non-Potable Service Areas

Figure 1-4

Greeley Non-Potable Water System Master Plan

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1.3 Field Visit Data

Field data was collected at each site and locations and elevations of features were recorded using a global positioning system (GPS) unit (Trimble Geo 7x). The GPS unit is accurate within a meter of the exact location. Along with the spatial data, specific operational information for each component was also recorded, as well as any of the operators' background knowledge on the specific item. Major system components visited included pump stations, meters, valves, wells, head gates, and storage ponds. For the pump stations, information that was collected included the number of pumps, the model numbers of the pumps and motors, the operating speed, the visual condition of the equipment, and the condition of the pump house. The unique meter number for each meter was also recorded, along with the transmitter number and diameter of the meter piping. The location and elevation of each valve was taken, and a note was made if the valve was equipped with a powered actuator. Notes were taken detailing the control logic for all actuating valves inventoried. The breakdown of components can be found in **Appendix A**. This information was compiled into a single database spreadsheet and used to update the NP GIS database.

1.4 GIS Mapping and System Inventory

Previously existing GIS data contained spatial locations for both point and linear NP water infrastructure. The point data included wells, pump stations, meters and valves. NP lines, ditches and irrigation areas were all contained in the linear data. Within the attribute table of each shapefile, there is additional information corresponding to each individual component within that infrastructure category. This information is summarized in **Table 1-1**.

Table 1-1 Previously Existing GIS Information

Type of Information	Number of Features	Relevant Attributes
Wells	51	Location, Type of well
NP pump stations	37	Names, Approximate addresses (incomplete)
NP meters	73	Customer number, Transmitter number, Meter number, Approximate addresses (incomplete)
Valves	383	Type of valve, R angle
NP irrigation areas	42	Name of well that supplies the area, Surface area
NP pipes	563	Length, Material, Installation year, Diameter
NP ditches	66	Name, Length, Above or below ground

Review of the GIS data with the operations team revealed that much of this information was either incomplete or out-of-date, especially the wells, ditches, and NP irrigation areas. The data from the field inventory was used for the wells, pump stations, and valves. The GIS data did not include a ponds shapefile; instead, information on ponds was included from the field data or historical documents and drawings. For the pump stations that were not included in the original GIS data, the data from the field inventory or historic documents was used. The NP GIS system should continue to be updated and maintained in the future. The NP pipelines are summarized by diameter in **Table 1-2**.

CDM Smith

Table 1-2 Non-Potable Pipe Lengths from City GIS Data

Pipe Diameter (in)	Total Length (ft)
0 (Blank) [1]	4,296
1	17
2	4,022
3	739
4	5,114
6	19,515
8	23,094
10	17,616
12	12,238
14	706
15	370
18	2,106
20	140
24	49
Total	**90,022**

[1] Pipes with no diameter were reconciled as part of model connectivity updates, described in **Section 4.1.1**.

Review of the NP pipelines shapefile showed that the file was not fully representative of the current system. This shapefile was updated extensively to support model connectivity and an updated shapefile was provided to the City. The following assumptions and key fixes were used to support connectivity:

- Pipes that were within 3 feet of another feature, such as collected field data, were rerouted to connect through that point.
- Pipes without a diameter were assigned a diameter based on design drawings or the diameter of connected features, such as pumps or valves.
- Areas with other NP infrastructure, but no pipes, had pipes added based on design drawings, City operator knowledge, or typical layouts for NP pump stations.
- Two-inch lines were drawn from main lines to meters where relevant.
- Topology checks were used to reconcile pipes that were not connected to each other, identify duplicate features, etc.

Operations and Maintenance (O&M) data for each pump station, as available, was also reviewed. This included original constructions documents, O&M manuals (including pump curves), equipment details, photos of the site, and other historical information. Some of this data was outdated and reflected historic construction, not current conditions. The data provided also contained discrepancies and gaps, due to obsolete data mixed with current data. The data was further reviewed in team meetings to ensure that a comprehensive and accurate understanding of the system was being incorporated into the model.

Additionally, hourly SCADA data was used for the past five years (September 2015 to September 2020) to evaluate the accuracy of the model of the existing NP system and to create diurnal curves that reflect current system usage. SCADA data was not available for all sites. **Table 2-5** includes a list of available SCADA data collected by location.

1.5 Zoning and Land Use Information

Current and planned land use and zoning data in GIS format, along with maps of zoning and land use available through previous master plans, was used to map existing NP customers and irrigation areas, and to identify potential new customers, such as parks, golf courses, and cemeteries.

Additional sources of information included planned unit development reports, a revised version of Greeley's Comprehensive Plan map, as well as other information developed in conjunction with the City's planning department as a part of the water and sewer master plans that contained detailed land use information. This information was used to develop future potable water and sewer demands, which are the basis for the development of future NP demands.

Parks represent a crucial existing and future demand, so the 2016 Parks, Trails, and Open Lands Master Plan was used to address future park demands. This master plan provides information on current parks, as well as park service goals and potential locations for future parks. These details were used to establish park demands for the future planning scenarios.

Current potable water customers were evaluated to determine areas that would be suitable for conversion to NP irrigation. These areas, referred to as conversion areas, were provided on three shapefiles and two PDF maps that showed the names of many of the systems. Conversion areas are discussed in **Section 3** of this report.

The City's NP water system currently serves several areas of varying land use, which includes residential areas, golf courses, parks, and schools with a combined total irrigation area of 890 acres. The current irrigation areas, including areas that are irrigated by private systems, can be seen in **Figure 1-5**. Private systems were not addressed as part of the master plan, as the master plan focused solely on City-owned infrastructure.

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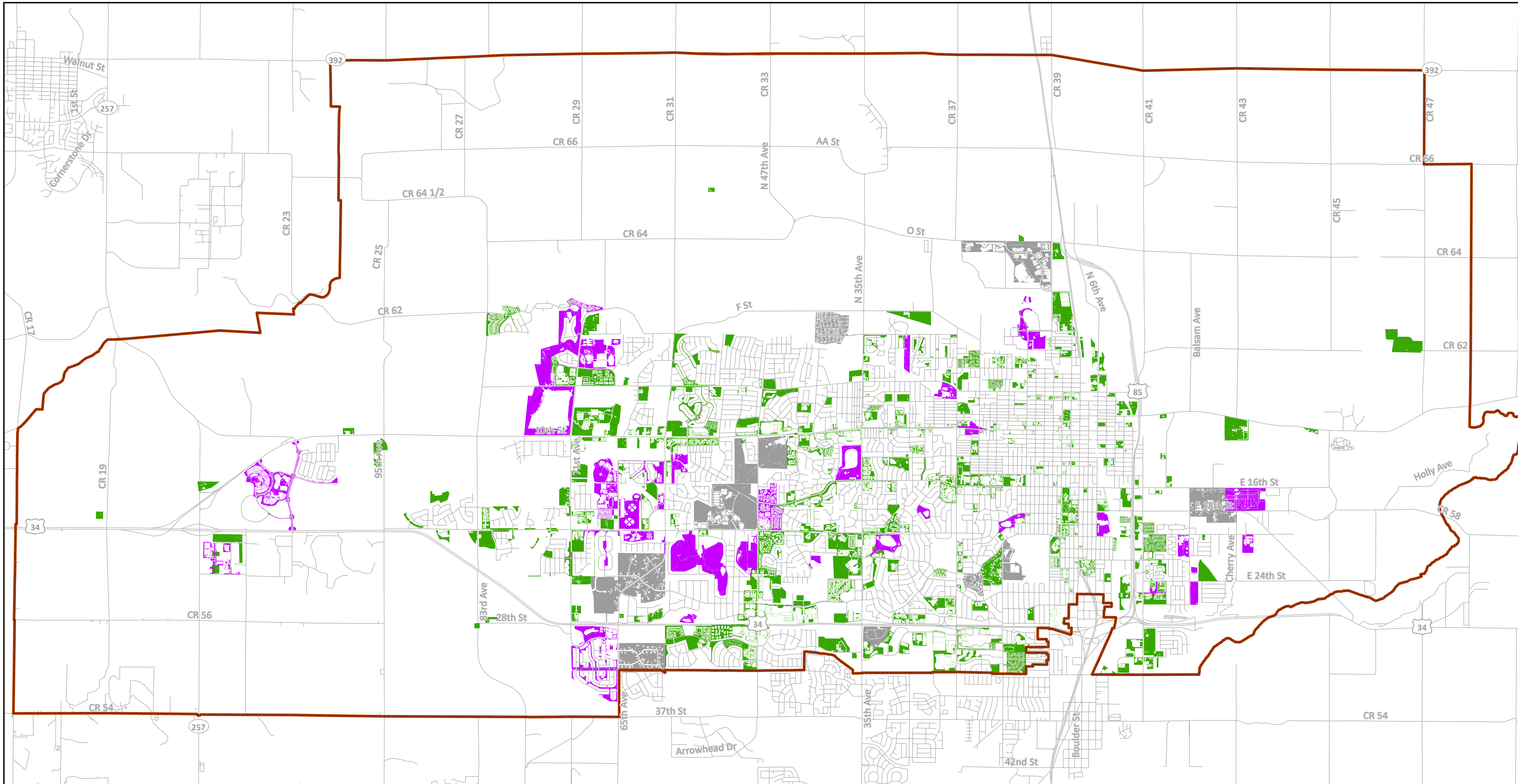

Legend

- Long-Range Expected Growth Area (LREGA)
- Existing NP Irrigated Areas
- Private NP Systems
- Conversion Areas

N

0 0.5 1 2

Miles

February 22, 2021

Non-Potable Water
Master Plan Area

Figure 1-5

Greeley Non-Potable Water System Master Plan

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1.6 Review of Supply and Demand

To determine reasonable expectations for supply and demand projections, historic projections were examined. The BBC report was also considered for supply and demand projections. The BBC report projects the NP water demand for an assumed buildout year of 2065 under three scenarios: low, middle, and high. As noted in the report, the middle projection represents the most likely demand scenario. Notably, the middle scenario for total water consumption produces the highest NP consumption. The BBC report included total projected demand at five-year increments, as well as the likely adoption rates per customer type. The results of the NP water demand projections from the BBC report are summarized in **Figure 1-6**.

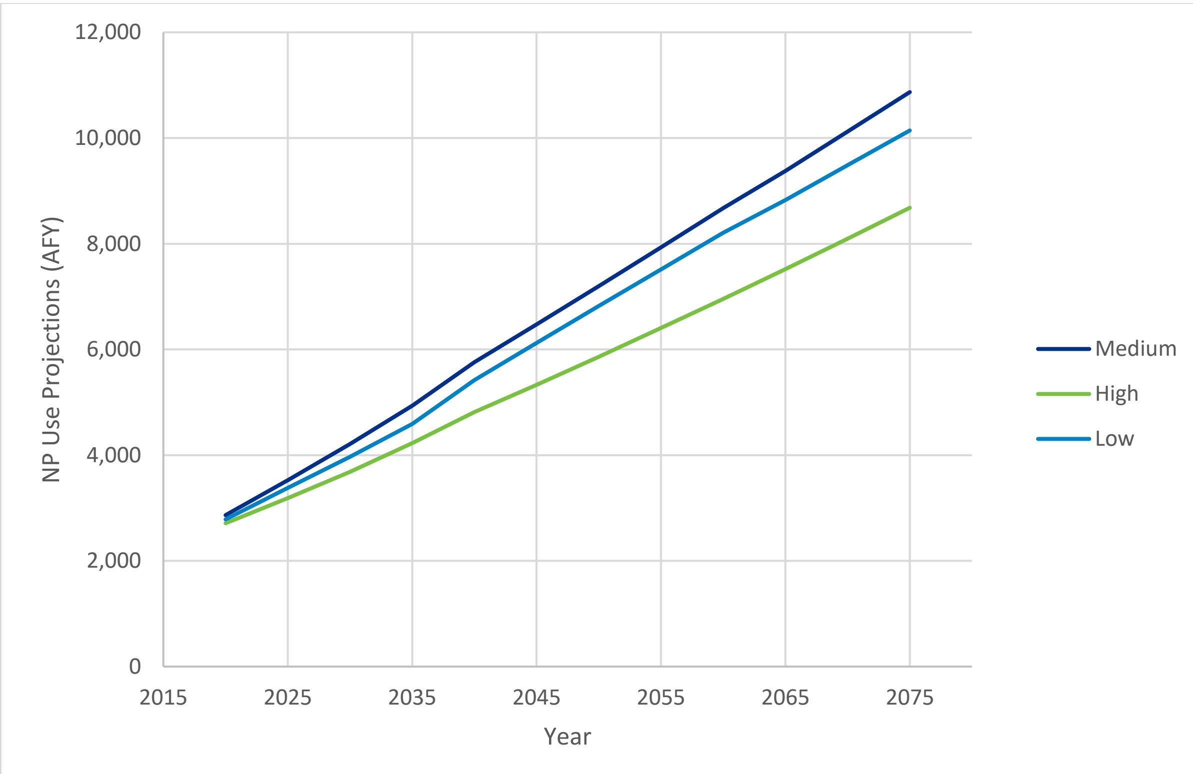

Figure 1-6 Non-Potable Use Projections (BBC Report, 2018)

To determine the actual NP water demand, the most recent water billing data was used. Billing data provided monthly demands from 2014 through 2019. The analysis of the provided data revealed a significant annual variation in demands, as shown in **Figure 1-7**. This annual variation could be due to changes in the City's irrigation control systems which significantly improved irrigation efficiency, especially in parks. As a result, only 2018 and 2019 billing data was used for the development of the models.

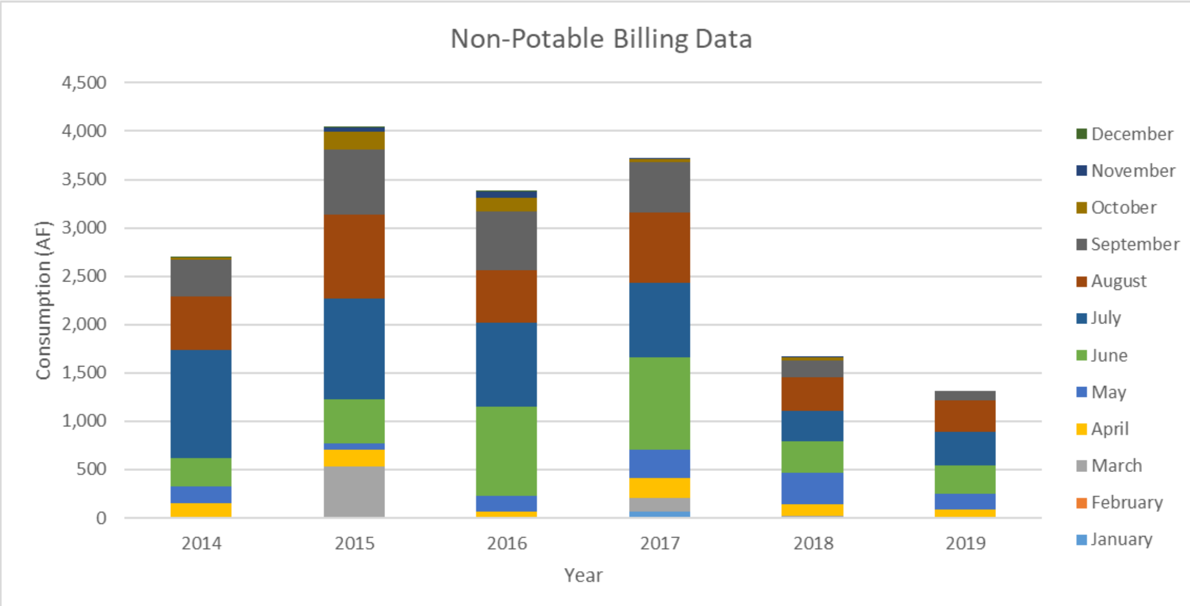

Figure 1-7 Non-Potable Demands (Billing Data)

The billing data was used to project NP demands through buildout. The demand that cannot be supplied by current NP infrastructure helped determine the necessary projects for the CIP. NP water demands were allocated with greater detail and are described further in **Section 3** of this report.

1.7 Costing

Data was collected for the pricing of CIP projects from several sources. This data was consistent across all three master plans. These sources included previous City bid tabs, City CIP databases (such as Greeley's CIP database for water, wastewater, and NP water projects), bid tabs from past CDM Smith projects along the Front Range and in Texas, as well as a consultant project cost estimator. Incorporating multiple data sources makes typical unit costs more robust. Analysis and selection of these line item unit costs are covered in **Section 6** of this report.

In the future, the City may consider mandating NP irrigation for new developments based on economic feasibility, and/or subsidizing NP infrastructure to make it economically feasible. Because of this, City policy could have a large impact on NP adoption. The City provided its draft policy, which was used as a basis for economic considerations. As of writing, the final policy has not been approved by the Water and Sewer Board. As a result, revisions to the draft policy may affect economic feasibility calculations. The final policy is attached in **Appendix K**.

1.8 Ongoing Projects

There are two ongoing projects considered in the NPMP: the Poudre Ponds Complex Project (Poudre Ponds) and the Upper Equalizer project. The information on both these projects is based on the 2016 City of Greeley Non-Potable Water Supply Upper Equalizer Infrastructure Feasibility Study. The Poudre Ponds project is also studied in greater depth in the 2021 Poudre Ponds

Reclamation and Restoration Improvements Project Mini Master Plan, which evaluated plans based on 2030 and 2065 demand scenarios.

The Poudre Ponds project seeks to expand an existing storage site by constructing a gravel pit pond and pump station on a newly acquired parcel. Project goals include improving water supply reliability, NP storage, and community assets via site enhancements for wildlife and recreation. This new pump station will convey 23 cubic feet per second (cfs) to the Greeley No. 3 Ditch or 27 cfs to the Poudre River, returning water back to its source as part of a water rights exchange.

The Upper Equalizer project seeks to expand an existing NP pump station, which currently provides irrigation to a golf course and high school. This project will transfer 31 cfs peak flow from the Greeley No. 3 Ditch to the Greeley-Loveland Irrigation Company (GLIC), which is 4 miles away, with about 200 feet in elevation gain. As 71st Avenue was paved since the writing of the feasibility report, the routing of the pipeline was changed to 83rd Avenue. The NPMP was coordinated with the ongoing design as available and the 31 cfs transfer was incorporated into the plan.

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Section 2

Administrative Considerations

In addition to the infrastructure construction and expansion, certain administrative improvements can help the City continue to grow its NP system and act as a leader in water conservation along the Front Range. This section describes recommendations related to policy, operations, monitoring, and data collection.

2.1 Stakeholder Engagement

Stakeholder engagement efforts were conducted with several local communities and municipalities in the Front Range to identify current system practices, user trends, planning recommendations, and economic considerations surrounding design and expansion of NP systems. These included the City of Westminster, Denver Water, the City of Evans, and the Town of Windsor. Through this process, it was discovered that the City's current NP system is more developed than many other surrounding raw-water suppliers.

Discussion topics during these meetings included factors for site selection, best practices for NP implementation, and potential challenges of NP use. Considerations for site selection include picking high acreage areas with a preference for larger customers, limitations based on pressure zones, economics (cost savings associated with cheaper irrigation water compared to potable), land use/zoning laws, and regulations regarding water reuse. Common best practices include the use of design standards to regulate construction, irrigating at night, use of subsidies to encourage implementation, and NP promotion through sustainability campaigns. Potential challenges with operating an NP system include the variability of supply of reuse water (raw water is less variable), water quality impacts on the distribution system and vegetation, additional education and focus on public perception, more training required for employees, and higher cost of treating NP water for communities that use potable reuse.

2.2 NP Policy Considerations

Modeling considerations and factors used for the hydraulic modeling of existing and future systems were developed with consideration of the City's current NP water supply policies. The City is currently working on drafting a policy related to NP adoption and standards. Policy-related decisions are a large driving force behind NP adoption, conversion, and expansion, and are a key part of the City's water resources conservation strategy. The NPMP is based on a draft version of the policy, and certain assumptions used throughout may be subject to change, depending on the final version. The following are key points to note from the draft policy and recommendations for the final policy:

- The final policy should mandate NP irrigation for new developments and redevelopments where technically and economically feasible. Mandating and enforcing NP irrigation will help promote sustainability for the potable water system and avoid unnecessary upsizing.

- The City should develop NP water rates based on a cost-of-service study to incentivize NP adoption by reducing the price of NP water compared to potable water.
- Growth should pay for growth. The policy should clarify how new developers participate in the construction of new NP infrastructure.
- Large users should be required to plan for at least an 8-hour watering window. The policy should clarify when this is required and should encourage users to use an even larger watering window, to reduce peak hour demands on NP infrastructure.
- The policy should require new developments to construct NP infrastructure, such as separate irrigation pipelines, even if an NP pump station will not be available until after construction is complete. Information should be included on when and how the City's water and sewer department will pay to upsize infrastructure to accommodate future demands.
- The City should develop an impact fee structure that encourages NP adoption and allows for City investment in upsizing the NP system to be repaid in the future.

2.3 Improved Operational Practices

The existing systems are operated efficiently and proactively. The pump stations are rebuilt on a timed cycle and maintenance is performed annually over the winter. The field inspection confirmed that the systems look and are reported to be well maintained and operated.

As the system expands in the future, some operational practices may need to be modified to expand with the system. Some improvements that would help minimize the operational needs of the future system may include:

- Improved SCADA control and monitoring. Generally, sites must be physically visited to monitor pond levels and check for operational issues. Improved SCADA could allow remote monitoring and automatic control of some processes allowing existing staff to operate additional sites. A suggested "default" SCADA system is listed in the next section.
- Implementing a CMMS to improve data and optimize maintenance activities. Adding NP infrastructure to an existing City CMMS will be considered in the future.
- The following systems have high peaking factors, or very high variability, which means the pump stations are limited by maximum flow but only operate for a short irrigation window. These systems could benefit from a longer watering window which would free up capacity for additional demands. Note that lengthening the water window in some cases may only require reprogramming the irrigation controller, but in many cases may require dividing the irrigation system into additional zones. Therefore, these modifications are likely best accomplished during major irrigation system maintenance or replacement. These systems include the following:
    - Mosier Hill (extremely varied)
    - Bittersweet Park

- Madison Elementary
- Saddle Club (extremely varied)
- Luther Park (extremely varied)
- Island Grove West
- Island Grove East
- Twin Rivers Park
- North Ridge School

2.4 Improved Monitoring Systems and Practices

The current NP system includes basic SCADA status communication. Each pump station is controlled by a vendor provided and programmed “island” programmable logic controller (PLC) that monitors pressure and flow. The PLC also monitors station health and protects the pumps from operating outside of safe ranges. Each station has a radio telemetry unit (RTU) that communicates limited status and data. **Table 2-1** summarizes the available data from each of the existing stations. Ultimately, it is recommended for the City to include SCADA for all existing and future pump stations, and eventually add ditch measurements and controls to the SCADA.

Table 2-1 Available SCADA Data from Existing Systems

Service Area	Pump Station	Flow	Pressure	Wet Well Level	Influent Flow
Promontory Park	Main	X	X	X	
	Transfer	X	X	X	
Greeley West Park	N/A				
St. Michaels	N/A	X	X	X	
Boomerang Golf	Boomerang North				
	Boomerang South				
	Boomerang Transfer	X	X		
	North Ridge Transfer	X			
	North Ridge School	X	X	X	
	Poudre River Ranch	X	X		
Youth Sports Center	Youth Sports	X	X	X	
	Twin Rivers Park	X	X	X	
Highland Hills Golf	N/A	X			
Josephine Jones Park	N/A				
Peakview Park	N/A	X	X	X	
Monfort	N/A	X	X	X	
Sanborn Park	N/A				
Cottonwood Park	N/A				
Bittersweet Park	N/A	X	X	X	
Ramseier	N/A	X	X	X	

Service Area	Pump Station	Flow	Pressure	Wet Well Level	Influent Flow
Madison Elementary and Houston Gardens	Madison Elementary	X	X		
	Houston Gardens	X	X		
Luther Park	N/A	X	X		
Glenmere Park	N/A				
Jackson Field Sports	N/A	X	X	X	
Delta Park	N/A	X			
Balsam Park	N/A	X			
East Memorial	N/A	X	X	X	
Bella Romero Elementary	N/A	X	X		
Linn Grove Cemetery	N/A				
Stoney Brook	N/A	X			
Poudre Ponds	N/A	X	X	X	X
Island Grove and Saddle Club	Island Grove West	X	X	X	
	Island Grove East	X	X	X	
	Saddle Club	X	X		

As existing pump stations are replaced and new pump stations are installed, a unified approach to SCADA communication should be followed to allow for future operations flexibility.

Newly installed or replaced stations should be capable of using the City's preferred Modbus TCP/IP communication protocol. It is anticipated that over time the City's fiber network (or at least broadband) will be extended to all pump stations. Broadband network connectivity will allow both data-rich SCADA, as well as the implementation of monitoring and security systems at each site. Alarms should be capable of custom alarm priorities and call-outs. Generally, any status or control available on the local operator interface should be accessible via SCADA. At a minimum, the datapoints for new equipment should include:

- Status to SCADA
  - Mode (local/off/remote)
  - Running (each pump)
  - Motor speed (each pump)
  - Setpoints (pressure, flow)
  - Station flow
  - Station pressure
  - Wet well level
  - Filter flush

- Alarms
  - All alarms available on the vendor package
  - Fault monitoring
  - Power monitoring
  - Communication lost (outside of vendor package, network side)
  - Intrusion (outside of vendor package)
  - Space temperature (may be outside of vendor package)
  - Smoke/fire (outside of vendor package)

- Control from SCADA
  - Mode (in auto)
  - Run
  - Percent speed
  - Setpoints (pressure, flow)
  - Filter flush interval

In some locations, additional information such as ditch level, pond level, headgate position, or other datapoints may be desirable for remote monitoring and operation.

The overall control philosophy will continue to be stations operated in "island" mode, with the local PLC controlling the system to maintain the operational setpoint and protect equipment. In the future, the capability should be retained for SCADA control and orchestration of multiple pump stations, while the local PLC continues to provide equipment protection.

2.5 Data Collection and Record-Keeping

Historically, comprehensive data collection has often been difficult or impossible for distributed NP systems that were built by multiple parties. However, the City's unique and advanced system calls for improved data collection and record-keeping practices to be implemented. Master planning efforts revealed certain gaps in data that could be remedied with further studies. The following recommendations may help the City to efficiently keep track of its system, pass on important knowledge and history to future employees, and fill in missing datasets:

- Conduct a study of the ditches and laterals throughout the LREGA. This will help identify good locations for future pump stations in undeveloped areas. Additionally, update the current ditches dataset in GIS to capture all stormwater runoff systems that are actually NP ditches, and vice versa. The City may also suggest having developers provide information on existing ditch laterals in a proposed development area as part of the existing conditions report.

- Update and enforce standards related to construction drawings and record keeping after construction or upgrades of an NP pump station, or other infrastructure. Require that developers provide detailed drawings showing the pump station, irrigation pipelines, and pump curves. The City should also develop and maintain its own internal record-keeping system to identify which documents are the most up to date. A CMMS including NP infrastructure could meet this intent.

- Create a system for regularly updating the NP GIS database. While some NP systems have detailed GIS information, other NP systems are not represented in GIS at all. Designating specific staff members with the task of updating the database after a new project and providing them with standard operating procedures may help with this effort.

- Install SCADA systems at new pump stations and pump stations that do not currently have it, to allow for further monitoring of flows and pressures.

Section 3

Demand and Economics

To plan for the future NP needs of the City, existing and future demands were established, and an analysis of economic feasibility of future expansion was completed. The NP water demands established were used in the WTDMP to show how potable water demand can be lowered by meeting demands that do not require the quality of potable water quality with NP water (e.g., irrigation or construction).

3.1 Existing System Demands

The first step in allocating demands in the NP water model is to examine how the City currently uses NP water. NP water is currently used mostly for irrigation, although it may be possible to expand the system so that it can meet some other demands that do not require potable service, such as construction. Information on NP demands was primarily found in the billing data and GIS data, as discussed in **Section 1** of this report.

3.1.1 Review of Billing Data and GIS Data

The existing irrigated areas were examined in GIS and the existing billing data was geolocated and categorized by customer type. Through this process, 99.3% of the total NP demands from the 2019 billing data were allocated to a geolocated meter. Additionally, the City requested that one "customer" be removed from the total, as it is a shoulder tap that feeds other billed customers. Shoulder taps are locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months, when the ditches may not have water but there are still irrigation demands. **Table 3-1** summarizes the billing customers and their associated demands by their City-assigned category. Categories were subsequently adjusted to match water and sewer customer categories.

Table 3-1 Categorized Billing Customers

Customer Category	Number of Billed Meters	Peak Month Consumption[1] (MG)	Percentage of Total Consumption
Church/Commercial	1	0.8	0.7%
Commercial	36	8.5	7.3%
Golf Course	5	41.4	35.9%
Multifamily Homeowners Association (HOA)	2	0.3	0.3%
Non-Potable	1	0.1	0.1%
Parks	16	34.4	29.9%
Residential	22	13.6	11.9%
School	13	16.0	13.9%
Total	**96**	**115.1**	

[1] Average of 2018 and 2019 billing data, in million gallons (MG)

Some NP irrigated sites, such as certain parks, were not included in the billing system. These demands were accounted for with historical pumping data collected weekly through most of August 2019. This data was used for 33 locations (including three wells) across 12 sites, where metered billing data was not available. **Table 3-2** contains the pumping data for these areas.

Table 3-2 Pumping Data

Site Name	Pumped Peak Month Demand[1] (1,000 gal)
Balsam Park	2,171
Bittersweet Park	4,585
Cottonwood Park	719
Delta Park	712
Glenmere Park	1,401
Greeley West Park	745
Island Grove	3,459
Island Grove Ball Field	3,300
Josephine Jones Park	1,102
Linn Grove	8,328
Saddle Club	69
Sanborn Park	2,783

[1] Average of 2018 and 2019 recorded pumping data

3.1.2 Variability in Demand

NP demands are much more irregular than potable water and wastewater demands. They are largely influenced by seasonal weather patterns, since most NP water is used for irrigation. In general, NP demand is highest in the summer and lowest in the winter. Both potable and NP demands were allocated based on summer usage. However, these seasonal variations do not account for year-to-year variability. This year-to-year variability is shown in **Figure 3-1**, where consumption based on billing data can more than double in certain years. A comparison with annual rainfall did not show a strong correlation to account for the annual variation.

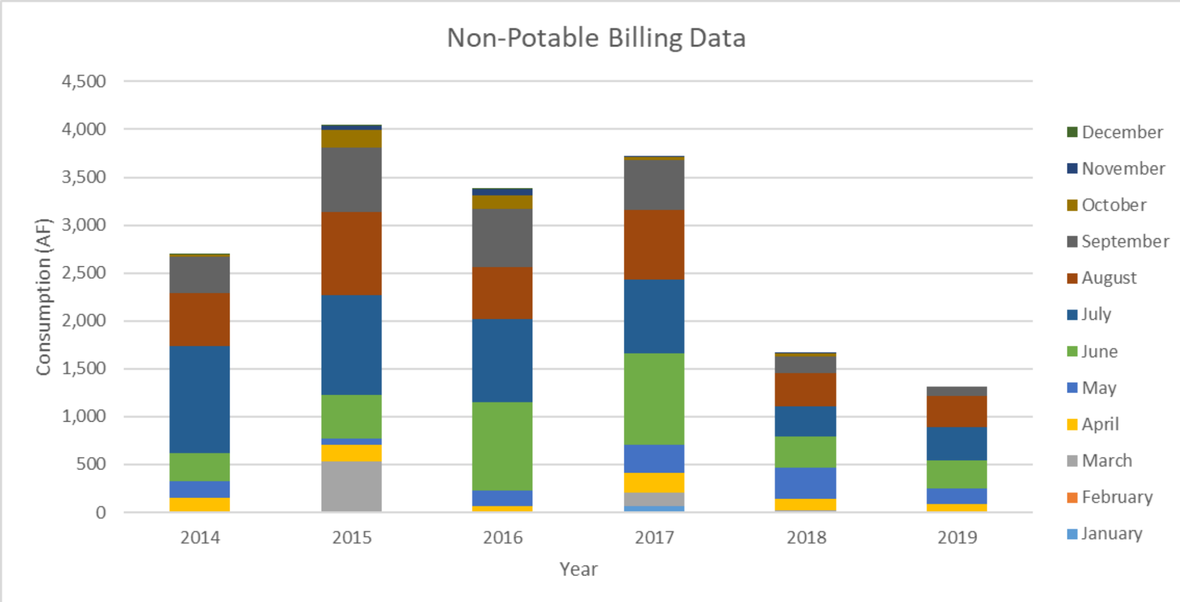

Figure 3-1 Variability in Annual Non-Potable Demand

Based on discussions with the City, it was determined that the reduction in annual demand was due to increased conservation efforts, especially the installation of water-efficient irrigation systems and smart irrigation controllers throughout City parks. To account for these changes, only billing data from 2018 and 2019 was considered for the development of this NPMP.

3.1.3 Flow Factor Development

To calculate future demand projections, it was necessary to establish flow factors. A flow factor is defined as the value used to estimate typical NP demand per acre for a given land use category. The historic billing data and the current NP irrigated areas shapefile were combined to produce flow factors by customer category. These flow factors were then used to estimate future NP demand scenarios through buildout based on land use projections established during the WTDMP.

Flow factors were calculated based on conversations with City staff to determine which areas were irrigated, and by which meters. The meters, and their associated area, had been previously categorized by the City, which was the basis for the flow factor categories. The peak month billed consumption by category was divided by the total irrigated acreage by category. This supplied the Irrigated Land peak month flow factor, as shown in **Table 3-3**. These values represent the amount of consumption for a site where the exact acreage being irrigated is known.

However, in undeveloped areas, the exact irrigated acreage is not known. To account for this, the percent of land that is irrigated out of a total parcel was estimated by category type. The total irrigated land by category was divided by the total (bulk) parcel area by category. These resulted in a Bulk Land peak month flow factor, also shown in **Table 3-3**. The flow factor calculation process is illustrated in **Figure 3-2**.

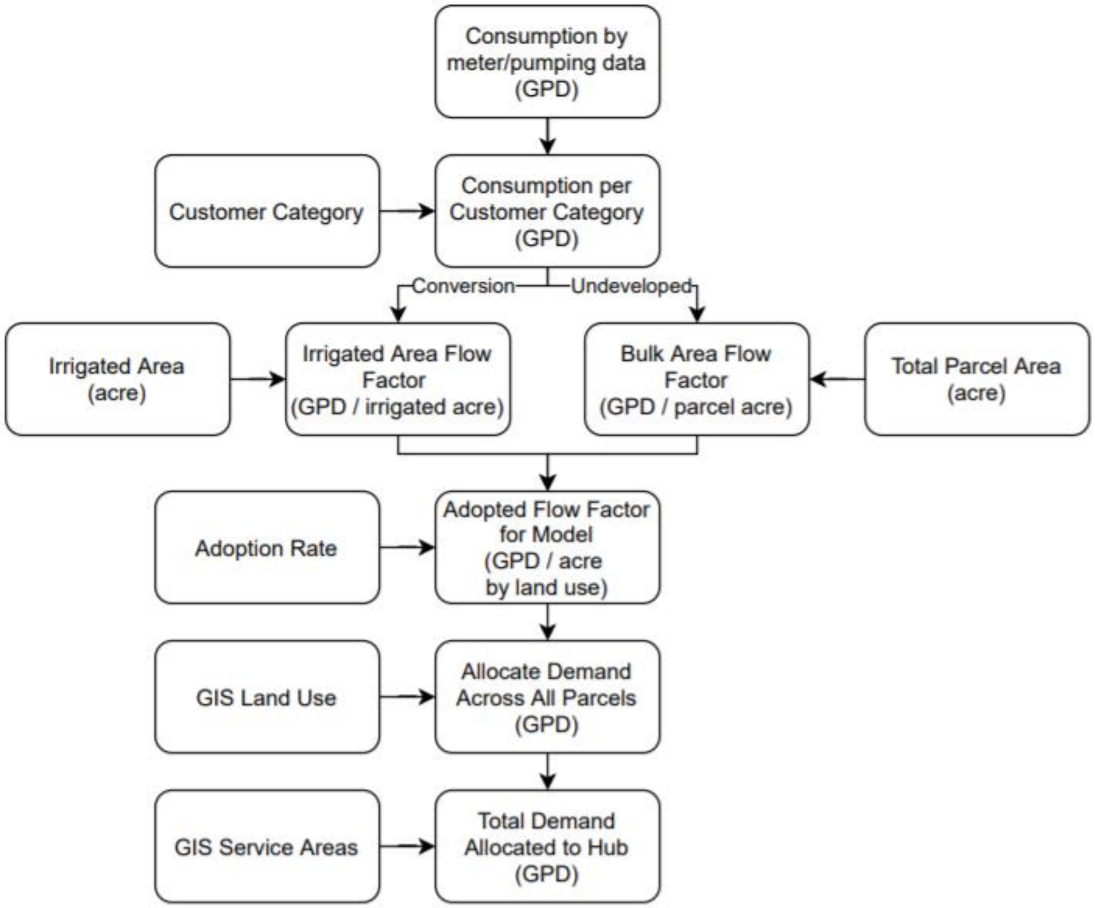

Figure 3-2 Flow Factor Calculation

These customer categories were coordinated with the WTDMP land use projections to examine areas throughout the LREGA. Generally, the Multifamily HOA category was associated with residential high density (R-H) land use category, the Residential customer category was associated with residential medium density (R-M), residential low density (R-L), and residential estate (R-E) land use categories, and the Commercial customer category was associated with commercial high intensity (C-H) and commercial low intensity (C-L) land use categories. However, because the existing NP system serves a limited number of areas, this process did not fully account for all types of land use within the City. The following changes were included in the final flow factors:

- Some land use types in the City do not currently have any examples of NP irrigation. This includes the industrial low intensity (I-L), industrial medium intensity (I-M), and R-E areas. For these areas, a flow factor was based on the difference between the summer and winter flow factors, as developed in the WTDMP and SSMP, respectively.
- Because schools are zoned as R-L, the R-L flow factor was based on a combination of the Residential and School flow factors.

- Because churches are considered commercial, the Commercial flow factor also includes churches. The Church category is used for conversion areas only. There are not many churches currently served by NP irrigation, so the Church flow factor also looks at existing churches that are only served by potable water and compares summer versus winter demand to determine an estimated flow factor.

Losses due to evaporation or seepage were not included in these calculations, as they primarily occur in the ponds and ditches rather than in the distribution system. These losses are estimated at 30%, based on operator knowledge, and are necessary for determining NP supply into ditches.

Table 3-3 Flow Factors

Category	Description	Peak Month Flow Factor for Irrigated Land (gpd/acre)[3]	Percent Irrigated	Peak Month Flow Factor for Bulk Land (gpd/acre)	Peak Month Flow Factor for Irrigated Land (in/week)	Annual Flow Factor for Irrigated Land (in/year)	Adoption Rate[2]
Church	For conversion areas only	2,000	63%	1,300	0.5	10.9	75%
Commercial	C-H and C-L; includes churches	3,200	42%	1,300	0.8	17.5	20%
Golf Course[1]	Golf course (NP category only)	5,000	87%	4,400	1.3	27.3	N/A
I-L	Industrial Low; Summer vs. winter flow factor	N/A	N/A	500	N/A	N/A	20%
I-M	Industrial Medium; Summer vs. winter flow factor	N/A	N/A	125	N/A	N/A	20%
Multifamily HOA	R-H	4,400	34%	1,500	1.1	24.0	15%
Parks	Parks (NP category only)	3,500	47%	1,600	0.9	19.1	90%
Residential	Single family residential; also used for R-M	5,200	17%	900	1.3	28.4	20%
R-E	Residential Estate; Summer vs. winter flow factor	N/A	N/A	80	N/A	N/A	15%
R-L	Residential Low; Residential and School average flow factor	4,700	26%	1,200	1.2	25.7	20%
School	For conversion areas only	4,300	48%	2,100	1.1	23.5	75%

[1] No additional golf courses are expected in the City through buildout.
[2] Adoption rates based on the BBC report; see **Section 3.2.1.**
[3] gpd/acre = gallons per day per acre

3.2 Future Usage and Demand Projections

Using a combination of the City's planning data, land use projections from the WTDMP, and flow factors developed during the existing demands allocations, future NP demands through the buildout scenario were projected and allocated. This section captures the assumptions and calculations used to arrive at this value.

3.2.1 Adoption Rates

The adoption rates are the estimate of the amount of land that could potentially be irrigated that is expected to use NP irrigation. Future scenarios used the adoption rates, as shown in **Table 3-3,** for undeveloped land and most conversion areas. Undeveloped land had the factors applied per land use category including churches in Commercial and Schools in R-L. Conversion used the same factors, although schools and churches used a 75% adoption rate to account for a push to convert existing large irrigated areas to NP.

3.2.2 Infill and Conversion Areas

As the NP system expands, it may become both feasible and beneficial for some areas that are already developed to convert from potable to NP irrigation. These areas, referred to as conversion areas, were identified by the City based on knowledge of the individual customers, its current usage, and open irrigated acreages. The City identified over 400 individual areas that could be eligible for NP conversion. These areas were then categorized to identify which flow factors best fit them. The total acreage expected to convert to NP by category is summarized in **Figure 3-3** and shown in **Figure 3-4.** Areas that were identified as undeveloped land, roads, or non-irrigated areas were not included in the categorization. This is because undeveloped land is captured in the demand projections for undeveloped land, and roads or medians are too small to be accurately categorized.

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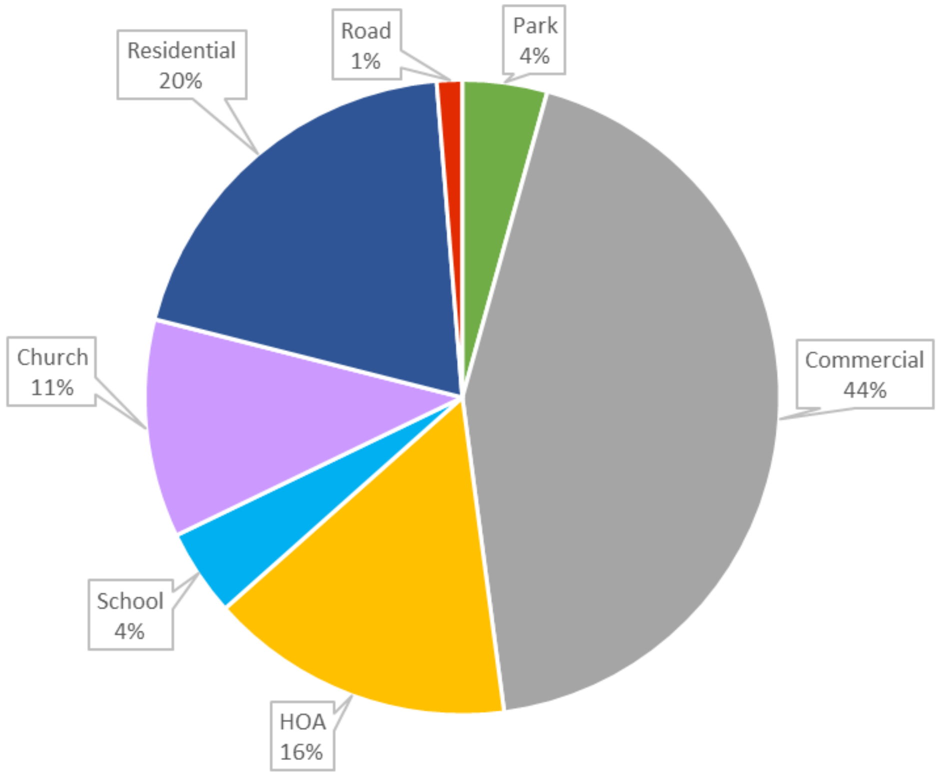

Figure 3-3 Conversion Area Categorization by Acreage

The conversion areas represent irrigable land; therefore the irrigable land flow factor was applied to each area for its category. It is not expected that all of these areas will convert to NP, and inclusion on this list is meant to identify a potential conversion, not set a requirement for conversion. To account for this, the adoption rates were applied to these areas.

Existing customers may be considered good candidates for potential conversion when they have a large irrigated area (greater than 15 acres), higher estimated demands (3,500 gallons per minute [gpm] per irrigated acre or higher), and/or are near existing or planned NP infrastructure. While a customer does not have to meet all these criteria to be eligible for conversion, the City should prioritize these properties. The City may also consider prioritizing customers that are public entities, such as parks and schools. Continued outreach to existing water customers can show them how NP irrigation can benefit them by lowering their water bill. For the purposes of the NPMP, it was assumed that all potential conversion areas will eventually convert to NP irrigation at the adoption rates noted above, regardless of whether they would be considered high priority or not.

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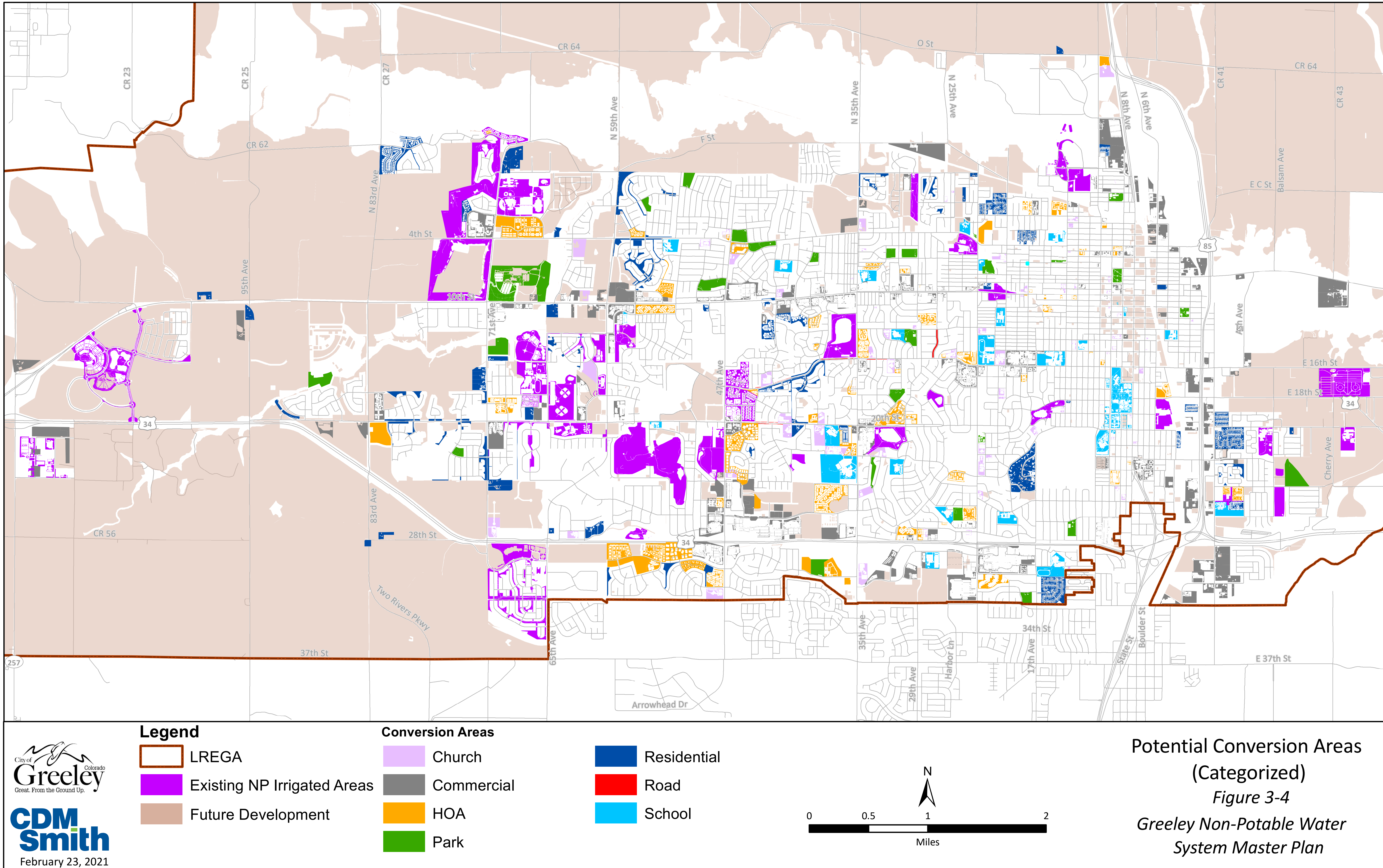

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CDM Smith

February 23, 2021

Potential Conversion Areas
(Categorized)

Figure 3-4

Greeley Non-Potable Water System Master Plan

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3.2.3 Parks and Schools

Two land use types required special attention due to their high NP consumption: parks and schools.

Park locations and sizes were primarily based on the City's Parks, Trails, and Open Lands Master Plan (2016). This document identified potential park locations for the next 20 years. These locations were supplemented by park locations included in this NPMP in order to extend parks service through the LREGA. It should be noted that the location and size of these parks is subject to change in future park master plans. The size of each park was based on population projections from the water and sewer master plans, and the park service goal of 8.25 acres/1,000 people from the 2016 Parks MP. This methodology was approved by the City's parks department. **Figure 3-5** shows all future park locations. Parks will serve as the hubs of the future NP system, and ponds serve both storage and aesthetic purposes.

Because schools represent large irrigable areas, it was desired to incorporate the location of future schools into the future demand projections. However, limited information is available as to the locations, numbers, and size of future schools. Because of this uncertainty, it was considered impractical to select a defensible number, and it was therefore decided to not include schools as a separate source of future demand projections. As schools are generally zoned as R-L, the R-L future flow factor was calculated as a weighted average between Residential and Schools flow factors. In this way, the NP demand from future schools is spread across the future land use areas where schools will eventually be planned.

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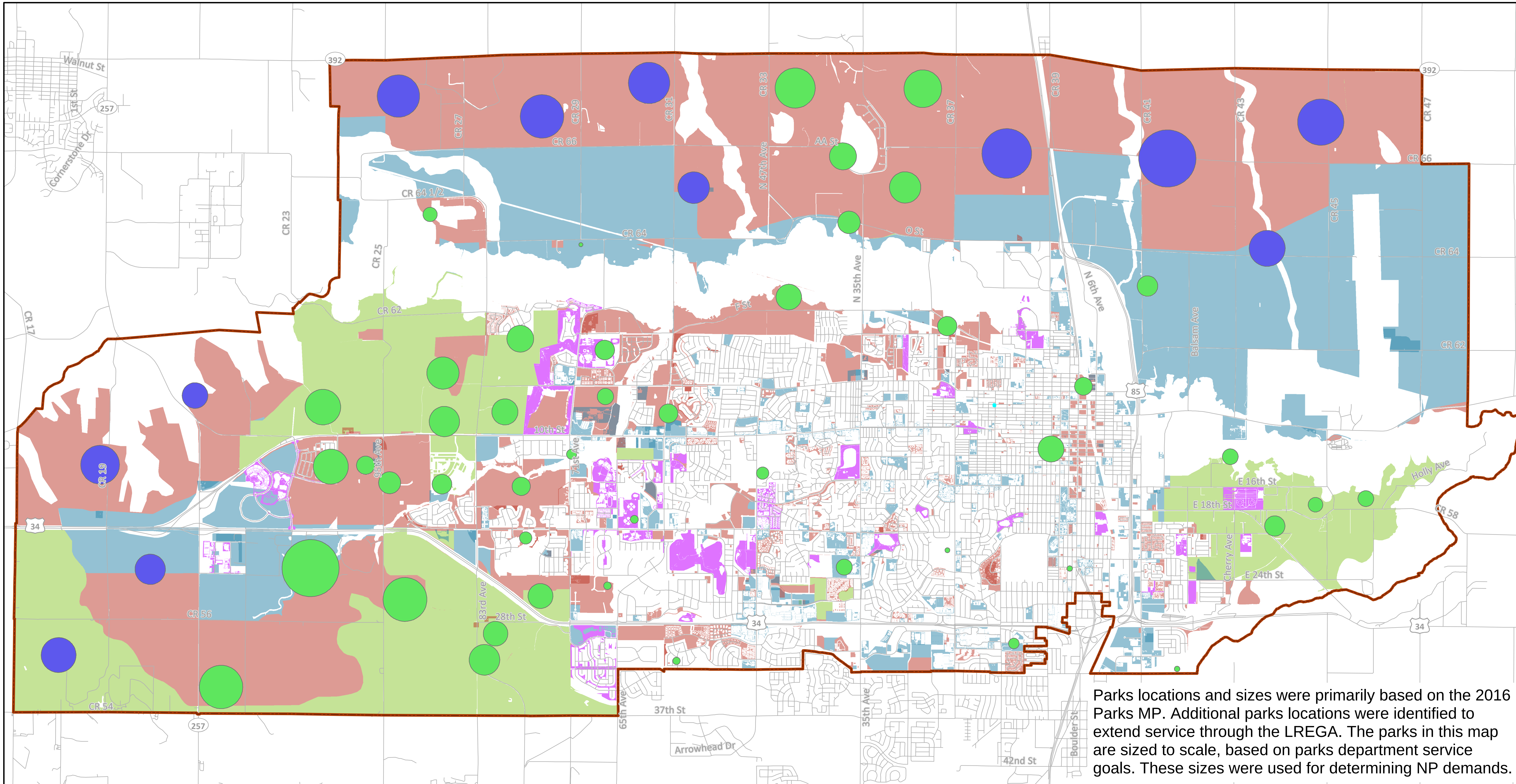

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Legend

LREGA

Existing NP Irrigated Areas

Future Non-Potable Demand

Commercial/Industrial

Residential

Mixed Use

Parks Areas (Buildout)

Potential Park Location (2016 Parks MP)

Potential Park Location (Approximate for Planning)

N

0 0.5 1 2

Miles

Future Parks Locations

Figure 3-5

Greeley Non-Potable Water System Master Plan

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3.2.4 Other Land Uses through the LREGA

Outside of conversion areas and parks, NP demand projections for undeveloped land throughout the LREGA were coordinated with the water demand projections. The WTDMP and SSMP used a complex land use categorization methodology to identify around 60 different land uses within the City, which were used to categorize all currently undeveloped areas or areas of redevelopment. Based on discussions with the City and a review of the available information, three tiers were used for the potable water demands, as described below:

1. ***Tier 1: Planned Developments.*** This data was taken from development reports and planning documents for twelve known developments, which are in various stages of design. These areas represent the most detailed planning information available.

2. ***Tier 2: City of Greeley Land Use (Sub-Areas) and Zoning Markup Map (Greeley Markup).*** After review of this data, the City marked up 11 areas of growth to apply a specific growth distribution to each area, based on trends developed after the creation of the document. The City's planning department assigned percentages of land use type to each growth area. These areas were then split into sub-areas to better align with the density distribution of the original *Imagine Greeley Comprehensive Plan*.

3. ***Tier 3: Zoning and Comprehensive Plan Information.*** For all remaining areas, including infill areas, zoning and land use information was used to distribute future populations and water demands. This data was taken from the following sources:

    a. Zoning from the *Annual Growth & Development Projections Report* (City of Greeley, 2019).

    b. Land use guidance from the *Imagine Greeley Comprehensive Plan* (City of Greeley Community Development Department, 2018).

Using this data, each parcel in the City was assigned with a residential and nonresidential (i.e. commercial or industrial) future water demand based on its land use category. For detailed information on the potable demand calculations, please see the WTDMP.

The water and sewer land use types were then coordinated with the NP flow factor categorizations to develop separate NP and potable water flow factors for each land use type. These flow factors were applied throughout the LREGA to determine total NP demand.

3.2.5 Buildout Projections Summary

The conversion areas, parks, and undeveloped land were combined to produce a total NP demand set for peak month at buildout. This was incorporated into the future water model to aid in appropriately sizing infrastructure. The peak month buildout demand projections for potable vs. NP are summarized in **Table 3-4.** The NP demand density is shown in **Figure 3-6**. The NP demands comprise 19.5% of all future peak month water demands through buildout. NP demands may decrease if planning shows that it is not hydraulically or economically feasible to serve certain areas or, conversely, NP demands may increase if aggressive NP use policies are adopted.

Table 3-4 Peak Month Buildout Demands Summary

Development Type	Total Future Water Demand (MGD)	Future Potable Water Demand (MGD)	Future Non-Potable Water Demand (MGD)
Existing Demand	47.3	46.0	1.3
Future Development	56.7	47.5	9.2
Conversion Areas	2.3	0	2.3
Total	106.3	93.5	12.8

3.3 Demand Estimates by Planning Horizon

To distribute the future demand parameters in the model at each planning horizon, the percent to which each future development tier is built out at the end of each planning horizon was estimated. The basis for these estimates is the BBC report. At the 2025 and 2040 planning horizons, the calculated population is matched to the BBC report. The overall buildout population is assumed to exceed the 2075 BBC projected population. The total buildout population is projected to be 425,271. For more information on the percentages used, please see the WTDMP. The total phased potable and NP demands are shown in **Table 3-5**.

It is assumed that the Tier 1 projects will be completed first. For this reason, the majority of the Tier 1 projects are assumed to be complete at the 2025 planning horizon, and all of them complete at the 2040 planning horizon.

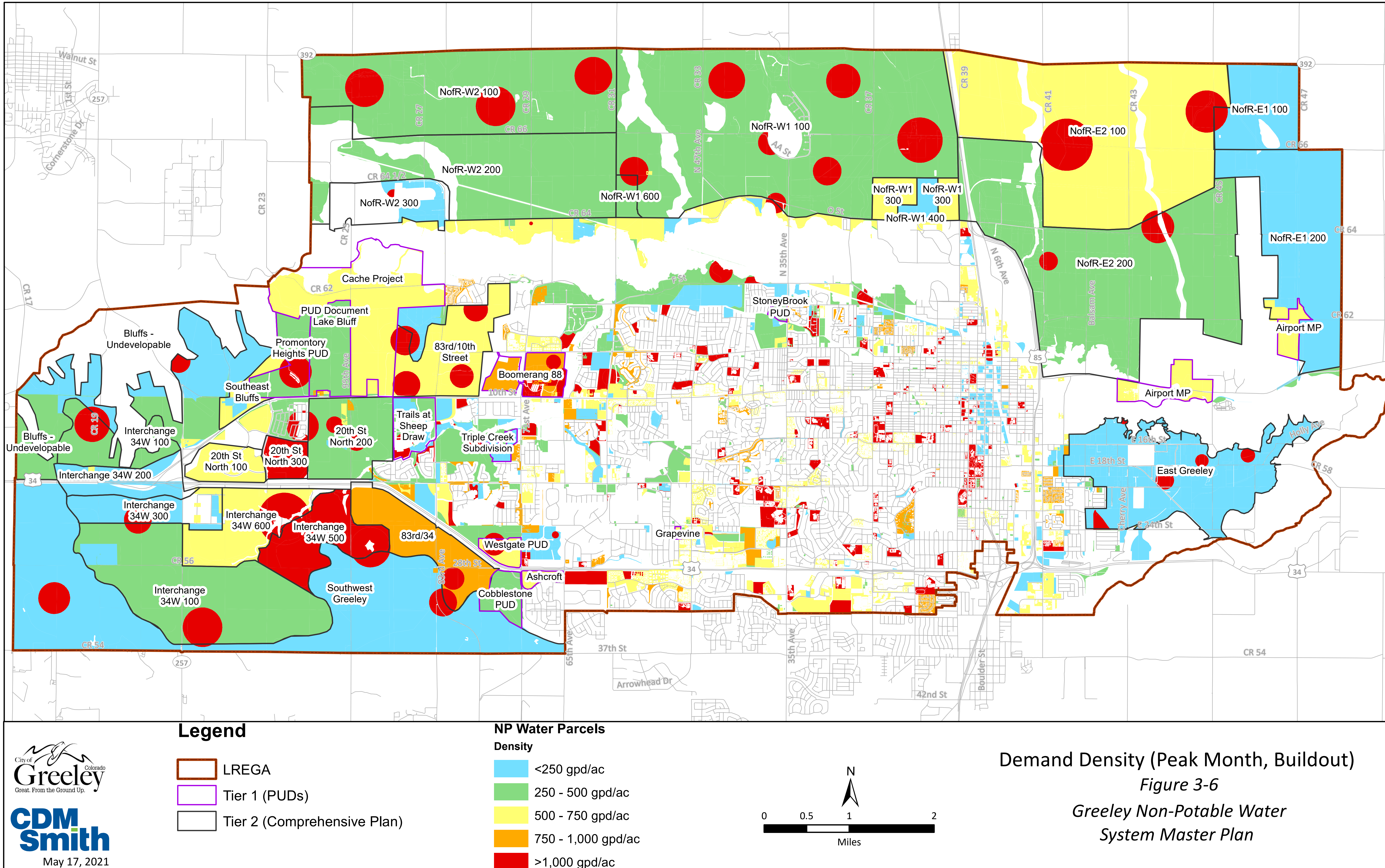
Because of the large areas within the Tier 2 projections category, the Tier 2 percent complete values for the 2025 and 2040 planning horizons have been developed through close discussions with the City. The Tier 2 areas identified for growth at the 2025 and 2040 planning horizons are the areas that the City's planning department have identified as the most likely growth areas.

The Tier 3 growth identified below for the 2025 planning horizon was chosen through discussions with the City. Tier 3 growth included in the 2040 planning horizon was assumed to include all of the infill around the Tier 1 and Tier 2 projected growth areas.

The rate at which existing developments will convert to NP irrigation will vary location-by-location based on economic feasibility, proximity to NP infrastructure, and the willingness of the owner to participate in conservation efforts. To estimate the rate of conversion areas, it was assumed that demand from conversion areas will increase at a similar rate to the total additional water projections. The percentage of water demands increase, as compared to the buildout projections, at each planning horizon was calculated, and this same percentage was applied uniformly to the conversion areas.

Table 3-5 Peak Month Demand by Planning Horizon

Planning Horizon	Total Future Water Demand (MGD)	Future Potable Water Demand (MGD)	Future Non-Potable Water Demand (MGD)
Existing	47.3	46.0	1.3
2025	51.8	49.4	2.4
2040	61.0	56.9	4.1
Buildout	106.3	93.5	12.8



Demand Density (Peak Month, Buildout)

Figure 3-6

Greeley Non-Potable Water System Master Plan

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3.4 Economic Feasibility for Future Projects

In most developments, the decision on whether or not to use NP irrigation is based on economic feasibility, meaning whether the cost savings from using NP over potable outweighs the initial cost of infrastructure construction. This evaluation should consider the current cost of infrastructure against the long-term benefits of reducing potable system expansion, reduced cost of treatment, and freeing up more valuable treatable water rights for potable use. Long-term savings to the eventual owners/occupants of the property should also be considered when evaluating feasibility.

3.5 Water Resources Correlation

It is important for the City to plan for the total annual water demands through buildout. Water conservation methods, such as improved landscaping practices and the encouragement and adoption of NP water for irrigation, may help reduce the City's annual water demands. The City previously conducted a water resources planning study (BBC report), which focused on developing three alternative scenarios for annual water demands. The NPMP primarily focused on planning for future infrastructure needs based on peak summer demands. **Table 3-6** provides a comparison summary between the BBC report and the NPMP.

Table 3-6 NPMP and BBC Report Comparison

NPMP Approach	BBC Approach
Focused on infrastructure sizing, particularly during peak month demands	Focused on supply-side annual demands for water resources planning
Used a peak month: average month ratio of 1.8 for potable demands and 2.5 for NP demands to estimate annual demands from the calculated peak month demands	Only calculated annual demands, and did not calculate demands for peak seasons
Separated residential and nonresidential potable water demands to account for different customer diurnal curves and peak hours	Established a universal gpcd value that included commercial, industrial, and residential demands
Correlated population projections to the BBC report and other City planning department data	Developed three population projections (low, medium, high)
Geolocated demands based on land use to incorporate demand density for infrastructure planning	Used bulk demands for water resources planning, and did not spatially locate demands within the City
Estimated a single most-likely demand scenario for 2025, 2040, and buildout based on historic data and planning data	Provided detailed water resources planning for three scenarios every five years through 2075 and a less detailed buildout scenario

The total annual demands developed for the WTDMP under the NP offsets demand scenario at buildout are captured in **Table 3-7**. These demands are within the range established by the BBC report of 62,000 to 84,000 AFY for total water demands at buildout. Although the six industrial high intensity (I-H) users are included in these totals, these users were not used for modeling purposes, as their location is unknown and could lead to oversizing the system. Each large user's location will require a specific evaluation as to whether each additional user could use NP irrigation, and whether additional infrastructure would be necessary to supply this water.

Table 3-7 NPMP Annual Demand Projections at Buildout

Demand	Total Water Demand (AFY)	Potable Water Demand (AFY)	NP Water Demand (AFY)
Existing	30,500	28,600	1,900
Future Demands	33,500	28,300	5,200
New I-H Users (6)	10,300	10,300	0
Total	74,300	67,200	7,100

[1] Potable demand shown in this table is for NP offset scenario

It is recommended that The City rely on the BBC report for supply-side planning, and the WTDMP and NPMP for infrastructure and distribution system planning.

Section 4

Development of the Non-Potable System Model

Two system models, existing and future, were developed to plan for the future NP needs of the City. These two system models used the same inputs and assumptions as the existing system; projection growth rates and water demands, future service areas, and pipe and infrastructure sizing constraints.

The supply and demand data, asset and infrastructure inventory, and land use analysis were used to develop a model of the existing and future NP system. The future NP system model was created in line with the City's Specifications for NP systems.

4.1 Development of the Existing System Model

A hydraulic model of the existing NP system was developed in InfoWater to simulate current conditions and identify areas that may need short or long-term improvements.

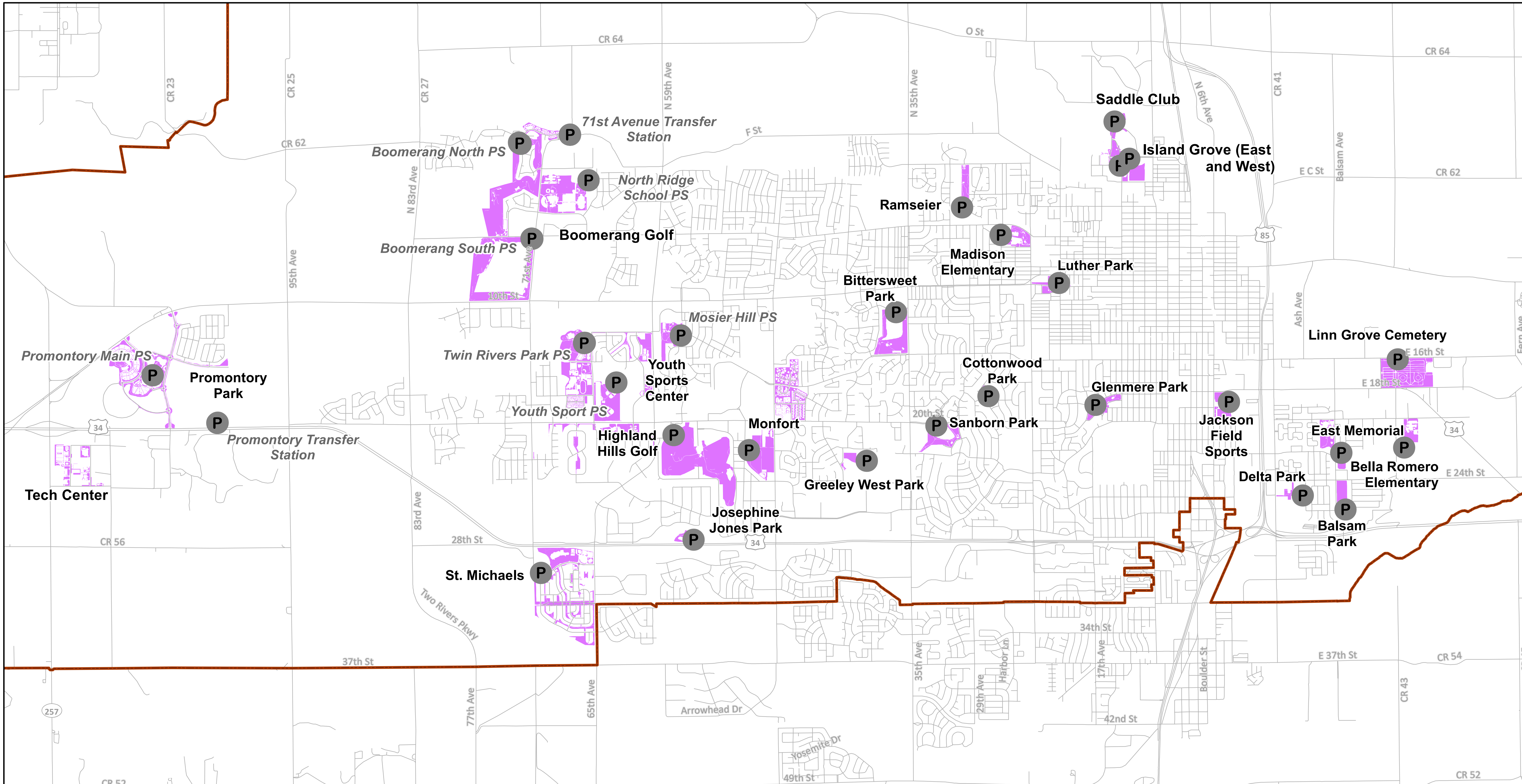
The NP system currently consists of 32 pump stations, including transfer stations, serving over one hundred customers. Most of these pump stations operate independently from other stations, creating 24 individual service areas. The systems at each service area are described in **Table 4-1,** and are shown in **Figure 4-1**. In a typical system, water flows by gravity from an irrigation ditch into a pond. From there, the water enters the wet well of the pump station and is pumped throughout the rest of the pressurized irrigation system.

Table 4-1 NP System by Service Area

Service Area	General Description
Balsam Park	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Bella Romero Elementary	A single pump station irrigates this park. This pump station pulls directly from a well, without a pond.
Bittersweet Park	A single pump station irrigates this park.
Boomerang Golf	The 71st Avenue Transfer Station provides water to Boomerang Golf Course (north and south), North Ridge High School, and Poudre River Ranch. The Boomerang Transfer pumps provide water specifically to Boomerang North and Boomerang South, while the North Ridge Transfer pumps provide water specifically to North Ridge High School. Boomerang North, Boomerang South, and North Ridge High School receive water from the 71st Avenue station into ponds, and then pressure pump from there. Poudre River Ranch has a dedicated irrigation pump at the 71st Avenue station.
Cottonwood Park	A single pump station irrigates this park.
Delta Park	A single pump station irrigates this park.
East Memorial	A single pump station irrigates this park. The pond can be filled by the ditch, a shoulder well, or a shoulder tap.
Glenmere Park	A single pump station irrigates this park.
Greeley West Park	A single pump station irrigates this park.
Highland Hills Golf	A single pump station irrigates this golf course.

Service Area	General Description
Island Grove and Saddle Club	Island Grove East, Island Grove West, and Saddle Club pump stations all pump from individual wells and irrigate separate areas. Saddle Club also has a truck filling station in addition to general irrigation.
Jackson Field Sports	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Josephine Jones Park	A single pump station irrigates this park.
Linn Grove Cemetery	A series of three wells pump either into the irrigation system directly or fill a pond. A pump station on the pond also serves the cemetery's pressurized irrigation system.
Luther Park	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Madison Elementary and Houston Gardens	A single pump station with two separate pumping systems irrigates this area, splitting into two pipes to serve the school and gardens. This pump station pulls directly from the ditch, without a pond.
Monfort	A single pump station irrigates this area, splitting into three pipes to serve the park, school, and residential/commercial areas.
Peakview Park	A single pump station (Mosier Hill Pump Station) irrigates this park.
Promontory Park	A transfer pump station moves water from the ditch into the main ponds. The main pump station provides irrigation to the park, offices, and residential area. A small water circulation pump at the main station moves water from the lowest pond to the highest pond (not included in the model), creating the water feature.
Ramseier	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Sanborn Park	A single pump station irrigates this park.
St. Michaels	A single pump station irrigates this development.
Tech Center	This area is currently fed by potable water at a shoulder tap and does not have an NP pump station. Eventually, it will be transferred to NP water service.
Youth Sports Center	Two pump stations operate independently, but in a similar area: Twin Rivers Park and Youth Sports. Together, they serve two major recreational areas, schools, businesses, and residential areas.

In addition to these areas, Poudre Ponds, Stonney Brook, and the future Upper Equalizer transfer water from one ditch into another. Because these systems do not represent demand, they were not analyzed in depth.



Legend

LREGA

Pump Station

Existing NP Irrigated Areas

N

0 0.5 1 2

Miles

City of Greeley Colorado Great. From the Ground Up.

CDM Smith

May 17, 2021

Existing Non-Potable Service Areas

Figure 4-1

Greeley Non-Potable Water System Master Plan

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4.1.1 Infrastructure Connectivity Updates

Before the existing system could be hydraulically modeled, the City's NP GIS data needed to be updated to reflect current infrastructure. As discussed in **Section 1**, a GIS field survey was conducted to document the existing system. This task identified the location of features such as valves, pumps, and ponds, but did not capture how these features were connected to each other, as most NP piping is underground.

To accurately represent the system, historic operational data was analyzed and translated into GIS updates. As discussed in **Section 1**, the City compiled O&M data for each pump station. The construction documents, photos of the site, and other O&M data was integrated with the GIS field data and the City's original GIS data to fully capture the system. These GIS updates do not represent the full extent of piping through areas such as parks. All GIS updates were verified with City staff. The following overarching assumptions were used to update the system connectivity:

- Where meters appeared to be offset from the main lines, 2-inch laterals were added.
- For areas where the pipe or valve diameter was unknown, the diameter was assigned based on adjacent infrastructure (pipes, pumps, valves, etc.).
- In areas where infrastructure was within a meter of a pipe, it was assumed that this was due to the one-meter accuracy of the GPS unit used to collect the field inventory data. Because the field inventory data is considered to be the most up to date information, the pipes were realigned to connect through the field data.

4.1.2 Modeling Inputs and Assumptions

In general, the NP modeling methodology attempted to follow the same methodology as the potable water system model, to facilitate future integration. However, because the NP system has unique features (such as ditches, shoulder taps, etc.) and because it represents a series of separate systems instead of one larger interconnected distribution system, a unique methodology was needed to accurately depict these features. This section discusses this methodology.

Ditches. When an NP system draws directly from a ditch without an intermediate storage pond, the ditch was modeled as a fixed head reservoir. Because transfer systems are not included in the model, there are no places where water flows into a ditch.

Pipes. All existing and future pipes have of roughness of C = 130, to represent PVC.

Ponds. For most systems, the distribution system begins at a pond. For these systems, the pond is modeled as a fixed head reservoir. The fixed head was based on the field inventory, construction drawings, or ground surface elevation, depending on what information was available. For the purposes of modeling, it was assumed that the ponds can supply water to meet the system demands at all times during peak season.

Shoulder Taps. Shoulder taps are locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months, when the ditches may not have water but there are still irrigation demands. These are modeled as a fixed head reservoir with a normally closed valve that prevents it from flowing. The head on the reservoir is set at peak month operating head in the potable water distribution system model. Notably, the shoulder taps do not typically operate during peak month conditions; therefore, this setting is considered conservative.

Wells. Like ditches, when an NP system draws directly from a well without an intermediate storage pond, the well suction conditions are modeled as a fixed head reservoir. The fixed head is the design pumping depth, as found in the O&M documents. The above ground well pump was modeled using available well pump curves, and submerged well pumps were not included in the model.

Pumps. Where available, the pump curve for each existing pump was used in the model, as provided in the O&M documentation. For pumps without a curve, a design point (defined as design head and flow) was used. Many NP pump stations also include a maintenance pump to maintain pressure during low flow. These are not included in the model.

4.1.3 Existing Demands Allocation

Existing demands were based on historic billing data and pumping data, as discussed in **Section 3.** To establish the peak month base demands used for this model, an average of demands, either billed or pumped, was taken for July and August of 2018 and 2019. The base demand derived from billing data was allocated to the appropriate meter and included in the model. For areas with demand based on pumping data, the demand was allocated to a node directly downstream of the pump station.

4.2 Extended Period Simulation Setup

Both the existing and future models were evaluated under extended period simulation (EPS) to examine how they perform throughout the day, instead of at a single point in time. All model scenarios had a 48-hour time duration. This section describes the methodology used to simulate EPS, including SCADA data calibration, diurnal peaking curves, and the approach to pump controls.

4.2.1 SCADA Data Calibration

As mentioned in **Section 1**, hourly SCADA data from September 1, 2015 to September 5, 2020 was used to calibrate the model. Not all SCADA data was available at all sites, and some sites do not have any SCADA data. For both the overall system and individual systems, a peak week with the highest usage was selected from the July and August 2018 and 2019 dataset. This peak week was selected to align with billing data used for demand projections. The data from the peak week was used for model calibration and diurnal curve development for each system.

Hourly pressure data, where available, was used to set up pump controls. The pump controls were set up to match pressure ranges that are typical to a given system. Diurnal curves were used to derive simple time-based controls to match typical pressure ranges for each system. For areas without available pressure data, pump controls were set so that pressures stayed within the 70 – 100 psi pressure range required by the City's Specifications.

4.2.2 Peaking Factors and Diurnal Curves

Diurnal curves were created from the SCADA data described above to show how the demands change on an hourly basis. These diurnal curves include the peak hour, which is the primary point in time used to evaluate the capacity of pumps and pipes. Ponds are sized on peak day.

The hourly data from the peak week for each system was used to create diurnal curves based on peaking during each day. Individual curves were created for pump stations that had their own SCADA data. These individual curves are included in **Appendix C**. Many of these individual diurnal curves revealed operational inefficiencies, such as watering during the day instead of only at night. Inefficient irrigation practices can increase costs and counteract water conservation goals. For more information on NP best practices, please see the City's WaterWise Landscaping Best Practices Manual Criteria in **Appendix F**.

A system-wide diurnal curve, shown in **Figure 4-2**, was created as a more generalized curve. It was based on SCADA data from the following pump stations: Promontory Main (not transfer), St. Michaels, Youth Sports Center, Monfort, Mosier Hill, Madison Elementary, Ramseier, Island Grove East and West, Luther Park, Jackson Field Sports, Bella Romero Elementary, East Memorial, Balsam Park, Delta Park, Highland Hills Golf, Twin Rivers Park, and North Ridge School (not transfer). The curve average is 1.35, which represents the ratio from peak month to peak week based on SCADA data so that the curve can be applied directly to the peak month demands developed. The individual curves each have different averages based on their own peak week: peak month ratios.

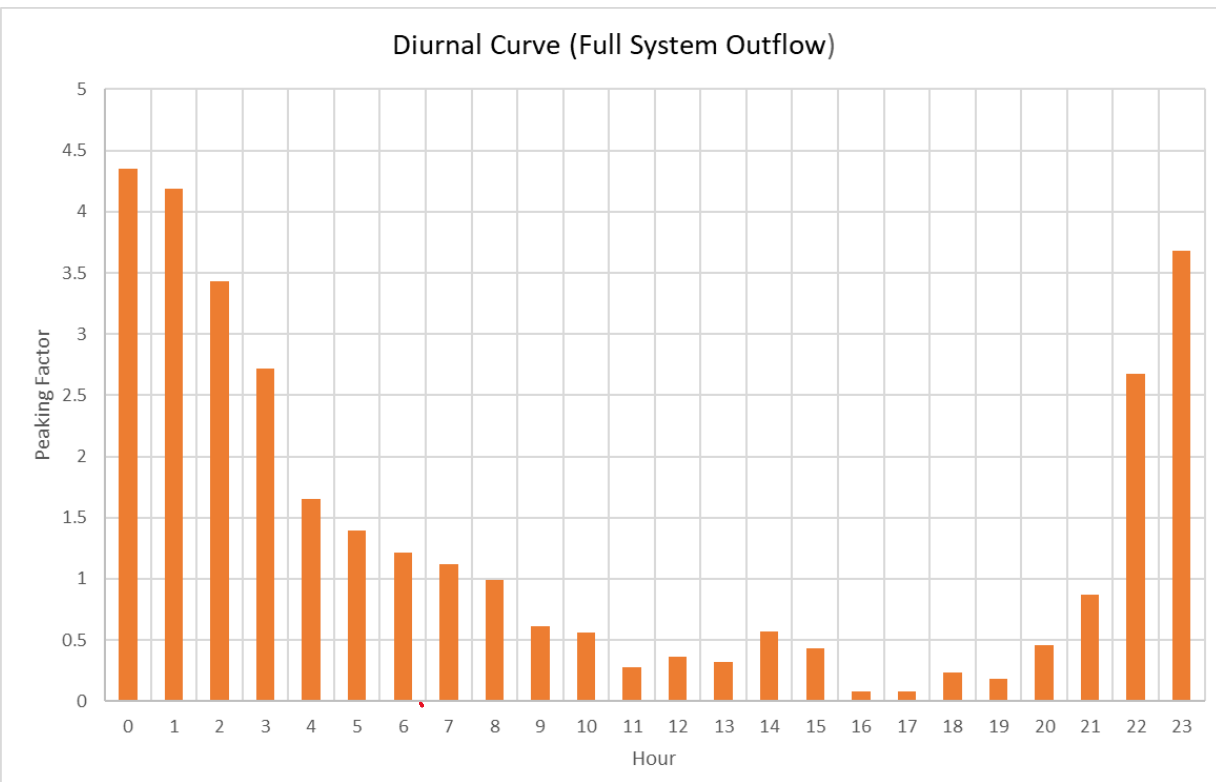

Figure 4-2 System-Wide Diurnal Curve

The peak hour of the system-wide diurnal curve occurs at midnight (hour 0) and has a peaking factor of 4.34. Limited watering appears to occur between 9 am and 8 pm, which aligns with the City's irrigation ordinances and best practices. This curve was applied to existing areas that do not have an individual curve, and to future developments.

For EPS modeling, these diurnal curves are repeated during a 48-hour runtime, in order to align with the potable water system model.

4.2.3 Pump Controls

Because each system is not connected and has unique demands and demand patterns, the modeled pump controls are also unique for each system. In general, pump controls are set by clock time based on the diurnal curve used by the system. For example, if demand drops to zero at hour 4, pumps will turn off or drop to a lower speed at hour 4 to accommodate this change. Because the NP pump stations use variable frequency drives (VFDs), the pumps may vary from 70% to 100% speed. At points where there is no demand in the system, the pumps are modeled as operating at the shutoff point; in real operations, this time period would likely be served by the maintenance pump. This methodology was used for both the existing system and the future system to ensure that appropriate pressures are maintained at all timesteps. This section is specific to modeling methodology; for more information on recommended operation of pump stations, see **Section 2.3** and **Section 2.4**.

4.3 Development of the Future System Model

Future infrastructure was projected throughout the LREGA to show how all areas through the City could be met with NP demand. This section discusses how future infrastructure, including pump stations and piping, was planned and modeled in InfoWater at each planning horizon. All planning horizons (2025, 2040, and buildout) were modeled using the same methodology.

4.3.1 Future Service Areas

In general, it is expected that the NP system will continue to operate as a set of independent systems using a hub-and-spoke methodology. The future parks, as shown in **Figure 4-3**, will serve as the hubs of the future system, as locating the pond and pump station in a park offers both recreational and aesthetic benefits, and provides the open space required for infrastructure.

Because of this, the land through the LREGA was divided into service areas based on the locations of the future parks and the existing NP system. The service areas were initially based on Thiessen polygons around the parks which were then reviewed and customized. The nearest source of NP water was identified, taking topography into account. This informed which areas should have their own pump station (those with a feasible NP source), and which should be served via pressure piping from another NP pump station. Final pump station and pond locations would ultimately be dependent on proximity to a ditch lateral or other water source during the design stage. The following assumptions were used to further refine the future service areas:

- Looping and connections between existing and future systems were attempted where possible. This can include systems with a similar hydraulic grade line or areas where it is less expensive to construct connecting pipe instead of installing new pumps or a new pump station.

- Railroad, river, and major road crossings were minimized where possible.
- NP water will flow by gravity into the ponds, located within parks, then will flow under pressurized conditions from the pump stations at the ponds.

A map of the future service areas, including future pump stations, is included in **Figure 4-3**.

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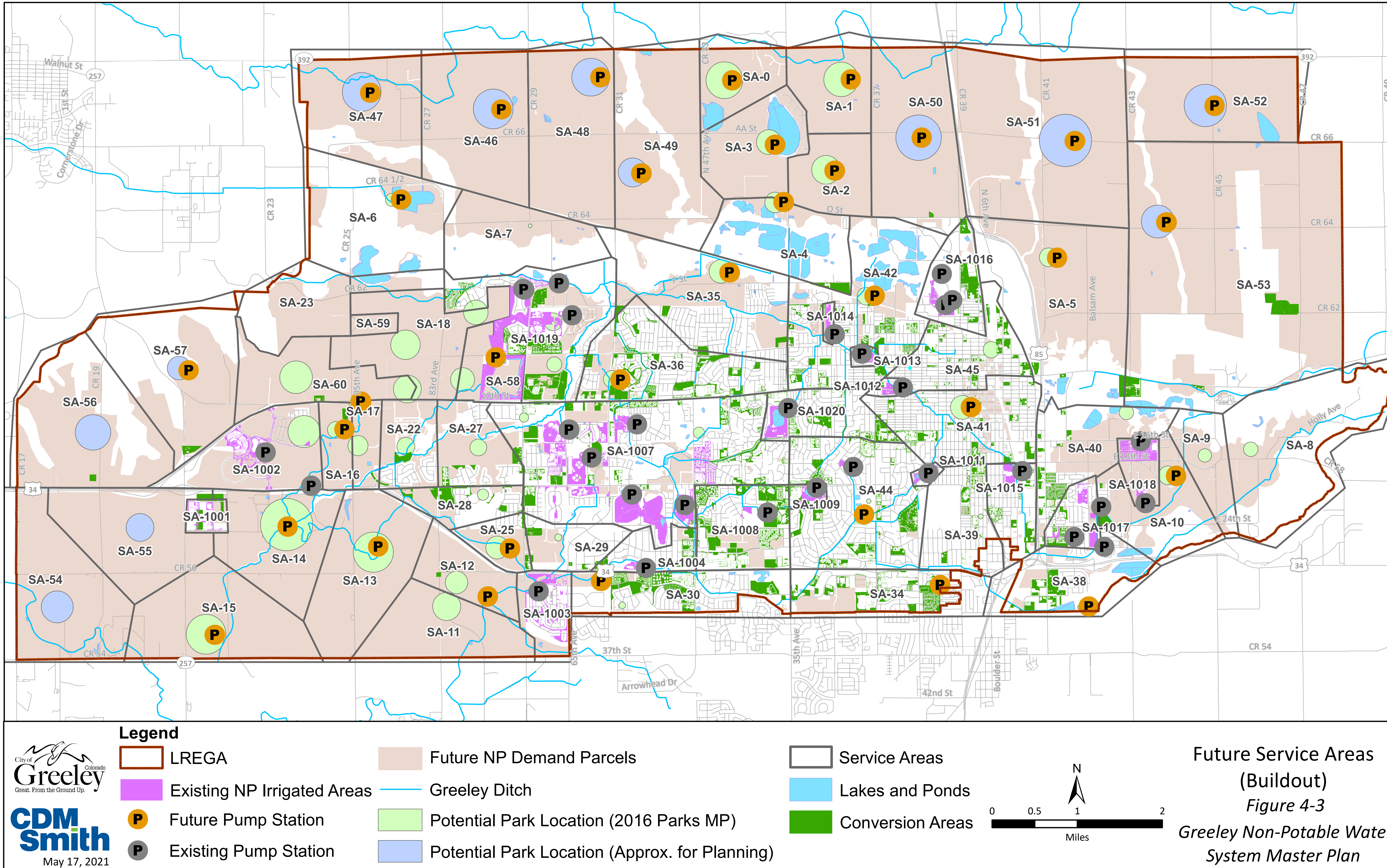
Legend
LREGA
Existing NP Irrigated Areas
Future Pump Station
Existing Pump Station
Future NP Demand Parcels
Greeley Ditch
Potential Park Location (2016 Parks MP)
Potential Park Location (Approx. for Planning)
Service Areas
Lakes and Ponds
Conversion Areas
0 0.5 1 2
Miles
N
City of Greeley Colorado
Great. From the Ground Up.
CDM Smith
May 17, 2021
Future Service Areas (Buildout)
Figure 4-3
Greeley Non-Potable Water System Master Plan

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4.3.2 Model Inputs and Assumptions

The preliminary future model was setup for the buildout scenario, which involves setting up infrastructure through the LREGA to account for a more than 800% increase from existing demands. The current City limit is 31,346 acres, while the LREGA is 58,306 acres, representing an 86% increase in land area by buildout, along with those areas that may convert from potable to NP irrigation. While it is impossible to perfectly predict future development needs, the model should provide a roadmap for future pump station locations and sizing, main pipe sizing, and potential interconnections between key areas. Developers should work with the City's engineering development review (EDR) and water and sewer department to discuss how new developments fit into the City's overall plan to provide NP irrigation service at acceptable pressures in both new and existing areas.

In order to establish infrastructure through the LREGA, pump stations were added into the model at each of the locations identified in **Figure 4-3**. Each pump station draws from a pond, modeled as a reservoir, and has two identical pumps in parallel. A typical pump station is shown in **Figure 4-4**. It is expected that each pump station would also have a smaller maintenance pump, not included in the model. Per the City's Specifications, pumps are required to operate with at least 80% efficiency; therefore, the pumps were modeled uniformly as 80% efficient. Pumps are expected to operate using a lead/lag methodology.

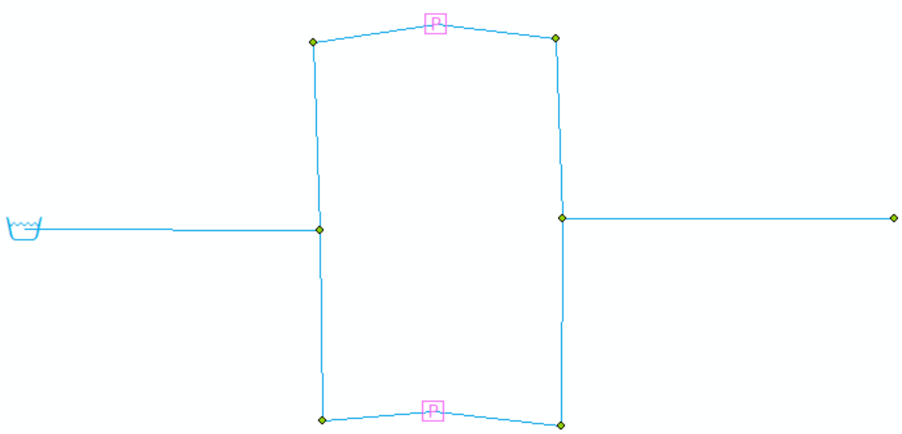


Figure 4-4 Typical Future Pump Station Configuration

In some areas, longer pipelines were drawn from the pump stations to serve undeveloped or conversion areas. These pipelines sometimes end at an anticipated parks location that is not expected to require its own pump station due to distance from a water source or proximity to another pump station. In other cases, the lines are expected to serve higher priority conversion areas, as described in **Section 3.2.2.** As with other infrastructure, these pipes do not represent final layout or sizing and should be reevaluated during the design stage.

The elevation of future nodes, including pumps and ponds, was based on ground surface elevation. Like the existing system, future pipes were modeled with a hydraulic roughness ("C") of 130.

4.3.3 Future Demand Allocation

After the piped network was established, the future demands were set up in the model for the new service areas. Details on demand projections through buildout can be found in **Section 3.**

Future demand datasets were created for each planning horizon, using the existing demand set with future peak month demands for both new developments and conversion areas. Existing and future demands were set as separate demands within the InfoWater demands database to allow for different diurnal curves for existing versus future demands. Each future demand point was tagged with the service area it is in, and all the demand was summed to produce a total demand per service area. This was allocated to the node downstream of the pumps. When there were multiple pump stations within a single service area, the demand was divided evenly between them.

4.3.4 Piping and Infrastructure Sizing Criteria

The hydraulic model is helpful in providing the preliminary sizing of infrastructure such as pump stations, storage ponds, and pipe sizes. These initial models are intended for planning purposes only, and do not constitute a preliminary design plan. Developers should work with the City's EDR and water and sewer department to discuss how new developments fit into the City's overall plan to provide NP irrigation service at acceptable pressures in both new and existing areas. All future infrastructure must comply with the City's Specifications.

As noted previously, each future pump station is modeled with two pumps in parallel. The City's Specifications state that NP pump stations must have a capacity of 120% of peak hour demand. All future pumps are therefore sized where the two pumps are identical, with a combined flow of 120% of the peak hour. An iterative process is used to identify the required design head for these pumps, so that pressure requirements are met downstream.

Per the City's Specifications, NP irrigation mains can be 4-, 6-, or 8-inch, and NP transmission mains can be 10 inch and larger. Per the City's direction, 8-inch will be the smallest pipe size recommended for the City's future NP system. After the meter, developers may use whatever size is required. Additionally, pressures are required to be 70 – 100 psi at each NP irrigation service meter and have a peak flow velocity less than 5 fps and headloss less than 10 ft/1,000 ft. Pipes within the model were sized large enough to meet these pressure and velocity requirements, without incurring extra costs by oversizing. Developers may use any line size that meets the hydraulic requirements described in the City's Specifications.

Ponds are designed to store four days of peak day flow, per the City's Specifications. Storage was calculated using peak day demand to provide preliminary pond sizes for the analysis phase of the project.

Section 5

Existing and Future System Model Evaluation

Existing and future system models were developed to plan for the future NP needs of the City. These models were analyzed for system-wide deficiencies and improvements for the current, the 2025, 2040, and buildout planning horizons. The NP model was incorporated into the potable models for evaluating overall potable and NP water system needs. This Section discusses the way the existing and future systems were analyzed.

5.1 Evaluation Criteria

The existing and future systems were analyzed through a combination of hydraulic modeling in InfoWater and desktop analyses, as discussed on **Section 4.** This section discusses how the various parts of the NP system (such as pipes, pumps, and storage) were evaluated to determine whether existing systems needed improvements and to determine project design points for future systems.

Because the NP system provides primarily irrigation waters, only the peak day was analyzed (which represents peak irrigation season during the summer), using EPS. This is discussed further in **Section 4.2**. Please see **Section 1** for more information on the development of the peak month demands, and **Section 3** for more information on their allocation in the model.

Per the City's Specifications, the NP system must generally provide a pressure between 70 – 100 psi at all meters, and must maintain a velocity of less than 5 fps and headloss of less than 10 ft/1,000 ft in all pipes. While the City's Specifications say that irrigation mains can be as small as 4 inches, it was determined after conversations with the City that all future systems will be designed with a minimum pipe diameter of 8 inches. Additionally, it is considered a best practice to upsize the inlet pipe, from pond to wet well, in order to account for any additional expected demands. A recommended but not required design criteria is to design for less than 6 inches of headloss throughout the length of the pipe. For this NPMP, the inlets were designed for the 10 ft/1,000 ft headloss criteria, which will ensure that the total headloss remains below 6 inches as long as the inlet is less than 50 ft long.

NP pump stations must have a capacity of 120% of the peak hour, per the City's Specifications. The design flow of the future pumps was based on this parameter, and the design head for the future pumps was based on the pressure requirements throughout the modeled system.

Also per the City's Specifications, "ponds shall be sized to accommodate a minimum four (4) days of supply during peak irrigation periods, plus losses." For the NPMP, this means that storage requirements will be 4 times the peak day flow determined, plus 10% for evapotranspiration losses. While 10% losses was used for master planning purposes, developers should ensure that they incorporate calculated losses into their own storage calculations for a design-level report. **Table 5-1** summarizes the evaluation criteria.

Table 5-1 System Evaluation Criteria

Metric	Evaluation Criteria	Comments
Piping		
Pressure	70-100 psi	
Velocity	< 5 fps	
Headloss	< 10 ft / 1,000 ft	
Minimum Main Size	8 inches	Not specified in design criteria, City preference for future
Maximum Inlet Pipe Headloss	6 inches	Not specified in design criteria, good practice
Pumping		
Pumping Capacity	120% of peak hour	
Irrigation Window Assumed	10 hours / day	Not specified in design criteria. For irrigation-only pumps, does not apply to transfer pumps.
Pump Station Layout	No standby pump, however low flow pump required	
Ponds		
Storage Volume	4 times peak day + losses	
Daily Irrigation Application Rate	24 gpm/acre	Peak season metric used in the design of irrigation systems per the City's Specifications. This value is appropriate for areas where the exact irrigated acreage is known but is not appropriate for planning-level estimates of bulk undeveloped land.

5.2 Existing System Evaluation

The existing model was evaluated in both the InfoWater model and through various desktop analyses. The existing model helped identify concerns with pressure and velocity, while desktop analyses helped identify pumps that are at or over capacity and the pond design storage requirements. Existing deficiencies are summarized in **Table 5-2**, and a description of the recommended upgrades and solutions can be found later in this section. For more detailed information on the analysis results for the existing system, including recommended pond sizing, please see **Appendix D**.

The existing system evaluation was limited to the available data on pipe diameters and SCADA data. Refer to **Section 1** for more information about the background data, including the system inventory and SCADA data. Existing pump capacity was based O&M data such as pump curves, along with information from City operators.

The identified deficiencies included possible undersized inlet lines at some areas. However, the inlet pipe size should be confirmed in the field. Another commonly identified deficiency was that in some areas, while the main NP pipelines are sized correctly, the individual taps off to the irrigation systems (which can have diameters as small as 1 inch) are undersized. This produces high velocities and headloss. However, because there is only monthly data available at these taps, rather than hourly data, they may not be experiencing the high peak hours predicted by modeling based on SCADA readings at the pump station and may actually be appropriately sized. (For example, the hourly flows from the pump station have higher peaking factors than the small diameter tap). If a customer notices low pressure, they may consider upsizing the tap off the mainline to mitigate this issue. Most pump stations (26 out of 34) were found to have sufficient capacity, even through buildout. However, increased NP irrigation adoption may lead to pump stations reaching capacity sooner than expected; flows should be continually monitored to note when pumps are getting close to capacity.

Table 5-2 Summary of Existing System Analysis

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Balsam Park	N/A	290	51	51	No deficiencies were identified for this pump station.
Bella Romero Elementary	N/A	330	109	109	No deficiencies were identified for this pump station.
Bittersweet Park	N/A	1,000	854	1,160	Small diameter pipes may be producing high headloss; limited data is available on pipe sizes. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Boomerang	Boomerang North	1,500	769	769	No deficiencies were identified for this pump station.
	Boomerang South	1,500	694	0	This system is being replaced by the Boomerang Regional Pump Station.
	Boomerang Transfer	1,800	951	621	Some of the Boomerang transfer lines are undersized; this issue will be resolved by the construction of the Boomerang Regional Pump Station.
	Boomerang Regional Pump Station	*3,260*	*N/A*	*2,716*	*This new pump station is part of a larger redevelopment project and will replace the existing Boomerang South pump station. This pump station is identified as a CIP project.*
	North Ridge Transfer	1,800	936	936	No deficiencies were identified for this pump station.
	North Ridge School	2,700	1,205	1,752	No deficiencies were identified for this pump station.
	Poudre River Ranch	175	205	205	The lines to Poudre River Ranch and the pump station do not meet hydraulic design criteria but do not appear to hinder system performance. While there are no recommended changes, additional demand should not be added to this area without upsizing.
Cottonwood Park	N/A	115	69	69	No deficiencies were identified for this pump station.
Delta Park	N/A	95	52	52	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
East Memorial	N/A	319	314	440	Bringing on all potential undeveloped and conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
Glenmere Park	N/A	180	135	304	The inlet may be undersized; inlet pipe size data was not available for this system. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Greeley West Park[1]	N/A	2,000	72	861	No deficiencies were identified for this pump station.
Highland Hills Golf	N/A	2,001	1,792	1,792	No deficiencies were identified for this pump station.
Island Grove and Saddle Club	Island Grove West	600	605	605	No deficiencies were identified for this pump station.
	Island Grove East	700	401	401	No deficiencies were identified for this pump station.
	Saddle Club	300	72	138	No deficiencies were identified for this pump station.
Jackson Field Sports	N/A	400	258	317	No deficiencies were identified for this pump station.
Josephine Jones Park	N/A	115	106	161	Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Linn Grove Cemetery	N/A	350	95	122	No deficiencies were identified for this pump station.
Luther Park	N/A	530	492	498	The small pipe diameter (4”) at the outlet does not meet hydraulic design criteria; while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Madison Elementary and Houston Gardens	Houston Gardens	125	310	310	While this system appears to be operating over the pump design head, it does not hinder system performance, as this system is designed for low pressures.
	Madison Elementary	500	90	93	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Monfort	N/A	2,400	1,423	1,745	The inlet is slightly undersized (10" diameter); while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Peakview Park	Mosier Hill	800	681	681	The pipes at Peakview Park have a small diameter (as low as 4") and do not meet hydraulic design criteria. Although this does not appear to significantly hinder system performance, the City may consider upsizing if other work is already being done in this area.
Promontory Park	Main	2,100	1,270	1,866	No deficiencies were identified for this pump station.
	Transfer	1,600	1,651	1,651	While this pump station sometimes operates slightly over its design flowrate, it is not significant enough to warrant upsizing. If additional demands in this area increase transfer station operations, expanding the length of time the transfer station operates each day will likely maintain an acceptable flowrate.
Ramseier	N/A	450	734	739	Additional evaluation of this site is needed as outlet pipe size and SCADA data were not available. While current modeling shows that the system is operating over the design head, the peaking factor may be lower than the system-wide diurnal curve, resulting in lower peak demands.
Sanborn Park	N/A	500	268	289	Small diameter lines may be causing high headloss; limited data is available on pipe sizes.
St. Michaels	N/A	1,120	1,121	1,167	This pump station may be undersized. Additional evaluation should be conducted to determine if demand management is effective and whether the pumps can be upsized without replacing the entire station.
Tech Center	N/A	N/A	N/A	N/A	This area is currently only served by a shoulder tap. A pump station is necessary to transition it to NP irrigation (future service area SA-14).
Youth Sports Center	Youth Sports	1,200	941	941	The inlet line does not meet hydraulic design criteria but does not appear to hinder system performance. This line should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
	Twin Rivers Park	4,200	1,314	1,692	No deficiencies were identified for this pump station.

[1] Greeley West Park is planned for replacement before 2025. The values shown in the table represent the design for the new pump station.

5.3 Future System Evaluation by Planning Horizon

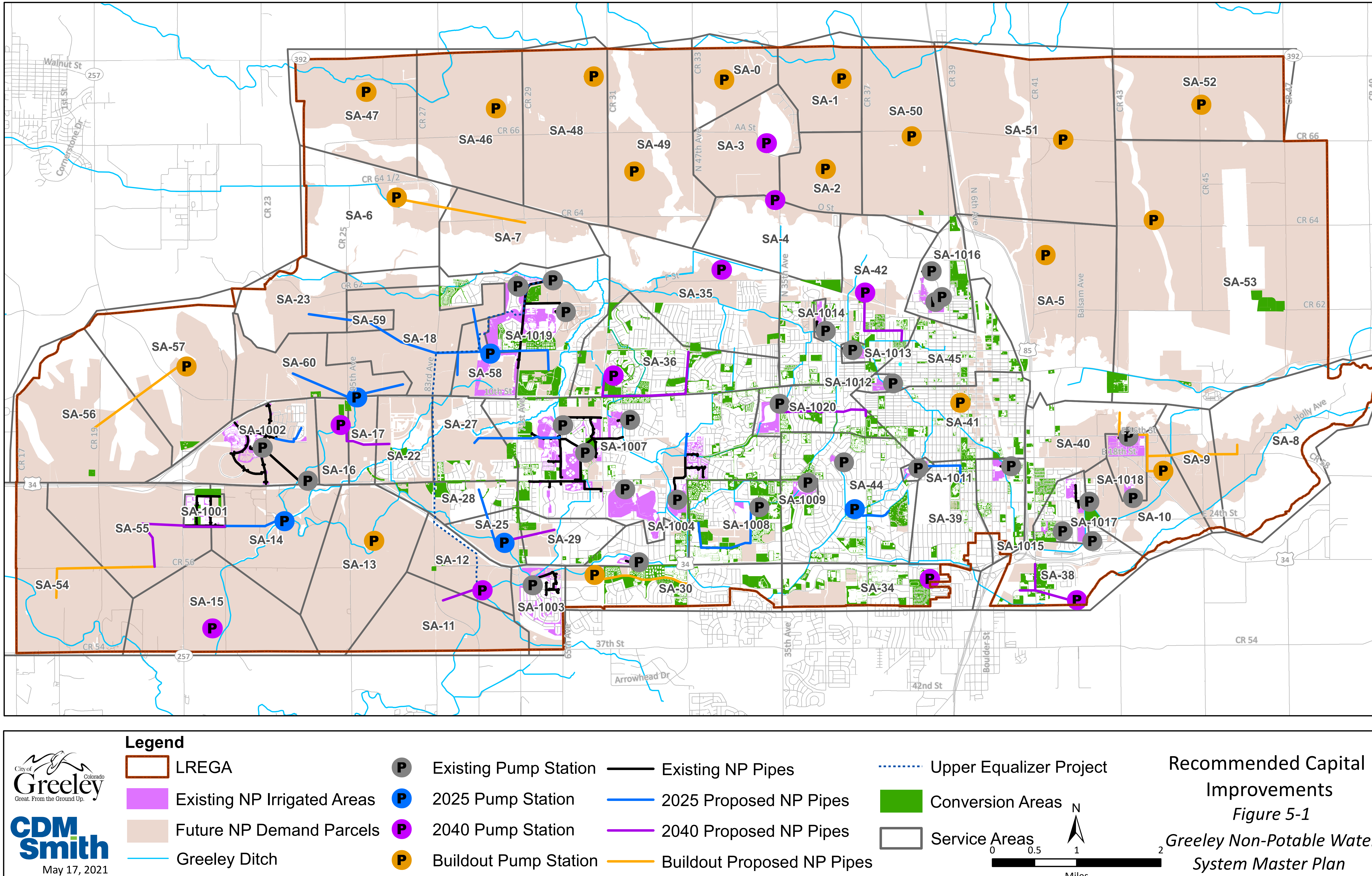
This section provides an overview of the preliminary results for sizing the pipes, pumps, and ponds to meet the design and evaluation criteria described above. For details on the sizing for each pump station, please see **Appendix E**. A map of all pump stations by planning horizon is shown in **Figure 5-1. Table 5-3** summarizes the proposed infrastructure (such as pipes and pump stations) by planning horizon. Only major piping (8 inches and larger) is accounted for in this plan. Detailed distribution piping will be per developer, City water and sewer department, and/or parks department plans. For some systems, it is expected that their pipelines will be expanded after construction as development occurs. For example, the pump station will be constructed to serve a smaller area, then the pipes will be expanded as development continues. It was assumed that pump stations will only be constructed after 20% of the potential buildout demand is met. The City should work with developers to determine best timing for construction of a new pump station as development projects become planned. All proposed projects described below were found feasible using the InfoWater methodology described in **Section 4,** but further design and confirmation is required for each system before construction.

Table 5-3 Proposed Infrastructure by Planning Horizon

Planning Horizon	Pump Stations[1]	Storage in Ponds (AF)	New Pipeline (ft) by Diameter					
			8-inch	10-inch	12-inch	16-inch	30-inch	Total
Existing	*37*	*Unknown*	*23,100*	*17,600*	*12,200*	*3,400 > 12”*		*90,000*
2025	5	35.1	21,800	18,500	0	19,000	26,700	86,000
2040	10	28.1	26,900	11,500	0	8,200	0	46,600
Buildout	18	75.7	28,300	1,000	200	14,800	0	44,300
Total New	33	139.0	77,000	31,000	200	42,000	26,700	150,200

[1] All new pump stations are expected to have a pond.

All existing and planned future pump stations are shown in **Figure 5-1**. Pump station locations and pipeline alignments are approximate and schematic.



Recommended Capital Improvements

Figure 5-1

Greeley Non-Potable Water System Master Plan

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5.3.1 2025 System Evaluation

The 2025 planning horizon includes improvements to the existing system. The improvements include new pump stations in areas that are already developed (but may experience conversion or infill) and new pump stations in areas that are expected to develop by 2025, especially planned developments. In total, 4 new pump stations are expected by the 2025 planning horizon. Please see **Table 5-4** and **Appendix E** for detailed information on these pump stations. The following are notable projects that are expected to be completed by 2025:

- Upper Equalizer Project[1]. This project will expand NP service further into the shoulder seasons by transferring water from the Greeley Irrigation Company (GIC) to the GLIC ditches. The proposed piping will be routed along 83rd Avenue.
- Boomerang Regional Pump Station. This project will be part of a larger project, which involves redevelopment of the southern 9 holes of the Boomerang Golf Course, construction of a new school, and residential development. The piping from the Boomerang Regional Pump Station is expected to serve far to the west, including past 95th Avenue.
- Upsizing of the Greeley West pump station to serve the Centerplace development, as well as other conversion and infill areas.
- Construction of a pump station to serve the Tech Center and adjacent undeveloped areas.
- Expansion of piping (new pipeline) from Glenmere Park along 8th Avenue to serve additional conversion and infill areas.
- Expansion of piping (new pipeline) from Promontory Park along 16th Street to serve newly developing areas.
- Expansion of piping (new pipeline) from Monfort along 47th Avenue to serve additional conversion and infill areas.
- Expansion of piping (new pipeline) from Twin Rivers Park to the west to serve additional conversion and infill areas.

5.3.2 2040 System Evaluation

The 2040 planning horizon includes 12 new pump stations, primarily in areas that are currently undeveloped. In particular, eight new pump stations are expected in the North of the River area due to potential NP demands through that area starting after 2025. However, very limited development is expected in this area until full buildout. The City may consider constructing the NP distribution pipe system but waiting to put in pump stations until there is further development in the area, similar to how the Tech Center was constructed. The following are notable projects that are expected to be completed between 2025 and 2040:

[1] Supply-side projects such as the Upper Equalizer Project were not studied as part of the NPMP, which was focused on the expansion of the distribution system.

- Westward expansion of pipelines from the Tech Center. It is expected that the southernmost 6 inch existing NP lines along the southern edge of the Tech Center are not sized large enough to handle the additional flows and will need to be either upsized or paralleled. The City may decide to complete this project when the new SA-14 pump station is constructed, depending on future development.
- Construction of a regional pump station west of St. Michaels (Cobblestone Regional).

Table 5-4 and **Appendix E** summarize these and other projects.

5.3.3 Buildout System Evaluation

The buildout planning horizon includes 19 new pump stations in areas that are either not expected to have any development, or have less than 20% development, until after the year 2040. The locations of these pump stations were based on even spacing throughout the LREGA, in coordination with the City's parks department. These locations are not final and should be coordinated with the construction of new parks or open spaces, where the ponds can serve as an amenity. **Table 5-4** and **Appendix E** summarize these and other projects.

Table 5-4 Future System Information

Pump Station Name	Planning Horizon	Pump Station Design		PS Outlet Size (in)	Pond Size (AF)[1]
		Flow (gpm)	Head (ft)		
SA-14	2025	3500	230	16	13.4
SA-25	2025	640	160	8	2.4
SA-44	2025	660	160	8	2.5
SA-60	2025	1120	200	10	4.2
Boomerang Regional PS	2025	3260	170	16	12.5
SA-3	2040	620	160	8	2.3
SA-4	2040	240	180	8	0.9
SA-12	2040	1160	210	10	4.4
SA-15	2040	1400	170	10	5.3
SA-16	2040	1040	180	10	4.0
SA-34	2040	560	170	8	2.1
SA-35	2040	620	160	8	2.3
SA-36	2040	900	170	8	3.4
SA-38	2040	160	180	8	0.5
SA-42	2040	720	180	8	2.7
SA-0	2075	780	170	8	3.0
SA-1	2075	780	170	8	3.0
SA-2	2075	660	180	8	2.5
SA-5	2075	620	170	8	2.4
SA-6	2075	360	180	8	1.4
SA-10	2075	1000	170	10	3.8
SA-13	2075	1220	170	10	4.6
SA-30	2075	440	155	8	1.7

Pump Station Name	Planning Horizon	Pump Station Design		PS Outlet Size (in)	Pond Size (AF)[1]
		Flow (gpm)	Head (ft)		
SA-41	2075	1120	160	10	4.3
SA-46	2075	1120	160	10	4.2
SA-47	2075	960	170	10	3.7
SA-48	2075	1040	170	10	4.0
SA-49	2075	1120	170	10	4.2
SA-50	2075	1540	170	12	5.9
SA-51	2075	2500	180	16	9.6
SA-52	2075	1300	170	10	5.0
SA-53	2075	1820	170	12	6.9
SA-57	2075	1480	200	16	5.7

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Section 6

Capital Improvement Plan

6.1 Approach to CIP Development

This Section builds on the capital improvement projects identified in **Section 5** at the 2025 and 2040 planning horizons and defines the approach for development of the 5-year and 20-year CIPs. The identified CIPs were developed with consideration of the City's current and long-range population as well as projected flows, using currently available information. Conditions will change with time and uncertainties will impact the accuracy of each plan in later years. As projects come closer to implementation, it is important that the City reevaluate each CIP to better reflect costs.

This section provides planning level cost estimates for capital improvement project scheduling. Major capital elements are itemized with unit prices. Information from past projects and outside resources, both locally and nationwide, were relied upon to develop unit prices for major capital categories. CIP projects were developed using pipeline quantity estimates and modeling data. GIS mapping was used to identify areas of interest, such as utilities and road crossings. The unit prices were then multiplied by the quantity of each element. Project elements that are difficult to estimate during the planning stage are included in the overall cost as either allowances or as a percentage of the total for the itemized project elements. During design development, the more specific data will be used to inform the design and resulting project cost estimate.

6.2 Cost Development

Unit costs were developed to aid in CIP budgeting, as described below. Cost estimating is considered Association for the Advancement of Cost Engineering (AACE) Class 5 – Conceptual engineering phase.

6.2.1 Project Implementation and Additional Project-Related Costs

Apart from the unit costs used to build-up project material costs (e.g., pipes, pumps, and ponds), several other elements were added as factors. Construction factors include items such as erosion control/stormwater pollution prevention and contractor mobilization and demobilization. These costs are estimated as a percentage of the construction unit costs. Contingency is applied to the subtotal of these construction cost elements to account for variations in unit prices or quantity estimates. Programmatic elements such as engineering, permitting, legal, and administration are estimated as a percentage of the construction cost. **Table 6-1** provides a breakdown of the assumptions used for project implementation and contingency.

Table 6-1 Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention[1]	2%
	Mobilization and Demobilization[1]	5%
	Contingency[2]	35%
Project Implementation[3]	Feasibility and Site Studies	9% for OPCC ≤ $1 million 6% for OPCC of $1 million to $10 million 5% for OPCC > $10 million
	Preliminary and Final Design	9% for OPCC ≤ $1 million 6% for OPCC of $1 million to $10 million 5% for OPCC > $10 million
	Engineering Services During Construction	5%
Additional Project-Related Costs[3]	Outside Construction Management - not used if OPCC value is < $1M	5%
	Outside Project Management - not used if OPCC value is < $1M	3%

[1] Construction bid cost costing factors erosion control/stormwater pollution prevention and mobilization and demobilization are applied to the subtotal of unit cost items.

[2] Contingency costing factor is 35% of the subtotal of the unit cost items, erosion control/stormwater pollution prevention, and mobilization and demobilization.

[3] Project implementation and additional project-related cost factors are applied to the total construction cost.

6.2.1.1 Erosion Control/Stormwater Pollution Prevention

Project erosion control and stormwater pollution prevention includes the contractor's cost to manage the stormwater during construction through best management practices such as silt fences, rock socks, vehicle tracking, and silt prevention at storm inlets. This category is assumed as 2% of the unit costs and is based on estimator's judgement. This costing factor is added to calculate project OPCC totals.

6.2.1.2 Mobilization and Demobilization

Contractor Mobilization and Demobilization includes the contractor's start-up costs and close-out costs. Start-up costs include items such as moving equipment and personnel to the project location, obtaining permits and bonds, etc. Close-out costs include items such as project cleanup, moving equipment and personnel from the project location, etc. The mobilization and demobilization category is estimated as 5% of the unit costs and is based on estimator's judgement. This costing factor is added to calculate project OPCC totals.

6.2.1.3 Contingency

During the planning phase, the design and field work has not yet been completed for the projects. Therefore, the cost development relies on estimated quantities for each construction element. Project contingency provides for these uncertainties by adding additional costs to the project total. The contingency at the planning level is typically 35% of the OPCC subtotal after the erosion control/stormwater pollution prevention and mobilization and demobilization costing factors have been included. Project contingency also provides for costs associated with items that are difficult to itemize at a planning level.

6.2.1.4 Feasibility and Site Studies

This cost element includes the planning and field investigations (such as geotechnical, survey, ground sampling, subsurface utility engineering [SUE] and locates, etc.) that are required to implement a project. These are estimated as a percentage of the subtotal of the previous elements and the percentage varies based on the OPCC, plus cost contingency.

6.2.1.5 Preliminary and Final Design

The preliminary and final design cost element includes the cost for engineering services to develop biddable plans and specifications in accordance with applicable standards. This cost is estimated using a percentage of the OPCC, plus cost contingency.

6.2.1.6 Engineering Services During Construction

Engineering services during construction includes the review of contractor submittals, requested changes, and design adjustments that may be required during construction. A percentage of the OPCC is used to estimate this cost element.

6.2.1.7 Additional Project-Related Costs

Outside construction and project management are estimated for projects that are not directly managed by the City. For purposes of this master plan, only projects in excess of $1 million were assigned these cost elements.

6.3 Identified CIP Projects

Projects are forecast over 5-years (for projects for 2022 through 2025) and 20-years (for projects for 2026 through 2040). Projects were named based on geographic location and service area number. Construction and total project costs were developed for the projects and are described in the following figures and tables.

Figures 6-1 and **6-2** illustrate the locations of the identified projects within the 5-year and 20-year CIPs respectively. For development driven projects, the City will negotiate with developers the cost difference for the installation of a larger pipe diameter or for additional pipe lengths to meet future needs versus the developer’s needs.

Table 6-2 provides a summary of project drivers. This summary identifies a driver as an existing deficiency or population growth driven, and also whether the project is proposed to be constructed by the City’s water and sewer department, the City’s parks department, or by developers. In many cases, project costs may be shared between some or all of these three entities. It is assumed that costs will be divided proportionately, based on future demands. Stakeholders for any given NP project should collaborate to develop cost sharing for projects that would mutually benefit all responsible parties.

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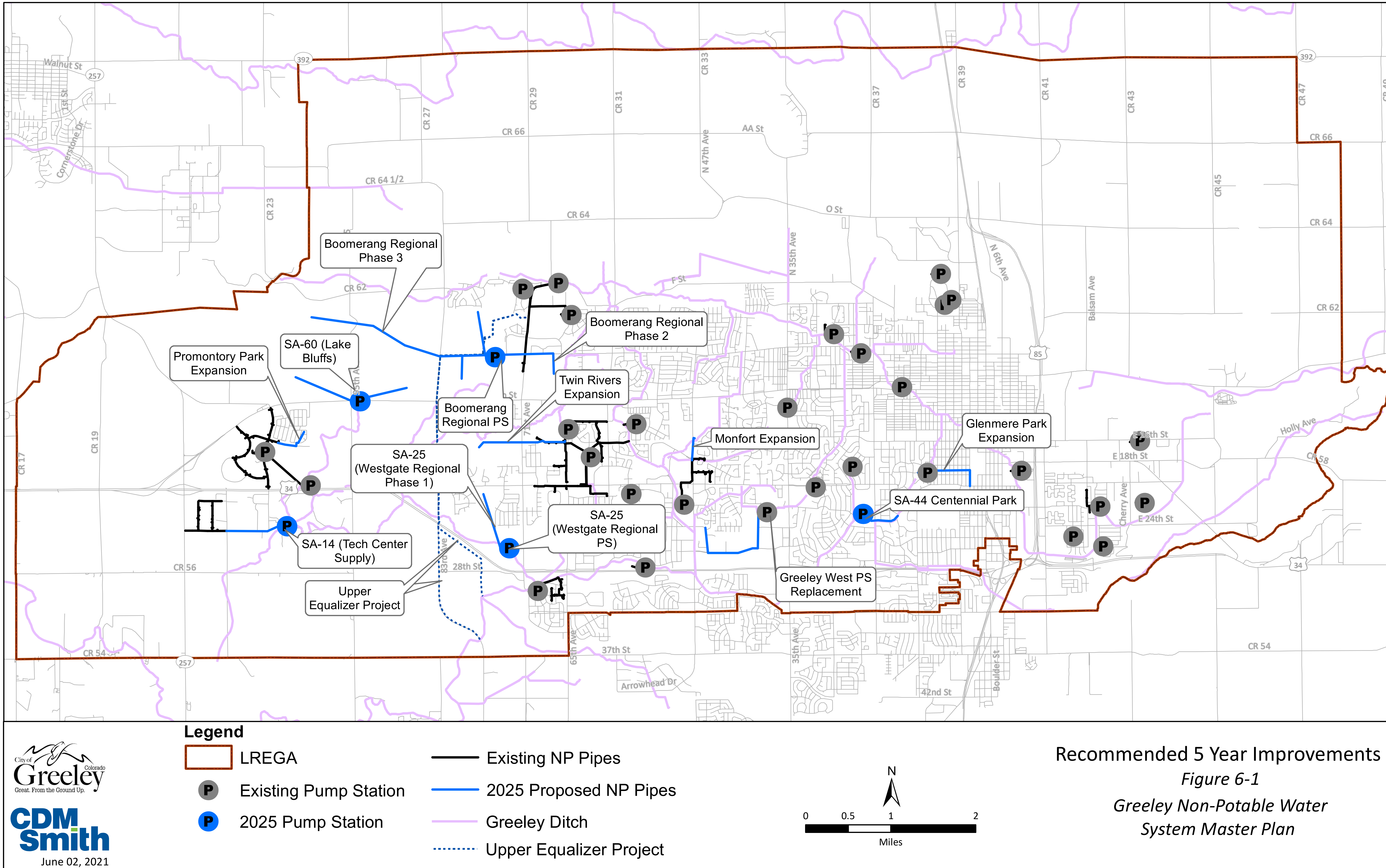

Recommended 5 Year Improvements

Figure 6-1

Greeley Non-Potable Water System Master Plan

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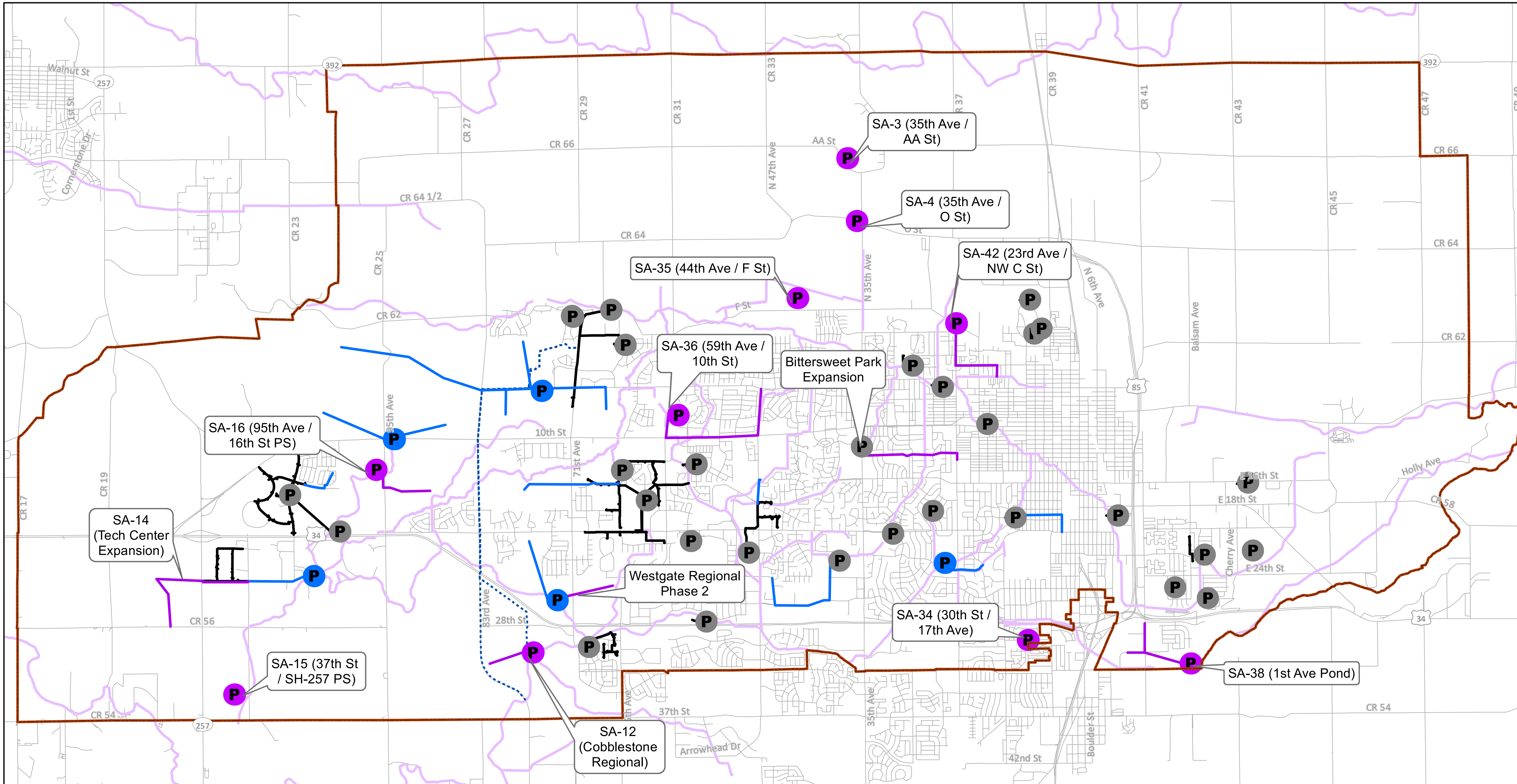

Legend

- LREGA
- Existing Pump Station
- 2025 Pump Station
- 2040 Pump Station
- Existing NP Pipes
- 2025 Proposed NP Pipes
- 2040 Proposed NP Pipes
- Greeley Ditch
- Upper Equalizer Project

N

0 0.5 1 2
Miles

City of Greeley Colorado
Great. From the Ground Up.

CDM Smith

June 02, 2021

Recommended 20 Year Improvements

Figure 6-2

Greeley Non-Potable Water System Master Plan

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Table 6-2 Project Information

Projects	Project Driver	Funding Source[1]	Planning Start Year[2]	Design Start Year[2]	Construction Start Year[2]	OPCC[3]	Total Cost[3]	City of Greeley Water/Sewer	City of Greeley Parks	Development
5-Year Planning Horizon										
SA-44 Centennial Park	Service Expansion	W/S, Parks, Dev	2020	2021	2022	$4,020,000	$5,030,000	$3,488,100	$1,379,300	$162,600
Boomerang Regional Pump Station	Service Expansion	W/S, Parks, Dev	2021	2021	2022	$5,530,000	$6,920,000	$221,300	$694,000	$6,004,700
Boomerang Regional Phase 2	Service Expansion	W/S, Parks, Dev	2021	2021	2022	$1,830,000	$2,390,000	$76,400	$239,700	$2,073,900
Greeley West Pump Station Replacement	Service Expansion	W/S, Dev	2021	2022	2023	$5,970,000	$7,470,000	$6,161,400	-	$1,308,600
Upper Equalizer Project	Shoulder Season Extension	W/S	2022	2023	2024	$20,010,000	$25,620,000	$25,620,000	-	-
SA-14 Tech Center Supply	Service Expansion	W/S, Dev	2024	2025	2026	$4,560,000	$5,930,000	$17,100	-	$5,912,900
Promontory Park Expansion	Service Expansion	Development	2024	2025	2026	$580,000	$720,000	-	-	$720,000
Monfort Expansion	Service Expansion	W/S, Parks, Dev	2024	2025	2026	$400,000	$500,000	$245,300	$76,000	$178,700
Twin Rivers Expansion	Service Expansion	W/S, Parks, Dev	2024	2025	2026	$1,830,000	$2,390,000	$1,172,400	$363,300	$854,300
SA-38 1st Ave Pond	Service Expansion	W/S, Dev	2024	2025	2026	$2,760,000	$3,590,000	$2,881,600	-	$708,400
SA-25 Westgate Regional Pump Station	Service Expansion	W/S, Parks	2025	2026	2027	$2,130,000	$2,670,000	$2,038,415	$631,585	-
SA-25 Westgate Regional Phase 1	Service Expansion	Dev	2025	2026	2027	$900,000	$1,160,000	-	-	$1,160,000
SA-60 Lake Bluffs	Service Expansion	W/S, Dev	2025	2026	2027	$4,650,000	$6,050,000	$57,000	-	$5,993,000
					5-Year Subtotal	**$55,170,000**	**$70,440,000**	**$41,979,015**	**$3,383,885**	**$25,077,100**
20-Year Planning Horizon										
SA-34 30th St/17th Ave	Service Expansion	W/S, Parks, Dev	2027	2028	2029	$2,300,000	$2,880,000	$1,932,500	$281,200	$666,300
Boomerang Regional Phase 3	Service Expansion	W/S, Parks, Dev	2028	2029	2030	$6,150,000	$8,000,000	$255,900	$802,300	$6,941,800
SA-4 35th Ave/O St	Service Expansion	W/S, Dev	2028	2029	2030	$1,000,000	$1,170,000	$262,400	-	$907,600
SA-3 35th Ave/AA St	Service Expansion	Development	2029	2030	2031	$1,750,000	$2,190,000	-	-	$2,190,000
Bittersweet Park Expansion	Service Expansion	W/S, Parks, Dev	2029	2030	2031	$2,520,000	$3,160,000	$2,475,181	$684,819	-
SA-35 44th Ave/F St	Service Expansion	W/S, Parks, Dev	2030	2031	2032	$2,060,000	$2,580,000	$166,000	$658,300	$1,755,700
SA-36 59th Ave/10th St	Service Expansion	W/S, Parks, Dev	2031	2032	2033	$6,550,000	$8,190,000	$3,810,800	$2,569,500	$1,809,700
SA-16 95th Ave/16th St	Service Expansion	W/S, Parks, Dev	2034	2035	2036	$4,040,000	$5,260,000	$205,300	$610,300	$4,444,400
SA-14 Tech Center Expansion	Service Expansion	W/S, Dev	2035	2036	2037	$2,660,000	$3,460,000	$10,000	-	$3,450,000
SA-15 37th St/SH-257 Pump Station	Service Expansion	Development	2036	2037	2038	$3,100,000	$3,880,000	-	-	$3,880,000
SA-12 Cobblestone Regional	Service Expansion	W/S, Dev	2037	2038	2039	$3,270,000	$4,260,000	$48,500	-	$4,211,500
Glenmere Park Expansion	Service Expansion	W/S, Parks, Dev	2037	2038	2039	$1,690,000	$2,200,000	$1,427,916	$603,228	$168,856
SA-25 Westgate Regional Phase 2	Service Expansion	W/S, Dev	2038	2039	2040	$950,000	$1,220,000	$857,400	-	$362,600
SA-42 23rd Ave/NW C St	Service Expansion	W/S, Parks, Dev	2039	2040	2041	$4,630,000	$6,030,000	$2,513,300	$1,421,100	$2,095,600
					20-Year Subtotal	**$42,670,000**	**$54,480,000**	**$13,965,198**	**$7,630,746**	**$32,884,056**
					Total	**$97,840,000**	**$124,920,000**	**$55,944,212**	**$11,014,631**	**$57,961,156**

August 2020 dollars as adjusted by ENR-CCI were used for project OPCCs, total costs, and project fund allocations – City of Greeley Water and Sewer Department, City of Greeley Parks Department, and Development.
[1] W/S: City of Greeley water and sewer department, Parks: City of Greeley parks department, Dev: Development
[2] Project planning, design, and construction years are subject to change pending future project updates, development of projects, and/or schedule changes.
[3] OPCC and total costs per project are subject to change pending future project updates, development of projects, and/or schedule changes.

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6.4 CIP Implementation Schedule

Projects identified in the 5-year and 20-year planning horizons were given projected planning, design, and construction start years to help the City schedule project implementation. Annual fiscal requirements from 2021 through 2042 are shown in **Figure 6-3.**

For scheduling purposes, 5-year improvements were identified from 2022 through 2027, based on design start year, while 20-year improvements were identified from 2028 through 2042. NP projects are usually considered lower priority than water, sewer, or transportation projects so they were generally moved in time to match other nearby projects. It was assumed that each stage (planning, design, and construction) will take at least one year with the construction phase taking two, three, or four years if the total CIP cost for a project was greater than $1 million, $5 million, or $10 million, respectively.

Estimated start years for each planning horizon were adjusted based on the following factors:

- Water and Sanitary Sewer Improvements. When applicable, start years of NP projects were adjusted to align with major water and sanitary sewer improvements.
- Transportation Improvements. When applicable, start years were adjusted to coincide with major transportation improvements identified as part of the City's Keep Greeley Moving Phase 2 initiative (City of Greeley, 2021).
- Scheduling. When applicable, start years were adjusted based on needed prioritization of projects.
- Funding. Projects were staggered as needed to balance funding requirements.

If a project start year was shifted, the project is left within its original 2025 or 2040 planning horizon for modeling and analysis purposes but will appear in the correct 5- or 20-year CIP total. Note that the Upper Equalizer Project has major outlays between 2024 and 2028 resulting in higher CIP budgets over that timeframe.

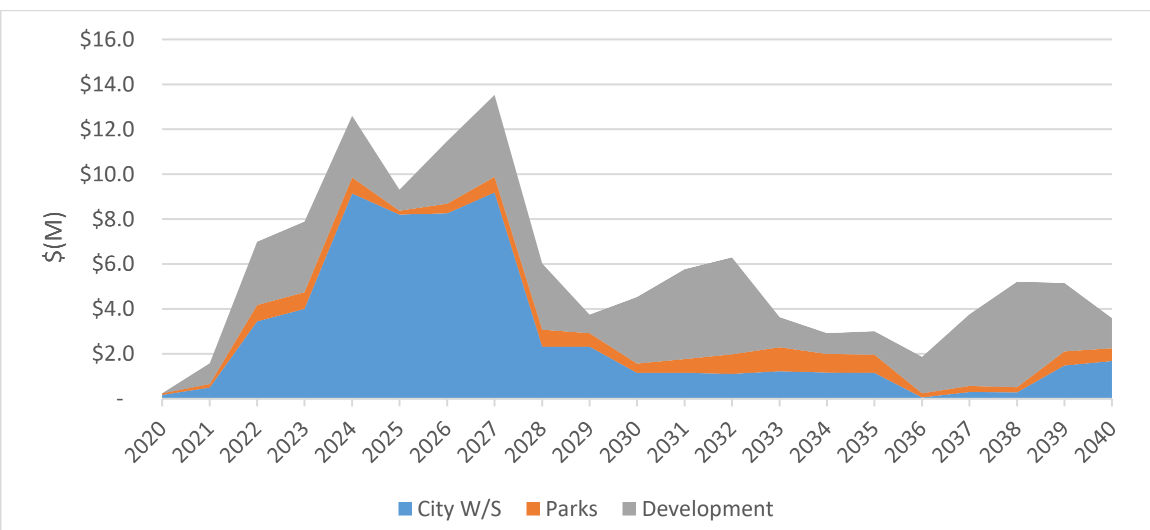

Figure 6-3 Annual NP Funding Projections by Fund

CIP costs are August 2020 dollars from ENR-CCI.

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Section 7

Findings and Recommendations

The findings and recommendations summarized in this section have been drawn from the planning and evaluation sections of this NPMP. The recommendations identify system needs, actions, and capital improvements through the buildout planning horizon. However, the actual implementation time frame will depend on actual growth rates, order of development, and the level of available capital funding. Additionally, the actual scope and implementation of these recommendations may vary with detailed planning and design.

7.1 Key Findings

Key findings identified as part of the NPMP include the following:

- Discussions with other Front Range stakeholders revealed that the City has a unique and advanced NP irrigation system, particularly for raw water suppliers. For more information, see **Section 2.1**.
- Historically, comprehensive data collection has often been difficult for the NP system. Additional studies or data collection, along with more standardized record keeping practices, can help the City keep track of the overall system. Record keeping practices could include recording ditch laterals in GIS, updating and enforcing construction drawing standards, creating a system for regularly updating the NP GIS database, and/or installing SCADA systems. For more information, see **Section 2.4** and **Section 2.5**.
- Review of historical demands showed that NP usage varies annually by significant amounts. In particular, demand dropped significantly as parks transitioned to improved control systems. Future NP demands are expected to come from two sources: 1) undeveloped lands that will use NP irrigation when they develop, and 2) existing areas that will convert to NP irrigation, referred to as conversion areas. NP peak season demands are expected to increase by 1.1 MGD by 2025, 2.8 MGD by 2040, and 11.5 MGD by buildout. NP adoption is strongly influenced by policy, which is a key conservation measure. For more information, see **Section 3**.
- Some of the existing systems were identified as needing improvement, but no critical deficiencies were identified. These include areas that are expected to have undersized inlet lines, pipes, or pumps by buildout. For more information, see **Section 5.2**.
- New recommended CIP projects were identified. These primarily consist of new pump stations or expansions of existing pipe systems to serve new areas and customers. New pump stations will be constructed primarily by development. It is estimated that the system will need 4 new pump stations by 2025, 12 new pump stations between 2025 and 2040, and 19 new pump stations between 2040 and buildout. For more information, see **Section 5.3**.

7.2 Recommendations

The recommendations for the NPMP include the following:

- Implement and enforce an NP policy to promote and expand NP irrigation practices. It is recommended for this policy to mandate that new developments and redevelopments use NP irrigation and for the policy to generally encourage the growth of the NP system.
- Consider implementing improved operational practices at existing pump stations either when it becomes necessary, or during other construction, such as rehabilitating a park irrigation system. This can include increasing the watering window to reduce peak hour demands by decreasing the size of irrigation zones and implementing SCADA where not currently installed. It is recommended for customers to use a watering window of 10 hours a day, where possible, and to use the best landscaping practices included in **Appendix F**.
- Create new standards for data collection and record keeping. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regularly updating the GIS database, and/or implementing a CMMS for NP infrastructure. It is also recommended for the City to conduct a study of ditches and laterals throughout the LREGA, and/or require developers to include this data in their plans.
- Implement and enforce requirements for the installation of SCADA systems at new or rebuilt pump stations. The City may consider including SCADA requirements in the City's Specifications.
- Continue monitoring and recording demands and pump station flows to identify major changes in operations that may impact system performance.
- Continue maintenance of the InfoWater model. This can include adding new pipes, deleting abandoned pipes, tracking open and closed valves, and reflecting operational changes as the system continues to expand.
- Evaluate the St. Michaels pump station to determine whether additional construction is needed at this site to meet higher demands. This evaluation should determine whether demand management could be an effective solution, and whether the pumps can be upsized without replacing the entire pump station.
- Coordinate this NPMP with other relevant planning documents, such as the WTDMP, SSMP, *Imagine Greeley Comprehensive Plan*, and BBC report. It is recommended to use this NPMP as a guide for infrastructure planning and to use the BBC report as a guide for water resources planning.
- Continue building the NP system through a hub-and-spoke approach. Consider looping or connecting systems where systems are on similar hydraulic grade lines and looping would improve operational flexibility.

- In areas with limited or interim development, require the construction of NP infrastructure, such as piped irrigation system, even if a pump station will not be constructed until later.
- New pipe and pump station layouts are conceptual in nature and are primarily intended to show hydraulic feasibility for master planning purposes. Conduct a detailed evaluation of pipe alignment and size, and pump station location and sizing as projects move into design and implementation stages when there is more certainty of development and design criteria. The InfoWater model can be used as a tool to support future planning decisions, if regularly maintained.
- Complete the capital improvements recommended in **Section 6**, prioritizing the 5-year CIP recommended projects. Coordinate closely with the City's parks department, other utilities, and developers to regularly update the scheduling of these projects. The City should consider using the InfoWater model as a tool to inform developer plans while coordinating with them.
- Update the NPMP every 5 years, including reevaluating demand and population projections every 5 to 10 years. Planning assumptions made for the NP system in the next 20 years and beyond is subject to change with time.

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Section 8

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Appendix A

Field Inventory Summaries

The following table summarizes the infrastructure identified and recorded as part of the field inventory conducted for the NPMP.

Asset Type	Number of Items Surveyed
Air release valve	19
Augmentation water discharge	1
Backflow preventer	1
Blow off	57
Control panel building	1
Curb stop valve	13
Ditch-point	14
Drain valve	7
Flume level sensor	1
Flush pit	3
Head gate	24
Manhole	4
Meter	131
Pond	20
Pressure release valve	1
Pump	71
Settling vault	1
Tracer wire	38
Truck fill	2
Valve	263
Weir	6
Well	9

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Appendix B

Naming System

The following table captures the naming system used to record infrastructure identified as part of the field inventory for the NPMP.

System	Location	Asset Type
NP-Non-Potable Water	BG-Boomerang Golf	WEL-Well
	BP-Bittersweet Park	MET-Meter
	BS-Balsam Sports	PMP-Pump
	CW-Cottonwood Park	VAL-Valve
	DP-Delta Park	FPT-Flush Pit
	EM- East Memorial	HGT-Head gate
	GM-Glenmere Park	MNH-Man Hole
	GW-Greeley West Park	FLF-Filter Flush
	HH-Highland Hills Golf	PND-Pond
	IG- Island Grove Park	PPL-Pump Panel
	JF-Jackson Field Sports	TKF-Truck Fill
	JJ-Josephine Jones Park	TRW-Tracer Wire
	LG-Linn Grove	SVT-Settling Vault
	LP-Luther Park	ARV-Air Relief Valve
	ME-Madison Elementary	CSV-Curb Stop Valve
	MF-Monfort Elementary	BOF-Blow Off
	NR-North Ridge School	PRV-Pressure reducing valve
	PM-Promontory Park	WER- Weir
	PP-Poudre Ponds	BFP-Backflow Preventor
	PV-Peak View Park	BDT-Boyd Ditch
	RE- Romero Elementary	ADS-Augmentation Discharge
	RP-Ramseier Park	
	SM-Saint Michaels	
	SP-Sanborn Park	
	TC-Tech Center	
	WP-Waggin Tail Dog Park	
	YS-Youth Sports Complex	
	TR-Twin Rivers Park	

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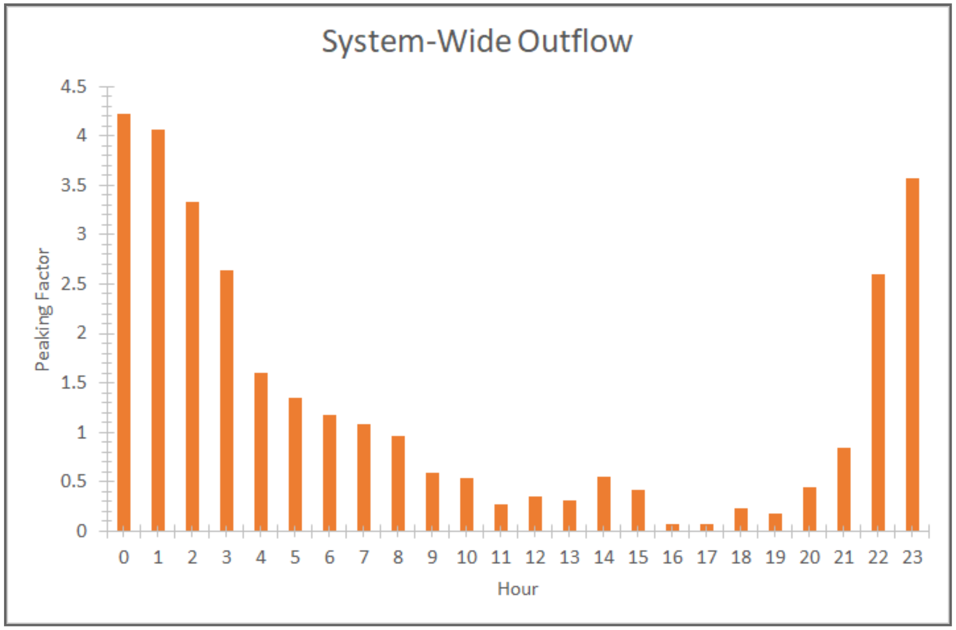
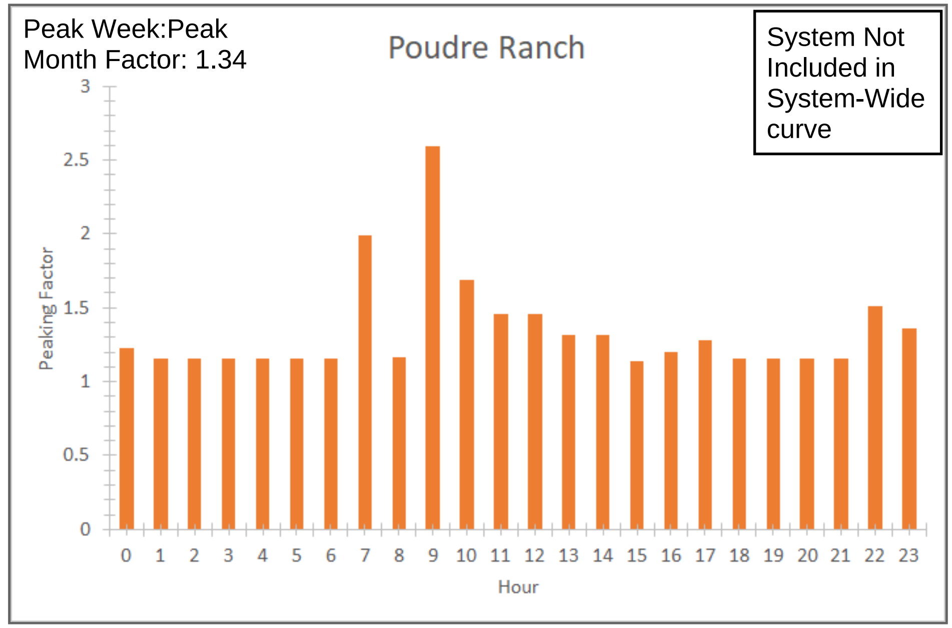
Appendix C

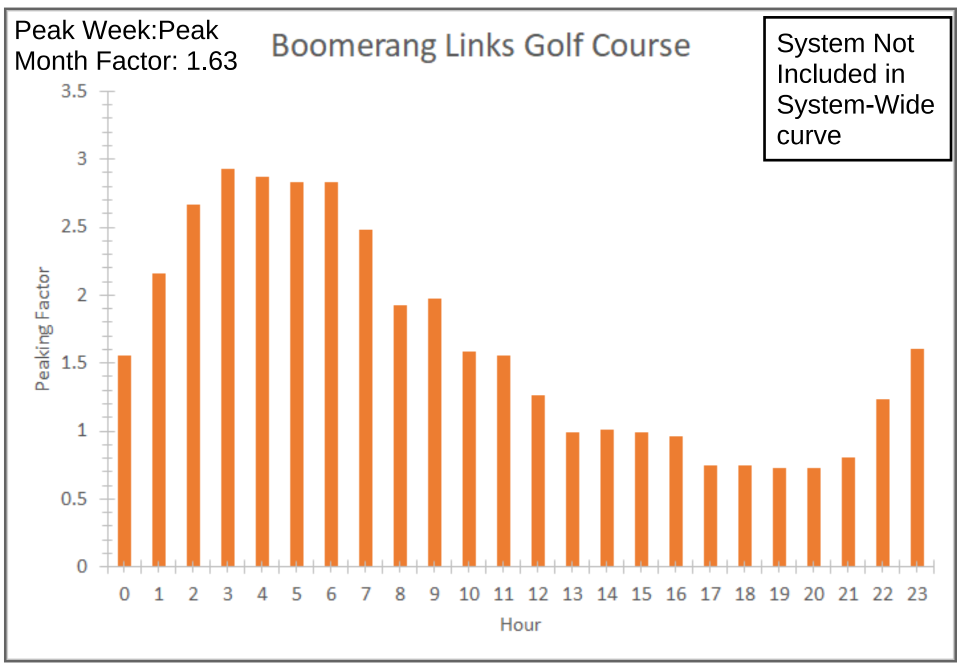
Individual Diurnal Curves

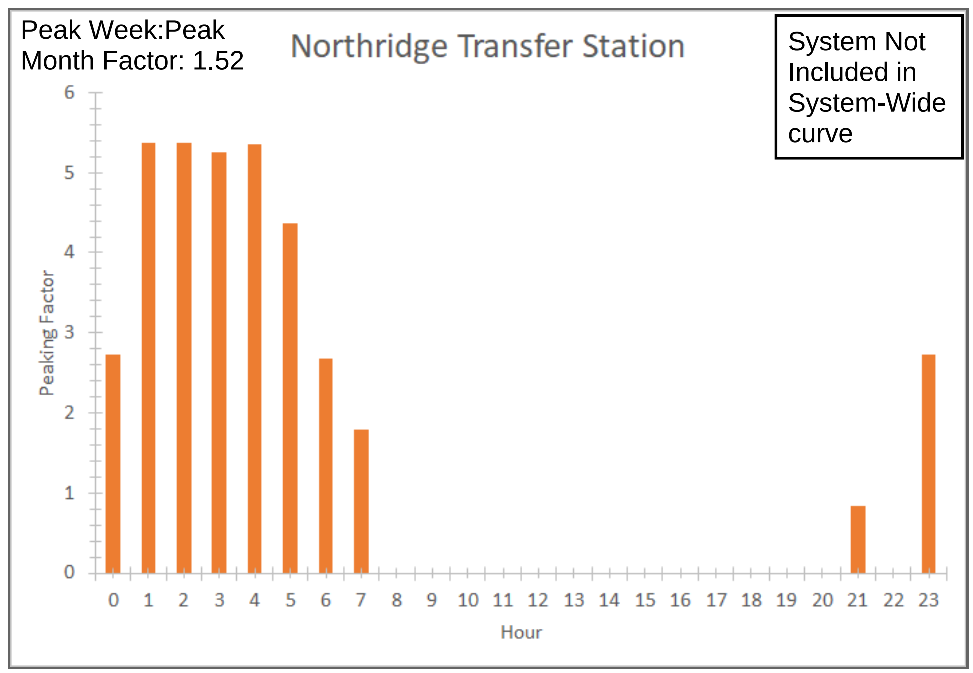
The graphs shown below are diurnal curves for each of the individual existing systems, where SCADA data was available. Each curve has a unique peak week : peak month factor and was based on the system's peak week (during July and August 2018 and 2019). Operational changes may improve individual system performance by flattening demand during periods of use while reducing peak demand factors. Such changes could result in downsizing future pipelines and pumps and potentially reducing future operating costs without changing future maximum month demands. It should be noted that current demand patterns are largely driven by end user choices, such as vegetation, watering schedule and duration, irrigation system configuration, and irrigation controls, as well as future weather conditions. Any or all of these factors could change in the future.

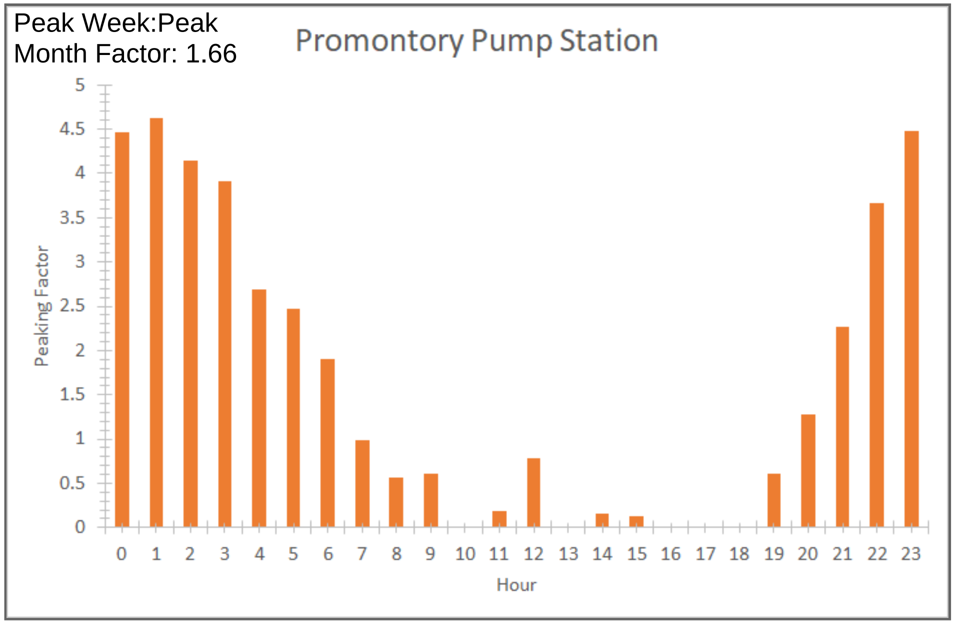
*** 0 hour = 12:00 AM

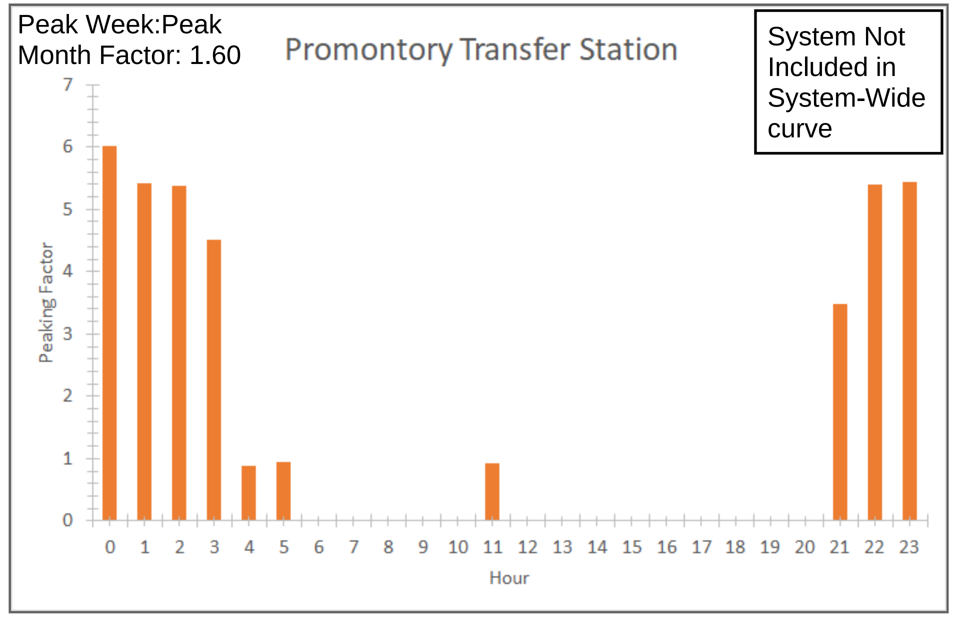


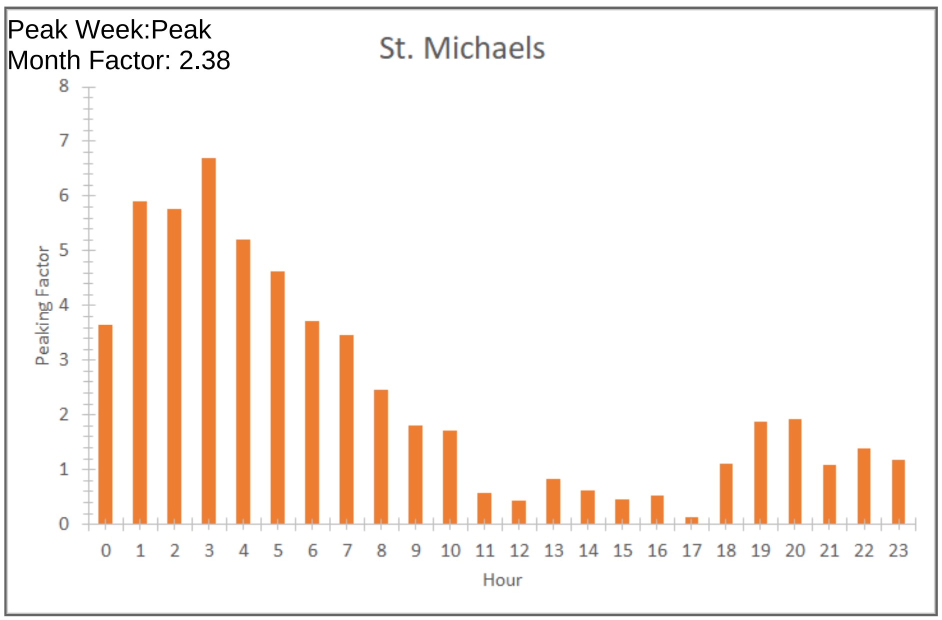


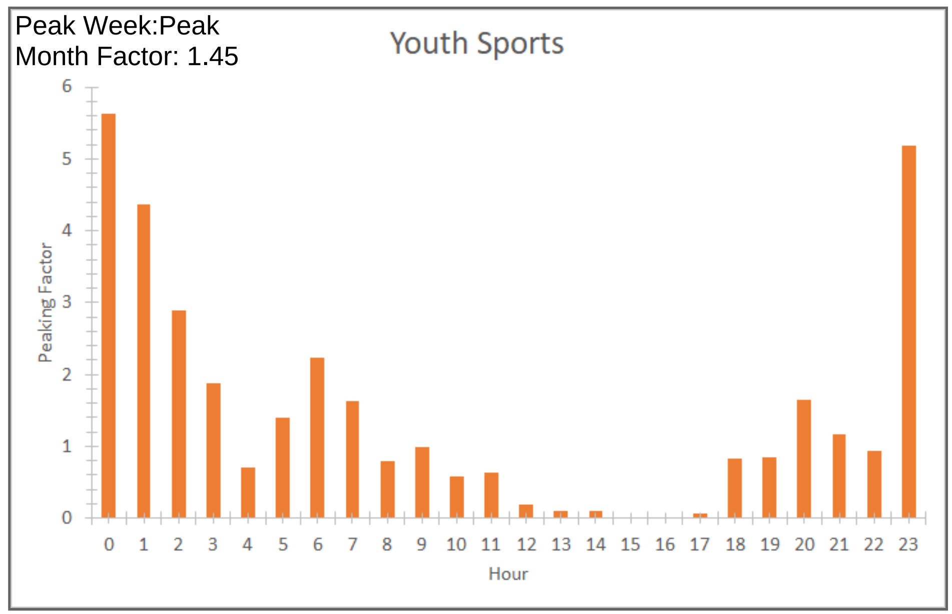


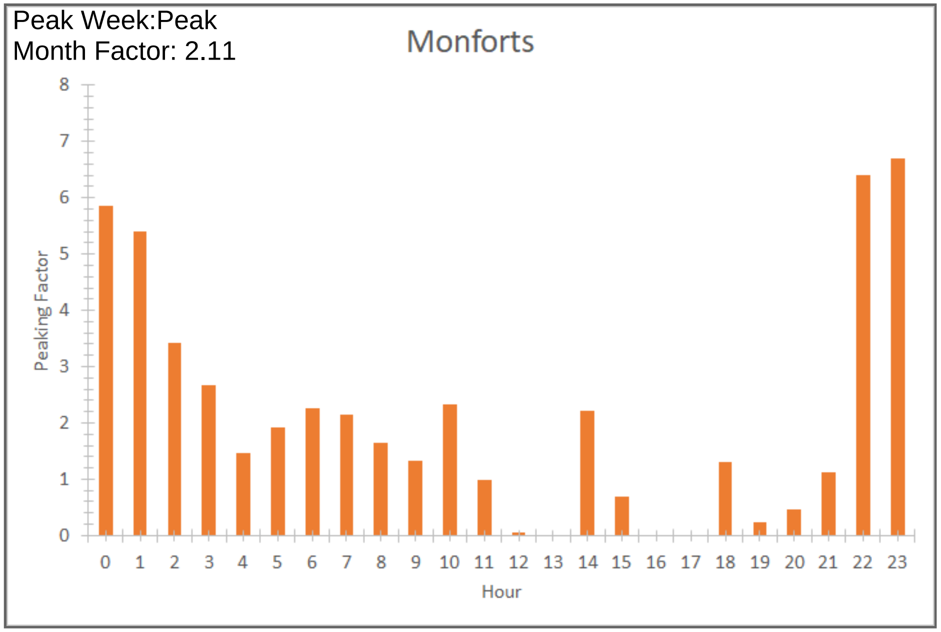


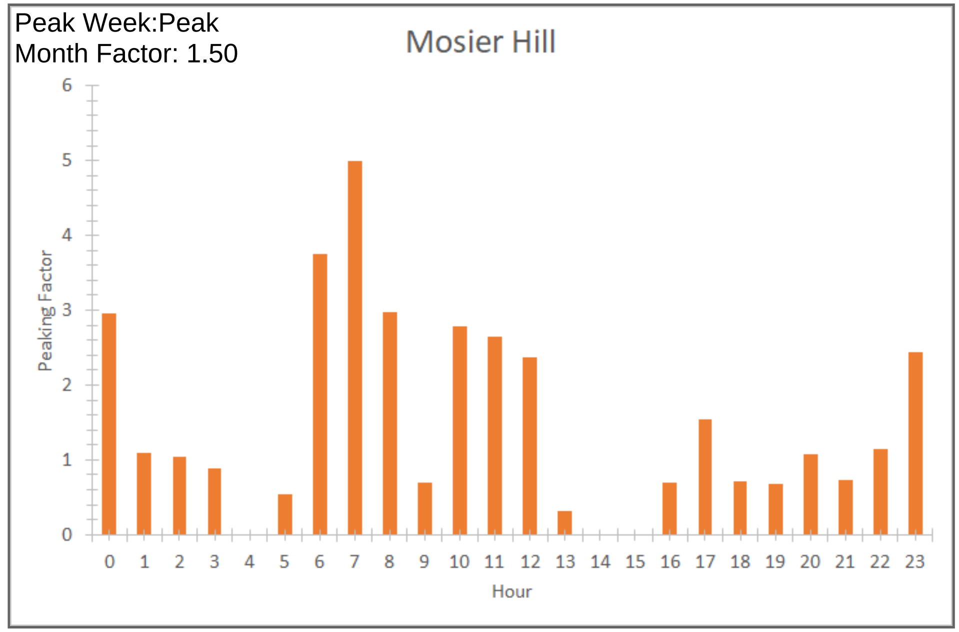

Peak Week:Peak
Month Factor: 1.66
Promontory Pump Station
Peaking Factor
Hour

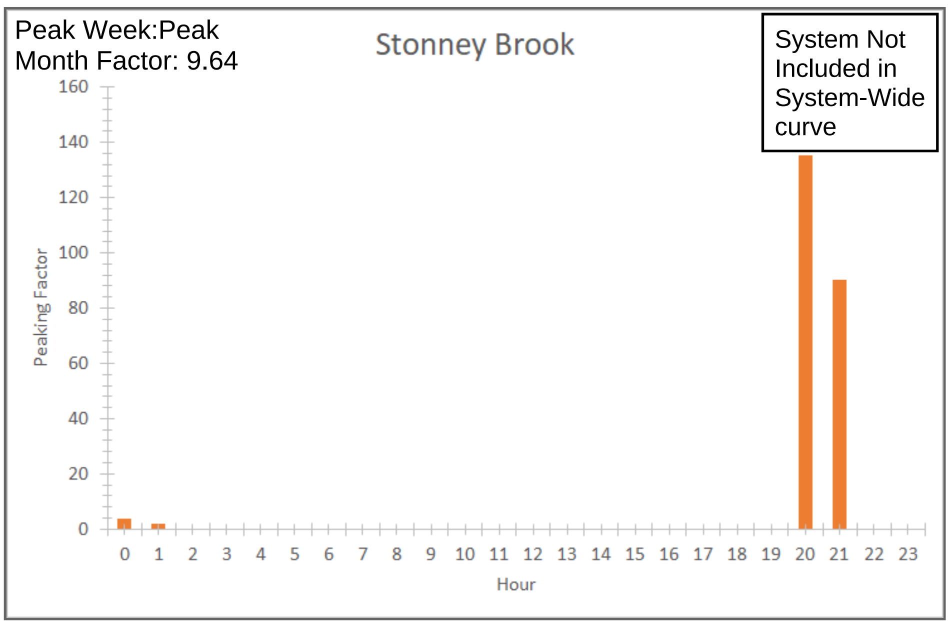

Peak Week:Peak
Month Factor: 1.60
Promontory Transfer Station
System Not Included in System-Wide curve
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 2.38
St. Michaels
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.45
Youth Sports
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 2.11
Monforts
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.50
Mosier Hill
Peaking Factor
Hour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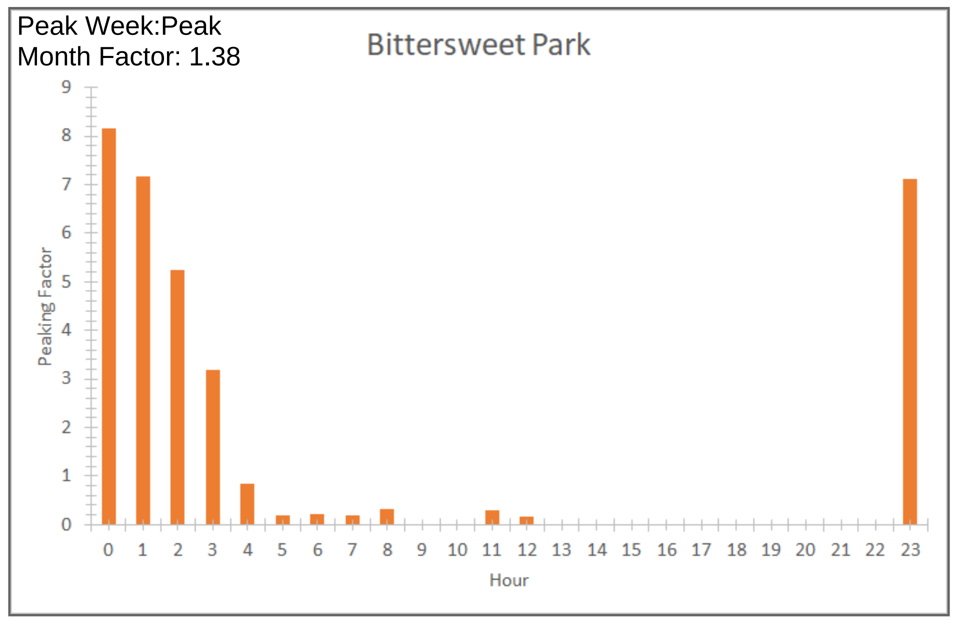
Stonney Brook
System Not Included in System-Wide curve
Peaking Factor
Hour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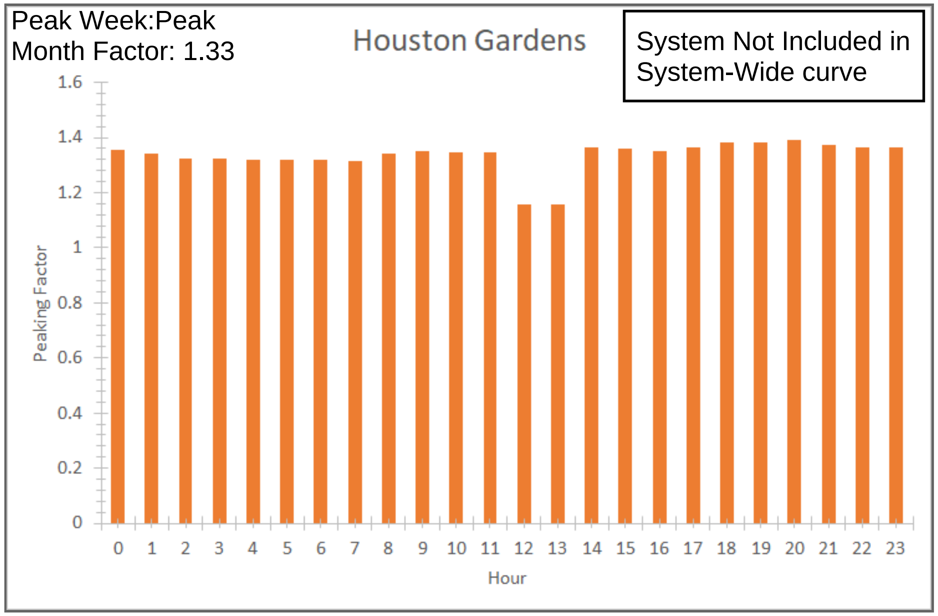
Month Factor: 1.38
Bittersweet Park
Peaking Factor
Hour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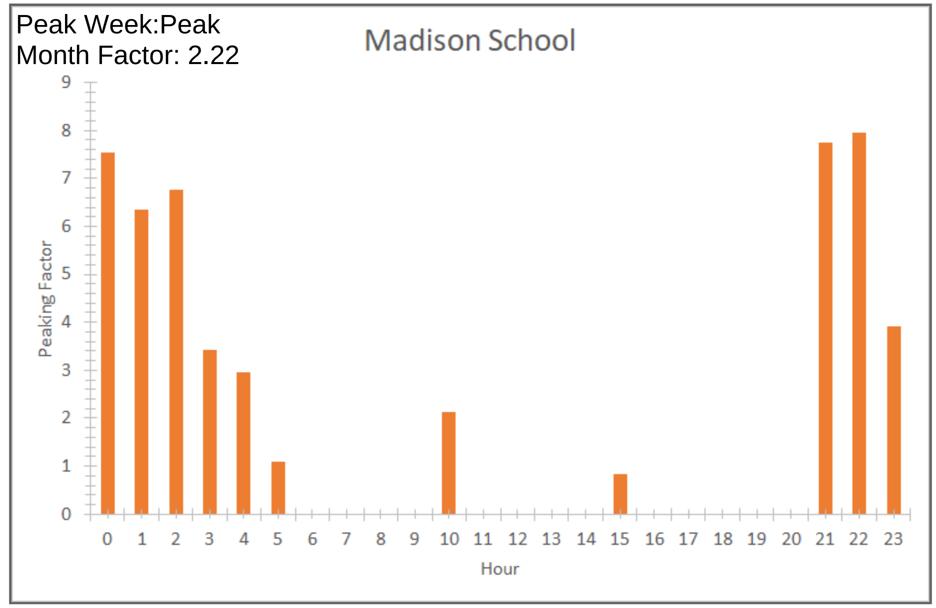
Month Factor: 1.33
Houston Gardens
System Not Included in
System-Wide curve
Peaking Factor
Hour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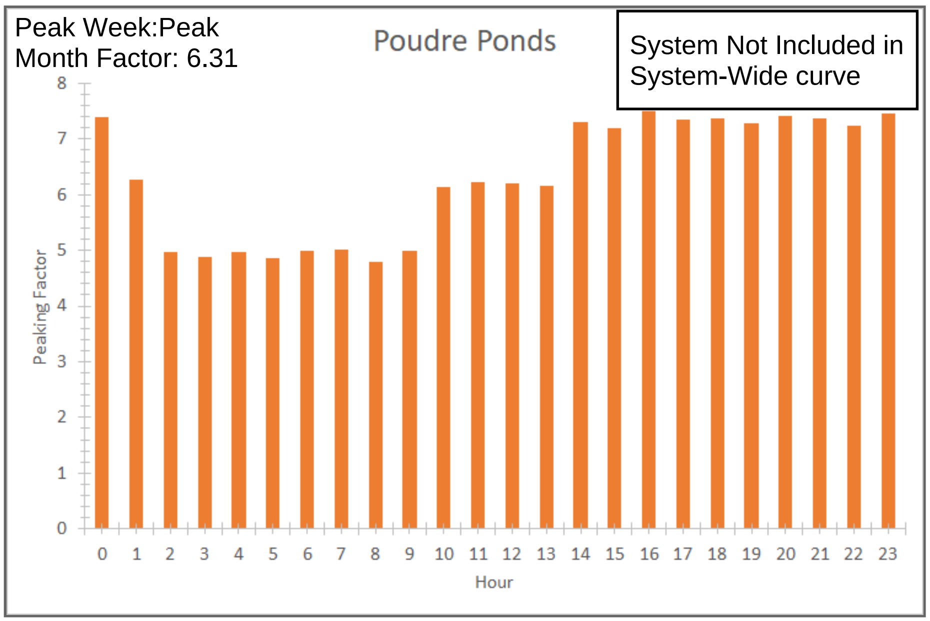
Month Factor: 2.22
Madison School
Peaking Factor
Hour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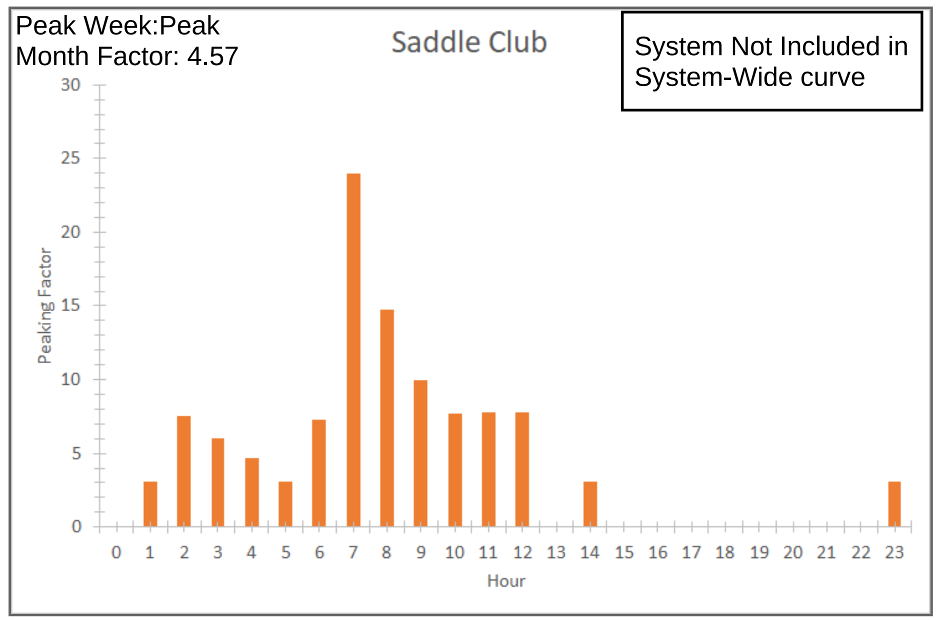
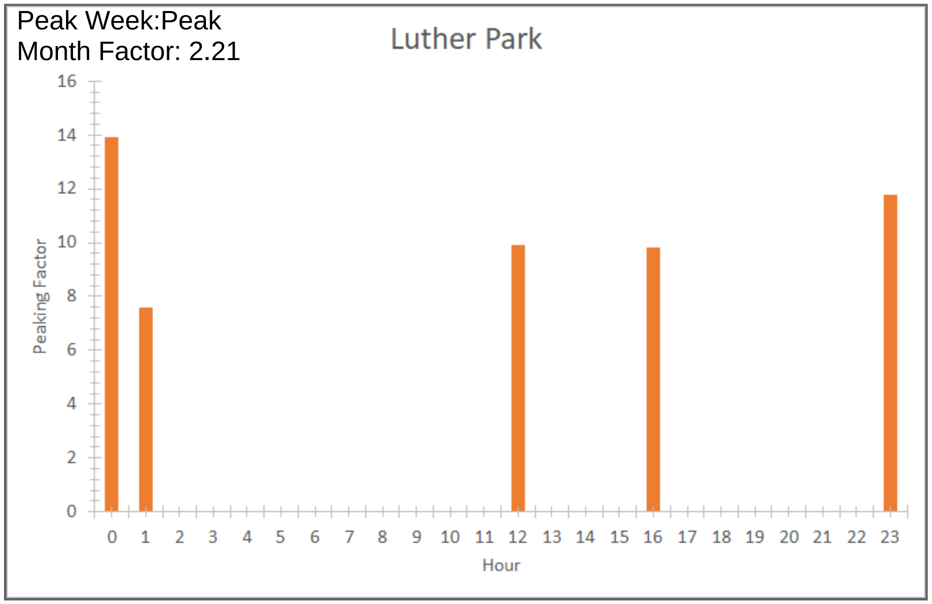
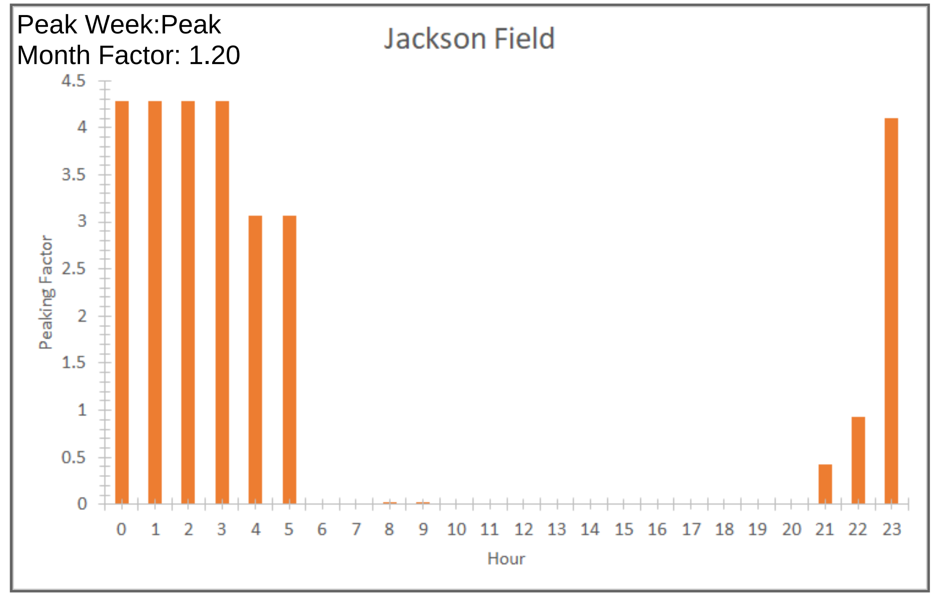
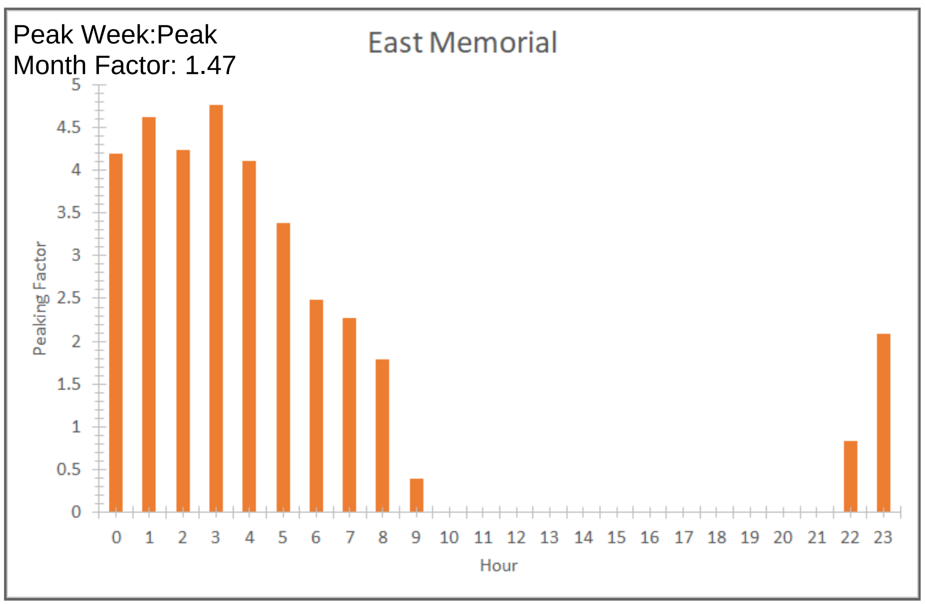
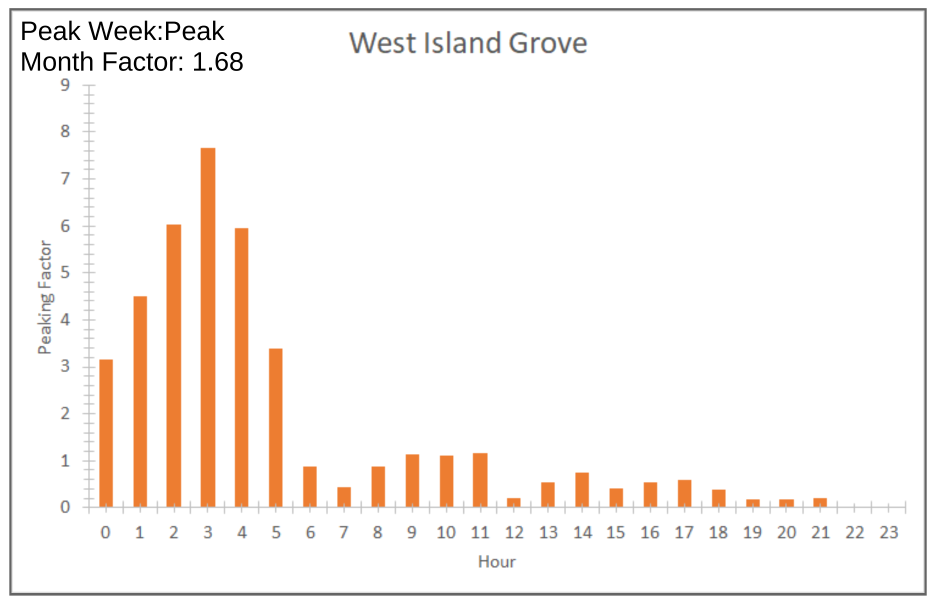
Month Factor: 6.31
Poudre Ponds
System Not Included in
System-Wide curve
Peaking Factor
Hour

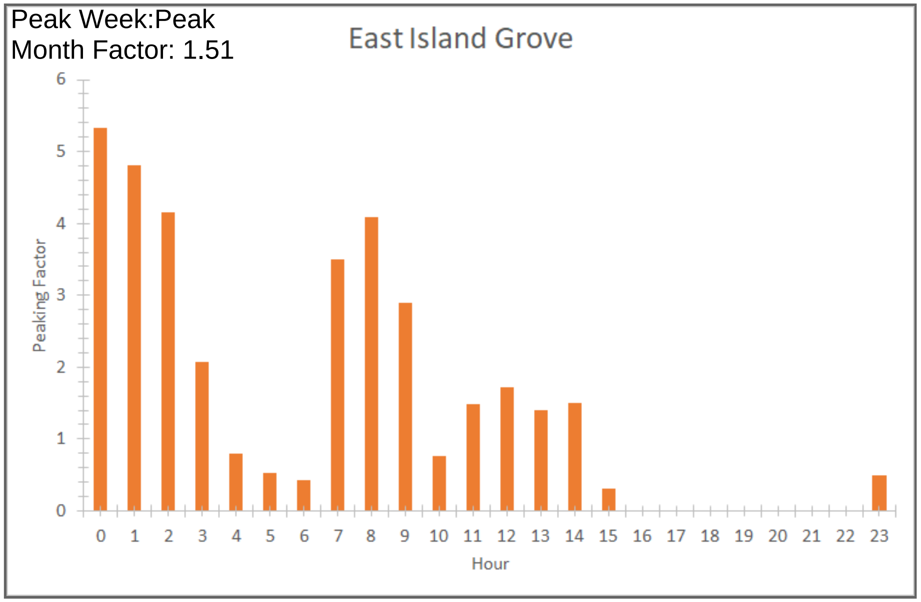

Peak Week:Peak
Month Factor: 4.57
Saddle Club
System Not Included in
System-Wide curve
Peaking Factor
Hour

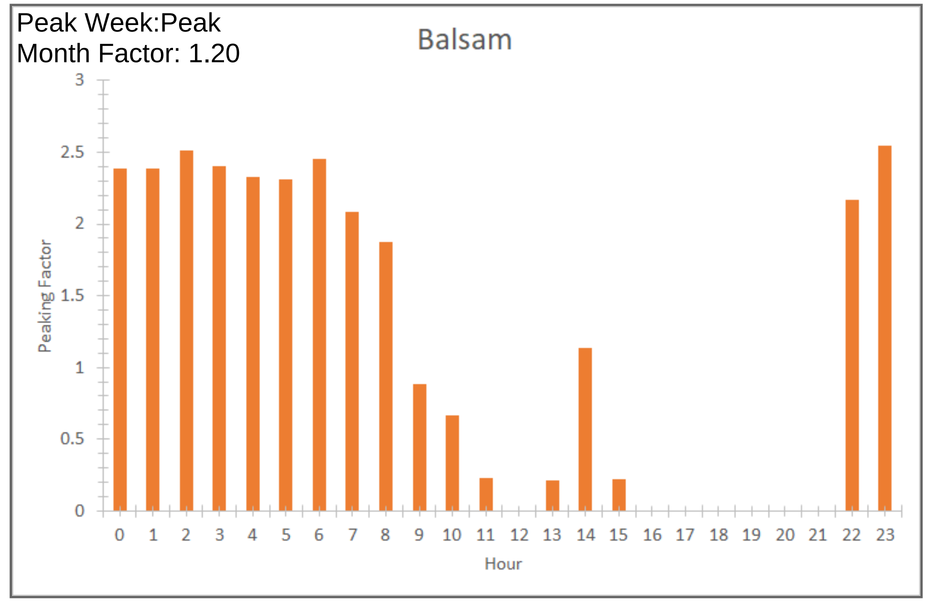

Peak Week:Peak
Month Factor: 2.21
Luther Park
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.20
Jackson Field
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.47
East Memorial
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.68
West Island Grove
Peaking Factor
Hour


Peak Week:Peak
Month Factor: 1.51
East Island Grove
Peaking Factor
0
1
2
3
4
5
6
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour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Month Factor: 1.20
Balsam
Peaking Factor
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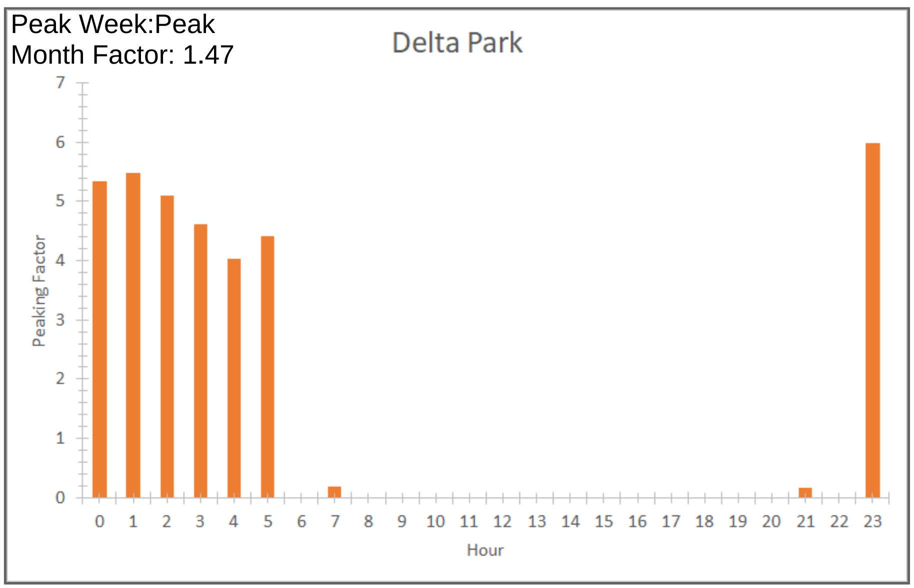
0.5
1
1.5
2
2.5
3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour


Peak Week:Peak
Month Factor: 1.47
Delta Park
Peaking Factor
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1
2
3
4
5
6
7
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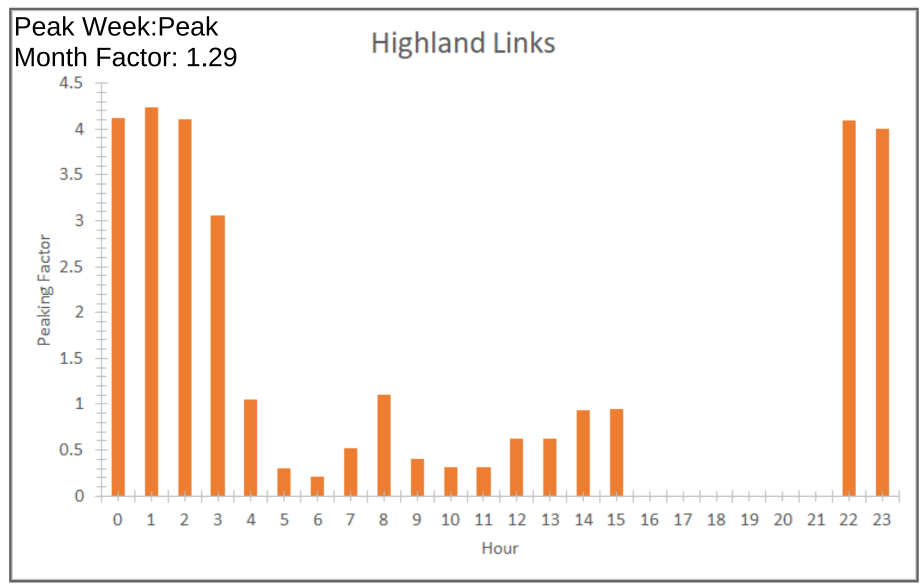
Hour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Month Factor: 1.29
Highland Links
Peaking Factor
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0.5
1
1.5
2
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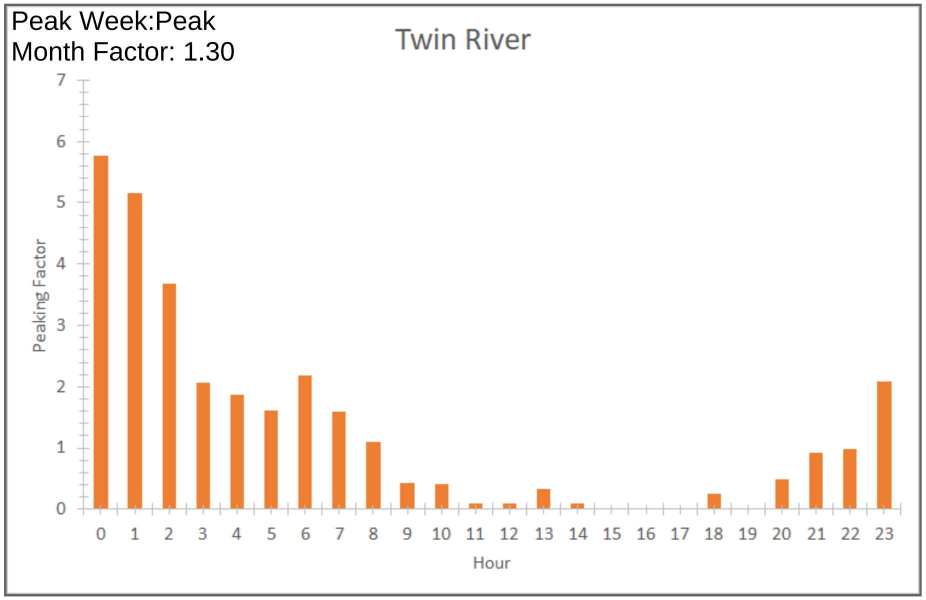
3
3.5
4
4.5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour


Peak Week:Peak
Month Factor: 1.30
Twin River
Peaking Factor
Hour
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1
2
3
4
5
6
7
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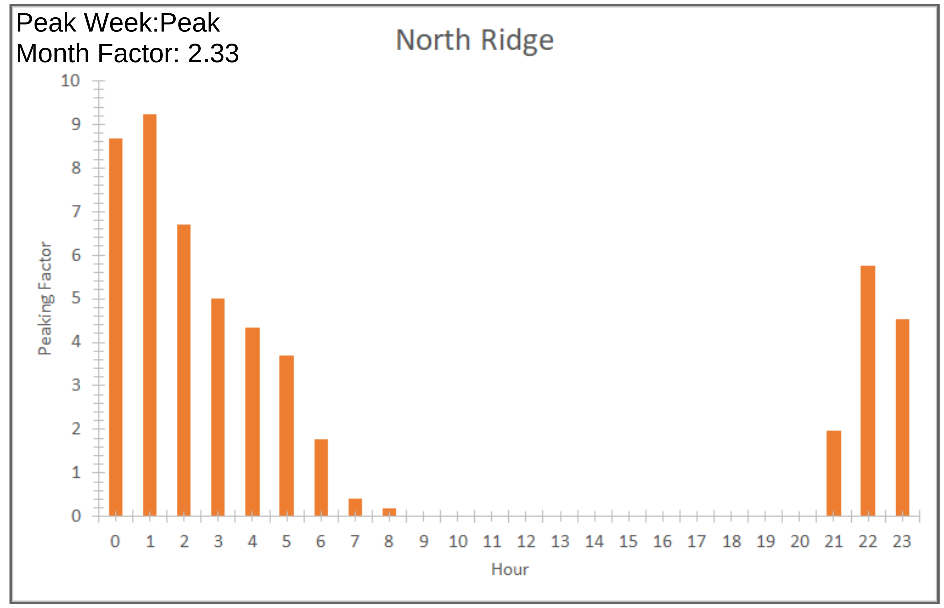
Peak Week:Peak
Month Factor: 2.33
North Ridge
Peaking Factor
Hour
0
1
2
3
4
5
6
7
8
9
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Appendix D

Existing Station Details

The following table contains the results of the modeling and desktop analyses for the existing system. For more information on recommended improvements to the existing system, please see **Section 5.2**.

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Pump Station Name	Pump Name	Pump Design Capacity (gpm) Existing	Station Design Capacity (gpm) Existing	Pumping Head (ft) Existing	Inlet Diameter (Smallest) (in) Existing	Max Hour Demand (gpm) Existing	Max Hour Demand (gpm) Buildout	Max Day Demand (gpm) Buildout	Max Day Demand (gpd) Buildout	Max Hour % of Pumping Capacity Buildout	Max Day % of Pumping Capacity Buildout, 10hrs	Recommended Pond Capacity (AF) Buildout	Inlet Max Headloss at Buildout (ft/1000 ft)	Max Day Demand without Adoption (gpd) Buildout	Notes
Twin Rivers	NP-TR-PMP-01	1,000	4,200	259	10	1,314	2,004	544	782,942	48%	31%	10.6	21	783,205	
	NP-TR-PMP-02	200													
	NP-TR-PMP-03	1,000													
	NP-TR-PMP-04	1,000													
	NP-TR-PMP-05	1,000													
Youth Sports	NP-YS-PMP-06	600	1,200	250	6	941	941	257	370,109	78%	51%	5.0	19	370,109	
	NP-YS-PMP-07	600													
Highland Hills Golf	NP-HH-PMP-01	667	2,001	289	10	1,792	1,792	571	822,053	90%	68%	11.1	18	822,053	
	NP-HH-PMP-02	667													
	NP-HH-PMP-03	667													
Monfort	NP-MF-PMP-01	800	2,400	234	10	1,423	1,745	589	848,074	73%	59%	11.5	21	848,337	
	NP-MF-PMP-02	800													
	NP-MF-PMP-03	800													
Josephine Jones Park	NP-JJ-PMP-01	115	115	223	4	106	161	52	75,413	140%	109%	1.0	30	75,472	
St. Michaels	NP-SM-PMP-01	560	1,120	288	20	1,121	1,167	426	613,800	104%	91%	8.3	0	613,800	
	NP-SM-PMP-02	560													
Peakview Park	NP-PV-PMP-01	400	800	240	8	681	681	148	213,048	85%	44%	2.9	9	213,048	
	NP-PV-PMP-02	400													
Boomerang South	NP-BG-PMP-01	500	1,500	307	N/A	694	0	0	0	0%	0%	0.0	N/A	0	Being replaced by Boomerang Regional Pump Station
	NP-BG-PMP-02	500													
	NP-BG-PMP-03	500													
North Ridge High School	NP-NR-PMP-01	900	2,700	272	18	1,205	1,752	486	699,811	65%	43%	9.4	1	699,811	
	NP-NR-PMP-02	900													
	NP-NR-PMP-03	900													
Boomerang North	NP-BG-PMP-04	500	1,500	307	8	769	769	250	359,309	51%	40%	4.9	11	359,309	
	NP-BG-PMP-05	500													
	NP-BG-PMP-06	500													
Poudre River Ranch	NP-BG-PMP-09	175	175	226	24	205	205	84	120,830	117%	115%	1.6	0	120,830	Single inlet for all 71st Avenue Transfer pumps
Boomerang Transfer	NP-BG-PMP-07	900	1,800	272		951	621	346	498,010	35%	46%	6.7		498,010	
	NP-BG-PMP-08	900													
North Ridge Transfer	NP-BG-PMP-10	900	1,800	272		936	936	269	387,346	52%	36%	5.2		387,346	
	NP-BG-PMP-11	900													
Promontory Park - Transfer	NP-PM-PMP-01	800	1,600	157	12	1,651	1,651	464	668,765	103%	70%	9.0	7	668,765	
	NP-PM-PMP-02	800													
Promontory Park - Main	NP-PM-PMP-03	700	2,100	261	14	1,270	1,866	674	970,200	89%	77%	13.1	3	970,200	
	NP-PM-PMP-04	700													
	NP-PM-PMP-05	700													
Greeley West Park	NP-GW-PMP-01	1,000	2,000	236	4	72	861	280	402,610	43%	34%	5.4	1,150	402,946	Pump station being replaced, proposed inlet size unknown
	NP-GW-PMP-02	1,000													
Sanborn Park	NP-SP-PMP-01	250	500	256	4	268	289	94	135,158	58%	45%	1.8	60	135,168	
	NP-SP-PMP-02	250													
Cottonwood Park	NP-CW-PMP-01	115	115	212	4	69	69	23	32,414	60%	47%	0.4	4	32,414	
Glenmere Park	NP-GM-PMP-01	180	180	226	4	135	304	99	142,214	169%	132%	1.9	127	142,215	
Bittersweet Park	NP-BP-PMP-01	500	1,000	250	6	854	1,160	258	371,563	116%	62%	5.0	150	371,626	
	NP-BP-PMP-02	500													
Luther Park	NP-LP-PMP-01	265	530	224	10	492	498	89	127,469	94%	40%	1.7	2	127,474	
	NP-LP-PMP-02	265													
Madison Elementary and Houston Gardens	NP-ME-PMP-01	125	125	200	8	310	310	298	428,616	248%	571%	5.8	3	428,618	Single inlet for two pumps
	NP-ME-PMP-02	500	500	231		90	93	27	38,203	19%	13%	0.5		38,203	

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Pump Station Name	Pump Name	Pump Design Capacity (gpm) Existing	Station Design Capacity (gpm) Existing	Pumping Head (ft) Existing	Inlet Diameter (Smallest) (in) Existing	Max Hour Demand (gpm) Existing	Max Hour Demand (gpm) Buildout	Max Day Demand (gpm) Buildout	Max Day Demand (gpd) Buildout	Max Hour % of Pumping Capacity Buildout	Max Day % of Pumping Capacity Buildout, 10hrs	Recommended Pond Capacity (AF) Buildout	Inlet Max Headloss at Buildout (ft/1000 ft)	Max Day Demand without Adoption (gpd) Buildout	Notes
Ramseier	NP-RP-PMP-01	225	450	235	8	734	739	240	345,485	164%	128%	4.7	11	345,490	
	NP-RP-PMP-02	225													
Island Grove and Saddle Club	NP-IG-PMP-01	600	600	290	N/A	605	605	135	194,242	101%	54%	2.6	N/A	194,242	
	NP-IG-PMP-02	700	700	300	N/A	401	401	120	172,267	57%	41%	2.3	N/A	172,267	
	NP-IG-PMP-03	300	300	259	N/A	72	138	48	69,595	46%	39%	0.9	N/A	69,677	
Jackson Field Sports	NP-JF-PMP-01	200	400	236	14	258	317	95	137,074	79%	57%	1.9	0	137,132	
	NP-JF-PMP-02	200													
Linn Grove Cemetery	NP-LG-PMP-03	350	350	305	4	95	122	40	57,168	35%	27%	0.8	11	57,168	
Bella Romero Elementary	NP-RE-PMP-01	330	330	263	N/A	109	109	35	50,803	33%	26%	0.7	N/A	50,803	
East Memorial	NP-EM-PMP-01	34	319	189	10	314	440	146	210,600	138%	110%	2.8	2	210,651	
	NP-EM-PMP-02	285		213											
Delta Park	NP-DP-PMP-01	95	95	231	4	52	52	6	8,928	55%	16%	0.1	2	8,928	
Balsam Park	NP-BS-PMP-01	290	290	120	4	51	51	19	27,749	18%	16%	0.4	0	27,749	

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Appendix E

Future Pump Station Details

The following table contains the preliminary design points used to design all future pump stations through buildout. This information is for planning purposes only and does not constitute a full hydraulic design. Additional engineering work, as well as coordination between developers and the City, will be necessary to design all future NP infrastructure.

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Pump Station Name	Planning Horizon	Pump Station Elevation (ft)	HGL (ft)[3]	Pump Station Demand (gpm)[2]			% of Buildout			Max Day Demand, Unadopted (gpd) Buildout	# Pumps	Pump Design		PS Outlet Size (in)	Pond Size (acre-ft)[1]	Notes
				2025	2040	Buildout	2025	2040	Buildout			Flow (gpm)	Head (ft)			
SA-0	2075	4741	4930	0	0	641	0%	0%	100%		2	390	170	8	3.0	
SA-1	2075	4742	4929	0	0	646	0%	0%	100%		2	390	170	8	3.0	
SA-2	2075	4714	4915	0	0	534	0%	0%	100%		2	330	180	8	2.5	
SA-3	2040	4709	4887	0	118	505	0%	23%	100%		2	310	160	8	2.3	
SA-4	2040	4692	4895	0	110	187	0%	59%	100%		2	120	180	8	0.9	
SA-5	2075	4697	4885	0	0	516	0%	0%	100%		2	310	170	8	2.4	
SA-6	2075	4732	4933	0	0	300	0%	0%	100%		2	180	180	8	1.4	
SA-10	2075	4643	4831	0	0	833	0%	0%	100%		2	500	170	10	3.8	
SA-12	2040	4919	5150	0	284	963	0%	29%	100%		2	580	210	10	4.4	
SA-13	2075	4896	5091	0	0	1006	0%	0%	100%		2	610	170	10	4.6	
SA-14	2025	4898	5150	217	353	2915	7%	12%	100%		2	1750	230	16	13.4	Tech Center
SA-15	2040	4996	5184	0	1	1158	0%	0%	100%		2	700	170	10	5.3	
SA-16	2040	4906	5104	0	265	866	0%	31%	100%		2	520	180	10	4.0	
SA-25	2025	4921	5098	186	374	521	36%	72%	100%		2	320	160	8	2.4	
SA-30	2075	4880	5053	0	0	360	0%	0%	100%		2	220	155	8	1.7	
SA-34	2040	4752	4939	0	190	464	0%	41%	100%		2	280	170	8	2.1	
SA-35	2040	4681	4859	0	381	508	0%	75%	100%		2	310	160	8	2.3	
SA-36	2040	4790	4976	0	284	737	0%	38%	100%		2	450	170	8	3.4	
SA-38	2040	4636	4843	0	46	118	0%	39%	100%		2	80	180	8	0.5	
SA-41	2075	4663	4840	0	0	928	0%	0%	100%		2	560	160	10	4.3	
SA-42	2040	4663	4861	0	278	596	0%	47%	100%		2	360	180	8	2.7	
SA-44	2025	4835	5011	48	147	549	9%	27%	100%		2	330	160	8	2.5	
SA-46	2075	4749	4927	0	0	921	0%	0%	100%		2	560	160	10	4.2	
SA-47	2075	4761	4949	0	0	799	0%	0%	100%		2	480	170	10	3.7	
SA-48	2075	4757	4945	0	0	862	0%	0%	100%		2	520	170	10	4.0	
SA-49	2075	4712	4901	0	0	920	0%	0%	100%		2	560	170	10	4.2	
SA-50	2075	4741	4929	0	0	1275	0%	0%	100%		2	770	170	12	5.9	
SA-51	2075	4730	4928	0	0	2083	0%	0%	100%		2	1250	180	16	9.6	
SA-52	2075	4724	4912	0	0	1078	0%	0%	100%		2	650	170	10	5.0	
SA-53	2075	4686	4874	0	0	1500	0%	0%	100%		2	910	170	12	6.9	
SA-57	2075	4894	5114	0	0	1232	0%	0%	100%		2	740	200	16	5.7	
SA-60	2025	4894	5081	342	733	922	37%	80%	100%		2	560	200	10	4.2	
Boomerang Regional PS	2025	4791	4978	829	1650	2716	31%	61%	100%		2	1630	170	16	12.5	

Notes and Equations:

[1]Pond size = ((peak hour demands, gpm) / (4.22 peak hour / peak month) * (1440 min / day) * (1 AF / 325851 gal)) * 1.1 (for ET losses)

[2]Peak hour demands

[3]Average head at downstream junction = (Elevation, ft) + (Downstream pressure @ max hour, psi)*(2.31 ft/1 psi)

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Appendix F

WaterWise Landscaping Best Practices Manual Criteria

The following manual was developed by the City of Greeley as a guide for implementing best practices for landscaping and irrigation to promote water conservation.

City of Greeley

WaterWise Landscaping Best Practices Manual Criteria

Draft

November 2019

Water Conservation
Water Reources

Table of Contents *Page*

WaterWise Landscaping

Best Practices Manual

Section 1 – Introduction

Prevalent landscaping practices used in of development today have disregarded the long-term effects on the region’s water supply. Nearly 75% of summer water use is consumed by outdoor vegetation. The drought in Colorado has highlighted the necessity of using WaterWise design practices in order to best use our limited water resources. Significant reductions can be gained through minor changes in the arrangement of plantings, alternative plant selection and soil preparation.

The City of Greeley has drafted criteria that includes WaterWise landscape practices that will be can be used to guide development in the design of landscaping. This criteria can also be used as a reference for esisting landscapes and irrigation design. The purpose of the project is to:

1. move closer to use of landscaping that matches our semi-arid environment
2. include specific direction in choice of plant material
3. include illustrations
4. to the extent possible, make language easy to understand and apply
5. include both xeriscape requirements and aspirational practices

Besides requirements for new development, the process also includes this “Best Practices Manual” that all citizens can use in making choices about their home landscaping. These Best Practices for landscape design are derived from the seven principles of Xeriscaping, as well as GreenCo’s Best Management Practices.

The intention for these Best Practices is to inform home and property owners about landscape and irrigation needs unique to Colorado, and to assist in creating responsible landscape and irrigation design decisions.

WaterWise Landscaping
Best Practices

Section 2 – WaterWise Principles and Guidelines
DSW, Sources: GreenCo BMPs, Xeriscape Principles

This section focuses on eight "principles" that act as goals for smart planting and irrigating in the Colorado region. Each principle offers a series of design recommendations and techniques in the form of "guidelines". The guidelines function as steps to achieve the goals. Each guideline is not imperative but still important to ensure healthy plant growth, reduced water waste and increased cost savings over time. The following principles, if used properly, will help to create a useful, efficient and enjoyable WaterWise landscape.

Principle #1 – Plan and design landscaping comprehensively.

Guidelines

A. Start with an inventory and analysis plan of the site that identifies "existing conditions." Conditions such as drainage areas, sun exposure, soil types, good views, existing plants, etc. will affect how the site is used (Figure 1). Next develop a list of activities and areas, also called a "program," expected to occur on the site. For example a backyard program might include a lawn play area, dog run, dining patio, barbecue grill, shade trees and shrub beds. Continue by diagramming possible locations for the program activities, while also providing access and traffic patterns or screening as needed. Finally, use this information to develop a plan that integrates plants into the overall scheme (Figure 2).
B. Now with your overall plan, consider options on how you would like to conserve water. Several recommendations for water conservation are addressed throughout this document.
C. Calculate the water requirements for your landscape using the Water Budget Worksheet provided in Section Seven of this manual. Try not to exceed an average total of 15 gallons per square foot annually.
D. Incorporate trees into the landscape to provide shade, reduce stormwater runoff, stabilize soil and protect against wind. If considering the gross site area, a minimum goal of 20 percent tree canopy coverage (at trees' maturity) for Front Range communities is recommended.
E. When designing plant placement on slopes, place lower-water demand plants at the tops of slopes and higher-demand plants at the bottom.
F. Artificial flowers and grass are discouraged. Exceptions may be granted for special use areas such as synthetic turf athletic fields.

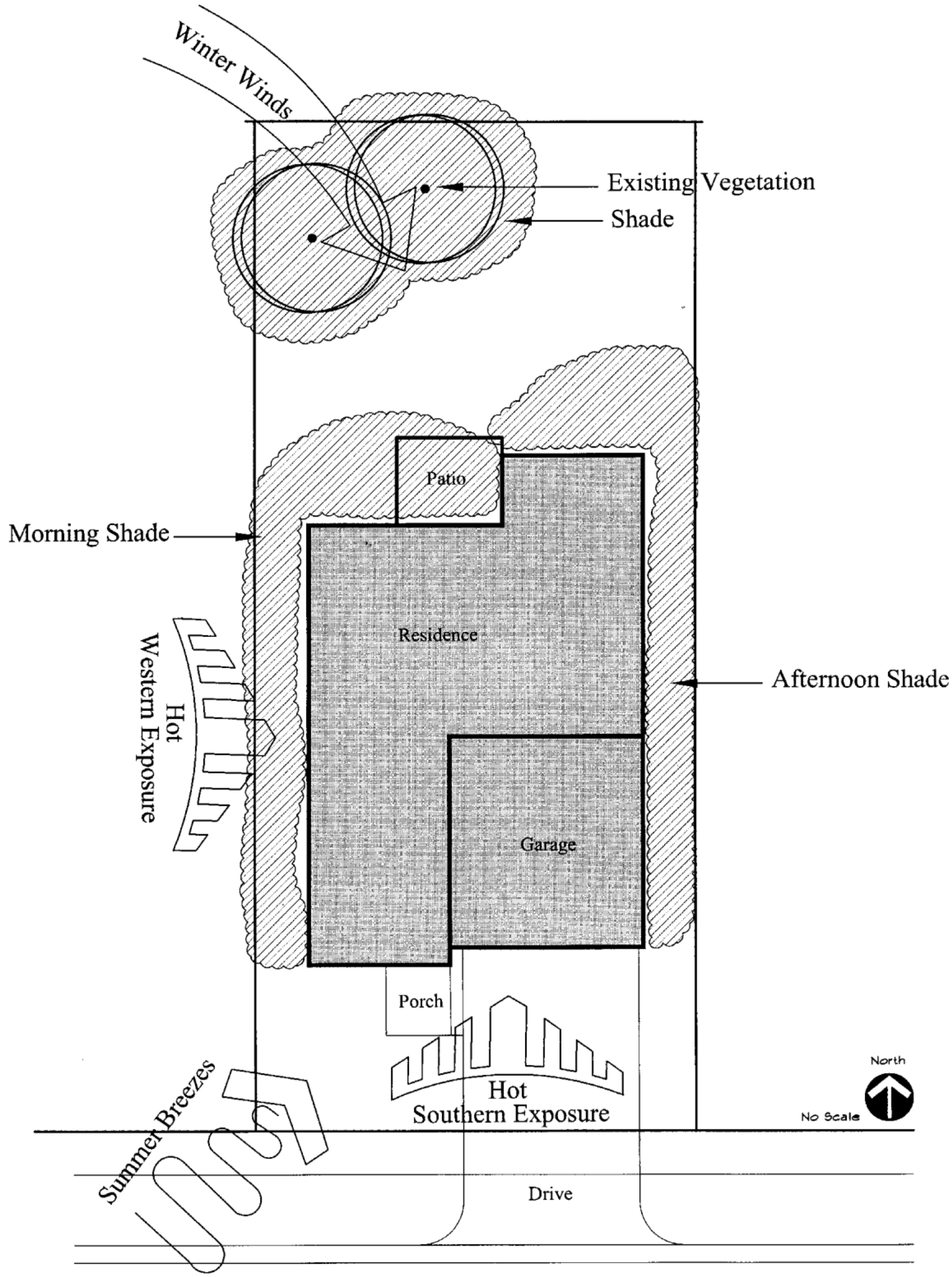

Figure 1. Inventory and Analysis Plan

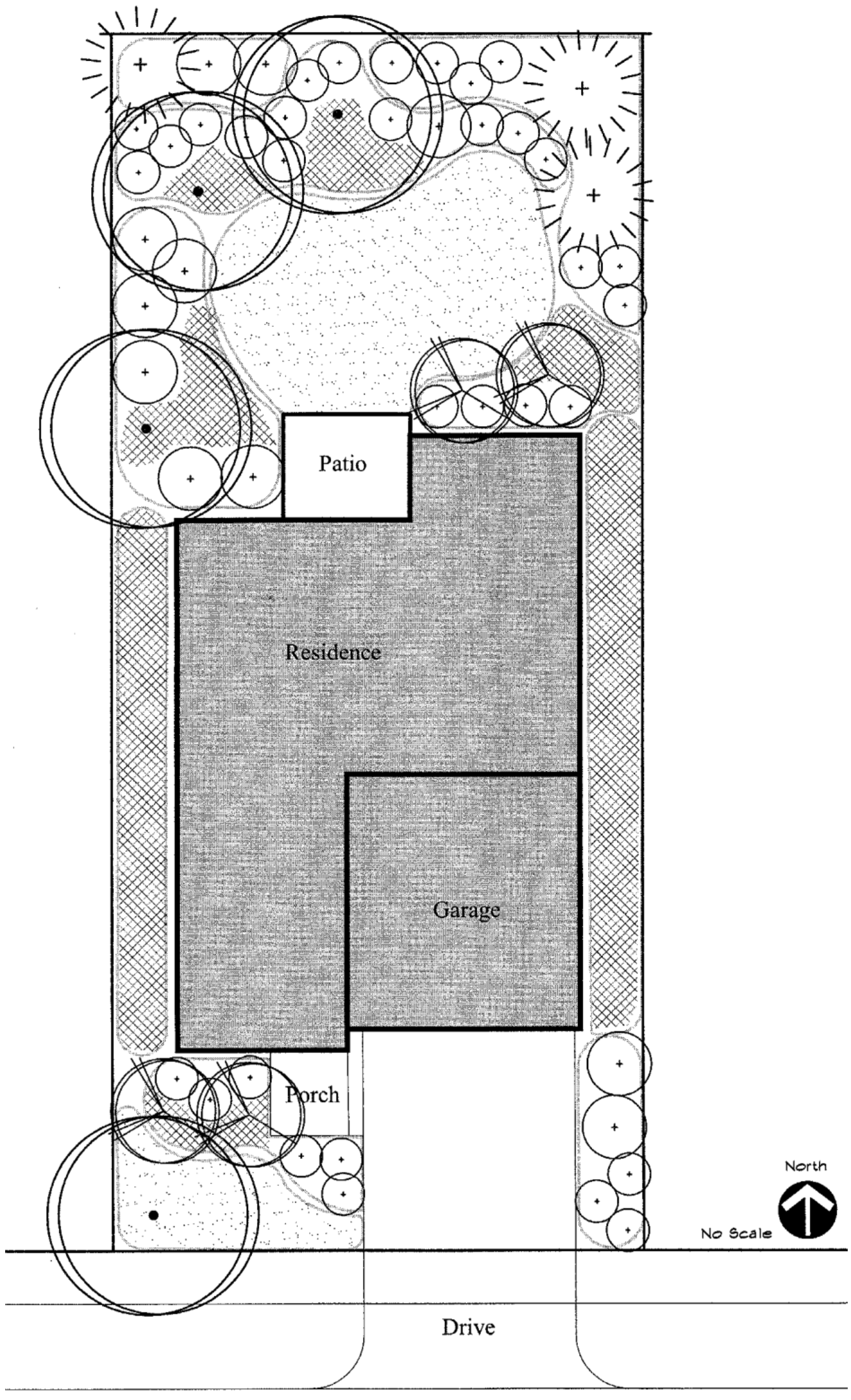

Figure 2. Overall Planting Plan

Principle #2 - Evaluate soil and improve, if necessary.

Guidelines

A. Soil suitability for planting should be evaluated to identify potential soil amendments that may improve plant health and survival (see Section Five).
B. Strip and stockpile existing topsoil prior to major site re-grading. Following completion of grading, replace topsoil and improve soil for planting with suitable soil amendments.
C. Improve soil as suitable (see Section Five) before planting and installing the irrigation system. Soil improvement promotes better absorption of water, improved water-holding capacity and drainage of the soils. It also allows for better oxygen transfer within the root zone.
D. Add organic material to the plant hydrozones, but only as needed. This typically means adding organic material for High and Moderate water zones, but not for Low and Very Low water zones. pH-balanced examples of organic materials are compost (from plants), sphagnum peat and animal manure (other than cow or horse).
E. Soil preparation should include the breaking up and loosening, or scarification, of soil to 6 inches, with incorporation of organic amendments, fertilizer, etc. as specified by a landscape designer, landscape architect or soil analysis (Figure 3).

For more information please refer to Section 5, Understanding Soils and Soil Preparation.

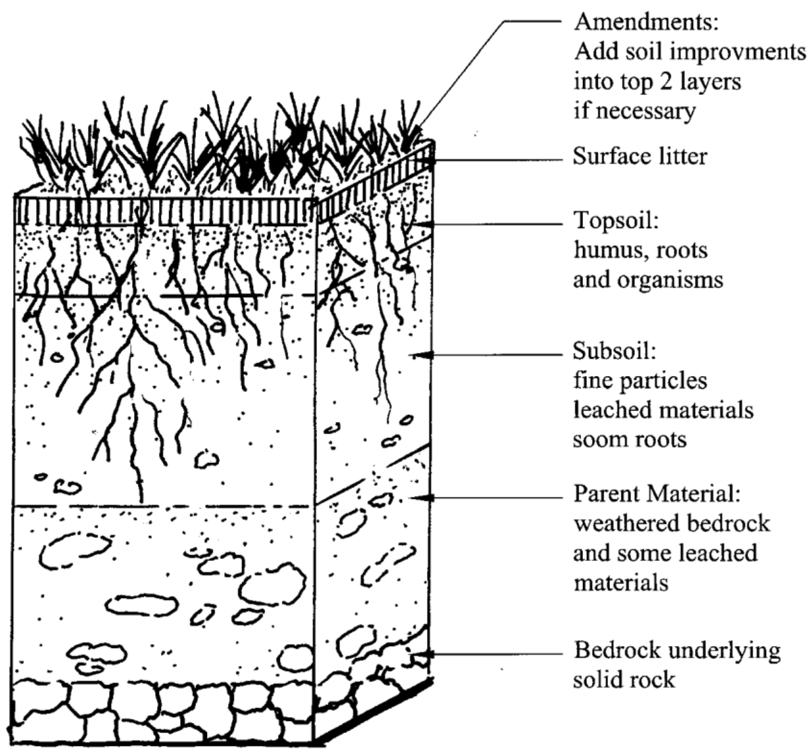

Figure 3. Soil Profile

Principle #3 - Create efficient turf areas.

Guidelines

A. Include turf areas where they provide defined functions (i.e., recreation, traffic areas, etc.). Plantings of trees, shrubs, ground covers and flowers are best separated from grass so they can be watered separately. Often, portions of turf areas can be replaced with more water-efficient ground covers and mulches (Figure 4).
B. When selecting turfgrass, consider the use, aesthetic and design goals of the site, estimated water use and maintenance budget. Alternative grass types, such as tall fescue, buffalograss, blue grama and wheat grass, may provide lower water and maintenance needs than bluegrass. In areas where irrigation is not planned for instance, a mix of mainly native bunch and sod-forming grasses might be used. (See Section Four for native seed mix options.)
C. Avoid using turf in areas less than 8 feet wide and on slopes steeper than 3:1. These areas require inefficient irrigation sprays. Consider using drip-irrigated shrubs or groundcovers with Low or Very Low water requirements as alternatives. A special exception may be streetscape tree lawns, where turfgrass may be most appropriate with careful consideration and monitoring of potential irrigation inefficiencies.
D. Some sites and turf areas with difficult irrigation or maintenance concerns may perform better with low water grass types or groundcovers. Consider street rights-of-way, industrial sites, drainageways and natural areas for such alternative grasses. (See Principle #8 below.)

Figure 4. Efficient Turf Area in Front Yard

Principle #4 - Use appropriate plants and group according to their water need, i.e. "hydrozoning".

Guidelines

A. Plants with lower water requirements, such as native species adapted to Colorado's climate, should be considered. However, other plants can have a place in xeriscape designs, even if they require larger amounts of water. The key is to use those plants in appropriate locations and not to interplant them with others that have very different, lower water requirements. In effect, the grouping of plants into "hydrozones" based on their water requirements allows them to be irrigated efficiently. A detailed list of Colorado landscape plants and their respective water requirements by "hydrozone category" is included in Section Three.
B. Group plants with like water needs together (Figure 5). Plants located within the drip line for large, mature trees and shrubs should have similar water requirements as the trees and shrubs. (A drip line is considered the outermost circle on the ground where water drips from the leaves of a tree or shrub canopy above.)
C. Plants of any water need may be used in the landscape, providing the total annual water use does not exceed Water Allowance for the ET (Evapo-Transpiration) Reference Location. For example, this allowance is 15 gallons/square foot/season in the Denver metro area. (See Section Six below for Water Budget calculations.)
D. High water zones should be separated from Low and Very Low water zones by Moderate water zones whenever possible.
E. Select plants that are well adapted to the climate, topographic and geologic conditions of the site.
F. Select plants with lower water requirements for areas with southern and western exposures.
G. Strips less than 8 feet wide should be landscaped with Low or Very Low water plants. (See Principle #3 above.)

Principle #5 - Water efficiently with a properly designed irrigation system

Guidelines

A. Irrigate according to the water need of each hydrozone, not solely on a fixed schedule (Figure 6). Well-planned sprinkler systems can save water when properly installed and operated. Turf areas should be watered separately from beds. Shrubs, flowers and ground covers can be watered more efficiently, by less frequent irrigation that is allowed to penetrate the root zone more deeply. (See Principle #4 above.)
B. Consider plant water requirements in irrigation design schemes.
C. Take into account the hydraulic principles when designing the irrigation system. Generally these principles deal with water volume, pressure and patterns of movement.

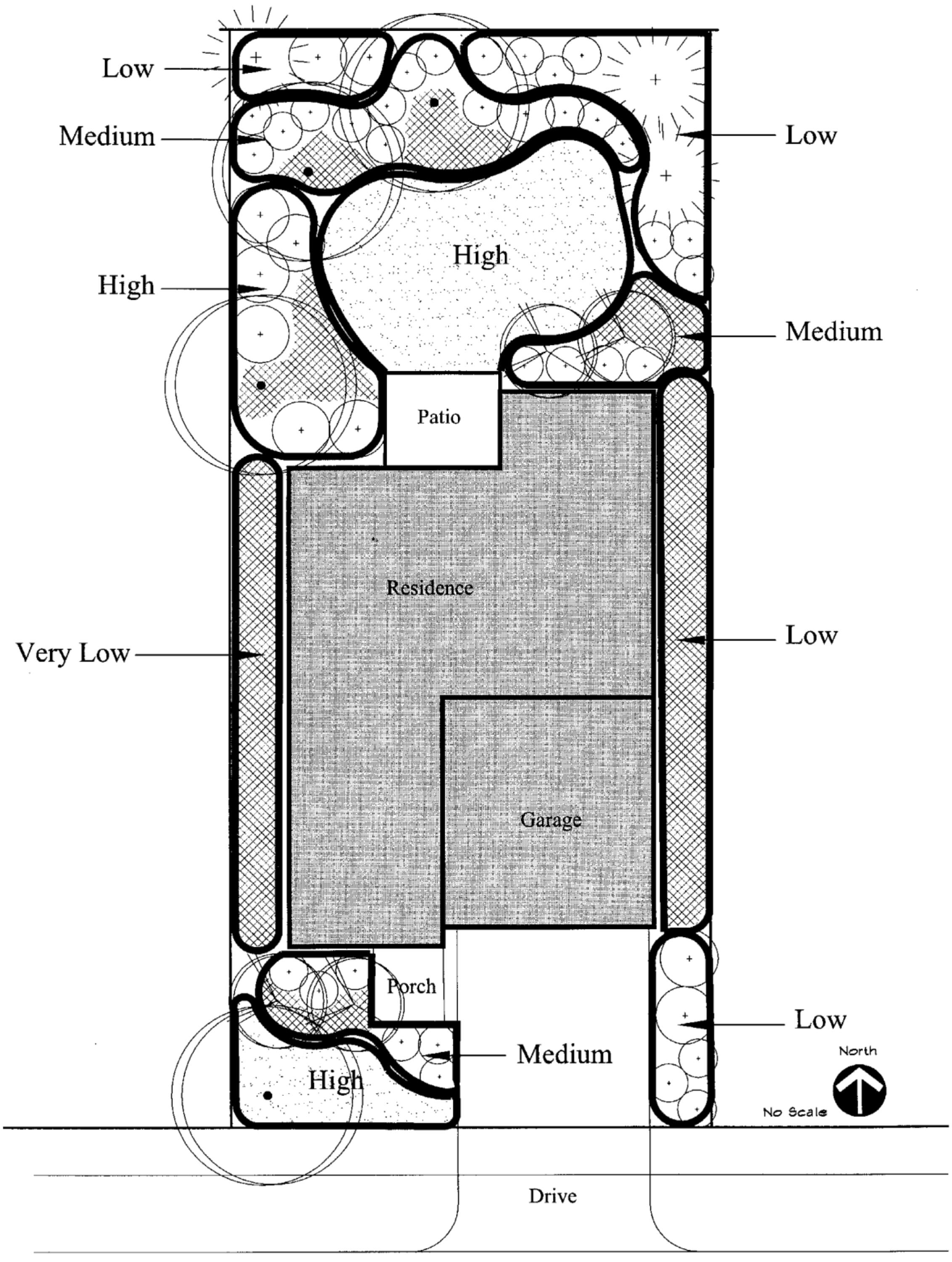

Figure 5. Hydrozone Outline Diagram with 4 water need types

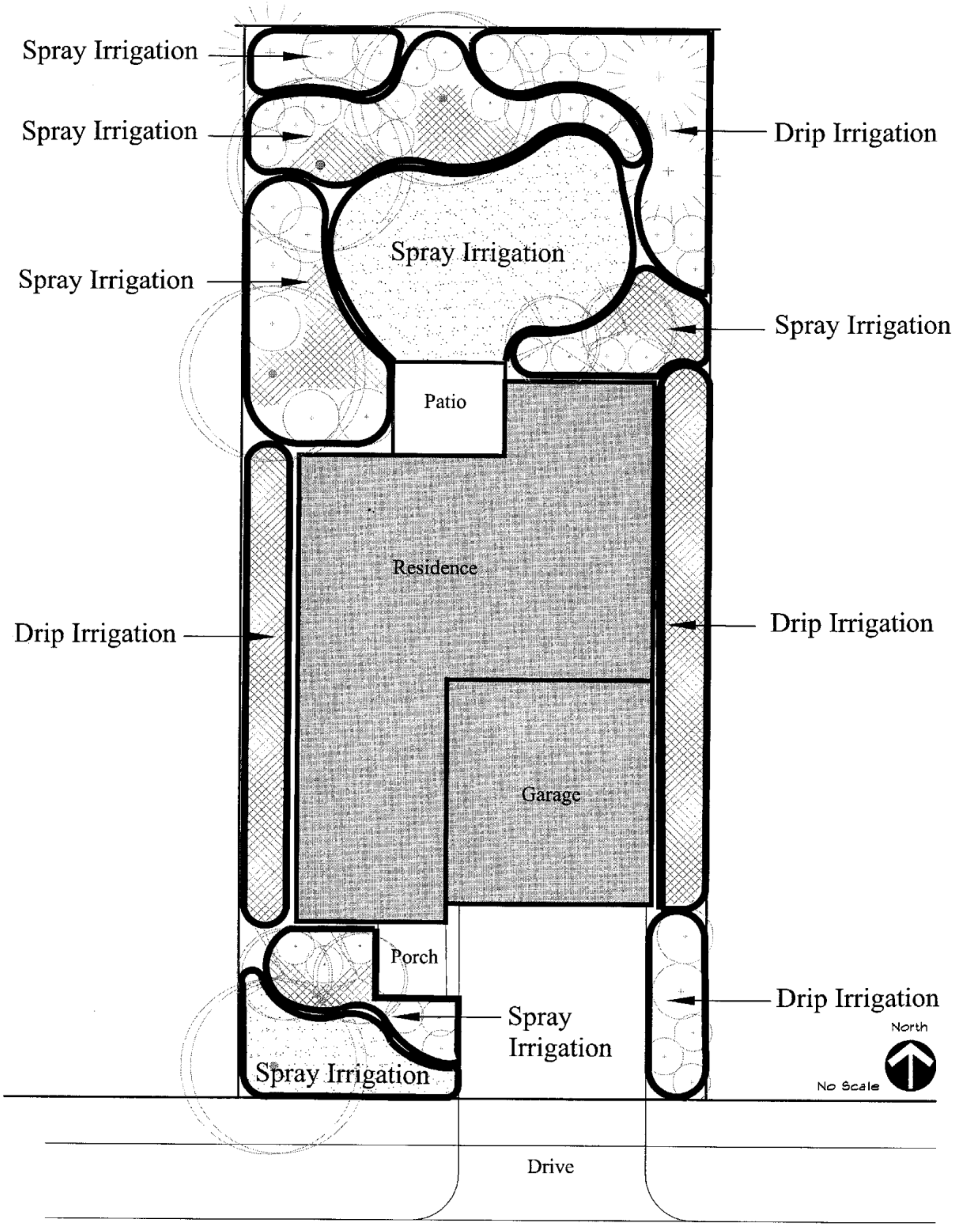

Figure 6. Irrigation Type Diagram

D. Install an irrigation controller that offers flexible programming. Landscapes should not need as much supplemental watering during a rainy period. Rain or moisture sensors are available to coordinate with controllers, and some controllers are self-adjusting based on weather conditions.
E. Ensure that the irrigation system is installed per plan and is accurate.
F. Provide "as-built" drawings of irrigation system after installation with dimensions shown for irrigation components. Such drawings will help to find and correct problems in the future.
G. Operate irrigation systems to maximize irrigation water efficiency.

For more information please refer to Section 6, Irrigation Design Techniques and Equipment.

<u>Principle #6</u> - Use mulches to reduce surface evaporation of water and weeds.

Guidelines

A. Mulched planting beds are an ideal replacement for expansive turf areas. Mulches protect and reduce temperature extremes in the soil, minimize evaporation, reduce weed growth and slow erosion. Mulches also provide landscape interest. Organic mulches are typically bark chips, wood grindings, chopped leaves or pole peelings. Inorganic mulches include rock and various gravel products.
B. Organic mulches are generally recommended for the most benefit of the plants, but the roots of some plants perform better with inorganic mulch. Landscape professionals can help determine suitable mulches for selected plants. Inorganic mulches may also be preferred as more stable in especially windy locations, areas requiring high maintenance or those apt to erosion.
C. Place mulch directly on the soil or on breathable fabric (Figure 7). Do not use solid sheet plastic beneath mulched areas, as these keep out water and air – both of which are vital to plant health.
D. All plantable areas not covered with turf should be covered with a minimum of four inches (4") of a suitable mulch to retain water, and inhibit weeds.
E. Mulching exceptions for Low and Very Low hydrozones should be considered.

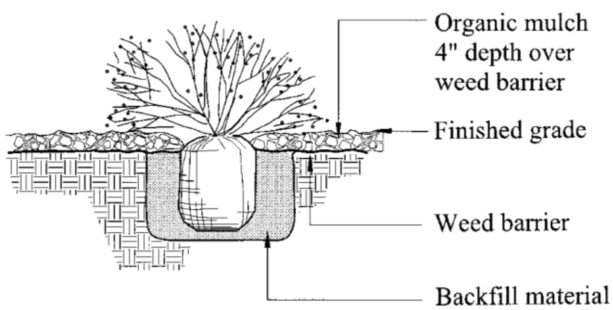

Figure 7. Shrub Planting in Mulch Bed

Principle #7 - Practice appropriate landscape maintenance.

Guidelines

A. Proper pruning, weeding, mowing and fertilization, plus attention to the irrigation system, are needed to maximize water savings. Regular maintenance of planting and irrigation system preserves the intended beauty of the landscape, and saves water and maintenance costs through efficient operations. Always water according to hydrozone need and current soil moisture conditions, rather than according to a rigid schedule.
B. Landscapes should be maintained to ensure water efficiency. A regular maintenance schedule should include but not be limited to checking, adjusting, and repairing irrigation equipment; resetting the automatic controller; aerating turf areas; replenishing mulch; fertilizing; pruning, and weeding in all landscaped areas.
C. Whenever possible, repair of irrigation equipment should be done with the originally specified materials or their equivalents so that original performance and efficiency can be maintained for longer periods. (See Section Six for more Irrigation information.)

Garden Maintenance

<u>Principle #8</u> – Preserve existing landscape and natural areas.

Guidelines

A. Where possible preserve existing native remnant plant communities and site conditions that support them.
B. Where possible preserve healthy trees – established plants have often developed a root system that is adapted to lower water conditions.
C. Local native plants and plants with documented lower water requirements should be given priority in landscape design. A native plant is a species that “occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human action” (Federal Native Plant Conservation Committee, 1994). A local native plant is derived from “a population or ecotype of the native plant species that was grown from genetically local plant materials” (Colorado Native Plant Society).
D. Use of native plants in the landscape supports local biodiversity, helps sustain local wildlife, enhances recreation experience, supports remnant native plant communities and reduces water consumption.

Natural Area

E. All landscapes have the potential to impact native plant communities through transport of seeds and plant propagules by wind and storm drainage.

Landscapes adjacent to native sites are particularly critical due to the potential of direct spread, but all projects (public or private) should not harbor or install exotic horticultural plant species that are known to be invasive and therefore threaten natural areas. A complete list of threatening plants to avoid is provided by the Colorado Native Plant Society web site: <http://carbon.cudenver.edu/~shill/species_avoid.pdf>.

F. Landscapes adjacent to native areas should emphasize the use of species with low fuel volume of low flammability. Mowing management can be used to limit build up of flammable plant materials. Information on the fire-resistance of some native plants can be found at <www.ext.colostate.edu/PUBS/NATRES/06307.html>.

G. Remove species that are designated state noxious weeds, especially ornamental species such as purple loosestrife, oxeye daisy, tamarisk, myrtle spurge and yellow toadflax. See Section Four below for the 2003 list of noxious weeds for Colorado, or for more information see the “Noxious Weed List (Rules and Regulations)” at <www.ag.state.co.us/DPI/weeds/weed.html>.

For more information please refer to Section 4, Natural Areas and Native Plants.

WaterWise Landscaping
Best Practices

Section 3 – WaterWise Plant Lists

A. The Four Hydrozones – WaterWise Plant Groupings

The key to WaterWise landscaping is to arrange plants in appropriate locations and not to interplant them with others that have very different, lower water requirements. This grouping of plants into "hydrozones" is based on their water requirements, and allows them to be irrigated efficiently. The following list shows how to group plants based their water needs.

Due to variability in plant water requirements due to location of the plant on a site, a range of hydrozone categories has been shown for many plants. For purposes of calculating the water budget for each hydrozone, the lowest hydrozone category for each plant shall be used.

High Water need
example: Bluegrass turf – always wet at the surface
uses 18-20 gals./ S.F./season = 3 waterings per week totaling 5 inches (in July)

Moderate Water need
example: turf-type Tall Fescue – ½ the water of Bluegrass turf
uses 10 gals./S.F./ season = ¾ inches of water, once per week

Low Water need
example: Buffalograss turf – needs rain and occasional watering
uses 0-3 gals./S.F./season = ½ inch of water per 2 weeks, optional

Very Low Water need
example: too dry for any turf grass (drier than Denver)
no irrigation required

B. Colorado WaterWise Plant List Summary

1. Shrubs (Deciduous, Rocky Mountain Natives)
2. Shrubs (Deciduous, Introduced to the region)
3. Trees (Deciduous, Rocky Mountain Natives)
4. Trees (Deciduous, Introduced to the region)
5. Evergreens (Coniferous Trees)
6. Evergreens (Coniferous Shrubs)
7. Evergreens (Non-coniferous)
8. Vines
9. Groundcovers (Including turf & meadow grasses)
10. Selected Perennials

The complete Plant Lists are provided on the following pages.
Copying and use of this list is encouraged, only if the following note, & the water needs of plants are included.
For more information see...WaterWise Landscaping with Trees, Shrubs, and Vines
Jim Knopf, Chamisa Books

SHRUBS

(Deciduous Rocky Mountain Natives)

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5"-- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Acer•glabrum	Rocky Mountain Maple	(M-H)
Acer•grandidentatum	Bigtooth Maple, Wasatch Maple	(M)
Alnus•tenuifolia	Rocky Mountain Alder	(H)
Amelanchier•alnifolia	Rocky Mtn. Serviceberry	(M+/-)
Amelanchier•utahensis *****	Utah Serviceberry	(VL- M)
Amorpha•canescens	Lead Plant	(L- M)
Amorpha•fruticosa	False Indigo	(M +/-)
Amorpha•nana	Dwarf Lead Plant	(L- M)
Atriplex•canescens	Four-wing Saltbush	(VL-L)
Atriplex•confertifolia	Shadscale	(VL-L)
Betula•fontinalis	Rocky Mtn. River Birch	(H)
Betula•glandulosa	Bog Birch	(H)
Ceratoides•lanata *****	Winterfat	(L)
Cercocarpus•montanus	Deciduous Mountain Mahogany	(L- M)
Chamaebatiaria•millefolium	Fernbush	(VL-L)
Chrysothamnus•spp.	Rabbitbrush species	(VL-L)
Cornus•sericea (now C. stolonifera)		
Cornus•stolonifera	Redtwig Dogwood	(H)
Corylus•cornuta	Beaked Hazelnut	(H- M)
Crataegus.•var.•occidentalis *****	Native Hawthorn	(M+/-)
Crataegus•erythropoda *****	(syn.? C. s. var. occidentalis)	(M+/-)
Crataegus•succulenta•var.•macrantha *****	Native Hawthorn	(M+/-)
Fallugia•paradoxa	Apache Plume	(VL-L)
Fendlera•rupicola	Cliff Fendlerbush	(L- M)
Forestiera•neomexicana	New Mexico Privet	(M+/-)
Fraxinus•anomala	Singleleaf Ash	(L)
Holodiscus•dumosus	Rock Spray	(L- M)
Jamesia•americana	Jamesia	(M - H)
Lonicera•involucrata	Twinberry	(H)
Lycium•pallidum *****	Pale Wolfberry	(L)
Ostrya•knowltonii *	Western Hop Hornbeam	(M+/-)

Parryella•filifolia *	Dunebloom	(M+/-)
Pentaphylloides•floribunda	= Potentilla•fruticosa	
Peraphyllum•ramosissimum *	Squaw Apple	(L- M)
Philadelphus•lewisii	Lewis's Mockorange	(M+/-)
Philadelphus•microphyllus	Littleleaf Mockorange	(M+/-)
Physocarpus•monogynus	Mountain Ninebark	(M+/-)
Poliomintha•incana *	Purple Sage	(VL-L)
Potentilla•fruticosa	Shrubby Potentilla	(M - H)
Prunus•americana	Wild Plum	(M+/-)
Prunus•besseyi	Sand Cherry	(L-M)
Prunus•pensylvanica *	Pin Cherry	(M+/-)
Prunus•pensylvanica•saximontana *	Dwarf Pin Cherry	(M+/-)
Prunus•virginiana	Chokecherry	(M - H)
Ptelea•trifoliata	Hoptree	(M+/-)
Purshia•tridentata	Bitterbrush	(L - H)
Quercus•gambelii	Gambel's Oak	(M+/-)
Quercus•turbinella *	Turbinella Oak	(L - M)
Quercus•undulata *	Wavyleaf Oak	(L - M)
Rhamnus•smithii *	-----	(M+/-)
Rhus•glabra	Smooth Sumac	(L- M)
Rhus•glabra•var.•cismontana	Rocky Mountain Smooth Sumac	(L-M)
Rhus•glabra•'Laciniata'	Cutleaf Smooth Sumac	(L-M)
Rhus•microphylla *	Littleleaf Sumac	(L-M)
Rhus•trilobata	Three-leaf Sumac	(L - M)
Ribes•aureum	Golden Currant	(M+/-)
Ribes•cereum *	Squaw Currant	(M+/-)
Ribes•inerme	Whitestem Gooseberry	(M+/-)
Rosa•woodsii	Wood's Rose	(M+/-)
Rubus•deliciosus	Boulder Raspberry	(M+/-)
Rubus•idaeus•var.•strigosus	Wild Raspberry	(M - H)
Rubus•parviflorus *	Thimbleberry	(M - H)
Salix•irrorata	Bluestem Willow	(H)
Sambucus•caerulea *	Blue Elderberry	(H)
Sambucus•melanocarpa *	Blackbead Elderberry	(H)
Sambucus•racemosa *	Red Elderberry	(H)
Sarcobatus•vermiculatus *	Greasewood	(VL-L)
Shepherdia•argentea	Silver Buffaloberry	(M+/-)
Shepherdia•canadensis *	Buffaloberry	(M+/-)
Sorbus•scopulina *	Rocky Mtn. Mountain Ash	(M - H)
Symphoricarpos•albus	Snowberry	(M+/-)
Symphoricarpos•orbiculatus *	Coralberry	(M+/-)
Tetradymia•canescens *	Gray Horsebrush	(L)

SHRUBS

(Deciduous, Introduced)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based their water needs.
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18-20 gals./ S.F./season July: 5"-- 3 times per week	10 gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Abelia•chinensis *	Chinese Abelia (China)	(M-H)
Abelia•x•grandiflora *	Abelia (origin unknown)	(M-H)
Abeliophyllum•distichum *	----- (Korea)	(M+/-)
Acanthopanax•senticosus *	Syn. Elentherococcus s.	
Acanthopanax•sieboldianus *	= Elentherococcus•sieboldianus	
Acer•azimovii * (= A.•ovczimmikovii?)	Azimov Maple	(M+/-)
Acer•campestre *	Hedge Maple (e. Europe & w. Asia)	(M-H)
Acer•ginnala	= Acer•tataricum•ssp.•ginnala	
Acer•maximowiczianum *	----- (China-Mongolia-Korea)	(M-H)
Acer•semenovii *	= Acer•tataricum•ssp.•semenovii	
Acer•tataricum	Tatarian Maple (A. Minor, se. Asia)	(L-M)
Acer•tataricum•ssp.•ginnala	Ginnala Maple (c. Asia)	(L-M)
Acer•tataricum•ssp.•semenovii *	Turkestan Maple (c. Asia)	(L-M)
Aesculus•parviflora *	Bottlebrush Buckeye (Ga., Ala.)	(H)
Aesculus•sylvatica *	----- (se. USA)	(H)
Alnus•cordata *	Italian Alder (Corsica, s. Italy)	(H)
Alnus•glutinosa *	European Alder (Eur., n. Africa, Turkey)	(H)
Alnus•rubra (was A.•oregona) *	Oregon Alder (w. N. Am.)	(H)
Amelanchier•stolonifera *	Running Serviceberry (ne. N. Am.)	(H)
Aralia•elata *	Angelica Tree (Jap., Kor., Manch.)	(M-H)
Aralia•spinosa *	Devil's Walkingstick (e. USA)	(M-H)
Aronia•melanocarpa	Chokeberry (e. N. America)	(M+/-)
Artemisia•abrotanum	Southernwood (s. Europe)	(M+/-)
Atraphaxis•caucasica *	----- (Transcaucasica)	(M+/-)
Atraphaxis•pyrifolia *	----- (c. Asia)	(L)
Berberis•koreana *	Korean Barberry (Korea)	(M+/-)
Berberis•oblonga *	----- (Turkestan)	(M-L)
Berberis•thunbergii	Japanese Barberry (Jap.)	(M-H)
Buddleja•alternifolia *	Butterflybush (nw. China)	(M+/-)
Buddleja•davidii	Butterflybush (China)	(M+/-)
Buddleja•globosa *	----- (Chile, Argentina, Peru)	(M+/-)
Buddleja•x•'Lochinch' *	----- (hort. hybrid)	(M+/-)
Callicarpa•bodinieri *	Beauty Berry (c. & w. China)	(M+/-)
Callicarpa•dichotoma *	Korean Beautyberry (e. USA)	(H)

Calycanthus•occidentalis *	California Allspice (sw. USA)	(H)
Calycanthus•chinensis *	----- (e. China)	(H)
Calycanthus•floridus *	Carolina Allspice (se. USA)	(H)
Caragana•arborescens	Siberian Peashrub (c. Asia - Mongolia)	(L-M)
Caragana•aurantiaca *	Dwarf Peashrub (Sib., Afghan., Turkestan)	(L-M)
Caragana•frutex *	Russian Peashrub (c. Asia, Siberia)	(L-M)
Caragana•maximowicziana *	----- (Tibet, n. China)	(L-M)
Caragana•microphylla	----- (nw. China, Sib.)	(L-M)
Caragana•pygmaea *	----- (nw. China)	(L-M)
Caragana•sinica *	Chinese Peashrub (n. China)	(L-M)
Caryopteris•incana *	----- (China, Jap.)	(L-M)
Caryopteris•mongolica *	----- (n. China, Mong.)	(L-M)
Caryotperis•x•clandonensis	Bluemist Spirea (hort. hybrid)	(L-M)
Ceanothus•sanguineus *	Oregon Tea (Cal. to BC)	(H)
Cerasus•verrucosa *	----- (Tajikistan)	(L-M)
Cercis•griffithii *	Griffith's Redbud (c. Asia)	(L-M)
Chaenomeles•japonica *	Dwarf Quince (Japan)	(M+/-)
Chaenomeles•lagenaria	= C. speciosa	
Chaenomeles•speciosa *	Flowering Quince (China, Japan)	(M+/-)
Chamaecytisus•hirsutus *	----- (Sib.-n. China)	(M+/-)
Chilopsis•linearis*	Desert Willow (desert southwest)	(L-M)
Chimonanthus•praecox *	Fragrant Wintersweet (China)	(H)
Chionanthus•retusus	Chinese Fringe Tree (China, Kor. Taiwan)	(H)
Chionanthus•virginicus	Fringe Tree (e. N. America))	(M-H)
Clematis•heracleifolia•var.•davidiana *	----- (e. China)	(M-H)
Clerodendrum•trichotomum *	Glory Bower (Japan)	(H)
Clethra•alnifolia *	Summer-sweet (e. N. America)	(H)
Clethra•delavayi *	Summer-sweet (w. China)	(M+/-)
Cornus•alba•'Elegantissima'	Variegated R'twig Dog'd (Sib., n. Chi., Kor.)	(H)
Cornus•alternifolia	Pagoda Dogwood (e. N. America)	(H)
Cornus•amomum *	Silky Dogwood (e. N. America)	(M-H)
Cornus•controversa *	Giant Dogwood (Japan, China, Him.)	(H)
Cornus•kousa *	----- (Japan, Korea, China)	(M-H)
Cornus•kousa•var.•chinensis *	----- (China)	(H)
Cornus•mas *	Cornelian Cherry (c. Europe-w. Asia)	(M-H)
Cornus•racemosa *	Gray Dogwood (ne. N Am)	(M-H)
Cornus•sericea (now C.•stolonifera)	(See: Native Rocky Mtn. deciduous shrubs)	
Cornus•stolonifera•'Flaviramea'	Yellowtwig Dogwood (N. Am.)	(H)
Coronilla•emerus *	Scorpion Senna (s. Norway, Spain, Greece)	(M-H)
Corylopsis•pauciflora *	Winter Hazel (Japan, Taiwan)	(H)
Corylopsis•sinensis *	Chinese Winter Hazel (c. China)	(M+/-)
Corylopsis•spicata *	Japanese Winter Hazel (Japan)	(H)
Corylus•avellana *	European Hazel (Europe)	(M-H)
Corylus•chinensis *	Chinese Hazel (sw. China)	(H)
Corylus•maxima *	Filbert (se. Eur., A. Minor)	(H)
Cotinus•coggygria	Smoke Tree (s. Europe-Asia)	(M+/-)
Cotinus•obovatus *	American Smoketree (s. USA)	(M-H)
Cotoneaster•actuifolius	Peking Cotoneaster (n. China)	(M+/-)
Cotoneaster•apiculatus	Cranberry Cotoneaster (China)	(M+/-)
Cotoneaster•bullatus *	----- (w. China)	(M+/-)
Cotoneaster•divaricatus	Spreading Cotoneaster (China)	(M+/-)
Cotoneaster•franchetii *	----- (sw. China, Tibet)	(M-H)
Cotoneaster•horizontalis	Rock Cotoneaster (w. China)	(M+/-)
Cotoneaster•ignavus*	----- (e. Turkestan)	(M+/-)
Cotoneaster•multiflorus•	Many-flowered Cotoneaster (nw. China)	(M+/-)
Cotoneaster•racemiflorus•songaricus *	----- (c. Asia)	(M+/-)
Cotoneaster•simonsii *	----- (Himal., Sikkim, Nepal)	(M-H)
Crataegus•x•mordanensis•'Toba'	Toba Hawthorn (hort. hybrid)	(M+/-)
Cudrania•tricuspidata *	Chinese Silkworm Thorn (China)	(H)
Cydonia•oblonga *	Quince (n. Persia)	(M+/-)
Cydonia•sinensis *	= Pseudocydonia•sinensis	

Cyrilla•racemiflora *	Leatherwood (e. N. America)	(H)
Cytisus•albus *	= Cytisus•multiflorus	
Cytisus•decumbens *	Prostrate Broom (s. Europe)	(L-M)
Cytisus•hirsutus	= Chamaecytisus•hirsutus	
Cytisus•multiflorus *	Portuguese Broom (se. Europe)	(L-M)
Cytisus•purgans *	----- (s. Eur. - n. Afr.)	(L-M)
Cytisus•scoparius *	Scotch Broom (c. & s. Europe)	(L-M)
Cytisus•x•praecox *	Warminster Broom (hort. hybrid)	(L-M)
Dalea•formosa *	Feather Plume (w. Tex., Okl., Colo.)(L	
Dalea•frutescens *	Black Dalea (w. Tex., Okla.)	(L)
Dalea•scoparia *	Broom Dalea (w. Tex., N. Mex., Az.)	(L)
Daphne•caucasica *	Caucasian Daphne (Caucusus)	(M+/-)
Daphne•genkwa *	----- (China)	(M+/-)
Daphne•giraldii *	Daphne (nw. China)	(M+/-)
Daphne•mezereum *	February Daphne (Europe, w. Asia)	(M+/-)
Decaisnea•fargesii *	----- Bluebean Shrub (w. China)	(M-H)
Deutzia•gracilis *	Slender Deutzia (Japan)	(M-H)
Deutzia•scabra *	Fuzzy Deutzia	(M-H)
Deutzia•x•lemoinei *	Lemoine Deutzia (Hort. hybrid)	(M-H)
Diervilla•lonicera *	----- (e. N. America)	(H)
Diervilla•sessilifolia *	Southern Bush-honeysuckle (se. USA)	(H)
Dipelta•floribunda *	----- (c. & w. China)	(M+/-)
Dipteronia•sinensis *	----- (China)	(M+/-)
Disanthus•cercidifolius *	----- (China, Jap.)	(H)
Elaeagnus•multiflora *	Cherry Elaeagnus (Jap., China)	(M-H)
Elentherococcus•sieboldianus *	----- (Jap., China)	(M+/-)
Eleutherococcus•senticosus *	Siberian Ginseng (ne. Asia)	(M-H)
Elsholtzia•stauntonii *	Mint Shrub (n. China)	(M+/-)
Euonymus•atropurpureus *	Wahoo (NY to Fla, Minn. to Tex.)	(M-H)
Euonymus•alatus	Burning Bush Euonymus (China, Jap., Kor.)	(M+/-)
Euonymus•bungeanus *	Winterberry (China, Korea, Manch., Jap.)	(M+/-)
Euonymus•europaeus *	Spindletree (Europe)	(M-H)
Euonymus•nanus•v.•turkestanicus *	Turkestan Euonymus (Caucasus - w. China)	(M+/-)
Euonymus•phellomanus *	----- (n. & w. China)	(M+/-)
Euonymus•sachalinensis *	Sakhalin Euonymus (ne. Asia)	(M+/-)
Exochorda•albertii (now E. korolkowii)		
Exochorda•giraldii *	Pearlbush (c. China)	(M+/-)
Exochorda•korolkowii *	Pearlbush (Uzbekistan, Tajikistan)	(M+/-)
Exochorda•racemosa *	Common Pearlbush (n. China)	(M-H)
Exochorda•serratifolia *	Pearlbush (Korea, Manchuria)	(M+/-)
Exochorda•x•macrantha *	Pearlbush (hort. hybrid)	(M+/-)
Fontanesia•phillyreoides•ssp.•fortunei *	----- (China)	(M+/-)
Forsythia•mandschurica *	Manchurian Forsythia (Manch.)	(M+/-)
Forsythia•ovata *	Early Forsythia (Korea)	(M+/-)
Forsythia•suspensa *	Forsythia (China)	(M+/-)
Forsythia•x•intermedia	Forsythia (hort. hybrid)	(M+/-)
Fothergilla•gardenii *	Fothergilla (Va. - Ga.)	(H)
Fothergilla•major *	----- (Allegheny Mts.)	(H)
Genista•tinctoria *	----- (Europe, w. Asia)	(L-M)
Halimodendron•halodendron *	Salt Tree (se. Russia-c. & w. Asia)	(VL-L)
Hamamelis•japonica *	Japanese Witch Hazel (Japan)	(H)

Hamamelis•mollis *	Chinese Witch Hazel (w. China)	(H)
Hamamelis•vernalis *	Witch Hazel (s.e. N. America)	(H)
Hamamelis•virginiana *	Common Witch Hazel (Canada to Georgia)	(H)
Heptacodium•miconioides *	----- (China)	(M+/-)
Hibiscus•syriacus	Rose-of-Sharon Hibiscus (China, India)	(M+/-)
Hippophaë•rhamnoides	Sea Buckthorn (Eurasia)	(M-H)
Holodiscus•discolor *	Rock Spirea (s. Ore.-s. Calif.)	(M+/-)
Hydrangea•arborescens	Hills-of-snow Hydrangea (e. USA)	(H)
Hydrangea•involucrata *	----- (Japan)	(H)
Hydrangea•paniculata	Peegee Hydrangea (China, Japan)	(H)
Hydrangea•quercifolia *	Oakleaf Hydrangea (se. USA)	(H)
Hydrangea•serrata *	----- (Jap., Korea)	(M-H)
Indigofera•amblyantha *	Pink Indigo (China)	(M+/-)
Indigofera•decora *	White Chinese Indigo (China)	(M+/-)
Indigofera•gerardiana *	= Indigofera•heterantha	
Indigofera•heterantha *	----- (Afghan.-w. China)	(M+/-)
Indigofera•incarnata *	= Indigofera•decora	
Indigofera•kirilowii *	----- (n. China, Korea)	(M+/-)
Indigofera•potaninii *	Potanin Indigo (nw. China)	(M+/-)
Itea•virginica *	Sweetspire (e. USA)	(H)
Jasminum•nudiflorum *	Winter Jasmine (China)	(M+/-)
Kerria•japonica	Kerria (Japan)	(M-H)
Kolkwitzia•amabilis	Beautybush (China)	(M+/-)
Leptodermis•oblonga *	----- (n. China)	(M+/-)
Lespedeza•bicolor *	----- (Japan)	(M+/-)
Lespedeza•thunbergii *	----- (Japan, China)	(M+/-)
Ligustrum•vulgare	Common Privet (Medit. region)	(M+/-)
Lindera•benzoin *	Spicebush (e. USA)	(M)
Lindera•obtusiloba*	----- (KOr., Jap., China)	(M-H)
Lonicera.•spinosa *	----- (nw Him., Tibet, e. Turkestan)	(M+/-)
Lonicera•alberti *	----- (Turkestan, Tibet)	(M+/-)
Lonicera•caerulea *	----- (Tibet, e. Siberia)	(M+/-)
Lonicera•chrysantha *	----- (ne. Asia, c. Japan)	(M-H)
Lonicera•etrusca *	----- (Medit. to s. Switzerland)	(M+/-)
Lonicera•fragrantissima *	Winter Honeysuckle (China)	(M-H)
Lonicera•hispida *	----- (Turkestan)	(M+/-)
Lonicera•korolkowii	----- (Mts. c. Asia, Afghan. Pak.)	(M+/-)
Lonicera•maackia*	Amur Honeysuckle (e. Asia)	(M-H)
Lonicera•maximowiczii•v.•sachalinensis *	Sakhalin Honeysuckle (Manch, China, Kor.)	(M-H)
Lonicera•microphylla *	----- (nw. Him., Tibet, Sib.)	(M+/)
Lonicera•morrowii *	Morrow Honeysuckle (Jap.)	(M-H)
Lonicera•pileata *	----- (China)	(M+/-)
Lonicera•quinquelocularis *	----- (Afghan. to Yunnan)	(M+/-)
Lonicera•spinosa•var.•alberti *	Fragrant Turkestan Honeysuckle (c. Asia)	(M+/-)
Lonicera•standishii *	Fragrant Winter Honeysuckle (China)	(M+/-)
Lonicera•syringantha	Lilac-scented Honeysuckle (China, Tibet)	(M-H)
Lonicera•tatarica•'Zabelii'	Zabel's Honeysuckle (c. Asia, Afghan.)	(M+/-)
Lonicera•thibetica *	Tibetan Honeysuckle (Tibet., w. China)	(M+/-)
Lonicera•xylosteum *	European Fly Honeysuckle (Eurasia)	(M+/-)
Lonicera•x•Xylosteoides *	----- (garden orgin)	(M+/-)
Lycium•chinense *	Chinese Wolfberry (e. Asia)	(M-H)

Magnolia•sieboldii *	Oyama Magnolia (Jap., Korea, w. China)	(H)
Magnolia•stellata	Star Magnolia (c. Japan)	(H)
Myrica•pensylvanica *	Bayberry (e. N. America)	(H)
Neillia•thibetica *	----- (Himalaya Mts.)	(M+/-)
Nevieusii•alambamensis *	----- (se. USA)	(H)
Orixa•japonica *	----- (Japan, China, Korea)	(M+/-)
Paeonia•lutea *	Tree Peony (China, Tibet)	(M+/-)
Paeonia•suffruticosa *	Tree Peony (China, Tibet)	(M+/-)
Parrotia•persica *	----- (Persia)	(M+/-)
Parrotiopsis•jacquemontiana *	----- (Himalaya)	(M-H)
Philadelphus•coronarius +	Sweet Mockorange (Europe, sw. Asia)	(M+/-)
Philadelphus•x•virginalis +	----- (Hort. Hybrid)	(M+/-)
Photinia•villosa *	Oriental Photinia (China, Korea, Jap.)	(M-H)
Physocarpus•opulifolius	Dwarf Ninebark (e. N. America)	(M+/-)
Poncirus•trifoliata *	Trifoliate Orange (c. & n. China)	(M-H)
Prinsepia•sinensis *	----- (Manchuria)	(M+/-)
Prinsepia•uniflora *	----- (nw. China)	(M+/-)
Prunus•andersonii *	Desert Peach (sw. U.S.A.)	(L-M)
Prunus•cerasifera	Cherry Plum (A. Minor, Cauc.)	(M+/-)
Prunus•cerasifera•'Newport'	Newport Plum (garden origin)	(M+/-)
Prunus•fruticosa *	European Dwarf Cherry (Eur.., Siberia)	(M+/-)
Prunus•nigra *	Canada Plum (ne. N. Am.)	(M-H)
Prunus•padus *	Bird Cherry (Eurasia)	(M+/-)
Prunus•tomentosa	Nanking Cherry (n. w. China, Tib. Kashmir)	(M-H)
Prunus•x•cistena	Cistena Plum (hort. hybrid)	(M+/-)
Pseudocydonia•sinensis *	Quince (China)	(M+/-)
Purnus•fasciculata *	Desert Almond (sw. USA)	(VL-L)
x•Pyracomeles•vilmorinii *	(Pyracanthus•crenatoserrataXOsteomeles•subrotunda)	(M+/-)
Rhamnus•dahuricus *	Common Buckthorn (e. Russia to Japan)	(M+/-)
Rhamnus•frangula	Glossy Buckthorn (Eur., Turk., n. Afr.)	(M+/-)
Rhamnus•frangula•'Asplenifolia' *	----- (Hort. Cultivar)	(M+/-)
Rhodotypos•scandens *	Jetbead (Japan, China)	(H)
Rhus•punjabensis *	----- (c., w. China)	(M+/-)
Rhus•typhina	Staghorn Sumac (e. N. America)	(M+/-)
Rhus•typhina•'Laciniata'	Cutleaf Staghorn Sumac (?)	(M+/-)
Ribes•alpinum	Alpine Currant (w. Europe)	(M-H)
Ribes•nevadense *	Sierra Currant (Ore., Cal., Nev.)	(M+/-)
Rosa•banksiae *	Banksia Rose (w. & c. China)	(M+/-)
Rosa•davidii *	David's Rose (w. & c. China)	(M+/-)
Rosa•ecae *	----- (c. Asia)	(M+/-)
Rosa•filipes *	----- (w. China)	(M+/-)
Rosa•foetida•'Bicolor'	Austrian Copper Rose (c. Asia)	(M-L)
Rosa•foetida•'Persiana'	Persian Yellow Rose (s.w. Asia)	(M-L)
Rosa•glauca	Redleaf Rose (c. & s. Europe)	(M+/-)
Rosa•helenae *	Helen Wilson's Rose (c. China)	(M+/-)
Rosa•hugonis	= R.•xanthira•f.•hugonis	
Rosa•kokanica *	----- (c. Asia, China)	(M+/-)
Rosa•laxa *	----- (c. Asia, nw. China)	(M+/-)
Rosa•moyesii *	Moyes Rose (w. China)	(M+/-)
Rosa•moyesii *	Moyes Rose (w. China)	(M+/-)
Rosa•persica *	Persian Rose (Persia, Afghan., c. Asia)	(M+/-)
Rosa•pulverulenta *	----- (s. Eur. to Afghanistan)	(M+/-)
Rosa•rubrifolia (now R.•glauca)		

Rosa•rugosa	Rugosa Rose (e. Russia)	(M+/-)
Rosa•sericea *	----- (c. Asia, w. China)	(M+/-)
Rosa•setigera *	Prairie Rose (e. & c. USA)	(M+/-)
Rosa•webbiana	----- (c. Asia, Afghan, Kashmir.)	(M+/-)
Rosa•wichuriana *	----- (e. Asia)	(M+/-)
Rosa•xanthina•f.•hugonis	Father's Rose (c. China)	(M+/-)
Rosa•x•harisonii *	Harison's Yellow Rose (Hort. hybrid)	(M+/-)
Salix•discolor	Pussy Willow (e. N. America)	(H)
Salix•matsudana•'Tortuosa'	Corkscrew Willow (China, Japan)	(H)
Sambucus•canadensis	Elderberry (e. N. America)	(H)
Sibiraea•altaiensis *	----- (w. China to Balkans)	(L-M)
Sibireae•laevigata	= Siberaea•altaiensis	
Sophora•davidii *	Father David's Sophora (China)	(L-M)
Sorbaria•sorbifolia	Ural False Spirea (Sib., Manch., Korea, Jap.)	(M+/-)
Sorbaria•tomentosa•v.•angustifolia *	----- (Afghan., Pak., Kashmir)	(L-M)
Spiraea•betulifolia•var.•lucida *	----- (B.C., Ore., Wyo., Mon.)	(M+/-)
Spiraea•cantoniensis *	----- (China)	(M+/-)
Spiraea•douglasii *	----- (B.C. to n. Cal.)	(M+/-)
Spiraea•japonica *	----- (Japan, China)	(M+/-)
Spiraea•japonica•'Albiflora' *	----- (Japan)	(M+/-)
Spiraea•japonica•'Anthony•Waterer'	Anthony Waterer Spirea (garden origin)	(M+/-)
Spiraea•japonica•'Bumalda'	----- (Hort. cultivar)	(M+/-)
Spiraea•japonica•'Froebelii'	Froebel's Spirea (garden origin)	(M+/-)
Spiraea•nipponica *	----- (Japan)	(M+/-)
Spiraea•trilobata	----- (n. Sib., Turkestan, n. China)	(L-M)
Spiraea•wilsonii *	----- (c. & w. China)	(M+/-)
Spiraea•x•vanhouttei	Vanhoutte Spirea (hort. hybrid)	(M+/-)
Spirea•x•arguta*	Garland Spirea (garden origin)	(M+/-)
Staphleya•trifolia*	Bladdernut (e. USA)	(M-H)
Staphylea•holocarpa *	Oriental Bladdernut (China)	(H)
Staphylea•pinnata *	European Bladdernut (c., se. Eur. A. Minor)	(H)
Stephanandra•incisa *	Lace Shrub (Jap., Korea, Taiwan)	(H)
Stephanandra•tanakae *	Lace Shrub (Japan)	(M-H)
Stephylea•bumalda *	Japanese Bladdernut (Japan)	(M-H)
Symphoricarpos•x•chenaultii•'Hancock' +	Hancock Coralberry (garden origin)	(M+/-)
Symplocos•paniculata *	Sapphireberry (Pakistan to Korea)	(M +/-)
Syringa•amurensis *	= Syringa•reticulata•v.•mandschurica	
Syringa•joskiaea *	Hungarian Lilac (Hungary)	(M+/-)
Syringa•meyeri *	----- (n. China)	(M+/-)
Syringa•microphylla *	Littleleaf Lilac (n. China)	(M+/-)
Syringa•oblata *	Early Lilac (n. China)	(M+/-)
Syringa•patula *	----- (Korea, China)	(M+/-)
Syringa•persica	Persian Lilac (Persia)	(M+/-)
Syringa•persica•'Laciniata' *	Cutleaf Persian Lilac (Persia ?)	(M+/-)
Syringa•reflexa *	Nodding Lilac (c. China)	(M+/-)
Syringa•reticulata•'Miss•Kim'	Miss Kim Lilac (hort. hybrid)	(M+/-)
Syringa•sweginzowii *	Chengtu Lilac (nw. China)	(M+/-)
Syringa•velutina *	Korean Lilac (Korea)	(M+/-)
Syringa•villosa	----- (China)	(M+/-)
Syringa•vulgaris	Common Lilac (s.e. Europe)	(M+/-)
Syringa•wolfii *	Wolf's Lilac (Korea, Manchuria)	(M+/-)
Syringa•x•chinensis	----- (hort. hybrid)	(M+/-)
Syringa•x•laciniata	Cutleaf Lilac (sw. Asia)	(M+/-)
Syringa•x•prestoniae *	----- (Canadian hort. origin)	(M+/-)
Viburnum•burejaeticum *	----- (n. China, Korea, Russia)	(M-H)
Viburnum•carlesii	Korean Spice Viburnum (Korea, Jap.)	(M-H)
Viburnum•cassinoides *	Witherod Viburnum (e. N. Am.)	(H)

Viburnum•dentatum	Arrowwood Viburnum (e. N. America)	(H-M)
Viburnum•dilatatum *	Linden Viburnum (China, Jap.)	(H)
Viburnum•farreri *	Fragrant Viburnum (n. China)	(H)
Viburnum•lantana	Wayfaring Vib. (Eur., n. Afr., Cauc. A. Minor)	(M+/-)
Viburnum•lentago	Nannyberry (e. N. America)	(M-H)
Viburnum•opulus	European Highbush Cranberry (Eurasia)	(H)
Viburnum•opulus•'Compactum'	----- (cultivar)	(H)
Viburnum•opulus•'Roseum'	European Snowball Viburnum	(H)
Viburnum•plicatum *	----- (Jap., China)	(H-M)
Viburnum•plicatum•'Sterile' *	Japanese Snowball Viburnum (Jap. China)	(H)
Viburnum•plicatum•form•'tomentosum' *	Doublefile Viburnum (Jap., China)	(H)
Viburnum•prunifolium	Black Haw (e. N. Am.)	(M-H)
Viburnum•sargentii *	Sargent's Vib. (e. Sib., n. & w. China, Jap.)	(M-H)
Viburnum•setigerum *	Tea Viburnum (c. & w. China)	(M+/-)
Viburnum•sieboldii *	----- (Japan)	(H)
Viburnum•trilobum	American Highbush Cranberry (N. America)	(H)
Viburnum•trilobum•'Compactum'	----- (cultivar)	(H)
Viburnum•x•bodnantense•'Pink•Dawn' *	----- (hort. hybrid)	(M-H)
Viburnum•x•carlcephalum	----- (hort. hybrid)	(M-H)
Vitex•agnus-castus•f.•latifolia *	Hardy Chaste Tree (s. Europe to c. Asia)	(L-M)
Vitex•negundo•var.•heterophylla *	Cutleaf Chaste Tree(n. China, Mongolia)	(M+/-)
Vitex•rotundifolia *	----- (Asia to Australia)	(M+/-)
Weigela•florida	Weigela (n. China, Korea, Jap.)	(H)
Weigela•middendorffiana *	Middendorff Weigela (n. China, Jap.)	(H)
Xanthocerus•sorbifolium	Yellowhorn (n. China)	(M+/-)
Zanthoxylum•piperitum *	Pepper Tree (China, Korea, Jap.)	(M+/-)
Zanthoxylum•schinifolium *	Pepper Tree (China, Korea, Jap.)	(M+/-)
Zanthoxylum•simulan *	----- (China, Taiwan)	(M-H)
Zenobia•pulverulenta *	Dusty Zenobia (N. Carolina-Florida	

Trees

(Deciduous Rocky Mountain Natives)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant:	Reference plant:	Reference plant:	Reference plant:
Bluegrass turf	Turf-type Tall Fescue	Buffalograss turf	Too dry for any turf
(Always wet at surface)	(Half of Bluegrass turf)	(Like Denver without irrigation)	(drier than Denver)
18-20 gals./ S.F./season	10 gals./S.F./ season	0-3 gals./S.F./season	No irrigation
July: 5"-- 3 times per week	.75" -- once per week	.5" per 2 weeks, optional	No irrigation

Celtis•occidentalis	Hackberry	(M-H)
Celtis•reticulata	Netleaf Hackberry	(M-H)
Fraxinus•cuspidata *	Fragrant Ash	(M+/-)
Fraxinus•pennsylvanica	Green Ash	(M-H)
Populus•angustifolia	Narrowleaf Cottonwood	(H)
Populus•deltoides	Plains Cottonwood	(H)
Populus•fremontii	Fremont's Cottonwood	(H)
Populus•tremuloides	Aspen	(H)
Populus•x•acuminata	Lanceleaf Cottonwood	(H)
Sapindus•drummondii *	Soapberry	(L-M)

Trees

(Deciduous, Introduced)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5"-- 3 times per week	10 gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Acer•capillipes *	Snake-bark Maple (Japan)	(H)
Acer•cappadocicum *	Caucasican Maple (Cauc., A. Minor, n. India)	(M-H)
Acer•cissifolium *	Ivy-leafed Maple (c. China)	(M-H)
Acer•davidii *	Snake-bark Maple (n. China)	(M-H)
Acer•griseum *	Paperbark Maple (China)	(M-H)
Acer•heldreichii *	Greek Maple (Cauc., Balk., n. Turkey)	(M-H)
Acer•macrophyllum *	Oregon Maple (w. N. Am.)	(H)
Acer•mandschuricum *	Manchurian Maple (Korea, Manch.)	(M-H)
Acer•monspessulanum *	Montpelier Maple (Medit.- c. Asia)	(M+/-)
Acer•palmatum	Japanese Maple (Kor., Jap.)	(H)
Acer•pectinatum	----- (Tibet, w. & c. China)	(M-H)
Acer•platanoides	Norway Maple (Eur. to n. Persia)	M-H)
Acer•platanoides•ssp.•turkestanicum *	Turkestan Maple (c. Asia)	(M+/-)
Acer•pseudoplatanus *	Sycamore Maple (nw. c. Eur. to w. Asia)	(M-H)
Acer•pseudosieboldianum *	Korean Maple (Korea-Manch.)	(H)
Acer•rubrum	Red Maple (e. N. America)	(M-H)
Acer•saccharinum	Silver Maple (e. N. Am.)	(M-H)
Acer•saccharinum•'Laciniatum' +	Cutleaf Silver Maple (Hort. cultivar	(M-H)
Acer•saccharum	Sugar Maple (e. N. America)	(H)
Acer•triflorum *	Three-flowered Maple (Manch., Korea)	(M+/-)
Acer•truncatum *	Shantung Maple (n. China, Manch., Korea)	(H)
Acer•turkestanicum *	= A. platanoides ssp. turkestanicum	
Aesculus•flava	Sweet Buckeye (e. N. America)	(M-H)
Aesculus•glabra	Ohio Buckeye (e. N. America)	(M-H)
Aesculus•hippocastanum	Horse Chestnut (Eurasia)	(M-H)
Aesculus•octandra	= Aesculus•flava	
Aesculus•pavia *	Red Buckeye (se. USA)	(H)
Aesculus•turninata *	Japanese Horsechestnut (Japan)	(M-H)
Aesculus•x•carnea *	Red-flowered Horsechestnut (hort. hybrid)	(M+/-)
Ailanthus•altissima	Tree of Heaven (n. China)	(L-M-H)
Albizia•julibrissin*	Silk Tree (Iran-Japan)	(M+/-)
Amelanchier•asiatica *	Asiatic Serviceberry (China)	(M+/-)
Asimia•triloba *	Paw Paw (ec. USA)	(H?)
Betula•albosinensis *	Chinese Red Birch (c., w., nw. China)	(M-H)
Betula•ermanii *	Russian Rock Birch (ne. Asia)	(H)
Betula•mandshurica•var.•japonica *	Japanese White Birch (Jap., Sakhalin Is.)	(H)
Betula•maximowicziana *	Monarch Birch (Jap.)	(H)
Betula•nigra	River Birch (e. USA)	(H)

Betula•papyrifera	Paper Birch (e. N. America)	(H)
Betula•pendula•'Lacinata'	Cutleaf Weeping Eur.. Birch (hort. hybrid)	(H)
Betula•pendula	European Birch (Eur.-w. Asia)	(H)
Betula•utilis•var.•jacquemantii *	Whitebarked Himal. Birch (Kash., c. Nepal)	(M-H)
Carpinus•betulus *	European Hornbeam (Eur.-w. Asia)	(H)
Carpinus•carolinana *	American Hornbeam (e. N. America)	(H)
Carpinus•cordata *	Heartleaf Hornbeam (China)	(M-H)
Carpinus•henryana *	----- (c. China)	(M-H)
Carpinus•japonica *	Japanese Hornbeam (Japan)	(H)
Carpinus•laxiflora *	----- (Jap., Kor., n. & w. China)	(M-H)
Carpinus•orientalis *	Oriental Hornbeam (se. Eur., A. Minor)	(M-H)
Carpinus•tschonoskii *	Yeddo Hornbeam (ne. & sw. China)	(M-H)
Carpinus•turczaninovii *	----- (w. China)	(M+/-)
Carya•illinoinensis *	Pecan (Iowa s. to Mexico)	(M+/-)
Carya•laciniosa *	Shellbark Hickory (e. N. America)	(M-H)
Carya•ovata *	Shagbark Hickory (e. N. America)	(H)
Castanea•crenata *	Japanese Chestnut (Jap.)	(H)
Castanea•dentata	American Chestnut (e. N. America)	(H)
Castanea•mollissima *	Chinese Chestnut (China, Korea)	(M-H)
Catalpa•bignonioides *	Southern Catalpa (se. USA)	(H)
Catalpa•bungei *	----- (n. China)	(M+/-)
Catalpa•fargesii *	----- (w. China)	(M+/-)
Catalpa•ovata *	Chinese Catalpa (China)	(H)
Catalpa•speciosa	Catalpa (e. N. America)	(M-H)
Celtis•australis *	Mediterranean Hackberry (Medit., Mid East)	(M+/-)
Celtis•caucasica *	Caucasican Hackberry (Asia Minor-Afghan.)	(M+/-)
Celtis•laevigata	Sugarberry (se. USA)	(M-H)
Cercidiphyllum•japonicum *	Katsura Tree (Japan, w. China)	(H-M)
Cercis•canadensis	Eastern Redbud (e. N. America)	(M-H)
Cercis•reniformis *	Texas Redbud (N. Mex., Tex., Okla.)	(M+/-)
Chitalpa	= x•Chitalpa•tashkentensis	
Cladrastis•lutea *	Yellowwood (se. USA)	(H)
Cladrastis•platycarpa *	Japanese Yellowwood (Jap., China)(H)	
Cladrastis•sinensis *	Chinese Yellowwood (China)	(H)
Corlyus•colurna	Turkish Hazel (se. Europe, w. Asia)	(M+/-)
Cornus•walteri *	Walter Dogwood (c. China)	(M-H)
Corylus•americana *	American Hazel (e. N. America)	(H)
Crataegus•altaica•'Hissarica' *	Hissar Hawthorn (Tajikistan)	(M+/-)
Crataegus•ambigua +	Russian Hawthorn (se. Russia)	(M+/-)
Crataegus•arnoldiana *	----- (New England)	(M+/-)
Crataegus•azarolus *	Red Azarole (s. Eur., n. Afr., w. Asia)	(M+/-)
Crataegus•crus-galli	Cockspur Hawthorn (se. N. America)	(M+/-)
Crataegus•laevigata *	English Hawthorn (Eur., n. Afr., India)	(M-H)
Crataegus•maximowiczii *	----- (ne. Asia)	(M$\underline{+}$)
Crataegus•mollis	Downy Hawthorn (e. N. America)	(M+/-)
Crataegus•monogyna *	Singleseed Hawthorn (Eur., n. Afr., w. Asia)	(M+/-)
Crataegus•pedicellata *	----- (ne. USA)	(M+/)
Crataegus•phaenopyrum	Washington Hawthorn (se. N. America)	(M+/-)
Crataegus•pinnatifida *	Chinese Hawberry (c. Asia, Korea)	(M+/-)
Crataegus•rivularis *	----- (Rocky Mtn. States)	(M+/-)
Crataegus•tianshanica *	Tien Shan Hawthorn (c. Asia)	(M+/-)
Crataegus•turkestanica *	Turkestan Hawthorn (Turkestan)	(M+/-)
Crataegus•viridis•'Winter•King' *	Winter King Hawthorn (e. USA)	(M+/-)
Crataegus•x•nitida *	Shining Hawthorn (s. USA)	(M+/-)
Cyrilla•racemiflora *	Leatherwood (e. N. Am. & e. S. Am.)	(H)
x•Chitalpa•tashkentensis *	Chiltalpa (Catalpa•bignonioides X Chilopsis•linearis)	(M+/-)
Diospyros•virginiana *	American Persimmon (e. USA)	(M-H)

Eucommia•ulmoides *	Hardy Rubber Tree (c. China)	(M+/-)
Evodia•daniellii *	= Tetradium•danielii *	
Evodia•hupehensis *	= Tetradium•hupehensis *	
Fagus•grandifolia *	American Beech (e. N. America)	(H)
Fagus•orientalis *	Oriental Beech (se. Eur.-Iran)	(M+/-)
Fagus•sylvatica	European Beech (Europe)	(H)
Fraxinus•americana	White Ash (e. N. America)	(M-H)
Fraxinus•americana•'Autumn•Purple'	Autumn Purple Ash (hort. cultivar)	(M-H)
Fraxinus•angustifolia•'Raywood' *	Raywood Ash (s. Europe-c. Asia, n. Afr.)	(M+/-)
Fraxinus•angustifolia•ssp.•syriaca *	Turkestan Ash (c. Asia, A. Minor)	(M+/-)
Fraxinus•chinensis *	Chinese Ash (China)	(M+/-)
Fraxinus•cuspidata *	Flowering Ash (N. Mex. to Mex.)	(L-M)
Fraxinus•excelsior *	European Ash (Europe, w. Asia)	(M+/-)
Fraxinus•latifolia *	Oregon Ash (w. US)	(M+/-)
Fraxinus•mandshurica *	Manchurian Ash (n. Asia)	(M+/-)
Fraxinus•nigra *	Black Ash (N. Am.)	(M+/-)
Fraxinus•ornus *	Flowering Ash (s. Europe-w. Asia)	(M+/-)
Fraxinus•oxycarpa•'Raywood' *	= F. angustifolia 'Raywood'	
Fraxinus•quandrangulata *	Blue Ash (Mich., to Ark.)	(M-H)
Fraxinus•sieboldiana *	----- (Japan, China)	(M-H)
Fraxinus•sogdiana *	= Fraxinus•angustifolia•ssp.•syriaca	
Fraxinus•velutina *	Velvet Ash (Ariz., N. Mex.)	(M+/-)
Ginkgo•biloba *	Ginkgo, Maidenhair Tree (se. China)	(M-H)
Gleditsia•caspica *	Caspian Honeylocust (Azerbaijan-n. Iran)	(M+/-)
Gleditsia•triacanthos•var.	Honeylocust varieties (c. & e. N. America)	(M-H)
Gymnocladus•dioica	Kentucky Coffeetree (c. & e. N. America)	(M-H)
Halesia•diptera *	Two-winged Silverbell (s. USA)	(H)
Halesia•tetraptera *	Silverbell Tree (se. USA)	(H)
Hemiptelea•davidii *	David Hemiptelea (n. China to Korea)	(M-H)
Hovenia•dulcis *		
Idesia•polycarpa *	----- (Sichuan)	M-H)
Juglans•ailanthifolia *	Japanese Walnut (Jap.)	(M+/-)
Juglans•ailantifolia *	Heartnut (Japan)	(H)
Juglans•cinerea *	White Butternut (N. America)	(M+/-)
Juglans•mandshurica *	Manchurian Walnut (Manchuria, ne. China)	(M+/-)
Juglans•microcarpa *	Little Walnut (OK., N. Mex., Tex., Kan., Mex.)	(M+/-)
Juglans•nigra	Black Walnut (e. USA)	(M-H)
Juglans•regia•varieties *	Carpathian Walnut varieties (se. Eur. - China)	(M+/-)
Kalopanax•pictus *	= Kalopanax•septemlobus	
Kalopanax•septemlobus *	Castor-aralia (China, Korea, Japan)	(M-H)
Koelreuteria•paniculata	Golden Raintree (n.China, Korea)	(M+/-)
Laburnum•alpinum *	Alpine Golden Chaintree (sc. Europe)	(M-H)
Laburnum•anagyroides *	Common Laburnum (c. & s. Eur.)	(M+/-)
Laburnum•X•'Waterer' *	Waterer Laburnum (hort. hybrid)	(H)
Larix•decidua	European Larch (Alps, Carpathian Mts.)	(H)
Larix•gmelinii *	Dahurian Larch (e. Asia)	(H)

Larix•kaempferi *	Japanese Larch (Japan)	(H)
Larix•laricina	Tamarack (n. N. America)	(H)
Larix•leptolepis *	= Larix•kaempferi	
Larix•occidentalis *	Rocky Mtn. Larch (B.C. to Montana)(M-H)	
Liquidambar•styraciflua *	Sweetgum (e. N. America to c. America)	(H)
Liriodendron•tulipifera *	Tulip Tree (e. N. America)	(H)
Maackia•amurensis *	Amur Maackia (Manchuria, Korea)	(M+/-)
Maackia•chinensis *	----- (c. China)	(M+/-)
Maclura•pomifera *	Osage Orange (Ark., Tex.)	(M+/-)
Magnolia•acuminata *	Cucmber Tree (e. N. AM)	(H)
Magnolia•kobus *	Tree Star Magnolia (Japan)	(M-H)
Magnolia•x•soulangiana	Saucer Magnolia (hort. hybrid)	(H)
Malus•'Hopa'	Hopa Crabapple (hort. cultivar)	(M+/-)
Malus•'Radiant'	Radiant Crabapple (hort. cultivar)	(M+/-)
Malus•'Snowdrift'	Snowdrift Crabapple (hort. cultivar)	(M+/-)
Malus•baccata	Siberian Crabapple (Manchuria, China)	(M+/-)
Malus•dolgo	Dolgo Crabapple (Siberia ?)	(M+/-)
Malus•ioensis	Prairie Crabapple (c. USA)	(M+/-)
Malus•ioensis•'Plena'	Bechtel Crabapple (hort. cultivar)	(M+/-)
Malus•sp.•'Golden•Delicious'	Golden Delicious Apple (hort. cultivar)	(M+/-)
Malus•sp.•'Red•Delicious'	Red Delicious Apple (hort. cultivar)	(M+/-)
Malus•sp.•'Winesap'	Winesap Apple (hort. cultivar)	(M+/-)
Malus•spp.	Common Apple (se. Europe, c. Asia)	(M+/-)
Mespilus•germanica *	Medlar (Europe-Asia Minor)	(M+/-)
Metasequoia•glyptostroboides *	Dawn Redwood (w. China)	(M-H)
Morus•alba	White Mulberry (Asia)	(M+/-)
Morus•australis *	----- (e. Asia)	(M+/-)
Morus•nigra *	Black Mulberry (sw. Asia)	(M+/-)
Morus•rubra *	Red Mulberry (e. N. America)	(M+/-)
Nothofagus•antarctica *	Southern Beech (Chile, Argentina)	(H)
Nyssa•sylvatica *	Blackgum (Ontario, Texas)	(H)
Ostrya•carpinifolia *	European Hop Hornbeam (s. Eur., se. Asia)	(M)
Ostrya•virginiana *	American Hop Hornbeam (e. N. America)	(H)
Paulownia•fortunei*	----- (China, Japan)	(H)
Paulownia•kawakamii*	----- (s. China, Taiwan)	(H)
Paulownia•tomentosa *	Empress Tree (c. & w. China)	(M-H)
Phellodendron•amurense *	Amur Cork Tree (n. China, Jap., Manch.)	(M-H)
Phellodendron•chinese *	Chinese Cork Tree (c. China)	(M-H)
Phellodendron•Japonicum *	Japanese Cork Tree (c. Japan)	(H)
Phellodendron•sachalinense *	Sakhalin Cork Tree (w. China, n. Jap., Kor.)	(H)
Pistacia•chinensis *	Chinese Pistachio (China, Taiwan)	(L-M)
Pistacia•vera *	Edible Pistachio (Persia, c. Asia)	(L-M)
Platanus•occidentalis *	Eastern Plane Tree (Ia., to Tex. to Mex.)	(H)
Platanus•orientalis *	Oriental Plane Tree (se. Eur., sw. Asia)	(M+/-)
Platanus•x•acerifolia *	London Plane Tree (hort. hybrid)	(H)
Prunus•armeniaca	Apricot (c. & e. Asia)	(M+/-)
Prunus•armeniaca•var.•mandshurica *	= Prunus•mandshurica	
Prunus•avium *	Bird Cherry (Eur.-A. Minor-e. Sib.)	(H-M)
Prunus•cerasus *	Pie Cherry (se. Eur., Iran, n. India)	(M+/-)
Prunus•cerasus•'Meteor'	Meteor Pie Cherry (hort. cultivar)	(M+/-)
Prunus•cerasus•'Morello'	Morello Pie Cherry (hort. cult.)	(M+/-)
Prunus•cerasus•x•'Montmorency'	Montmorency Pie Cherry (hort. cultivar)	(M+/-)
Prunus•cerasus•x•'North•Star'	North Star Pie Cherry (hort. cultivar)(M+/-)	
Prunus•maackii	Manchurian Cherry (Kor. Manch.)	(M-H)

Prunus•mahleb *	St. Lucie Cherry (Eur.-Asia Minor)	(M+/-)
Prunus•mandshurica *	Manchurian Apricot (Manchuria, Korea)	(M+/-)
Prunus•persica	Peach (c. & e. Asia)	(M+/-)
Prunus•salicina *	Japanese Plum (China, Jap.)	(H-M)
Prunus•sp.•'Green•Gage'	Green Gage Plum (hort. cultivar)	(M+/-)
Prunus•sp.•'Stanely'	Stanley Plum (hort. cultivar)	(M+/-)
Prunus•spp.	Domestic Plums	(M+/-)
Prunus•x•dasycarpa * (P. •armenica x P.•cerasifera)	Black Apricot (c. Asia-Asia Minor)	(M-L)
Pseudolarix•kaempferi *	Golden Larch (e. China)	(H?)
Ptelea•polyadenia*	----- (sw. USA)	(M+/-)
Pterocarya•fraxinifolia *	Caucasian Walnut (Caucasus, Persia)	(M+/-)
Pteroceltis•tartarianovii *	Tartar Wingceltis (n., c. China)	(M+/-)
Pterostyrax•hispida *	Fragrant Epaulette Tree (Japan, China)	(H?)
Pyrus•bucharica *	= Pyrus•korshinsky	
Pyrus•calleryana•'Bradford'	Bradford Pear (China)	(M+/-)
Pyrus•communis +	Common Garden Pear (Europe, w. Asia)	(M+/-)
Pyrus•communis•'Maxine'	Maxine Pear (hort. cultivar)	(M+/-)
Pyrus•communis•'Moonglow'	Moonglow Pear (hort. cultivar)	(M+/-)
Pyrus•korshinsky *	Buchara Pear (Turkestan)	(L-M)
Pyrus•salicifolia *	Willow-leafed Pear (se. Europe, w. Asia)	(M+/-)

Quercus•acutissima *	Sawtooth Oak (Japan, China, Korea)	(M-H)
Quercus•alba	White Oak (e. USA)	(M+/-)
Quercus•bicolor	Swamp White Oak (ne. N. Am.)	(M+/-)
Quercus•douglasii *	California Blue Oak (w. US)	(M+/-)
Quercus•frainetto *	Hungarian Oak (s. Italy, Balk., Turkey)	(M+/-)
Quercus•glandulifera *	----- (Jap., Korea, China)	(M+/-)
Quercus•imbricaria *	Shingle Oak (e. & c. USA)	(M-H)
Quercus•kelloggii *	California Black Oak (w. US)	(M+/-)
Quercus•macrocarpa	Bur Oak (c., ne. N. America)	(M+/-)
Quercus•mongolica *	Mongolian Oak (ne. Asia)	(M+/-)
Quercus•muehlenbergii *	Chinquapin Oak (e. USA)	(M-H)
Quercus•palustris	Pin Oak (ne. N. America)	(M-H)
Quercus•phellos *	Willow Oak (se. USA)	(M-H)
Quercus•prinus *	Chestnut Oak (e. USA)	(M-H)
Quercus•robur	English Oak (Europe, n. Afr., w. Asia)	(M-H)
Quercus•rubra	Northern Red Oak (ne. USA)	(M-H)
Quercus•sadleriana *	Deer Oak (w. USA)	(M+/-)
Quercus•shumardii *	Shumard's Oak (c. USA)	(M-H)
Quercus•vacciniifolia *	Huckleberry Oak (w. US)	(M+/-)

Salix•pentandra *	Laurel-leaf Willow (Eur.)	(H)
Sassafras•albidum *	Sassafras (e. N. Am.)	(H)
Sophora•davidii *	David's Sophora (China)	(L-M)
Sophora•japonica (aka Styphnolobium•japonicum)	Japanese Pagoda Tree (China, Korea)	(M+/-)
Sorbus*torminalis *	Chequer Tree (A. Minor, n. Africa, Eur. Asia)	(H)
Sorbus•alnifolia *	----- (Jap., Korea)	(H)
Sorbus•americana	American Mtn. Ash (ne. N. America)	(M-H)
Sorbus•aria*	Whitebeam Mtn. Ash (Eur.)	(H)
Sorbus•aucuparia	European Mtn. Ash (Eurasia)	(M-H)
Sorbus•cashmeriana *	Kashmir Mountain Ash (Himalaya)	(H)
Sorbus•commixta *	----- (Korea, Japan)	(M-H)
Sorbus•decora	Showy Mountain Ash (ne. N. America)	(M-H)
Sorbus•forrestii *	Forest's Mountain Ash (China)	(M-H)
Sorbus•hupehensis *	Hupeh Mtn. Ash (c., w. China)	(M-H)
Sorbus•intermedia *	Scandinavian Mtn. Ash (Scand.)	(H)
Sorbus•latifolia *	----- (Europe)	(M-H)
Sorbus•pohuashanensis *	----- (n. China)	(H)
Sorbus•prattii *	Pratt's Mountain Ash (w. China)	(M+/-)
Sorbus•tianschanica *	Tien Shan Mtn. Ash (c. Asian mtns.)	(H)

Sorbus•x•hybrida *	Oakleaf Mtn. Ash (hort. hybrid)	(H)
Stranvaesia•davidiana *	Chinese Stranvaesia (w. China)	(H)
Styphnolobium•japonicum	see Sophora•japonica	
Styrax•japonicum *	Japanese Snowball (Japan, China)	(H)
Styrax•obassia *	Fragrant Snowbell (Japan)	(H)
Syringa•pekinensis	Peking Tree Lilac (n. China)	(M+/-)
Syringa•reticulata	Japanese Tree Lilac (n. Japan)	(M-H)
Syringa•reticulata•var.•mandschurica	Manchurian Tree Lilac (Japan)	(M+/-)
Taxodium•ascendens *	Pond Cypress (se. USA)	(H)
Taxodium•distichum	Bald Cypress (se. N. America)	(H)
Tetradium•danielii *	Korean Evodia (China, Korea)	(H)
Tetradium•hupehensis *	Hupeh Bee Bee Tree (sw. China, Korea)	(M+/-)
Tilia•americana	Basswood (c., e. N. America)	(H)
Tilia•amurensis *	Amur Linden (Manch., Korea)	(M-H)
Tilia•cordata	Littleleaf Linden (Eur. to Caucasus)	(H)
Tilia•mongolica *	Mongolian Linden (Mon., e. Russia, n. China)	(M-H)
Tilia•platyphyllos *	Bigleaf Linden (se., Europe)	(M-H)
Tilia•tomentosa *	Silver Linden (se. Europe, w. Asia)	(M+/-)
Tilia•x•euchlora *	Crimean Linden (hort. hybrid)	(M-H)
Toona•sinensis	----- (China)	(M-H)
Ulmus•parvifolia *	Chinese Elm (China, Japan, Korea)	(M-H)
Ulmus•americana•cvs.	American Elm (DED resistant cultivars)	(L-M-H)
Zelkova•carpinifolia *	Caucasian Zelkova (Cauc.)	(M-H)
Zelkova•serrata *	Japanese Zelkova (Jap., Taiwan, e. China)	(H)
Zelkova•sinica *	Chinese Zelkova (e. China)	(H)
Ziziphus•jujuba *	Chinese Jujuba (temp. Asia)	(H-M)

EVERGREENS

(Coniferous Trees)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant:	Reference plant:	Reference plant:	Reference plant:
Bluegrass turf	Turf-type Tall Fescue	Buffalograss turf	Too dry for any turf
(Always wet at surface)	(Half of Bluegrass turf)	(Like Denver without irrigation)	(drier than Denver)
18-20 gals./S.F./season	10 gals./S.F./season	0-3 gals./S.F./season	No irrigation
July: 5"-- 3 times per week	.75" -- once per week	.5" per 2 weeks, optional	No irrigation

Abies•cilicica *****	Cilician Fir (s. Turkey, nw. Syria, Lebanon)	(M-H)
Abies•concolor	White Fir (Colo. to Mex.)	(M-H)
Abies•holophylla *****	Manchurian Fir (Manch., Korea)	(M-H)
Abies•homolepis *****	Nikko Fir (Japan)	(H)
Abies•koreana *****	Korean Fir (s. Korea)	(H)
Abies•lasiocarpa	Subalpine Fir (Rocky Mtns.)	(H)
Abies•nordmanniana *****	Caucasian Fir (Greece, Cauc., Turkey)	(M)
Calocedrus•decurrens *****	Incense Cedar (w. Ore.-Baja Calif.)	(M-H)
Cedrus•atlantica *****	= Cedrus•libani•ssp.•atlantica	
Cedrus•deodara *****	Deodara Cedar (Himilaya Mts. Afghan.-w. Nepal)	(M-H)
Cedrus•libani *****	Lebanon Cedar (nw. Syria, se Turkey)	(M-H)
Cedrus•libani•ssp.•atlantica *****	Atlas Cedar (Atlas Mts.)	(M-H)
Cedrus•libani•ssp.•stenocoma *	Hardy Turkish Cedar (s. Turkey)	(M-H)
Cupressus•arizonica *****	Arizona cypress (Ariz., N. Mex., Tex., Mex.)	(L-M)
Cupressus•bakeri *	Modoc Cypress (Calif., Oregon)	(M+/-)
Picea•abies	Norway Spruce (n. & c. Europe)	(H)
Picea•engelmannii	Engelmann Spruce (B.C. to N. Mex.)	(H)
Picea•glauca	White Spruce (n. N. Am.)	(M-H)
Picea•glauca•'Black•Hills'	Black Hills Spruce (Black Hills S.Dak.)	(M-/-)
Picea•glauca•'Conica'	Dwarf Alberta Spruce (hort. cultivar)	(H)
Picea•omorika *****	Serbian Spruce (Balk.)	(M-H)
Picea•pungens	Colorado Spruce (Wyo., Colo., N. Mex., Utah)	(M-H)
Picea•schrenkiana•ssp.•tianshanica *****	----- (c. Asia)	(M+/-)
Pinus.•heldreichii (was P.•leucodermis) *****	Bosnian Pine (w. Balkans - se. Italy - Greece)	(M+/-)
Pinus•aristata	Bristlecone Pine (Mts. Cal. to Colo.)	(M, H)
Pinus•bungeana *****	Lacebark Pine (nw. China)	(M+/-)
Pinus•cembra *****	Swiss Stone Pine (c. Eur. mtns.)	(M-H)
Pinus•contorta•ssp.•latifolia	Lodgepole Pine (Alaska, Cal., to Colo.)	(M-H)
Pinus•densiflora *****	Japanese Red Pine (Jap., Korea)	(M-H)
Pinus•flexilis	Limber Pine (Albt. to Cal. to Tex.)	(M-H)
Pinus•nigra	Austrian Pine (se. Eur., w. Asia, n. Afr.)	(M-H)
Pinus•peuce *****	Macedonian Pine (Balk.)	(M-H)
Pinus•ponderosa	Ponderosa Pine (w. North America)	(M+/-)
Pinus•pumila *	Dwarf Siberian Pine (ne. Asia)	(H)
Pinus•strobiformis	Southwestern White Pine (Colo., Ariz., n. Mex.	(M-H)

Pinus•strobus	Eastern White Pine (e. N. America)	(H)
Pinus•sylvestris	Scotch Pine (n. Eurasia)	(M-H)
Pinus•wallichiana *****	Himalayan White Pine (Himalaya Mtns.)	(M-H)
Pseudotsuga•menziesii	Douglas Fir (B.C. to Mex. to Tex.)	(M-H)
Sequoiadendron•giganteum *****	Giant Sequoia (Sierra Nevada Mts.)	(H)
Tsuga•canadensis	Canada Hemlock (ne. N. America)	(H)

EVERGREENS

(Coniferous Shrubs)

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./ S.F./season July: 5"-- 3 times per week	10 gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Chamaecyparis•pisifera *	----- (Japan)	(H)
Juniperus•chinensis	Chinese Juniper (e. Asia)	(L-M)
Juniperus•chinensis•'Hetzii•Glauca'	Hetzi Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Pfitzeriana'	Pfitzer Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Pfitzeriana•Compacta'	Compact Pfitzer Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Tortulosa' *	Hollywood Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•var.•sargentii	Sargent's Juniper (e. Asia)	(L-M)
Juniperus•communis•saxatilis	Mountain Common Juniper (circumboreal)	(L-M)
Juniperus•horizontalis	Horizontal Juniper (Nov. Sc. to Alaska, N J., to Mon.,)	(L-M)
Juniperus•horizontalis•'Bar•Harbor'	Bar Harbor Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Blue•Chip'	Blue Chip Juniper (e. Asia)	(L-M)
Juniperus•horizontalis•'Plumosa'	Andorra Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Prince•of•Wales'	Prince of Wales Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Wiltonii'	Wilton Carpet Juniper (hort. cultivar)	(L-M)
Juniperus•monosperma	Oneseed Juniper (Colo., Utah, Tex., Mex.)	(VL-L)
Juniperus•osteosperma	Utah Juniper (sw. USA)	(VL-L)
Juniperus•procumbens var. & cv.	Japgarden Juniper varieties and cultivars	(M-H)
Juniperus•sabina	Savin Juniper (w. Asia)	(L-M)
Juniperus•sabina•'Buffalo'	Buffalo Juniper (hort. cultivar)	(L-M)
Juniperus•sabina•'Skandia'	Skandia Juniper (hort. cultivar)	(L-M)
Juniperus•sabina•var.•tamariscifolia	Tam Juniper (hort. cultivar)	(L-M)
Juniperus•scopulorum	Rocky Mtn. Juniper (B.C. to s. Ariz., to Tex.)	(L)
Juniperus•squamata	----- (India, Tibet, Taiwan)	(M+/-)
Juniperus•squamata•'Meyeri'	----- (hort. cultivar)	(M+/-)
Juniperus•virginiana	Eastern Redcedar (e. N. Am.)	(M-H)
Microbiota•decussata *	Siberian Cypress (Siberia)	(M+/-)
Pinus•edulis	Piñon Pine (Wyo., Cal., Mex.)	(VL-M)
Pinus•mugo	Mugo Pine (c. Eur. Balk.)	(M-H)
Platycladus•orientalis *	Oriental Arborvitae (China, Korea)	(M+/-)
Taxus•baccata *	English Yew (Eur., n. Afr., w. Asia)	(H)

Taxus•brevifolia *****	Anticancer Yew (pnw. USA)	(H)
Taxus•cuspidata *****	Japanese Yew (Jap., Kor., Manchuria)	(H)
Taxus•x•media *****	----- (hort. hybrid)	(H)
Thuja•occidentalis•var.	Western Arborvitae varieties (e. N. Am.)	(H)
Thuja•orientalis (now Platycladus•orientalis)		
Thuyopsis•dolabrata *****	False Arborvitae (Japan)	(H)

7. EVERGREENS

(Non-coniferous)

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant:	Reference plant:	Reference plant:	Reference plant:
Bluegrass turf	Turf-type Tall Fescue	Buffalograss turf	Too dry for any turf
(Always wet at surface)	(Half of Bluegrass turf)	(Like Denver without irrigation)	(drier than Denver)
18-20 gals./S.F./season	10 gals./S.F./season	0-3 gals./S.F./season	No irrigation
July: 5"-- 3 times per week	.75" -- once per week	.5" per 2 weeks, optional	No irrigation

Agave•parryi *	Parry's Agave (Cal., N.Mex., Mex.)	(VL-L)
Agave•utahensis *	Utah Agave (Cal., Nev. Utah, Ariz.)	(VL-L)
Allenrolfea•occidentalis *	Iodine Bush (sw. USA, deserts)	(L-VL)
Arctostaphylos•patula *	Greenleaf Manzanita (sw. USA)	(M+/-)
Artemisia•cana •(a.k.a. Seriphidium•canum)	Black Sage (w. USA)	(VL-M)
Artemisia•tridentata (a.k.a. S. tridentata)	Big Western Sage (intermtn. w. N. America)	(VL-M)
Aucuba•japonica *	Spotted Laurel (China, Taiwan, s. Japan)	(H)
Berberis•candidula *	Paleleaf Barberry (China)	(M+/-)
Berberis•julianae	Wintergreen Barberry (w. China)	(M+/-)
Berberis•triacanthophora *	= Berberis•X•wisleyensis	
Berberis•verruculosa *	Warty Barberry (w. China)	(M+/-)
Berberis•x•wisleyensis *	Threespike Barberry (hort. hybrid)	(M+/-)
Bruckenthalia•spiculifolia *	Spike Heath (se. Europe, Asia Minor)	(M+/-)
Buxus•microphylla•v.•koreana *	Korean Boxwood (Jap., Korea)	(M-H)
Buxus•sempervirens *	Common Boxwood (s. Eur., w. Asia , n. Afr.)	(M-H)
Ceanothus•fendleri	Fendler Ceanothus (Rocky Mtn. West)	(M+/-)
Ceanothus•integerrimus *	Deerbrush (sw. N. America)	(M+/-)
Ceanothus•sanguineus *	Oregon Tea (B.C. to Mont. to Calif.)	(M+/-)
Ceanothus•velutinus *	Snowbrush Ceanothus (Western Mtns., USA)	(M-H)
Cercocarpus•breviflorus	= Cercocarpus•ledifolius•v.•paucidentatus	
Cercocarpus•intricatus	= Cercocarpus•ledifolius•v.•intracatus	
Cercocarpus•ledifolius	Curlleaf Mtn. Mahogany (Intermtn. USA)	(VL-L)
Cercocarpus•ledifolius•v.•intracatus	Littleleaf Mtn. Mahogany (Intermtn. sw. USA)	(VL-L)
Cercocarpus•ledifolius•v.•paucidentatus	Hairy Mtn. Mahogany (Ariz., N. Mex., Mex.)	(VL-L)
Chamaebatiaria•millefolium	Fernbush (Ore., e. Cal., Wyo., Ariz.)	(VL-L)
Cistus•laurifolius *	Laurel Rock Rose (sw. Europe)	(M+/-)
Coronilla•emerus *	Scorpion senna (c. & s. Europe)	(L-M)
Cotoneaster•congestus *	Pyrenees Cotoneaster (Himilaya Mts.)	(M+/-)
Cotoneaster•conspicuus *	Wintergreen Cotoneaster (c. China, se. Tibet)	(M+/-)
Cotoneaster•dammeri *	Bearberry cotoneaster (c. China)	(M-/-)
Cotoneaster•glaucophyllus *	Brightbead Cotoneaster (w. China)	(L-M)
Cotoneaster•microphyllus *	Littleleaf Cotoneaster (mtns. Afghan. to China)	(L-M)
Cowania•mexicana (syn. Purshia•mexicana)	Cliff Rose (intermtn. sw. USA & Mex.)	(VL-L)
Cytisus•scoparius *	Scotch Broom (Europe)	(M+/-)

Cytisus•x•praecox *	Warminster Broom (hort. hybrid)	(M+/)
Daphne•cneorum	Daphne (mtns. c. & s. Europe)	(M+/-)
Daphne•retusa *	= Daphne•tangutica	
Daphne•tangutica *	----- (nw. & w. China)	(M+/-)
Daphne•x•burkwoodii	-----	(M+/-)
Daphne•x•burkwoodii•'Carol•Mackie'	Carol Mackie Daphne (hort. cultivar)	(M+/-)
Daphne•pontica *	----- (A. Minor, se. Eur., Cauc.)	(M+/-)
Elaeagnus•pungens *	----- (Jap., China)	(VL, M)
Ephedra•americana•v.•andina *+	----- (Andes, Ecuador. to Patagonia)	(VL-M)
Ephedra•equisetina +	----- (c. Asia, w. china)	(VL)
Ephedra•gerardiana *+	----- (China, Himalaya)	(VL-L)
Ephedra•glauca *	----- (c. Asia-Seravshan Mts.)	(VL-L)
Ephedra•minima *+	----- (China)	(VL-L)
Ephedra•minuta *	----- (c. Asia-Seravshan Mts.)	(VL-L)
Ephedra•nevadensis *+	Nevada Ephedra (Great Basin)	(VL-L)
Ephedra•regaliana *	----- (c. Asia-Pamir Mts.)	(VL-L)
Ephedra•torreyana +	Torrey Ephedra (intermtn. sw. USA)	(VL-L)
Ephedra•viridis +	Green Ephedra, Mormon Tea (Intermtn. sw. USA)	(VL-L)
Euonymus•fortunei•'Vegetus'	Euonymus (c. & w. China)	(M-H)
Euonymus•kiautschovicus•'Manhattan'	Manhattan Euonymus (hort. cultivar)	(M-H)
Fargesia•murielae, A. m., Sinarundinaria m. (see Thamnocalamus•spathaceus) *		
Fargesia•nitida., Arundinaria n., Sinarundinaria n., Thamnocalamus•nitida (see Sinarundinaria•nitida) *		
Fargesia•spathacea, Arundinaria s. (see Thamnocalamus•spathaceus) *		
Fuchsia•magellanica *	Fuchsia (Peru, Chile, Argentina)	(H)
Garrya•flavescens *	Yellow Silktassel (e. Cal., w. Az., s. Utah, s. Nev.)	(L)
Garrya•fremontii *	Fremont's Silktassel (w. Wa., Ore., Cal.)	(M+/-)
Garrya•wrightii *	Wright's Silktassel (sw. AZ., s. N. Mex., w. Tex.)	(L)
Gelsemium•sempervirens *	Carolina Yellow Jasmine (s. USA to c. Am.)	(H)
Hesperaloe•parviflora +	Hesperaloe (sw. Texas)	(VL-M)
Iberis•sempervirens	Evergreen Candytuft (Eurasia)	(M-H)
Ilex•aquifolium *	English Holly (Eur., n. Afr., w. Asia)	(H)
Ilex•cornuta *	Chinese Holly (China, Korea)	(H)
Ilex•crenata *	Japanese Holly (Sakhalin Is., Jap., Korea)	(H)
Ilex•opaca *	American Holly (e. USA)	(H)
Ilex•wilsonii *	Wilson's Holly (c., w., e. China, Taiwan)	(M-H)
Ilex•x•meserveae var.	Blue Prince & Blue Princess Hollies etc. (hort. hybrids)	(H)
Jasminum•fruticans *	----- (Medit. Asia Minor)	(L-M)
Kalmia•angustifolia *	Lambkill Kalmia (Hudson Bay to Georgia)	(H)
Kalmia•latifolia *	Mountain Laurel (e. N. Am.)	(H)
Lavandula•angustifolia var.	English Lavender varieties (Medit.)	(VL-M)
Lavandula•stoechas *	Spanish Lavender (c. Spain, ne. Portugal)	(VL-M)
Leucophyllum•minus *	Cenzia, Texas Ranger (Texas, New Mexico)	(L)
Lonicera•nitida *	Boxleaf Honeysuckle (China)	(H)
Lonicera•pileata *	Privet Honeysuckle (China)	(H)

Mahonia•aquifolium +	Oregon Hollygrape (Cascade mtns.)	(M-H)
Mahonia•fremontii +	Fremont Mahonia (sw. USA)	(VL-L)
Mahonia•haematocarpa +	Redberry Mahonia (sw. USA)	(VL-L)
Mahonia•repens +	Creeping Mahonia (Rocky Mtn. West)	(L-H)
Mahonia•trifoliata *+	Three-leaf Mahonia, Algerita (Ariz., N. Mex., Tex., Mex.)	(L)
x•Mahoberberis•miethkeana *	----- (Berberis•julianae•X•Mahonia•aquifolium)	(M+/-)
Nandina•domestica *	Heavenly Bamboo (India to e. China)	(M-H)
Nolina•microcarpa *	Bear Grass (sw. USA)	(L)
Opuntia•imbricata	Cholla (Colo., Kan., Tex., & Mex., to Ariz.)	(VL-L)
Opuntia•polycantha ,etc.	Prickly Pear Cactus species (w. USA, Can., Mex.)	(VL-L)
Osmanthus•americanus *	Devilwood (se. USA)	(H)
Osmanthus•decorus•'Baki•Kasapligil' *	----- (Caucasus)	(H)
Osmanthus•heterophyllus *	Holly Osmanthus (Japan, Taiwan)	(H)
Osmanthus•x•burkwoodii *	----- (garden origin)	(H)
Paxistima•canbyi	Eastern Mtn. Lover (e. N. America)	(M+/-)
Paxistima•myrsinites	= Paxistima•myrtifolia	
Paxistima•myrtifolia *	Western Mtn. Lover (B.C. Cal., Mont., Colo., N. Mex.)	(M-H)
Phillyrea•vilmoriniana *	= Osmanthus•decorus	
Photina•villosa *	Oriental Photina (Japan, Korea, China)	(H)
Photinia•serrulata *	Chinese Photinia (China)	(H)
Photinia•x•fraseri *	Photina (hort. hybrid)	(H)
Phyllostachys•aureosulcata *	Yellow-groove Bamboo (ne. China)	(H)
Phyllostachys•nigra *	Black Bamboo (e., c. China)	(H)
Phyllostachys•nuda *	Bamboo (China)	(H)
Pieris•japonica *	Japanese Pieris (Jap., Taiwan, e. China)	(H)
Prunus•laurocerasus•'Schipkaensis' *	Schipkanensis Cherry Laurel (Bulgaria)	(M-H)
Prunus•laurocerasus•'Zabeliana'*	Zabeliana Cherry Laurel (garden origin)	(M-H)
Purshia•mexicana	= Cowania•mexicana	
Purshia•tridentata	Antelope Bitterbrush (Rocky Mtn. West)	(L-M)
Pyracantha•coccinea	Pyracantha (Eurasia)	(M+/-)
Quercus•grisea *	Gray Oak (Tex., N. Mex., Mex., s. Colo.)	(M+/-)
Quercus•turbinella *	Turban Oak (Cal., & n. Baja. Ca.. to w. Tex. & se. Colo.)	(M+/-)
Quercus•vacciniifolia *	Huckleberry Oak (w. US)	(M+/-)
Quercus•virginiana•v.•fusiformis *	Texas Shrub Live Oak (Ok., Tex., Mex.)	(L-M)
Rosmarinus•officinalis•'Arp' *	Rosemary 'Arp' (a hardy cultivar from Arp, Texas)	(L-M)
Santolina•chamaecyparissus	Santolina (w. & c. Medit.)	(VL-M)
Santolina•rosmarinifolia	Green Santolina (Portugal to France)	(L-M)
Santolina•viridis	= Santolina•rosmarinifolia	
Sasa•kurilensis *	Kurile Islands Bamboo (Jap. Kor.)	(H)
Sasa•palmata *	Palmate Bamboo (n. Japan)	(H)
Shepherdia•rotundifolia *+	Roundleaf Buffaloberry (Az., Utah)	(L-M)
Sinarundinaria•nitida *	Fountain Bamboo (c. China)	(H)
Thamnocalamus•spathaceus *	Umbrella Bamboo (c. China)	(H)
Viburnum•davidii *	David's Viburnum (w. China)	(M-H)

Viburnum•farreri *	Fragrant Viburnum (China)	(M-H)
Viburnum•rhytidophyllum *	Leatherleaf Viburnum (c. & w. China)	(M-H)
Viburnum•x•burkwoodii	Burkwood Viburnum (hort. hybrid)	(M-H)
Viburnum•x•rhytidophylloides•'Mohican'	Mohican Lantanaphyllum Viburnum (garden origin)	(M-H)
Yucca•baccata +	Banana Yucca (Colo. Plateau)	(VL-L)
Yucca•elata +	Soaptree Yucca (Az., N. Mex., Mex.)	(VL-L)
Yucca•glauca +	Front Range Yucca (w. Great Plains)	(VL-L)
Yucca•harrimaniae +	Harriman Yucca (Colo. Plateau)	(VL-L)

VINES

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5"-- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Akebia•quinata *****	Five-leaf Akebia (Japan, Korea, China)	(M-H)
Akebia•trifoliata *****	Three-leaf Akebia (c. China, Jap.)	(M-H)
Akebia•x•pentaphylla *	(A. quinata x A. trifoliata) (Japan)	(M-H)
Ampelopsis•aconitifolia *****	Monkshood Vine (n. China, Mong.)	(M+/-)
Ampelopsis•brevipedunculata *****	Porcelain Vine (China, Jap., Korea)	(M+/-)
Ampelopsis•delavayana *	----- (w. China)	(M+/-)
Ampelopsis•humulifolia *****	----- (n.China)	(M+/-)
Ampelopsis•megalophylla *****	----- (w. China)	(M+/-)
Aristolochia•durior *****	= Aristolochia•macrophylla	
Aristolochia•macrophylla *****	Dutchman's Pipe (Appalachian Mts.)	(M-H)
Campsis•grandiflora *****	Chinese Trumpet Creeper (Jap., China)	(M-H)
Campsis•radicans +	Trumpet Creeper (e. USA)	(M-H)
Celastrus•loeseneri *****	Loeserner Bittersweet (c. China)	(M-H)
Celastrus•orbiculatus *	Oriental Bittersweet (ne. Asia)	(M-H)
Celastrus•scandens	Bittersweet (e. N. America)	(M-H)
Clematis (hort. varieties & hybrids)	----- (hort. hybrids & varieties)	(M-H)
Clematis•alpina *****	----- (Eurasia)	(M-H)
Clematis•brevicaudata *	----- (Jap., China., w. Mong.)	(M+/-)
Clematis•chrysocoma *****	----- (sw. China)	(M+/-)
Clematis•crispa *****	Curly Clematis (se. USA)	(H)
Clematis•fargesii *	----- (China)	(M+/-)
Clematis•flammula	----- (s. Eur., to Turkestan)	(M+/-)
Clematis•grata *****	----- (China, Himalaya)	(M+/-)
Clematis•ligusticifolia	Western Virgin's Bower (Man. to B.C., Mo., to Calif.)	(M+/-)
Clematis•macropetala *****	----- (Siberia, n. China, Mongolia)	(M+/-)
Clematis•maximowicziana	= Clematis•terniflora	
Clematis•montana var. *****	----- (Afghanistan. to sw. & c. China, Himalaya)	(M+/-)
Clematis•paniculata *****	New Zealand Clematis (New Zealand)	(H)
Clematis•paniculata	= Clematis•terniflora	
Clematis•rehderiana *****	Rehder's Clematis (w. China)	(M+/-)
Clematis•tangutica	Golden Lantern Clematis (Mongolia, nw. China)	(M+/-)
Clematis•terniflora	Sweet Autumn Clematis (Korea, China, Japan)	(M+/-)
Clematis•texensis *****	Texas Clematis (sw. USA)	(M+/-)
Clematis•tibetana *****	----- (Tibet, China, n. India)	(M+/-)
Clematis•vernayi (now C. tibetiana)		
Clematis•viorna *	Leather Flower (s. N. Am.)	(M-H)

Clematis•vitalba *	Traveller's Joy (Eur., Cauc., c. Asia, n. Afr.)	(M+/-)
Clematis•viticella *	----- (s. Europe, w. Asia)	(M+/-)
Dicentra•scandens *	----- (Nepal, to se. China)	(M+/-)
Euonymus•fortunei var.	Wintercreeper varieties (China)	(M-H)
Hedera•colchica *	Persian Ivy (Cauc., Turkey)	(M+/-)
Humulus•americanus	= Humulus•lupulus	
Humulus•lupulus	Hop Vine (n. Temperate regions worldwide)	(M+/-)
Hydrangea•anomala *	Climbing Hydrangea (Himalaya, China)	(H)
Hydrangea•anomala•ssp.•petiolaris*	= Hydrangea•petiolaris	
Hydrangea•petiolaris *	Climbing Hydrangea (Japan, China, Korea, Taiwan)	(H)
Jasminum•beesianum *	----- (China)	(M+/-)
Lathyrus•latifolius	Perennial Sweetpea (c. & e. Europe)	(M+/-)
Lonicera•alesuosmoides *	Evergreen Honeysuckle (w. China)	(M+/-)
Lonicera•caprifolium *	Italian Honeysuckle (Eur., s. Asia)	(M+/-)
Lonicera•flava *	Yellow Honeysuckle (se. USA)	(H)
Lonicera•henyri *	----- (w. China)	(M+/-)
Lonicera•japonica•'Halliana'	Hall's Honeysuckle (e. Asia)	(M-H)
Lonicera•periclymenum	Woodbine Honeysuckle (Eur., w. Asia)	(M+/-)
Lonicera•periclymenum•'Graham•Thomas'	Graham Thomas Honeysuckle (hort. cultivar)	(M+/-)
Lonicera•prolifera *	Grape Honeysuckle (c. USA)	(M+/-)
Lonicera•sempervirens	Scarlet Trumpet Honeysuckle (e. & s. USA)	(M-H)
Lonicera•sempervirens•'Alabama•Crimson'	-----	(M-H)
Lonicera•sempervirens•'Sulphurea	-----	(M-H)
Lonicera•tragophylla *	Chinese Woodbine (w. China)	(M+/-)
Lonicera•x•brownii•'Dropmore•Scarlet'	(L.s. x L. brownii)	(M+/-)
Lonicera•x•heckrottii	Heckrottii Honeysuckle (hort. hybrid)	(M-H)
Lycium•halimifolium *	Common Matrimony Vine (se. Europe, w. Asia)	(M+/-)
Mennispermum•canadense *	Moonseed Vine (e. N. America)	(M-H)
Parthenocissus•quinquefolia	Virginia Creeper (e. N. America to Rocky Mtns.)	(M-H)
Parthenocissus•tricuspidata	Boston Ivy (Japan, c. China)	(M-H)
Passiflora•incarnata *	Passion Flower (c. USA)	(H)
Polygonum•aubertii	Silver Lace Vine (w. China, Tibet, Tajikistan)	(M+/-)
Polygonum•baldschuanicum *	Buchara Fleeceflower (c. Asia, Tajikistan)	(M+/-)
Schisandra•chinensis *	Magnolia Vine (China)	(H)
Schizophragma•hydrangeoides *	Hydrangea Vine (Japan, Korea)	(M-H)
Smilax•rotundifolia *	Common Greenbriar (e. USA)	(H)
Tripterygium•regelii *	Regel's Tripterygium (Manchuria, Japan, Korea)	(M-H)
Vitis•amurensis *	Amur Grape (Manchuria)	(M+/-)
Vitis•arizonica	Arizona Grape (w. Tex.- Cal. & Mex.)	(M+/-)
Vitis•coignetiae *	Gloryvine (Japan, Korea)	(M+/-)
Vitis•riparia	Riverbank Grape (Nov. Sc. - Man., Tenn. & Tex. - Rocky Mts.)	(M-H)

Vitis•vinifera•varieties *****	Eurasian Grape varieties (Eur., A. Minor, Cauc. Turkestan)	(M+/-)
Wisteria•floribunda *****	Japanese Wisteria (Japan)	(M-H)
Wisteria•macrostachys *	Kentucky Wisteria (c. USA)	(H)
Wisteria•sinensis *****	Chinese Wisteria (China)	(M-H)

GROUND COVERS

(Icluding turf & meadow grasses)

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./ S.F./season July: 5"-- 3 times per week	10 gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Achillea•ageratifolia	Grecian Yarrow (Greece)	(L-M)
Achillea•serbica	Serbian Yarrow (Balkans)	(L-M)
Aegopodium•podagraria	Bishop's Weed (Europe)	(H)
Ajuga•reptans	Ajuga (Eur., Persia, Transcaucasia.)	(H)
Akebia•quinata *	Five-leaf Akebia (Jap., Korea, China)	(M-H
Andropogon•scoparius	Little Blue Stem (syn. Schizachyrium•scoparium)	(L-M+/-)
Anemopsis•californica *	Yerba Mansa (sw. USA, Mex.)	(M-H)
Antennaria•parvifolia	Pussytoes (G. Plains, w. to B.C., Wash., Ariz.)	(M+/-)
Antennaria•rosea	Pussytoes (Alaska to Cal. & N. Mex.)	(M+/-)
Arabis•alpina *	Alpine Rock-cress (Europe, Siberia)	(M+/-)
Arctostaphylos•uva-ursi	Kinnikinnick (circumpolar)	(M+/-)
Arenaria•balearica *	Corsican Sandwort (Balearic Is. & Corsica)	(M+/-)
Aronia•melanocarpa	Chokeberry (e. N. Am.)	(M-H)
Asperula•odorata	= Galium•odoratum	
Astroturfoides•ultradeceptiverous	Astro Turf (Houston, Texas)	(L+/M-)
Aurinia•saxatilis	Basket-of-gold (c. & se. Europe)	(L-M)
Bouteloua•gracilis	Blue grama (N. America)	(L+/-)
Buchloë•dactyloides	Buffalograss (Great Plains)	(L)
Campanula•poscharskyana	Poscharsky Bellflower (Dalmatia)	(M-H)
Cerastium•tomentosum	Snow-in-summer (Eur. to w. Asia)	(L-M)
Ceratostigma•plumbaginoides	Plumbago (w. China)	(M+/-)
Convallaria•majalis	Lily-of-the-valley (Eurasia, e. N. America)	(M-H)
Cotoneaster•apiculatus *	Cranberry Cotoneaster (China)	(M+/-)
Cotoneaster•dammeri *	Creeping Cotoneaster (China)	(M+/-)
Cotoneaster•microphyllus *	Littleleaf Cotoneaster (Mts. Afghan., China)	(L-M)
Delosperma•cooperi	Hardy Pink Ice Plant (s. Africa)	(M+/-)
Delosperma•nubigenum	Hardy Yellow Ice Plant (s. Africa)	(M+/-)
Duchesnea•indica	Mock Strawberry (Korea, Jap., to India)	(M-H)
Epimedium•alpinum *	Alpine Epimedium (s. & c. Europe)	(M-H)
Epimedium•grandiflorumum *	Longspur Epimedium (n. Japan, Korea, s. Manch.)	(M-H)
Euonymus•fortunei•'Coloratus'	Purpleleaf Wintercreeper (hort. cult.)	(M+/-)

Euonymus•obovatus *****	Running Euonymus (e. USA)	(H)
Festuca•elatior•cvs.	Turf-type Tall Fescue (Eur., Siberia)	(M+/-)
Galium•odoratum	Sweet Woodruff (Eurasia)	(M-H)
Genista•pilosa *****	Dwarf Broom (Europe)	(M+/-)
Geranium•spp.	Hardy Geraniums	(M+/-)
Hosta•spp.	Host species (Jap., China, Korea)	(H)
Juniperus•spp. & cultivars +	Juniper species and cultivars	(L-M)
Lamium•maculatum	Spotted Deadnettle, Lamium (Eur., n. Afr., w. Asia)	(M-H)
Lathyrus•latifolius	Perennial Sweetpea (c. & e. Europe)	(M-H)
Lonicera•japonica•'Halliana'	Hall's Honeysuckle (e. Asia)	(M+/-)
Lonicera•sempervirens	Scarlet Trumpet Honeysuckle (e.& s. N. America)	(M-H)
Lonicera•x•heckrottii	Heckrottii Honeysuckle (hort. hybrid)	(M+/-)
Lysimachia•nummularia	Moneywort (Europe)	(H)
Mahonia•repens	Creeping Mahonia (Rocky Mtn. West)	(L-M-H)
Mazus•reptans *****	----- (Himalayas)	(M-H)
Marrubium•rotundifolium	----- (Asia Minor)	(L-M)
Poa•pratensis	Kentucky Bluegrass (Eurasia, n. Africa)	(H)
Osteospermum•berberae	South African Daisy (S. Africa)	(M+/-)
Pachysandra•terminalis	Pachysandra (Japan, nc. China)	(M-H)
Parthenocissus•quinquefolia	Virginia Creeper (e. N. America to Rocky Mts.)	(M-H)
Phlox•stolonifera	Creeping Phlox (se. USA)	(M+/-)
Phlox•subulata	Moss Phlox (Penn. to Ga.)	(M+/-)
Polygonum•affine•'Border•Jewel'	Himalayan Border Jewel (Himalayas)	(M-H)
Polygonum•japonicum•var.•compactum	Fleece Flower (e. Asia)	(M-H)
Polygonum•reynoutria	= Polygonum•japonicum•var.•compactum	
Potentilla•nevadensis	----- (Spain)	(L-M)
Potentilla•verna•'Nana'	Creeping Potentilla (hort. cult.)	(M-H)
Rhus•trilobata	Three-leaf Sumac (w. N. Am.)	(L-M)
Saponaria•ocymoides	Saponaria (mtns. sw. & sc. Europe)	(M+/-)
Schizachyrium•scoparium	= Andropogon•scoparius	
Symphoricarpos•x•chenaultii•'Hancock'	Hancock Coralberry (hort. cult.)	(M+/-)
Teucrium•chamaedrys	Germander (c. & s. Europe, w. Asia)	(M+/-)
Thymus•spp.	Thyme species (Eurasia, N. Africa)	(L-M)
Waldsteinia•fragarioides	Barren Strawberry (e. USA)	(H)

Veronica•liwanensis	Turkish Veronica (ne. Anatolia, Cauc.)	(M-H)
Veronica•pectinata	Woolly Veronica (e. Balkans, A. Minor)	(L-M)
Vinca•major	----- (Italy, Balk.)	(M-H)
Vinca•minor	Vinca (Europe , w. Asia)	(H)

SELECTED PERENNIALS

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

***** = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant:	Reference plant:	Reference plant:	Reference plant:
Bluegrass turf	Turf-type Tall Fescue	Buffalograss turf	Too dry for any turf
(Always wet at surface)	(Half of Bluegrass turf)	(Like Denver without irrigation)	(drier than Denver)
18-20 gals./ S.F./season	10 gals./S.F./ season	0-3 gals./S.F./season	No irrigation
July: 5"-- 3 times per week	.75" -- once per week	.5" per 2 weeks, optional	No irrigation

Achillea x 'Coronation Gold'	Coronation Gold Yarrow	(VL)
Achillea x 'Moonshine'	Moonshine Yarrow	(VL-L-M)
Aesclepias•tuberosa	Butterfly Weed	M-H
Agastache cana	Double Bubble Mint	(M+/-)
Alchemilla•vulgaris	Lady's Mantle	M-H
Anthemis•tinctoria	Golden Margurerite	M-H
Aquilegia•spp.	Columbines	H
Arum•italicum	Italian Arum	M-H
Aster porteri	Porter's Aster	(VL-L)
Aster•novae-angliae	New England Aster	M-H
Aster•x•frikartii	Frikart's Aster	M-H
Aurinia saxatilis	Basket-of-gold	(L-M)
Baptisia•australis	Baptisia	M-H
Berlandiera lyrata	Chocolate Flower	(VL-L)
Boltonia•asteroides	Boltonia	H
Borago•laxiflora	Borage	M-H
Callirhoë involucrata	Poppy Mallow	(L-M)
Centranthus ruber	Centranthus	(L-M-H)
Cerastium tomentosum	Snow-in-summer	(L-M)
Chrysanthemum•x•morifolium	Chrysanthemums	H
Chrysanthemum•x•superbum	Shasta Daisy	M-H
Convallaria•majalis	Lily-of-the-valley	H
Crocosmia•x•crocosmiiflora	Crocosmia	H
Crocus spp. *	Crocus species	(L-M)
Datura meteloides	Sacred Datura	L-M
Delosperma cooperi	Hardy Pink Ice Plant	(M+/-)
Delphinium•x•elatum	Hybrid Delphiniums	H
Dianthus•spp.	Various Dianthus	L-M
Dicentra•eximia	Bleeding Heart	H
Dictamnus•albus	Gas Plant	L-M
Digitalis•purpurea	Common Foxglove	H
Echinacea•purpurea	Echinacea	M+/-
Echinops•ritro	Globe Thistle	H
Eremurus•spp.	Foxtail Lily	L-M
Eryngium•spp.	Sea Holly	L-M
Gaillardia aristata	Native Gaillardia	(L-M)
Geranium•spp.	Hardy Geraniums	M-H
Helianthemum•spp.	Sun-roses	M+/-
Helianthus maximiliani	Maximilian Sunflower	(M+/-)

Helianthus•spp.	Sunflowers	M+/-
Helleborus•spp.	Hellebores	M-H
Hemerocallis•spp.	Daylilies	M-H
Hosta•spp.	Hostas	H
Iberis•sempervirens	Candytuft	M+/-
Incarvillea•delavayii	Hardy Gloxinia	M+/-
Iris bucharica	Buchara Iris	(M+/-)
Iris germanica cvs..	Bearded Iris varieties	(L-M)
Kniphofia•spp.	Poker Plants	M-H
Lavandula spp.	Various Lavenders	(VL-M)
Liatris punctata	Dotted Gay Feather	(VL-L)
Liatris•punctata	Dryland Gayfeather	VL-L
Liatris•spicata	Wetland Gayfeather	H
Limonium•spp.	Sea Lavenders	L-M
Linum•perenne	Blue Flax	L-H
Lobelia•cardinalis	Cardinal Flower	H
Lobelia•syphilitica	Great Blue Lobelia	H
Lychnis•coronaria	Rose Campion	L-H
Malva•alcea	Hollyhocks	M+/-
Mirabilis multiflora	Native Four O'clock	(VL-L-M)
Monarda•spp.	Monardas	M-H
Narcissus spp.	Daffodils	(L-M)
Nepeta x faassenii	Faassen's Catnip	(L-M)
Paeonia•spp.	Peonies	M+/-
Papaver•orientale	Oriental Poppies	M-H
Penstemon pinifolius	Pineleaf Penstemon	(L-M)
Penstemon strictus	Rocky Mountain Penstemon	(L-M)
Perovskia atriplicifolia	Russian Sage	(VL-L)
Phlomis russeliana	Russel Phlomis	(M+/-)
Phlox subulata	Moss Phlox	(M+/-)
Phlox•paniculata	Garden Phlox	H
Platycodon•grandiflorus	Platycodon	H
Primula•spp.	Primroses	H
Ruta•graveolens	Rue	M+/-
Salvia azurea var. grandifora	Pitcher Sage	(L-M)
Salvia officinalis	Cooking Sage	(L-M)
Salvia•spp.	Salvias	M+/-
Santolina chamaecyparissus	Santolina	(VL-M)
Saponaria ocymoides	Soapwort	(L-M-H)
Saponaria•ocymoides	Rock Soapwort	M+/-
Scabiosa ochroleuca	Yellow Pincushion Flower	(L-M)
Scabiosa•ochroleuca	Yellow Scabiosa	L-H
Secum•spp.	Sedums	M+/-
Silene laciniata	Mexican Campion	(M+/-)
Tanacetum niveum	Silver Tansy	(L-M)
Verbascum•chaxii	Nettle-leaf Mullein	M+/-
Zauschneria arizonica	Arizona Zauschneria	(L-M)
Zinnia grandiflora	Prairie Zinnia	(VL-L)

WaterWise Landscaping
Best Practices

Section 4 – Natural Areas and Native Plants

A. Proactive Multi-Purpose Drainage Design

1. **Introducing the Opportunity**
The Front Range prairie is frequently characterized as a rolling grassy landscape folded into meandering wooded drainages. The natural processes that developed this landscape can support the erosion control goals of the drainage design while providing enhanced recreational open space and habitat value. Proactively planned multipurpose drainage design can deliver these goals while saving installation costs and maintenance effort by working with the natural processes.

2. **Natural Landscape and Generative Processes**
Expanding Front Range developments are covering upland prairies with homes and roads, but the regional landscape can still be seen in the natural drainages. The fundamental character of these drainage areas is defined by the distribution of the thickets of woody species. Wild Plum, Chokecherry, Golden Currant, Snowberry, Sandbar willow and Three-leaf sumac are scattered along the native drainages among occasional towering Plains cottonwoods and the smaller Peach-leaved willows. These species generally occupy the sub-irrigated zones intermediate between the moist central channel areas and the drier upland grasslands.

   The natural processes by which woody vegetation expands into upland drainages depend upon a connection to the larger riparian systems below. (Remember: nature abhors a vacuum.) A shallow, young grassy drainage will eventually develop into a deeper, wooded channel. In natural systems normal precipitation cycles coupled with disturbance (grazing, fire, or drought), eventually will lead to erosion and deposition along the grassy channels. In development areas the process is accelerated by the installation of roads or trails, pipelines, and drainage features. Any action that weakens a grassland root system can provide an opening for change.

   Seeds of woody species use either wind or wildlife to relocate into disturbed areas in drainages. Native deciduous trees such as the Plain cottonwood and Peach-leaved willow and the smaller Sandbar willows release seeds on the spring winds. When a newly exposed moist soil deposit occurs within a few miles of a well-vegetated river, stream or irrigation ditch, a few seeds from these species will blow into to the site. Once a tree has taken root, it will attract birds as well as raccoons, fox, coyote, and skunks. All these animals follow the drainages in their search for food. They eat the plums, chokecherries, currants, snowberries, hawthorns, sumac or any other wild fruits. As they travel, they rest in and under small trees. Seeds are dropped in these locations as the animals move on. Droppings from animals are concentrated near existing trees. The shade and leaf litter beneath the trees provide a moist protected site favorable for establishment.

3. **Choices**
Engineers design channels for expected run off from the new paved surfaces (roofs and pavement) and existing or proposed vegetation. When a natural channel contains a well-developed woody plant community, the plans may accommodate the existing vegetation conditions, allowing the woody vegetation to remain. Woody vegetation supports to goals of the drainage program by decreasing peak flows, slowing flow rates, protecting slopes channel edges from excess erosion.

   New developments, lacking historic drainage channels, must make decisions related to the establishment of woody vegetation. In a short time, windblown woody species will find suitable sites in new drainages. Heavier seeded plants will eventually follow. If plans do not create channels with adequate flow capacity for the natural process of woody plant establishment, they will predetermine a maintenance program including expensive woody vegetation control. The erosion control and recreational benefits possible from woody vegetation will be diminished in the battle to prevent the inevitable. Channels can be sized to accommodate woody vegetation to improve slope stabilization. If this is done well, the maintenance program will be able to allow the natural process of woody vegetation development to occur. This requires an approach acknowledging and working with the natural processes typical of these riparian corridors.

4. **Cost effectiveness**
Proactive, multipurpose drainage design is more cost effective that rigorous maintenance designed to remove all woody vegetation. The woody vegetation serves the underlying purpose of slope stability and erosion control, becoming an ally to the drainage program, instead of a problem. Installation costs of woody vegetation become part of the erosion control program. Costly maintenance aimed at prevention or removal of woody vegetation is no longer necessary. Mowing requirements may mostly be eliminated as perennial vegetation becomes well established. Multipurpose corridors can become more diverse, improving in habitat and passive recreational value, over time.

5. **Lower water usage**
In the interest of developing a more water efficient landscape, multipurpose designed drainages within a development can provide a cool, shady wooded retreat area without requiring installation and maintenance of a supporting irrigation system. Properly selected and placed native woody species can be largely self sufficient once installed.

6. **Urban Drainage and Flood Control Support**
UDFCD encourages the natural channel concept in drainage design (V. 1, MD-3-9). “Open channel planning and design objectives are often best met by using natural-like vegetated channels”. Guidance for planning and execution of this concept is included within the Drainage Criteria manual (V. 2.) revegetation section. Native seed mixtures for a variety of soil types as well as recommended uses and installation methods for trees and shrubs within drainage designs, are included.

7. **Success**

During the spring of the drought year of 2002, a number of drainage improvement projects were installed. Native woody plantings of trees and shrubs were successfully established in spite of limited or no irrigation. Marcy Gulch at Highlands Ranch, Niver Creek in Thornton, Cottonwood Creek in Greenwood Village, and Lilly Gulch in Littleton were successfully established in spite of many days of unseasonably hot dry conditions.

B. Native Seed Mixes

1. Colorado Native Seed Mix Summary

a. Short Grass Prairie (grasses & wildflowers)
b. Mixed Grass Prairie (grasses & wildflowers)
c. Tall Grass Prairie (grasses & wildflowers)
d. Moist or Wetland Soils (grasses & wildflowers)
e. Sandy Loam Soils (grasses & wildflowers)
f. Clay Loam Soils (grasses & wildflowers)
g. Select Shrubs and Trees for natural areas

The complete Native Seed lists are provided on the following pages.


Shortgrass prairie species Easter daisy/Townsendia grandiflorus


Heavily grazed native shortgrass prairie

Table 1. Native shortgrass mixture for loam to cloay loam dry upland sites. Some taller species included. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Buffalograss	*Buchloe dactyloides*	Sharp's	4-6"	56000	6.5	
Sideoats grama	*Bouteloua curtipendula*	Butte	18"	191000	3.0	
Blue grama	*Chondrosum gracile*	Hachita	6-8"	825000	8.0	
Western wheatgrass	*Pascopyrum smithii*	Barton	18"	110000	4.0	
Sand dropseed	*Sporobolus cryptandrus*	Native	18"	5,200,000	2.0	
TOTAL POUNDS/ACRE					**23.5**	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OUNCES /ACRE	Double wildflower seeding rate for more color.
Purple prairieclover	*Dalea purpurea*		12"	210000	3.0	
Blanket flower	*Gailardia aristata*		12-18"	132000	4.0	
Golden aster	*Heterotheca villosa*		6-8"	920000	2.0	
Gayfeather	*Liatris punctata*		12-18"	138000	4.0	
Flax	*Linum lewisii*		18"	293000	2.0	
Bluemist penstemon	*Penstemon virens*		8"	850000	3.0	
Sidebells penstemon	*Penstemon secundiflorus*		18"	610000	2.0	
Scarlet globemallow	*Sphaeralcea coccinea*		6-8"	500000	3.0	
Easter daisy	*Townswndia grandiflora*		6-8"	1200000	0.5	
TOTAL OUNCES/ACRE					**23.5**	
AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Shortgrass Prairie

This vegetation type is typical of high plains areas with 10- 16 inches on annual precipitation. In native areas shallow soil depth, clay soil, low precipitation, alkaline conditions, heavy grazing or compaction all may contribute to a


Prairie coneflower/Ratibida columnifera in restored mixed grass prairie


Restored mixed grass prairie with wildflowers.

Table 2. Native mixed grass for sandy loam, loam, clay loam upland sites. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Sideoats Grama	*Bouteloua curtipendula*	Butte	18"	191000	4.8	
Buffalograss	*Buchloe dactyloides*	Texoca	4-6"	56000	5.0	
Blue Grama	*Chondrosum gracile*	Hachita	6-8"	825000	4.5	
Switchgrass	*Panicum virgatum*	Blackwell	24-36"	389000	2.0	
Western wheatgrass	*Pascopyrum smithii*	Ariba	18"	110000	3.0	
Little bluestem	*Schyzachrium scoparium*	Pastura	18-24"	260000	2.0	
Sand dropseed	*Sporobolus cryptandrus*	native	18"	5,200,000	0.5	
Green needlegrass	*Stipa viridula*	native	24"		1.5	
TOTAL POUNDS PLS/ACRE					**23.3**	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OUNCES /ACRE	Double wildflower seeding rate for more color.
Smooth aster	*Aster laevis*				2.0	
Purple prairieclover	*Dalea purpurea*			210000	3.0	
Blanket flower	*Gaillardia aristata*			132000	6.0	
Golden aster	*Heterotheca villosa*				2.0	
Gayfeather	*Liatris punctata*			138000	4.0	
Flax	*Linum lewisii*			293000	2.0	
Penstemon	*Penstemon angustifolia*		24"	590000	2.0	
Prairie coneflower	*Ratibida columnifera*			1230000	2.0	
TOTAL OUNCES/ACRE					**23.0**	
*AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Mixed grass midgrass Prairie
Native areas with richer clay-loam to loamy soil, 14-18 inches of precipitation, and less grazing impact may exhibit the taller grasses typical of mixed grass prairie. Restored mixed grass prairie is possible on sites with g

Purple prairie clover/Dalea purpurea in restored tallgrass prairie. Grasses will later become 36" or more in height.

Table 3. Native tallgrass mixture for north and east facing sites, low areas. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	TOTAL LBS PLS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Big bluestem	*Andropogon gerardi*	Pawnee	3-4'	130,000	1.5	
Sideoats grama	*Bouteloua curtipendula*	Butte	18"	191000	2.8	
Blue grama	*Chondrosum gracile*	Hachita	6-8"	825000	3.5	
Switchgrass	*Panicum virgatum*	Blackwell	36"	389000	3.0	
Western wheatgrass	*Pascopyrum smithii*	Ariba	18"	110000	6.0	
Little bluestem	*Schizachyrium scoparium*	Pastura	24"	26000	3.4	
Yellow Indiangrass	*Sorghastrum avenaceum*	Holt	3-4'	170000	2.1	
TOTAL POUNDS PLS/ACRE					**22.3**	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OUNCES /ACRE	Double wildflower seeding rate for more color.
Showy milkweed	*Asclepias speciosa*	native				
Blue aster	*Aster laevis*	native	18"		2.0	
Blanket flower	*Gailardia aristata*	native	12-18"	132000	2.0	
Prairie coneflower	*Ratibida columnifera*	native	18-24"	1230000	4.0	
Purple prairieclover	*Dalea (Petalostemum) purpurea*	native	12"	210000	4.0	
Flax	*Linum lewisii*	native	18"	293000	3.0	
Penstemon	*Penstemon strictus*	native	24"	590000	4.0	
TOTAL OUNCES/ACRE					**19.0**	
*AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Tallgrass seed mixture

The taller grasses are limited to areas of higher precipitation 16-18 inches along the foothills and moist bottomlands near streams. Rocky soils may contribute to greater moisture availability and the presence of remnant tallgrass

Restored wetland area in small drainage on school grounds with outdoor classroom/boardwalk.

Restored floodplain meadow in Commons Park near downtown Denver.

Table 4. Native wetland mix for drainages, swales or detention ponds (soil is moist between precipitation events). Application rate 1/2 - 1 pound PLS/1000 ft. sq. Broadcast, harrow or rake to cover with 1/10 - 1/3 inch soil.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
ADAPTED NATIVE GRASSES AND GRASS-LIKE PLANTS						
Wooly sedge	*Carex lanuginosa*	Native	18"	322,340	0.1	
Nebraska sedge	*Carex nebraskensis*	Native	12"	534,100	0.1	
Inland saltgrass	*Disticlis stricta*	Native	8"-10"	603,820	0.5	
Baltic rush	*Juncus balticus*	Native	12-18"	12,300,000	0.1	
Prairie cordgrass	*Spartina pectinata*	Native	24"+	183,000	9.5	
Switchgrass	*Panicum virgatum*	Blackwell	36"+	389000	6.0	
Western wheatgrass	*Pascopyrum smithii*	Arriba	24"	110,000	8.0	
TOTAL POUNDS/ACRE					**24.3**	
					TOTAL OZ/ACRE	1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS						Double wildflower seeding rate for more color.
Aster	*Aster laevis*	native	18"	1216000	3.0	
Showy milkweed	*Asclepias speciosa*	native	30"	58,112	2.0	
Swamp milkweed	*Asclepias incarnata*	native	36"	68,100	2.0	
Nuttall's sunflower	*Helianthus nuttallii*	native	6'+	250,000	1.0	
Wild Bergamot	*Monarda fistulosa*	native	24"	1,400,136	3.0	
TOTAL OUNCES/ACRE					**11.0**	

* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.

Moist lwetland seed mixture

Damp soils along streams, near seeps, and in drainage swales supports wet meadow vegetation. Drainage channels, areas where water flows or pools after a storm are good sites for these moisture loving species. Using such speci

Scarlet globemallow/*Sphaeralcea coccina* and Western wheatgrass/*Agropyron smithii* in mixed grass prairie remnant along Coal Creek in Erie.

Restored shortgrass prairie with Sidebells penstemon/*Penstemon secundiflorus*.

Table 5. Recommended native sand prairie for sandy to sandy loam soil. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	TOTAL PLS /ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Sand bluestem	*Andropogon hallii*	Garden	36"	113300	2.0	
Sideoats grama	*Bouteloua curtipendula*	Butte	18"	191000	3.2	
Prairie sandreed	*Calamovilfa longifolia*	Goshen	24-36"	273000	2.1	
Blue grama	*Chondrosum gracile*	Hachita	6-8"	825000	2.5	
Switchgrass	*Panicum virgatum*	Blackwell	36"	389000	2.0	
Western wheatgrass	*Pascopyrum smithii*	Arriba	18-24"	110000	6.5	
Little bluestem	*Schizachyrium scoparium*	Pastura	24"	26000	3.0	
Sand dropseed	*Sporobolus cryptandrus*		18"	1758000	0.5	
TOTAL POUNDS/ACRE					**21.8**	
						1 acre = 43560 square feet. Divide this per acre seed quantity by 20 to 40 for each 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					TOTAL OZ/ACRE	Double wildflower seeding rate for more color.
Blue aster	*Aster laevis*		18"		2.0	
Blanket flower	*Gailardia aristata*		12-18"	132000	6.0	
Prairie coneflower	*Ratibida columnifera*		24"	1230000	3.0	
Purple prairieclover	*Dalea (Petalostemum) purpurea*		12"	210000	3.0	
Flax	*Linum lewisii*		18"	293000	4.0	
Penstemon	*Penstemon strictus*		18-24"	592000	4.0	
TOTAL OUNCES/ACRE					**22.0**	

* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.

Sandy loam seed mixture

Isolated areas of sandy soil are better suited to these deep rooted species. Some native shrubs such as Yucca/Yucca glauca, Rabbitbrush/Chrysothamnus nauseosus, and Sand sagebrush/Artemisia filifolia are well suited to these areas

Needle-and-threadgrass/*Stipa comata* with Blanketflower/*Gaillardia aristata* in mixedgrass prairie.

Table 6. Native seed mixture for use on clay loam soils. Application rate on clean seed bed 1/2-1 pound PLS/1000 sq. ft. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Buffalograss	*Buchloe dactyloides*	Sharp's	6"	56000	7.6	
Sideoats grama	*Bouteloua curtipendula*	Butte	18"	191000	3.5	
Blue grama	*Chondrosum gracile*	Hachita	6-8"	825000	6.0	
Western wheatgrass	*Pascopyrum smithii*	Barton	18"	110000	4.8	
TOTAL POUNDS/ACRE					**21.9**	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					0Z/ACRE	Double wildflower seeding rate for more color.
Purple prairieclover	*Dalea purpurea*		12"	210000	3.0	
Blanket flower	*Gailardia aristata*		12-18"	132000	3.0	
Gayfeather	*Liatris punctata*		12-18"	138000	3.0	
Flax	*Linum lewisii*		18"	293000	4.0	
Prairie coneflower	*Ratibida columnifera*		18-24"		3.0	
Scarlet globemallow	*Sphaeralcea coccinea*		6"		4.0	
TOTAL OUNCES/ACRE					**20.0**	
* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Clay loam seed mixture
The shortgrass prairie species are well adapted to clay loam soils.

Native woody shrubs and trees stabilize stream channel in Front range open space area. Shade, habitat, and passive recreational value area also enhanced. No irrigation water is required for this amenity.

Table 7. Native shrub and tree species adapted to the Front Range high plains area. Little or no water is required for these species if properly located on landscape. Useful for erosion control, shade, and habitat improvement in drainages.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	LOCATION
NATIVE WOODY VEGETATION						
Rabbitbrush	*Chrysothamnus nauseosus*	Native	2-4'			Upland areas, establishment watering. Use smaller plants or seed for best results.
Plains Cottonwood	*Populus sargentii*	Native	45-60'			Naturally subirrigated lowlands, moist areas, open space drainages. Plant rootball 2-4' into saturated soil, monthly deep watering if planted in upland areas.
Chokecherry	*Padus virginiana*	Native	10-12'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Wild plum	*Prunus americana*	Native	6-8'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Golden current	*Ribes aureum*	Native	3-4'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Three-leaf sumac	*Rhus trilobata*	Native	4-8'			Upland areas, water monthly 1 year to establish
Peachleaf willow	*Salix amygdaloides*	Native	15-35'			Naturally subirrigated lowlands, moist areas, open space drainages.
Sandbar willow	*Salix exigua*	Native	5-6'			Naturally subirrigated lowlands, moist areas, open space drainages.
Snowberry	*Symphoricarpos occidentalis*	Native	2'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages.
Yucca	*Yucca glauca*	Native	2'			Upland areas, water 1 year to establish
TOTAL POUNDS PLS/ACRE					0	
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* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.

Woody plants

Most native woody vegetation are adapted to drainages and sites with elevated moisture, such as springs or north-facing slopes. These species provide critical habitat for wildlife, shade and diversity, and erosion control in drainage areas.

Best Practices

Section 4 – Natural Areas and Native Plants

C. Plants to Avoid – The 2003 State Noxious Weed List

The following noxious weed listings have been excerpted from the Rules and Regulations Pertaining to the Administration and Enforcement of the Colorado Weed Management Act, as of May 2003. The full text and current listing are available at <www.ag.state.co.us/DPI/weeds/weed.html>.

"Noxious weed" means an alien plant or parts of an alien plant that have been designated by rule as being noxious or has been declared a noxious weed by a local advisory board, and meets one or more of the following criteria:

(a) Aggressively invades or is detrimental to economic crops or native plant communities;
(b) Is poisonous to livestock;
(c) Is a carrier of detrimental insects, diseases, or parasites;
(d) The direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems.

The following weed species, listed in alphabetical order, are identified as the State Noxious Weeds. They have been identified by individual counties as problem weeds in the county's area or have been recommended for management through public testimony. These weed species should be considered by each local advisory board and local governing body in the development, adoption and enforcement of their noxious weed list and noxious weed management plan. The State Noxious Weeds are:

Absinth wormwood (*Artemisia absinthium*)
African rue (*Peganum harmala*)
Black henbane (*Hyoscyamus niger*)
Black nightshade (*Solanum nigrum*)
Blue mustard (*Chorispora tenella*)
Bouncingbet (*Saponaria officinalis*)
Bull thistle (*Cirsium vulgare*)
Camelthorn (*Alhagi pseudalhagi*)
Canada thistle (*Cirsium arvense*)
Chicory (*Cichorium intybus*)
Chinese clematis (*Clematis orientalis*)
Coast tarweed (*Madia sativa*)
Common burdock (*Arctium minus*)
Common crupina (*Crupina vulgaris*)
Common groundsel (*Senecio vulgaris*)
Common mullein (*Verbascum thapsus*)
Common St. Johnswort (*Hypericum perforatum*)
Common tansy (*Tanacetum vulgare*)
Common teasel (*Dipsacus fullonum*)
Cypress spurge (*Euphorbia cyparissias*)
Dalmatian toadflax, broad-leaved (*Linaria dalmatica*)
Dalmation toadflax, narrow-leaved (*L. genistifolia*)
Dame's rocket (*Hesperis matronalis*)
Diffuse knapweed (*Centaurea diffusa*)
Downy brome (*Bromus tectorum*)
Dyer's woad (*Isatis tinctoria*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Field bindweed (*Convolvulus arvensis*)
Flixweed (*Descurainia sophia*)
Giant salvinia (*Salvinia molesta*)
Green foxtail (*Setaria viridis*)
Hairy nightshade (*Solanum sarrachoides*)
Meadow knapweed (*Centaurea pratensis*)
Mediterranean sage (*Salvia aethiopis*)
Medusahead rye (*Taeniatherum caput-medusae*)
Moth mullein (*Verbascum blattaria*)
Musk thistle (*Carduus nutans*)
Myrtle spurge (*Euphorbia myrsinites*)
Orange hawkweed (*Hieracium aurantiacum*)
Oxeye daisy (*Chrysanthemum leucanthemum*)
Perennial pepperweed (*Lepidium latifolium*)
Perennial sowthistle (*Sonchus arvensis*)
Plumeless thistle (*Carduus acanthoides*)
Poison hemlock (*Conium maculatum*)
Puncturevine (*Tribulus terrestris*)
Purple loosestrife (*Lythrum salicaria*)
Quackgrass (*Elytrigia repens*)
Redstem filaree (*Erodium cicutarium*)
Rush skeletonweed (*Chondrilla juncea*)
Russian knapweed (*Centaurea repens*)
Russian-olive (*Elaeagnus angustifolia*)
Russian thistle (*Salsola collina and S. iberica*)
Saltcedar (*Tamarix parviflora and T. ramosissima*)
Scentless chamomile (*Anthemis arvensis*)
Scotch thistle (*Onopordum acanthium and O. tauricum*)
Sericea lespedeza (*Lespedeza cuneata*)
Shepherdspurse (*Capsella bursa-pastoris*)
Spotted knapweed (*Centaurea maculosa*)
Spurred anoda (*Anoda cristata*)
Squarrose knapweed (*Centaurea virgata*)
Sulfur cinquefoil (*Potentilla recta*)
Swainsonpea (*Sphaerophysa salsula*)
Tansy ragwort (*Senecio jacobaea*)
Velvetleaf (*Abutilon theophrasti*)

Halogeton (*Halogeton glomeratus*)
Hoary cress (*Cardaria draba*)
Houndstongue (*Cynoglossum officinale*)
Hydrilla (*Hydrilla hydrilla*)
Johnsongrass (*Sorghum halepense*)
Jointed goatgrass (*Aegilops cylindrica*)
Kochia (*Kochia scoparia*)
Leafy spurge (*Euphorbia esula*)
Mayweed chamomile (*Anthemis cotula*)
Venice mallow (*Hibiscus trionum*)
Wild caraway (*Carum carvi*)
Wild mustard (*Brassica kaber*)
Wild oats (*Avena fatua*)
Wild proso millet (*Panicum miliaceum*)
Yellow foxtail (*Setaria glauca*)
Yellow nutsedge (*Cyperus esculentus*)
Yellow starthistle (*Centaurea solstitialis*)
Yellow toadflax (*Linaria vulgaris*)

The following weed species are recognized as the top ten prioritized weed species for the State of Colorado. After analysis of a statewide survey of counties, these species are acknowledged to be the most widespread and to cause the greatest economic impact in the State of Colorado. These species shall be considered by each local advisory board and local governing body in the development, adoption and enforcement of their noxious weed list and noxious weed management plan. They are listed in alphabetical order:

Canada thistle (*Cirsium arvense*)
Dalmation toadflax (*Linaria dalmatica* and *L. genistifolia*)
Diffuse knapweed (*Centaurea diffusa*)
Field bindweed (*Convolvulus arvensis*)
Hoary cress (*Cardaria draba*)
Houndstongue (*Cynoglossum officinale*)
Leafy spurge (*Euphorbia esula*)
Musk thistle (*Carduus nutans*)
Russian knapweed (*Centaurea repens*)
Yellow toadflax (*Linaria vulgaris*)

The following weed species may not be present or are not yet widespread or causing great economic impact within the State of Colorado. However, counties and local advisory boards are encouraged to contain and eradicate these species before they proliferate and significantly impact the economic and environmental values of the lands of the State. They are listed in alphabetical order:

Absinth wormwood (*Artemisia absinthium*)
African rue (*Peganum harmala*)
Bouncingbet (*Saponaria officinalis*)
Camelthorn (*Alhagi pseudalhagi*)
Coast tarweed (*Madia sativa*)
Common crupina (*Crupina vulgaris*)
Common teasel (*Dipsacus fullonum*)
Cypress spurge (*Euphorbia cyparissias*)
Dyer's woad (*Isatis tinctoria*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Giant salvinia (*Salvinia molesta*)
Hydrilla (*Hydrilla hydrilla*)
Meadow knapweed (*Centaurea pratensis*)
Moth mullein (*Verbascum blattaria*)
Myrtle spurge (*Euphorbia myrsinites*)
Orange hawkweed (*Hieracium aurantiacum*)
Rush skeletonweed (*Chondrilla juncea*)
Sericea lespedeza (*Lespedeza cuneata*)
Spurred anoda (*Anoda cristata*)
Squarrose knapweed (*Centaurea virgata*)
Sulfur cinquefoil (*Potentilla recta*)
Tansy ragwort (*Senecio jacobaea*)
Venice mallow (*Hibiscus trionum*)
Yellow starthistle (*Centaurea solstitialis*)

WaterWise Landscaping

Best Practices

Section 5 – Understanding Soils and Soil Preparation

A. Introduction to Soils (See Native Plant Revegetation Guide available at: *http//parks.state.co.us/cnap/revegetation-guide/reveg_index.html*)

Prairie soils have developed over thousands of years. Native topsoil is a living material containing soil microorganisms, seeds, plant roots, and invertebrate animal in a matrix of minerals (derived from rocks) and dead organic matter (developed from the breakdown of dead plants and animals). Areas with adequate topsoil are better able to develop and support healthy vegetation. Native drought tolerant vegetation may be adapted to a broad or narrow range of soil types. Successful native and drought tolerant landscapes should consider soil properties when designing planting areas. Soil properties include texture, chemistry, and structure. Soil pH, salinity, and percent organic matter may be more critical to the establishment of native and drought tolerant vegetation than soil macronutrient levels (nitrogen, phosphorus, and potassium). In order to better plan for specific soils, consult the reference above.

Topsoil may be recognized in general by its darker color (very dark to deeper brownish earth tones). The distinct transition to brighter earth tones may mark the boundary with subsoil. Recent precipitation may color surface soils darker and should not be mistaken for topsoil. In general topsoil may be 6 to 12 inches deep, deeper in drainages and shallower on slopes and hilltops. Old agricultural fields may have less distinct boundaries due to years of mixing of upper soils and accelerated erosional loss. Pits may be dug to identify topsoil depths prior to removal

B. Salvage of Soils

Topsoil is a living material and must be handled carefully to preserve its quality. Planned developments are frequently re-graded. Topsoil should be salvaged from all areas and stockpiled prior to grading. Topsoil under roads and staging areas should also be removed and stock piled. All salvaged topsoil should be reapplied to the portions of the development site to be revegetated. Salvage topsoil in drainages before erosion of denuded upland areas can contaminate them.

Topsoil is best if it can be removed and hauled directly to the placement site. If storage is necessary it should be for as short a time as possible. The topsoil should be placed in a low mound, in a weed free area, with side slopes of 7:1 or less. A ditch and berm structure around the pile will help reduce loss to erosion. If the pile is to remain for more than four weeks, it should be seeded with a sterile hybrid wheatgrass such as “Regreen”. The depth of the pile should be no greater than 2-3 feet to minimize loss of living microbial components. In general it is best to move topsoil when it is moist. Avoid moving wet soils (may harden to brick-like consistency) or overly dry soils. Dormant hauled soils preserve residual native seed and propagules.

C. Topsoil Sources

If topsoil is to be imported to a site a soil sample or recent soil test should be obtained from the supplier. If possible the source site should be visited to check for weed contamination. Soil sources should be free of noxious weed species. If a prepared soil is to be used, the organic content should only be 2 percent for native seeding areas. (Conventional lawns and higher water usage areas may utilize higher organic matter.)

D. Topsoil Testing

Imported topsoil should be a sandy loam or loam soil as defined by the USDA Soil Conservation Service soil Classification system, as follows:

Textural Class	% Total Weight	Average %
Sand (0.05-2.0 mm dia. Range)	45 to 75	60
Silt (0.002-0.05 mm dia. range)	15 to 35	25
Clay (less than 0.002 mm dia. range)	5 to 25	15

Topsoil should be free of stones over 1” in diameter (lawns and gardens) or over 4” (native seeded areas). Topsoil should be free of debris and excessive plant litter.

Topsoil should have a pH of 6-7.5 and salinity less than 4 mmhos/cm.

Soil Testing is available through the **Colorado State University Extension Service:**

Contact Information: CSU Soil Testing Lab, Ft. Collins, Colorado
Phone: 970-491-5061
Fax: 970-491-2930
Web: www.colostate.edu/Depts/SoilCrop/soillab.html
Cost: Routine Analysis = $18.00 (as of 6/03)
Procedure: Application & Instruction Forms follow

E. Soil Amendments

It is best to plan native and drought tolerant vegetation around the existing soil conditions. If extreme soil conditions exist, some amendments may improve the soil conditions:

1. pH

If the pH is very high it may be possible to adjust by adding aluminum sulfate. Soil in the Front Range tends to have a high pH and thus, does not generally require the addition of lime, which would further elevate the pH value.

2. Texture

Soil texture effects water availability within soils. Very sandy soils do not retain water well. Very clayey soils do not allow water to penetrate or drain easily. Organic matter may improve both of these extreme soils. Native or to low water usage landscapes generally no more than 2 percent organic matter. Generally, if sandy or clay soils are amended, 2 cubic yards of composted organic matter/1000 square feet is adequate. To improve deep root penetration in a heavy clay or sandy subsoil (under all water usage levels of landscape) apply 2 cubic yards of compost prior to re-application of topsoil. All compost should be deeply ripped into the soil at least 12 inches. This helps with root penetration into the deeper layers of the soil and makes all landscape types more drought tolerant. Avoid over-working the soil to preserve the soil structure.

3. **Organic Amendment**
   Organic amendments should be composted. Compost may be a mixture of manures (not from stock yards, which may be high in salts), yard wastes (ground grass clippings, leaves and branches), organic byproducts such as brewery wastes, and sewage sludge (should not be used alone due to a high clay content.) Prepared topsoil companies maintain sanitary controlled compost production and are a good source of organic amendments.

4. **Nutrient Amendment**
   Nutrient amendments may not be required for native vegetation. Macro nutrient (N,P,K) levels are low in native prairies. Addition of nutrients to native and drought tolerant planting areas may encourage weeds and damage root systems. If topsoil is very poor or lacking, a slow release organic amendment such as Biosol may be added at a rate of 800 to 1200 pounds per acre to improve plant growth.

SUGGESTED INSTRUCTIONS FOR SUBMITTING SOIL SAMPLES
Use the following steps to submit soil samples:

1. Obtain a spade, trowel, soil tube, or soil auger free of rust and soil.

2. Dig 5-10 samples (depending on the size of the area) from the soil depth where your plants will be rooting. The samples should represent a uniform area consisting of land that is similar in slope, texture, drainage, or other characteristics that make the soil the same. A front and back yard would most likely be very similar to each other, however a garden area may be different from a turf grass area.

3. Place all of the samples into a plastic container and mix well to get your final sample for submittal to the lab. If possible, air dry the sample by spreading it out on paper towels.

4. Remove about 1 1/2 - 2 pints of soil from the container and place it in a plastic bag or soil sample bag.

5. Seal the bag and label the sample with name, address and location of the sample.

6. Complete this soil sample information form as much as possible and include it with the soil sample.

7. Mail the sample to the lab using the following address:

   Soil, Water and Plant Testing Laboratory
   Colorado State University
   Room A 319 NESB
   Fort Collins, CO 80523-1120

8. Be sure to keep samples cool before mailing. If samples heat up; the nitrogen readings can change dramatically. Keeping the samples in the shade will prevent excessive heating.

9. **DO NOT PREPAY**, you will be billed for the analysis.

10. The lab **DOES NOT** do herbicide or pesticide analysis.

11. If you have additional questions please contact the lab at: (970) 491-5061 or your local county Cooperative Extension agent.

SOIL TESTS AVAILABLE

TEST	COMMENTS
Routine- pH, soluble salts, organic matter, nitrate-nitrogen, phosphorus, potassium, zinc, iron, lime (estimate), texture, copper and manganese.	Basic evaluation for characterizing the soil fertility status for growing crops. a fertilizer recomendation is given. Normally this test is sufficient unless a special problem is suspected.
Subsoil Nitrate	Evaluation of nitrate supply below soil surface. Fertilizer nitrogen recommendation based on routine soil test of surface soil is adjusted if subsoil nitrate is unusually high.
Subsoil Salinity	It is important to determine the salt content of subsoil for crop management.
Sodium Evaluation - sodium adsorption ratio (ratio of sodium to calcium and magnesium), gypsum, and % lime.	Some Colorado soils contain excess sodium. This test determines whether or not chemical amendments such as gypsum or sulfur will be effective and the amounts of these materials needed.
Routine plus Sodium Evaluation	See above explanations. A recommendation for fertilizer and/or amendments for sodium reclamation is given.
Boron, Sulfate and Molybdenum	Colorado soils usually have sufficient quantities of these nutrients. However, in some soils near mine sites, boron or molybdenum may be found in toxic quantities.

Form from the CSU Soil-Water-Plant Laboratory website
<www.colostate.edu/Depts/SoilCrop/soillab.html>

SOILSAMPLEINFORMATIONFORHORTICULTURALAPPLICATIONS - **PLEASE PRINT IN LANDSCAPE MODE!**

See the reverse side for sampling information

SOIL, WATER & PLANT TESTING LABORATORY

DATE:______ ________________

FULL NAME:______________________________

SSN:______________________________________

ADDRESS:__________________________________

____

CITY: ____________________STATE:__________

ZIPCODE:______________ _____________

PHONE:______________________ FAX:_________

COUNTY:______________SAMPLEID:______________

CLIENTTYPE(Check One)	
Homeowner	Operator
Dealers/Distributor	Extension Agent
Lawn Care Company	Regulatory Agency
Golf Course	Consultant
Nursery /Garden Center	Government/School
Other_______________	

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

PLEASECIRCLE ANALYSISDESIRED
Routine(pH, conductivity, organic matter, NO_3, P, K, Zn, Fe Cu, Mn, lime estimate, texture estimate)
Routine + Sodium Evaluation (SAR)
Routine + Boron, Molybdenum, Cadmium, Lead
Routine + Nitrate OR Salinity on Subsoil
Routine + Salinity + Nitrate on Subsoil
NOTE: A subsoil is a separate sample taken 6" underneath your surface sample.
MINIMUM CHARGE

The following information will help us give you a written explanation of the laboratory results:

PLEASECIRCLEALLTHATAPPLY.

1. The sample is from:

A. Lawn E. Golf course
B. Vegetable garden F. Container plantings
C. Flower bed G. Reclamation site
D. Greenhouse H. Other (please specify)___________

2. What do you plan to grow at the site or what is currently growing at the site?

A. Vegetables B. Flowers C. Turfgrass (How old is the lawn?)____ D. Trees E. Other______________

If you are growing turf please answer the following:

Is this site to be____ Seeded_______Sodded?

Is it an existing lawn? ________

If the lawn is established was it: Seeded_________ Sodded_________

3. Will this site be irrigated/watered? Yes____or No______

4.If yes which method? A. Sprinkler C. Drip B. Flood D. Other please specify____________

5.If sprinkler is used is it: A. Automatic C. Hose end B. In ground D. Other___________

6. About how much water do you apply each time you irrigate/water?

A. Less than 1 inch. B. 1-3 inches C. 4-6 inches D. More than 6 inches

7. How often do you irrigate/water?Daily______ Once per week___ Twice per week_______ Other________

8.If possible, indicate the types of previous crops or plants that grew at this site.________________________

9. What have you added or plan to add to the soil?______________________________

10. Is there a specific problem with this site? Yes_______ No__________

If yes, please describe the problem, what caused the problem and why you think it was the cause (use a separate sheet if necessary).

____

11. If you wish to have a fertilizer recommendation based on organic fertilizers please answer the following questions.
What is the type of material that will be used for organic fertilizer?

A. Composted manure B. Composted sludge C. Other__________________________

Do you know the nutrient levels in the organic fertilizer?Yes_______No_________

If so please supply the following information for the organic fertilizer.

% nitrogen	% phosphorus	% potassium	pH	Salts (mmhos/cm)

Additional Comments: ____

By accepting service or goods, I agree to submit payment in full to Colorado State University upon receipt of invoice or University Billing Statement.Late payment charges of 1.5% per month and other penalties specified may be assessed for late payment.

Please call lab for prices.

revised 10-11-2001

Form from the CSU Soil-Water-Plant Laboratory website
<www.colostate.edu/Depts/SoilCrop/soillab.html>

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Section 6 – Irrigation Design Techniques and Equipment

The following information builds upon some of the Guidelines described above in Section 2, Principle #5.

A. Consider plant water requirements in irrigation design schemes

1. Each valve should irrigate a landscape with similar site, slope and soil conditions and plant material with similar watering needs.
2. Soil types, infiltration rate & slopes should be considered in order to avoid runoff, & overspray, where water flows onto adjacent property, non-irrigated areas, walks, roadways, or structures. Proper irrigation equipment, schedules, and repeat cycles should be used to minimizing runoff.
3. Special attention should be given to avoid runoff from slopes, and to avoid overspray in planting areas with a width less than ten feet, like medians.
4. Turf and non-turf areas should be irrigated on separate valves.
5. Drip emitters and sprinklers should be place on separate valves.
6. Bubblers for trees should be placed on a separate valve. Bubbler selected should not exceed 1.5 gallons per minute (gpm) for each device.
7. Hand watering may be considered for Low and Very Low hydrozones.

B. Employ hydraulic principles when designing the irrigation system.

1. The irrigation system should be designed to provide peak season irrigation within a six night, six hour per night watering period.
2. The tap size should be based on the water demand of the site and will take into consideration the areas of each plant type (i.e., turf, native seed, perennials and annuals and shrubs), the evapotranspiration for the site, the water demand of each plant type at peak season, and the water window.
3. The maximum flow rate required for the site should be based on the tap size:

¾” meter	15 gallons per minute
1” meter	25 gpm
1.5” meter	50 gpm
2” meter	80 gpm

4. The mainline system should be designed such that velocities within the mainline piping do not exceed five feet per second.
5. A reduced pressure backflow preventer should be used on all systems. Where the irrigation point of connection is from the domestic water service, the irrigation tap and backflow preventer shall be installed after the water meter but before any backflow or pressure-reducing valve for the building.
6. A pressure-reducing valve should be used when the static water pressure exceeds the pressure needed by the system by 15 pounds per square inch (psi). Pressure reducing valves can be installed within the project, on the mainline or at the valve, if elevation changes require it.

7. Turf and grass area design principles:
    a. No single zone should mix head types, such as rotors and pop-up spray heads on the same zone.
    b. Sprinklers should be spaced for "head-to-head" coverage, where the spray pattern from one head will reach to the next head. (Another way to describe this is that all sprinkler heads should be spaced at a maximum of 50% of design performance diameter of the sprinkler.) Spacing should be reduced below 50% of design performance diameter when conditions demand.
    c. No overhead sprinkler irrigation systems should be installed in strips less than 8 feet wide.
    d. Small areas (25 ft wide or less) should be irrigated with fixed nozzle pop-up spray heads with matched precipitation nozzles. Nozzles should be sized to provide head to head coverage. Heads shall pop-up a minimum of 4" in turf areas. Heads can be specified with pressure reducing features, where needed.
    e. Large areas (wider than 25 ft) should be irrigated with gear driven rotor heads with a minimum precipitation rate of 0.45" per hour for a full circle head. Heads should pop-up a minimum of 4" in turf areas.
    f. Check valves should be included in heads or valves where low-head drainage will occur due to elevation changes. See irrigation head catalogs for elevation change tolerances.
8. Shrub bed areas with plant material one gallon in size or larger should be irrigated with a drip or subsurface system.
9. Perennial and annual beds should be spray irrigated with 12" pop-up spray heads with a maximum spacing of 10' on center.
10. Booster pumps should be installed on systems where supply pressure does not meet minimum recommended pressure of the irrigation system, based on hydraulic calculations.
11. Where the water supplied will be from secondary or other non-potable water sources, the use of non-potable color indicators on the equipment is recommended. This includes purple handles on quick coupler valves and gate valve, caps for irrigation heads, valve box lids and marker tape buried above the mainline.
12. All systems should be equipped with an automatic rain shut-off device.
13. All wire connections should be made with watertight connectors and contained in a valve box.

C. Employ irrigation control systems that offer flexibility in programming.

1. All irrigation systems should include an electric automatic controller with multiple programs and multiple repeat and rest cycle capabilities and a flexible calendar program.
2. All controllers should be capable of temporarily shutting down the system by utilizing internal/external options such as rain and wind sensors.
3. The controller should have the ability to adjust run times based on a percentage of maximum ET (evapotranspiration) rate.
4. Each zone/valve should have its own station on the controller. The exception is drip valves, which can be doubled on the controller.

D. Ensure installation of irrigation system is per plan and is accurate.

1. Irrigation system should be installed per plans.

2. The irrigation system should be monitored during installation, especially to verify mainline and lateral line depth, spacing of irrigation heads and construction of valve clusters and quick coupler components.
3. Mainline should be tested to ensure its ability to maintain required pressure for 2 hours.
4. Before acceptance, each zone should be operated and each valve box opened to verify accurate installation.

E. Provide "as-built" drawings of irrigation system after installation with dimensions shown for irrigation components.

1. The "as-built" drawings should show all points of connection, including tap size, line size and static water pressure of service. Dimensions that will be used to locate components shall be shown on plans. Components to be located include meters, backflow preventers, all valves, including quick coupler, control, gate, and manual drain valves, and controller locations.
2. The drawings should also show zone number, valve size and gallons per minute.

F. Operate systems to maximize irrigation water efficiency.

1. Irrigation should be scheduled to operate between 10 PM and 8 AM to reduce water loss from wind and evaporation and to take advantage of the better water pressure.
2. The target efficiency for rotor heads should be 70%, and 55% for spray heads.
3. Program valves for multiple repeat cycles to reduce runoff, especially on slopes and with soils with slow infiltration rates.
4. All zone run times should be determined based on the precipitation rate of the heads on that zone. The run times should be adjusted seasonally and at least once a month to accommodate the ET rate.
5. System should be winterized in the fall using a compressor to remove water in the lines and components. System should be reopened and adjusted for proper operation in the spring.
6. After each mowing, each zone should be operated for a very short period of time to verify the heads are operating as designed and no damage has occurred.
7. When repairs are made, the new components installed should match exactly those damaged and removed.
8. Run times for zones should be adjusted based on exposure (north and east vs. south and west), slope and soil types to reduce overwatering.

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Section 7 – Water Budgeting

A. Calculating a Water Budget

A Water Budget is the target amount of water a landowner should use in a typical watering season. This target provides simple-to-achieve, realistic goals for landscape irrigation. Water Budgeting focuses less on watering time limits, and is more concerned with a user's water allotment and reducing over-watering. This form can help any user create a target Water Budget from which to work.

The information below will help guide you through the Water Budget Worksheet on the following page.

Step 1. ET Reference Location:
Because climate conditions vary throughout Colorado, the rate at which water evaporates (evaporation) and the rate at which plants use water (transpiration) varies in different areas of the state. Based on those climatic differences, it is important to identify the general Evapo-Transpiration (ET) Reference Locations in which you are located. The four largest regions can be categorized as: Denver, Colorado Springs, Grand Junction and Pueblo.

Step 2. Gallons of Water Needed by Plant Category:
Different plants have different water needs. A plant list that identifies the water needs of landscape plants (High, Moderate, Low, Very Low) is included in Section Three of this Best Practices Manual. The ET Rates are provided on the worksheet, and will need to be applied in the calculations in Step 4 below.

Step 3. Irrigation Areas (zones) based on Plant Water Need Category:
Both automatic irrigation systems and hand-placed yard sprinklers deliver water to plants by watering areas or "zones", and have set watering amounts determined by you, the user. If you have High water need plants within Low or Very Low water plant groupings, the entire area must be considered a High-water area and irrigated as such; however some plants may be over-watered if this occurs. The area of each watering zone can be determined by physically measuring the zone, and multiplying Length (in feet) by Width (in feet). The resulting areas (in square feet, or S.F.) can be entered in Step 4 below.

Step 4. Water-Use Calculations:
Fill in the blanks with area and water need per zone. For example, in the Denver region you might have an area of 300 S.F. in a High Water Zone that would require 20 gallons of water per S.F. After multiplying you would find that area requires 6,000 gallons of water per season.

After calculating the irrigation needs of all areas, determine your average overall water needs per season. To do this, add the total gallons needed for all zones, and divide by the total Square Footage for all zones. The average for the overall site needs to be no more than 15 gallons per S.F. per season. If your average is more than this, you might consider modifying your planting layout to create more Low/Very Low Water Zones that would balance your High/Moderate Water Zones, and reduce over-watering.

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B. Water Budget Worksheet

1. ET Reference Location:

Identify the general Evapo-Transpiration (ET) Reference Location in which you are located. The four largest regions are listed below and include surrounding metropolitan areas:

__Denver __Colorado Springs __Grand Junction __Pueblo

2. Gallons of Water Needed by Plant Category:

Determine the water needs of the various plants in your design. A plant list that identifies water needs (High, Moderate, Low, Very Low) is included in Section Three of this Best Practices Manual.

Plant Water Need Category		Gallons of Water used (ET Rate)*
H =	**High water plants**	(20 gallons/SF/season -- Denver)
M =	**Moderate water plants**	(10 gallons/SF/season -- Denver)
L =	**Low water plants**	(0-3 gallons/SF/season -- Denver)
VL =	**Very Low water plants**	(no irrigation needed; typical rainfall is sufficient)

The ET Rates for regions other than Denver are not yet accurate. One might assume that the ETR for Colorado Springs is 10% less than Denver's, and those for Grand Junction and Pueblo may be as much as 25% higher than Denver's.

3. Irrigation Areas (zones) based on Plant Water Need Category:

Identify each zone requiring irrigation, and calculate the area (in square feet) of each zone. If plants are already installed and/or not grouped together by water need, pick the highest water need category included in each zone.

4. Water-Use Calculations:

HIGH WATER ZONES: ________S.F. x (gals./S.F.) =________________gals / season

MODERATE WATER ZONES:____________S.F. x (gals. /S.F.) =________________gals / season

LOW WATER ZONES: ________S.F. x (gals./S.F.) =________________gals / season

VERY LOW WATER ZONES:_____S.F. x (gals./S.F.) =_______gals / season TOTAL

gallons needed by ALL ZONES: =________________________gals / season

TOTAL Square Feet (S.F.) of ALL ZONES: =________________S.F.

***AVERAGE GALS./S.F./SEASON, ALL ZONES:** Total Gals / Total SF **=________________gals / season**

**The average needs to be a maximum of 15 gals. / S.F. / season.*

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Section 8 – Additional Resources

Water Conservation Internet Sources

- Waterwiser, National Water Efficiency Clearinghouse, www.waterwiser.org
- Water Saver Home, www.h2ouse.org
- U.S. Geologic Survey, Water use in the United States, www.water.usgs.gov/watuse
- Western States Water Council, www.westgov.org/wswc
- Colorado Water Conservation Board, www.cwcb.state.co.us
- Colorado Nonpoint Source Program, www.ourwater.com
- Denver Water, www.water.denver.co.gov/indexmain.html
- WaterSaver from Denver Water, www.watersaver.org

WaterWise Landscaping Internet Sources

- GreenCO Best Management Practices, www.grennco.org/bmp_list.html
- National Association of Irrigation Design/ Certification, www.irrigation.org/certification.html
- American Nursery and Landscape Association, www.anla.org
- Associated Landscape Contractors of Colorado, www.alcc.com
- Smart Gardening, www.smartgardening.com
- Xeriscaping, www.xeriscape.org
- Colorado State University Horticulture Department, www.hla.agsci.coloradostate.edu
- CSU Cooperative Extension Service, www.ext.colostate.edu/garden
- Colorado Nurseries, www.colorado-nusery-assn.org

- Gardening Colorado, www.gardeningcolorado.com
- Xeriscape Gardening, www.xratedgardening.com

Seed and Plant Sources

- Garden Centers of Colorado, www.gardencentersofcolorado.org
- Colorado Native Plant Society, www.carbon.cudenver.edu/~shill/conps.html
- High Country Gardens, www.highcountrygardens.com
- Arkansas Valley Seed Solutions, www.seedsolutions.com
- Rocky Mountain Sod Growers Association, www.rockymountainsodgrowers.com

Demonstration Gardens

- Colorado Xeriscape Demonstration Gardens, www.xeriscape.org/demogardens.html

Waterwise Gardening Books

- *The Xeriscape Flower Gardener*, Jim Knopf, Boulder, CO, Johnson Books, 2003
- *Waterwise Landscaping with Trees, Shrubs, and Vines*, Jim Knopf
- *Xeriscape Plant Guide,* Rob Proctor/David Winger, Fulcrum Publishing, 1996
- *Xeriscape Handbook*, Gayle Weinstein/ David Winger, Fulcrum Publishing, 2003
- *Xeriscape Color Guide*, David Winger/Denver Water, Fulcrum Publishing, 1998
- *Western Garden Book*, Kathleen Norris Brenzel, Sunset Publishing, 2001
- *Water-Efficient Landscape Guidelines,* Richard E Bennett/ Michael S. Hazinski, American Water Works Association, 1993
- *The Rocky Mountain Perennial Plant Guide,* Colorado Nursery Association, 1995
- *Rocky Mountain Plant Guide,* Colorado Nursery Association, 1993

Appendix G

5-Year Opinion of Probable Construction and Capital Improvement Plan Costs

OPCCs and CIP total estimates for 5-Year recommended CIP Projects are presented below in **Table G-1** through **Table G-12**. The estimated cost for each line item, also known as the extended cost within a project is determined by multiplying the line item quantity times the unit cost. Each line item extended cost is added to the project total cost column to determine OPCC estimates. All costs are August 2020 dollars from ENR-CCI.

Table G-1 – SA-44 Centennial Park OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,520	$172/LF	$605,939	$605,939
Water Distribution 8" (Trenchless J&B)	200	$478/LF	$95,617	$95,617
Pump Station - 1,300 gpm	1	LS	$1,734,548	$1,734,548
New Pond	3	$60,964/AF	$154,330	$154,330
Tier 1 Dewatering	1,800	$105/LF	$189,000	$189,000
Unit Cost Subtotal				$2,779,435
Erosion Control/Stormwater Pollution Prevention		2%		$55,589
Mobilization & Demobilization		5%		$138,972
Subtotal				$2,973,995
Contingency		35%		$1,040,900
Opinion of Probable Construction Cost (rounded)				**$4,020,000**
Feasibility and Site Studies		6% of OPCC		$242,000
Preliminary and Final Design		6% of OPCC		$242,000
Engineering Services During Construction		5% of OPCC		$201,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$201,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$121,000
Capital Improvement Plan Total				**$5,030,000**

Table G-2 – Boomerang PS OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 3,100 gpm	1	LS	$3,064,486	$3,064,486
Pond Expansion	12.52	$60,964/AF	$763,000	$763,000
Unit Cost Subtotal				$3,827,486
Erosion Control/Stormwater Pollution Prevention		2%		$76,550
Mobilization & Demobilization		5%		$191,374
Subtotal				$4,095,410
Contingency		35%		$1,433,400
Opinion of Probable Construction Cost (rounded)				**$5,530,000**
Feasibility and Site Studies		6% of OPCC		$332,000
Preliminary and Final Design		6% of OPCC		$332,000
Engineering Services During Construction		5% of OPCC		$277,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$277,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$166,000
Capital Improvement Plan Total				**$6,920,000**

Table G-3 – Boomerang Regional Phase 2 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	5,472	$178/LF	$974,896	$974,896
Tier 2 Dewatering	5,472	$52.50/LF	$287,280	$287,280
Unit Cost Subtotal				$1,262,176
Erosion Control/Stormwater Pollution Prevention		2%		$25,244
Mobilization & Demobilization		5%		$63,109
Subtotal				$1,350,528
Contingency		35%		$472,690
Opinion of Probable Construction Cost (rounded)				**$1,830,000**
Easement		5% of OPCC		$92,000
Feasibility and Site Studies		6% of OPCC		$110,000
Preliminary and Final Design		6% of OPCC		$110,000
Engineering Services During Construction		5% of OPCC		$92,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$92,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$55,000
Capital Improvement Plan Total				**$2,390,000**

Table G-4 – Greeley West Pump Station Replacement OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	6,993	$178/LF	$1,245,879	$1,245,879
Pump Station - 2,000 gpm	1	LS	$2,299,902	$2,299,902
Pond Expansion	9.55	$60,964/AF	$582,203	$582,203
Unit Cost Subtotal				$4,127,984
Erosion Control/Stormwater Pollution Prevention		2%		$82,560
Mobilization & Demobilization		5%		$206,399
Subtotal				$4,416,943
Contingency		35%		$1,545,930
Opinion of Probable Construction Cost (rounded)				**$5,970,000**
Feasibility and Site Studies		6% of OPCC		$359,000
Preliminary and Final Design		6% of OPCC		$359,000
Engineering Services During Construction		5% of OPCC		$299,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$299,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$180,000
Capital Improvement Plan Total				**$7,470,000**

Table G-5 – Upper Equalizer Project OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 36"	25,646	$421/LF	$10,805,334	$10,805,334
Water Distribution 36" (Trenchless J&B)	850	$1,960/LF	$1,665,681	$1,665,681
Water Distribution 36" (Trenchless HDD)	250	$1,796/LF	$449,047	$449,047
Tier 1 Dewatering	350	$105/LF	$36,750	$36,750
Tier 2 Dewatering	17,000	$52.50/LF	$892,500	$892,500
Unit Cost Subtotal				$13,849,313
Erosion Control/Stormwater Pollution Prevention		2%		$276,986
Mobilization & Demobilization		5%		$692,466
Subtotal				$14,818,764
Contingency		35%		$5,186,570
Opinion of Probable Construction Cost (rounded)				**$20,010,000**
Easement		5% of OPCC		$1,001,000
Feasibility and Site Studies		5% of OPCC		$1,001,000
Preliminary and Final Design		5% of OPCC		$1,001,000
Engineering Services During Construction		5% of OPCC		$1,001,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$1,001,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$601,000
Capital Improvement Plan Total				**$25,620,000**

Table G-6 – SA-14 Tech Center Supply OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	3,286	$224/LF	$735,751	$735,751
Pump Station - 1,120 gpm	1	LS	$1,573,250	$1,573,250
New Pond	13	$60,964/AF	$818,868	$818,868
Tier 1 Dewatering	250	$105/LF	$26,250	$26,250
Unit Cost Subtotal				$3,154,120
Erosion Control/Stormwater Pollution Prevention		2%		$63,082
Mobilization & Demobilization		5%		$157,706
Subtotal				$3,374,908
Contingency		35%		$1,181,220
Opinion of Probable Construction Cost (rounded)				**$4,560,000**
Easement		5% of OPCC		$228,000
Feasibility and Site Studies		6% of OPCC		$274,000
Preliminary and Final Design		6% of OPCC		$274,000
Engineering Services During Construction		5% of OPCC		$228,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$228,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$137,000
Capital Improvement Plan Total				**$5,930,000**

Table G-7 – Promontory Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	2,237	$178/LF	$398,546	$398,546
Unit Cost Subtotal				$398,546
Erosion Control/Stormwater Pollution Prevention		2%		$7,971
Mobilization & Demobilization		5%		$19,927
Subtotal				$426,444
Contingency		35%		$149,260
Opinion of Probable Construction Cost (rounded)				**$580,000**
Feasibility and Site Studies		9% of OPCC		$53,000
Preliminary and Final Design		9% of OPCC		$53,000
Engineering Services During Construction		5% of OPCC		$29,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$0
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$0
Capital Improvement Plan Total				**$720,000**

Table G-8 – Monfort Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	1,458	$172/LF	$250,983	$250,983
Tier 1 Dewatering	200	$105/LF	$21,000	$21,000
Unit Cost Subtotal				$271,983
Erosion Control/Stormwater Pollution Prevention		2%		$5,440
Mobilization & Demobilization		5%		$13,599
Subtotal				$291,022
Contingency		35%		$101,860
Opinion of Probable Construction Cost (rounded)				**$400,000**
Feasibility and Site Studies		9% of OPCC		$36,000
Preliminary and Final Design		9% of OPCC		$36,000
Engineering Services During Construction		5% of OPCC		$20,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$0
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$0
Capital Improvement Plan Total				**$500,000**

Table G-9 – Twin Rivers Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	5,574	$172/LF	$959,519	$959,519
Tier 1 Dewatering	256	$105/LF	$26,880	$26,880
Tier 2 Dewatering	5,318	$52.50/LF	$279,195	$279,195
Unit Cost Subtotal				$1,265,594
Erosion Control/Stormwater Pollution Prevention		2%		$25,312
Mobilization & Demobilization		5%		$63,280
Subtotal				$1,354,185
Contingency		35%		$473,970
Opinion of Probable Construction Cost (rounded)				**$1,830,000**
Easement		5% of OPCC		$92,000
Feasibility and Site Studies		6% of OPCC		$110,000
Preliminary and Final Design		6% of OPCC		$110,000
Engineering Services During Construction		5% of OPCC		$92,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$92,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$55,000
Capital Improvement Plan Total				**$2,390,000**

Table G-10 – SA-38 1st Ave. Pond OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	4,558	$172/LF	$784,623	$784,623
Water Distribution 8" (Trenchless HDD)	350	$585/LF	$204,582	$204,582
Pump Station - 260 gpm	1	LS	$604,548	$604,548
New Pond	0.55	$60,964/AF	$33,253	$33,253
Tier 1 Dewatering	807	$105/LF	$84,735	$84,735
Tier 2 Dewatering	3,751	$52.50/LF	$196,928	$196,928
Unit Cost Subtotal				$1,908,669
Erosion Control/Stormwater Pollution Prevention		2%		$38,173
Mobilization & Demobilization		5%		$95,433
Subtotal				$2,042,276
Contingency		35%		$714,800
Opinion of Probable Construction Cost (rounded)				**$2,760,000**
Easement		5% of OPCC		$138,000
Feasibility and Site Studies		6% of OPCC		$166,000
Preliminary and Final Design		6% of OPCC		$166,000
Engineering Services During Construction		5% of OPCC		$138,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$138,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$83,000
Capital Improvement Plan Total				**$3,590,000**

Table G-11 – SA-25 Westgate Regional PS OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 860 gpm	1	LS	$1,323,329	$1,323,329
New Pond	2.40	$60,964/AF	$146,386	$146,386
Unit Cost Subtotal				$1,469,716
Erosion Control/Stormwater Pollution Prevention		2%		$29,394
Mobilization & Demobilization		5%		$73,486
Subtotal				$1,572,596
Contingency		35%		$550,410
Opinion of Probable Construction Cost (rounded)				**$2,130,000**
Feasibility and Site Studies		6% of OPCC		$128,000
Preliminary and Final Design		6% of OPCC		$128,000
Engineering Services During Construction		5% of OPCC		$107,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$107,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$64,000
Capital Improvement Plan Total				**$2,670,000**

Table G-12 – SA-25 Westgate Regional Phase 1 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,527	$172/LF	$607,144	$607,144
Tier 1 Dewatering	100	$105/LF	$10,500	$10,500
Unit Cost Subtotal				$617,644
Erosion Control/Stormwater Pollution Prevention		2%		$12,353
Mobilization & Demobilization		5%		$30,882
Subtotal				$660,880
Contingency		35%		$231,310
Opinion of Probable Construction Cost (rounded)				**$900,000**
Easement		5% of OPCC		$45,000
Feasibility and Site Studies		9% of OPCC		$81,000
Preliminary and Final Design		9% of OPCC		$81,000
Engineering Services During Construction		5% of OPCC		$45,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$0
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$0
Capital Improvement Plan Total				**$1,160,000**

Table G-13 – SA-60 Lake Bluffs OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,424	$172/LF	$589,414	$589,414
Water Distribution 8" (Trenchless J&B)	250	$478/LF	$119,521	$119,521
Water Distribution 10"	3,786	$178/LF	$674,517	$674,517
Pump Station - 1,120 gpm	1	LS	$1,573,250	$1,573,250
New Pond	4.25	$60,964/AF	$258,879	$258,879
Unit Cost Subtotal				$3,215,581
Erosion Control/Stormwater Pollution Prevention		2%		$64,312
Mobilization & Demobilization		5%		$160,779
Subtotal				$3,440,672
Contingency		35%		$1,204,240
Opinion of Probable Construction Cost (rounded)				**$4,650,000**
Easement		5% of OPCC		$233,000
Feasibility and Site Studies		6% of OPCC		$279,000
Preliminary and Final Design		6% of OPCC		$279,000
Engineering Services During Construction		5% of OPCC		$233,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$233,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$140,000
Capital Improvement Plan Total				**$6,050,000**

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Appendix H

20-Year Opinion of Probable Construction and Capital Improvement Plan Costs

OPCCs and CIP total estimates for 20-Year recommended CIP Projects are presented below in **Table H-1** through **Table H-11**. The estimated cost for each line item, also known as the extended cost within a project is determined by multiplying the line item quantity times the unit cost. Each line item extended cost is added to the project total cost column to determine OPCC estimates. All costs are August 2020 dollars from ENR-CCI.

Table H-1 – SA-34 30th St./17th Ave. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 1,000 gpm	1	LS	$1,460,713	$1,460,713
New Pond	2.14	$60,964/AF	$130,246	$130,246
Unit Cost Subtotal				$1,590,959
Erosion Control/Stormwater Pollution Prevention		2%		$31,819
Mobilization & Demobilization		5%		$79,548
Subtotal				$1,702,326
Contingency		35%		$595,820
Opinion of Probable Construction Cost (rounded)				**$2,300,000**
Feasibility and Site Studies		6% of OPCC		$138,000
Preliminary and Final Design		6% of OPCC		$138,000
Engineering Services During Construction		5% of OPCC		$115,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$115,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$69,000
Capital Improvement Plan Total				**$2,880,000**

Table H-2 Boomerang Regional Phase 3 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	15,382	$224/LF	$3,444,104	$3,444,104
Tier 2 Dewatering	15,382	$52.50/LF	$807,555	$807,555
Unit Cost Subtotal				$4,251,659
Erosion Control/Stormwater Pollution Prevention		2%		$85,033
Mobilization & Demobilization		5%		$212,583
Subtotal				$4,549,275
Contingency		35%		$1,592,250
Opinion of Probable Construction Cost (rounded)				**$6,150,000**
Easement		5% of OPCC		$308,000
Feasibility and Site Studies		6% of OPCC		$369,000
Preliminary and Final Design		6% of OPCC		$369,000
Engineering Services During Construction		5% of OPCC		$308,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$308,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$185,000
Capital Improvement Plan Total				**$8,000,000**

Table H-3 – SA-4 35th Ave./O St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 280 gpm	1	LS	$634,613	$634,613
New Pond	0.86	$60,964/AF	$52,560	$52,560
Unit Cost Subtotal				$687,172
Erosion Control/Stormwater Pollution Prevention		2%		$13,743
Mobilization & Demobilization		5%		$34,359
Subtotal				$735,274
Contingency		35%		$257,350
Opinion of Probable Construction Cost (rounded)				**$1,000,000**
Feasibility and Site Studies		6% of OPCC		$60,000
Preliminary and Final Design		6% of OPCC		$60,000
Engineering Services During Construction		5% of OPCC		$50,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$0
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$0
Capital Improvement Plan Total				**$1,170,000**

Table H-4 – SA-3 35th Ave./AA St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 620 gpm	1	LS	$1,068,076	$1,068,076
New Pond	2.33	$60,964/AF	$141,861	$141,861
Unit Cost Subtotal				$1,209,937
Erosion Control/Stormwater Pollution Prevention		2%		$24,199
Mobilization & Demobilization		5%		$60,497
Subtotal				$1,294,633
Contingency		35%		$453,130
Opinion of Probable Construction Cost (rounded)				**$1,750,000**
Feasibility and Site Studies		6% of OPCC		$105,000
Preliminary and Final Design		6% of OPCC		$105,000
Engineering Services During Construction		5% of OPCC		$87,500
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$87,500
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$53,000
Capital Improvement Plan Total				**$2,190,000**

Table H-5 – Bittersweet Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	6,296	$172/LF	$1,083,805	$1,083,805
Water Distribution 8" (Trenchless J&B)	600	$478/LF	$286,851	$286,851
Tier 1 Dewatering	200	$105/LF	$21,000	$21,000
Tier 2 Dewatering	6,696	$52.50/LF	$351,540	$351,540
Unit Cost Subtotal				$1,743,196
Erosion Control/Stormwater Pollution Prevention		2%		$34,864
Mobilization & Demobilization		5%		$87,160
Subtotal				$1,865,220
Contingency		35%		$652,830
Opinion of Probable Construction Cost (rounded)				**$2,520,000**
Feasibility and Site Studies		6% of OPCC		$152,000
Preliminary and Final Design		6% of OPCC		$152,000
Engineering Services During Construction		5% of OPCC		$126,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$126,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$75,600
Capital Improvement Plan Total				**$3,160,000**

Table H-6 – SA-35 44th Ave./F St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 820 gpm	1	LS	$1,282,689	$1,282,689
New Pond	2.34	$60,964/AF	$142,566	$142,566
Unit Cost Subtotal				$1,425,256
Erosion Control/Stormwater Pollution Prevention		2%		$28,505
Mobilization & Demobilization		5%		$71,263
Subtotal				$1,525,023
Contingency		35%		$533,760
Opinion of Probable Construction Cost (rounded)				**$2,060,000**
Feasibility and Site Studies		6% of OPCC		$124,000
Preliminary and Final Design		6% of OPCC		$124,000
Engineering Services During Construction		5% of OPCC		$103,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$103,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$62,000
Capital Improvement Plan Total				**$2,580,000**

Table H-7 – SA-36 59th Ave./10th St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	134	$172/LF	$23,067	$23,067
Water Distribution 10"	8,754	$178/LF	$1,559,620	$1,559,620
Water Distribution 10" (Trenchless J&B)	400	$581/LF	$232,590	$232,590
Pump Station - 1,580 gpm	1	LS	$1,970,903	$1,970,903
New Pond	3.40	$60,964/AF	$207,115	$207,115
Tier 1 Dewatering	900	$105/LF	$94,500	$94,500
Tier 2 Dewatering	8,388	$52.50/LF	$440,370	$440,370
Unit Cost Subtotal				$4,528,165
Erosion Control/Stormwater Pollution Prevention		2%		$90,563
Mobilization & Demobilization		5%		$226,408
Subtotal				$4,845,137
Contingency		35%		$1,695,800
Opinion of Probable Construction Cost (rounded)				**$6,550,000**
Feasibility and Site Studies		6% of OPCC		$393,000
Preliminary and Final Design		6% of OPCC		$393,000
Engineering Services During Construction		5% of OPCC		$327,500
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$327,500
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$197,000
Capital Improvement Plan Total				**$8,190,000**

Table H-8 – SA-16 95th Ave./16th St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	4,640	$178/LF	$826,666	$826,666
Pump Station - 1,220 gpm	1	LS	$1,663,880	$1,663,880
New Pond	3.99	$60,964/AF	$243,309	$243,309
Tier 1 Dewatering	575	$105/LF	$60,375	$60,375
Unit Cost Subtotal				$2,794,230
Erosion Control/Stormwater Pollution Prevention		2%		$55,885
Mobilization & Demobilization		5%		$139,711
Subtotal				$2,989,826
Contingency		35%		$1,046,440
Opinion of Probable Construction Cost (rounded)				**$4,040,000**
Easement		5% of OPCC		$202,000
Feasibility and Site Studies		6% of OPCC		$243,000
Preliminary and Final Design		6% of OPCC		$243,000
Engineering Services During Construction		5% of OPCC		$202,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$202,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$122,000
Capital Improvement Plan Total				**$5,260,000**

Table H-9 – SA-14 Tech Center Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	8,221	$224/LF	$1,840,722	$1,840,722
Unit Cost Subtotal				$1,840,722
Erosion Control/Stormwater Pollution Prevention		2%		$36,814
Mobilization & Demobilization		5%		$92,036
Subtotal				$1,969,572
Contingency		35%		$689,360
Opinion of Probable Construction Cost (rounded)				**$2,660,000**
Easement		5% of OPCC		$133,000
Feasibility and Site Studies		6% of OPCC		$160,000
Preliminary and Final Design		6% of OPCC		$160,000
Engineering Services During Construction		5% of OPCC		$133,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$133,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$80,000
Capital Improvement Plan Total				**$3,460,000**

Table H-10 – SA-15 37th St./SH-257 Pump Station OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 1,400 gpm	1	LS	$1,820,808	$1,820,808
New Pond	5.33	$60,964/AF	$325,186	$325,186
Unit Cost Subtotal				$2,145,994
Erosion Control/Stormwater Pollution Prevention		2%		$42,920
Mobilization & Demobilization		5%		$107,300
Subtotal				$2,296,213
Contingency		35%		$803,680
Opinion of Probable Construction Cost (rounded)				**$3,100,000**
Feasibility and Site Studies		6% of OPCC		$186,000
Preliminary and Final Design		6% of OPCC		$186,000
Engineering Services During Construction		5% of OPCC		$155,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$155,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$93,000
Capital Improvement Plan Total				**$3,880,000**

Table H-11 – SA-12 Cobblestone Regional OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	2,023	$178/LF	$360,419	$360,419
Pump Station - 1,180 gpm	1	LS	$1,627,947	$1,627,947
New Pond	4.44	$60,964/AF	$270,436	$270,436
Unit Cost Subtotal				$2,258,802
Erosion Control/Stormwater Pollution Prevention		2%		$45,176
Mobilization & Demobilization		5%		$112,940
Subtotal				$2,416,918
Contingency		35%		$845,930
Opinion of Probable Construction Cost (rounded)				**$3,270,000**
Easement		5% of OPCC		$164,000
Feasibility and Site Studies		6% of OPCC		$196,200
Preliminary and Final Design		6% of OPCC		$196,200
Engineering Services During Construction		5% of OPCC		$164,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$164,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$99,000
Capital Improvement Plan Total				**$4,260,000**

Table H-12 – Glenmere Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	4,136	$172/LF	$711,979	$711,979
Water Distribution 8" (Trenchless J&B)	100	$478/LF	$47,808	$47,808
Pond Expansion	2.91	$60,964/AF	$177,404	$177,404
Tier 1 Dewatering	143	$105/LF	$15,015	$15,015
Tier 2 Dewatering	4,093	$52.50/LF	$214,883	$214,883
Unit Cost Subtotal				$1,167,089
Erosion Control/Stormwater Pollution Prevention		2%		$23,342
Mobilization & Demobilization		5%		$58,354
Subtotal				$1,248,785
Contingency		35%		$437,080
Opinion of Probable Construction Cost (rounded)				**$1,690,000**
Easement		5% of OPCC		$85,000
Feasibility and Site Studies		6% of OPCC		$102,000
Preliminary and Final Design		6% of OPCC		$102,000
Engineering Services During Construction		5% of OPCC		$85,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$85,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$51,000
Capital Improvement Plan Total				**$2,200,000**

Table H-13 – SA-25 Westgate Regional Phase 2 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,782	$172/LF	$651,041	$651,041
Unit Cost Subtotal				$651,041
Erosion Control/Stormwater Pollution Prevention		2%		$13,021
Mobilization & Demobilization		5%		$32,552
Subtotal				$696,613
Contingency		35%		$243,820
Opinion of Probable Construction Cost (rounded)				**$950,000**
Easement		5% of OPCC		$48,000
Feasibility and Site Studies		9% of OPCC		$86,000
Preliminary and Final Design		9% of OPCC		$86,000
Engineering Services During Construction		5% of OPCC		$48,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$0
Outside Project Management- not used if OPCC value is < $1M		3% of OPCC		$0
Capital Improvement Plan Total				**$1,220,000**

Table H-14 – SA-42 23rd Ave./Northwest C St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	5,924	$172/LF	$1,019,769	$1,019,769
Water Distribution 8" (Trenchless J&B)	150	$478/LF	$71,713	$71,713
Pump Station - 1,180 gpm	1	LS	$1,627,947	$1,627,947
New Pond	2.75	$60,964/AF	$167,555	$167,555
Tier 1 Dewatering	41	$105/LF	$4,305	$4,305
Tier 2 Dewatering	5,883	$52.50/LF	$308,858	$308,858
Unit Cost Subtotal				$3,200,146
Erosion Control/Stormwater Pollution Prevention		2%		$64,003
Mobilization & Demobilization		5%		$160,007
Subtotal				$3,424,156
Contingency		35%		$1,198,460
Opinion of Probable Construction Cost (rounded)				**$4,630,000**
Easement		5% of OPCC		$232,000
Feasibility and Site Studies		6% of OPCC		$278,000
Preliminary and Final Design		6% of OPCC		$278,000
Engineering Services During Construction		5% of OPCC		$232,000
Outside Construction Management - not used if OPCC value is < $1M		5% of OPCC		$232,000
Outside Project Management - not used if OPCC value is < $1M		3% of OPCC		$139,000
Capital Improvement Plan Total				**$6,030,000**

Appendix I

CIP Development

I.1.1 Variability in Data

Data was obtained from past contractor bidding information provided by the City and other Front Range communities, as well as national sources. This data included unit costs for different potential capital expenditures within wastewater, water, and NP projects. The data varied in level of detail and definition of each cost element. For example, pipeline costs may or may not include dewatering, restoration, or paving project sites. Pipe cost data from the different sources also varied by construction depth, ground conditions, and method of installation for pipeline. For example, one data source may have identified unit price for a given pipe diameter size at a given depth, while another data source provided unit costs for given pipe diameter sizes of various depths within developed or undeveloped land areas. Both data sources provide information regarding pipe installation costs but need to be considered based on the level of detail that is desired for project CIP development.

I.1.2 Unknown Elements and Assumptions

Assumptions made during CIP development mean planning level costs will vary from construction bid costs. The assumptions are necessary to capture costs for project elements that cannot be defined at the planning level. Examples of undefinable costs include dewatering areas, utility pipeline crossings, permitting for project implementation, final contractor bid quantities, seasonal soil and ground conditions, and stormwater management of project sites. Assumptions are also made for method of pipe installation, timing of projects, and materials of construction. During design development, additional field information including survey, geotechnical data, groundwater levels, traffic control requirements, and final pipe alignment of project areas should be available to help refine the project elements and construction methods.

Trendlines and linear interpolation were used to develop costs for project elements with insufficient data. For example, cost data was obtained for the trenchless installation of water distribution and transmission lines for 4 inch through 60-inch diameter pipe, however there was limited cost information for 36-inch pipe. Trend line equations for linear, polynomial, and logarithmic and their respective R2 values were compared to identify the most probable estimation equation. In this case, the trendline equation with an R2 value closest to 1 was selected as the most probable estimation equation. Because the trendline with the most pertinent R2 value may not reflect the true cost, CDM Smith recommends the City readjust cost data throughout the planning horizon.

An example of comparing different trend line equations and their respective R2 values for approximating missing data in shown in **Figure I-1**. This example highlights the jack and bore (J&B) trenchless installation of water distribution and transmission pipeline items. In this example, the second order polynomial trend line (shown by the purple dotted line below) has the closest R2 value to 1 compared to the exponential and logarithmic trend lines (shown by the blue and green dotted lines below, respectively) based on available data. As a result, without additional industry knowledge and experience, the linear trend line would be assumed to best approximate unit costs for J&B trenchless pipe installation for pipe diameter sizes not available from the given data set. This assumption may conflict with actual J&B trenchless pipe installation data trends known in industry, which may better be approximated by exponential or logarithmic trend lines. This would especially be true when predicting trenchless pipe installation for large pipe diameter sizes (i.e., greater than 24 inch) where predictions of data points of the trend lines begin to greatly diverge. At a planning level, this limitation is acceptable when a cushion of construction cost contingency (i.e., 30%) is added to help absorb this unit cost uncertainty. However, at an engineering design level, where construction cost contingency is lowered, the chosen trend line that best reflects industry data trends should be used to model trenchless pipe installation. This should also be used for all unit cost items where trendlines are used, regardless of if the chosen trend line has an R2 value closest to 1 in order to avoid unnecessary error.

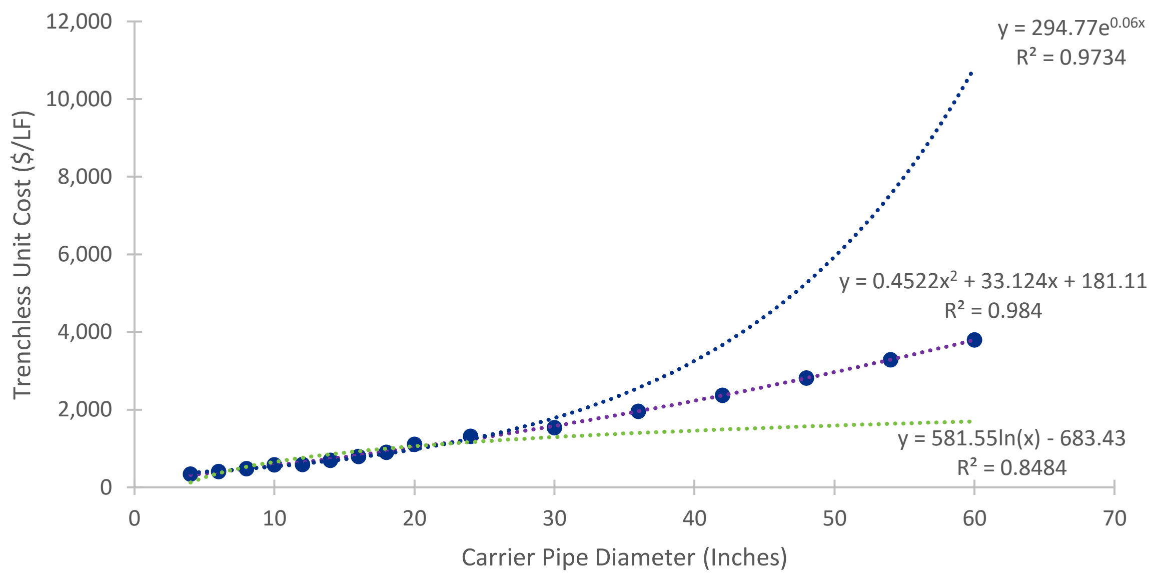

Figure I-1 Example of Different Trendlines for Finding Missing Data of a Line Item

I.1.3 Unpredictability

There is inherent unpredictability to consider during CIP development. This unpredictability is captured in the cost range that is provided for the overall CIP. Examples of unpredictability include future economic trends and inflation rates. Prior to COVID-19, a global pandemic, cost inflation tools provided high confidence for predicting unit prices within a given year. However, after COVID-19, these cost inflation tools may not prove to be as accurate.

I.1.4 Data Sources

Major sources for cost factors included city bid tabs and databases, past project data and contractor construction bid tabs, vendor quotes and cost estimates from CDM Smith's estimating department. A list of external sources that CDM Smith used to develop unit costs for the City's CIP water transmission and distribution cost estimates includes the following:

- City of Greeley Project Initiation Form (City of Greeley, 2021)
- Operation Rehab Project 2021 – 2025 Spreadsheet (City of Greeley, 2021)
- Water and Sewer Department 10 Year CIP 2021 – 2030 Spreadsheet (City of Greeley, 2021)
- Collection, Distributions, Transmission Projects Phase I – (CMAR) (City of Greeley, 2019)
- City of Greeley Pipe Rehabilitation Cost Estimating Template (City of Greeley, 2019)
- Keep Greeley Moving Phase 2 by Neighborhood 2023 – 2029 (City of Greeley, 2021)
- City of Aurora Wastewater Master Plan (AECOM, 2017)

The data was compiled in a single file with line item data reflected as unit costs (dollars per linear foot, dollars per each, etc.). When needed, unit costs for specific line items were calculated using trend line equations. Line items that were not specific or harder to estimate using specific unit cost quantity were reflected as a percentage addition to project costs (mobilization and demobilization, erosion control and stormwater pollution prevention, etc.).

The costs estimated for each project are in August 2020 dollars. Historical data was adjusted to the equivalent August 2020 data by using Engineering News Record's 20-City Construction Cost Index (ENR-CCI). ENR estimates a project each month in 20 different cities around the U.S. and calculates the composite index. Costs are adjusted by multiplying a cost element with the ratio of the current day 20-City ENR-CCI and date of data.

$$\textbf{Construction Unit Cost }(\mathbf{T2}) = \textbf{Construction Cost }(\mathbf{T1}) \times \frac{\mathbf{CCI}(\mathbf{T2})}{\mathbf{CCI}(\mathbf{T1})}$$

T2 and T1 reflect the desired projected year and month desired and the originally year and month of unit costs, respectively.

I.1.5 Major Cost Elements

NP water distribution system CIP costs were developed using five general cost element categories, as shown in **Figure I-2** and described below.

Construction Bid Cost
- Pipelines, Pump Stations & Ponds
- Major Crossings
- Land Considerations
- Dewatering
- Erosion Control
- Mobilization
- Contractor OH&P

Project Implementation
- Planning Studies
- Preliminary and Final Design
- Engineering Services during Construction

Additional Project Related Costs
- Significant Permitting (above typical)
- Outside Program Management
- Outside Construction Management

Figure I-2 CIP Categories for Cost Definition

Each of these cost elements is discussed in more detail in the following subsections. Unit priced line items, mobilization and demobilization, and stormwater pollution prevention and erosion control was rounded to the nearest whole dollar. Project contingency was rounded to the nearest $10 and added to the OPCC subtotals to determine the OPCC project totals which were rounded to the nearest $10,000. Subsequent costing factors were added to the OPCC project totals to determine CIP estimates used for high-level planning of water transmission and distribution, sewer, and NP master plans.

I.1.6 Pipeline, Pump Stations, & Ponds

Installation of Pipe

NP water lines were generally assumed to be installed using open cut construction. Open cut construction is where contractors remove surface soils to insert pipe, except for arterial roadway and highway, railroad, irrigation ditch, river, and lake crossings. In such instances, trenchless pipe installation was assumed which inserts pipe through tunneling and boring, J&B, or horizontal direct drilling (HDD) methods. Open cut pipeline installation unit costs (in dollars per linear foot of pipe, $/LF) include the pipe and bedding, excavation, installation including traffic control, tie-ins for service laterals, backfill, restoration, and flow and throttle control valves. Distribution pipelines were classified with pipe diameters up to 20 inch while transmission lines were classified with pipe diameters 24 inch and above.

The open cut installation was divided into developed and undeveloped categories. The developed category includes pipe installed in developed areas such as in neighborhoods, along major City streets, across two lane roads, through developed commercial property and designated agricultural land, and around City boundaries. The undeveloped category was assigned to pipe installed in permanent open space designated as city parks. It was assumed that all NP water lines were installed at less than 10 ft depth unless using trenchless installation for crossings.

Trenchless installation costs (in $/LF of pipe) include the casing and carrier pipe, supports and grouting of the interstitial space, launching and receiving pits, and ground monitoring using J&B drilling or HDD. Unit prices were developed using bid tabs and CDM Smith's construction cost data base.

Table I-1 gives the unit cost breakdown for installation of NP water lines.

Table I-1 – Unit Costs for NP Lines

Pipe Diameter Size (In.)	Unit Cost ($/LF of Pipe)			
	Undeveloped Land Designation	Developed Land Designation	Trenchless J&B (Crossings)	Trenchless HDD (River Crossings)
8	119	172	478	585
12	131	184	584	803
16	158	224	791	944
18	171	256	897	1,023
20	184	289	1,105	1,107
24	211	315	1,314	1,272
30	237	368	1,531	1,530
36	264	421	1,960	1,796
42	302	486	2,370	2,054
48	355	566	2,813	2,312
54	395	657	3,288	2,570
60	460	763	3,796	2,827

<u>Pump Stations</u>

Construction costs of new pump stations were developed using Chapter 29 of *Pumping Station Design, Revised 3rd Ed*. (Jones et al. 2006). High and low trend line estimates were averaged based on 2006 cost projections and then projected to the inflated August 2020 equivalents. The cost estimates only include construction of new pump station infrastructure including enclosures, wet wells, instrumentation, electrical, and pumps. The updated August 2020 high, low, and averaged pump station equations are shown below:

$$\textbf{Low Limit New PS Cost}(\$) = \$\mathbf{2,367} \times \textbf{PS Flow Rate } (\textbf{gpm})^{\mathbf{0.77}}$$

$$\textbf{High Limit New PS Cost}(\$) = \$\mathbf{33,648} \times \textbf{PS Flow Rate } (\textbf{gpm})^{\mathbf{0.62}}$$

$$\textbf{Averaged Limit New PS Cost}(\$) = \$\mathbf{15,844} \times \textbf{PS Flow Rate } (\textbf{gpm})^{\mathbf{0.66}}$$

Figure I-3 depicts the comparison of the three equations used for new pump station construction estimates. This master plan assumes all new pump stations costs using the averaged pump station equation.

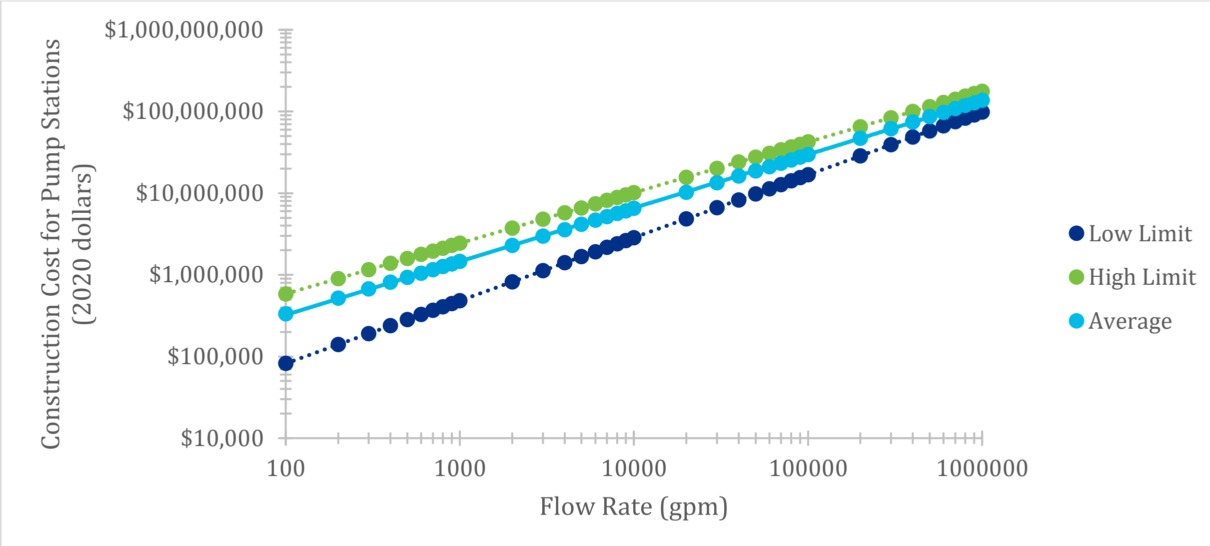

Figure I-3 Pump Station Design High, Low, and Averaged Estimated Construction Costs (Jones et al. 2006)

<u>Ponds</u>

Construction costs for either ponds to accommodate additional storage, or the installation of new ponds, assumed the installation cost of new ponds as a conservative estimate. Pond replacement and new pond installation in $/AF included costs for pond excavation, subgrade, pond liners and fabric, covering of soil over lake bottom, rip rap, and aeration systems. Pond sizing (in AF) for each project was estimated on future buildout conditions identified in the future system model.

I.1.7 Crossings, Land Considerations, and Dewatering

<u>Irrigation Ditch, River Crossings, and Lake Crossings</u>

ArcMap GIS and City-provided information was used to identify irrigation ditch, river, and lake crossing locations. Irrigation ditch, river, and lake crossings were assumed as 100 ft in length, 250 ft in length, and estimated lake crossing length, respectively. Unit costs for irrigation ditch, river, and lake crossings were approximated by trenchless pipe installation, regardless of pipe depth, using J&B for ditch crossings and HDD drilling for river and lake crossings.

<u>Utility, Roadway, and Railway Crossings</u>

ArcMap GIS, the City's online GIS, and Google Maps were used to identify road, utility, and railroad crossings. Unit prices were developed assuming installation by J&B, where applicable, using the following assumptions:

- Roads were separated into typical (defined as: two to three lane roads located on side streets and in neighborhoods), arterial (defined as: major roadways of four lanes or more assumed at 200 ft wide), and highways (defined as: major roadways with Colorado Department of Transportation Right-of-way requirements at 250 ft wide). Widths were based on the U.S. Department of Transportation Federal Highway Administration (USDOT, 2014). Typical road crossings were included as part of overall open cut installation described in **Section I.3.3,** while arterial road and highway crossings were accounted as a part of trenchless pipe installation costs described in **Section I.2.2**.

- Railway crossings were estimated as 150 ft in length included in trenchless installation costs, described in **Section I.2.2**.
- Other City and non-City utilities were not included as unit cost estimates but assumed to be covered under project contingency, described in **Section 5.3.5**.

Easements

Easement acquisition was assumed to be required for all new pipeline, not in a City right-of-way or on City-owned property. Easement acquisition was assumed as a costing factor multiplier of the total OPCC at 5%.

Dewatering

A three-tiered approach was used to determine projected dewatering. The three tiers used for unit cost estimation were developed considering land elevations in and around the City (between approximately 4,600 ft to 5,060 ft), 100-year floodplain maps, and proximity to irrigation ditches and water bodies. Tier 1 includes water distribution and transmission line construction within the 100-year floodplain or within 50 ft of an irrigation ditch, pond, or lake. Tier 2 includes pipe that is not in Tier 1, is below the median elevation of the City (4,828 ft), and is assumed to require 50% of the dewatering needed for Tier 1. Tier 3 includes pipe in areas above the median elevation and assumes no dewatering is required.

Figure I-4 illustrates the three-tiered dewatering profile. **Table I-2** lists the unit costs developed for the three-tiered dewatering categories in $/LF of pipe.

Table I-2 – Unit Costs for Dewatering by Tier

Tier	Unit Cost ($/LF of Pipe)
1	105
2	52.50
3	0

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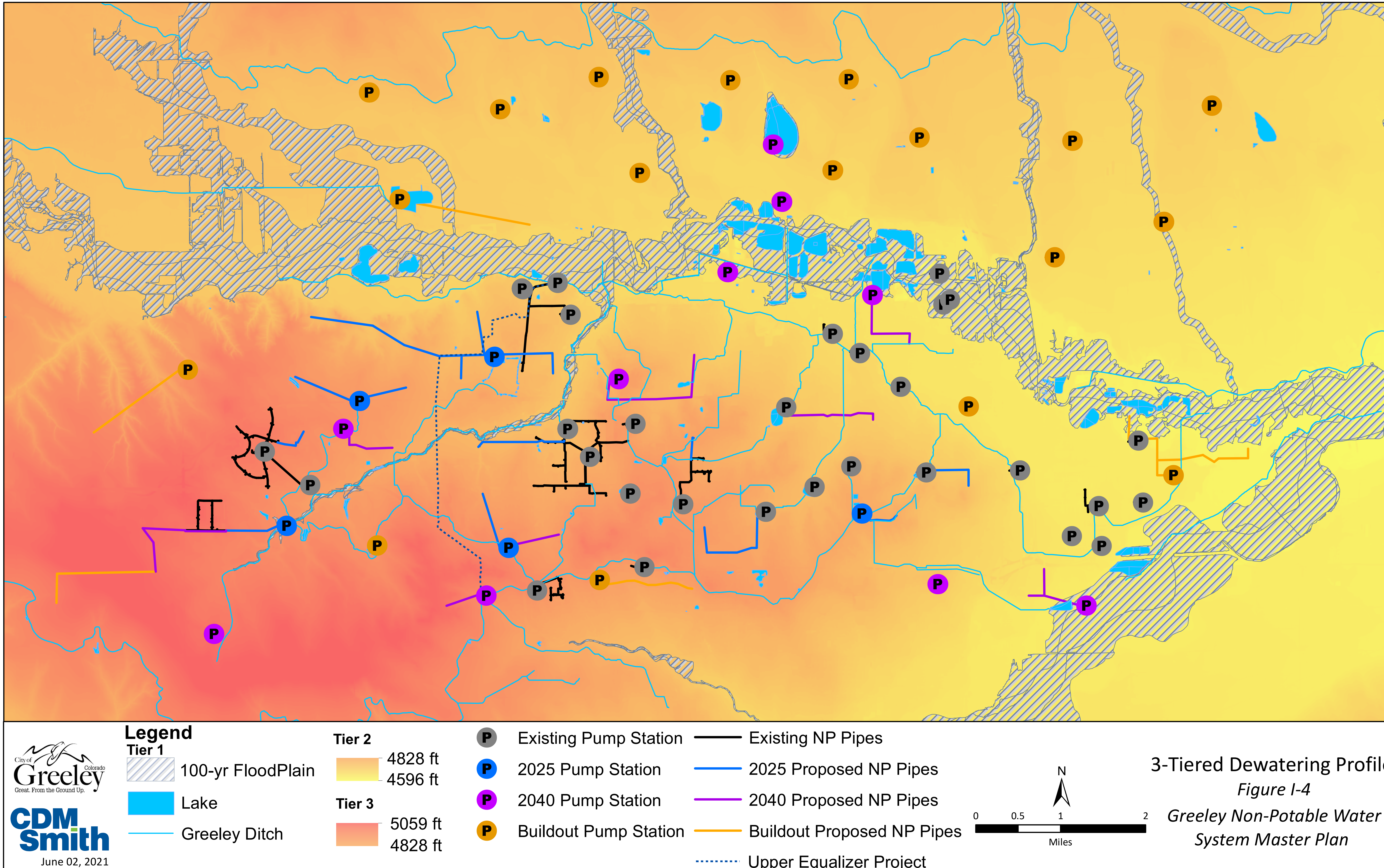

3-Tiered Dewatering Profile

Figure I-4

Greeley Non-Potable Water System Master Plan

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I.1.8 Project Implementation and Additional Project-Related Costs

Project elements considered part of project implementation as well as additional project related costs are difficult to quantify at the planning level. Construction elements include items such as erosion control and stormwater pollution prevention and contractor mobilization and demobilization. These costs are estimated as a percentage of the subtotal pipe, pump stations, ponds, and equipment. Contingency is applied to the subtotal of these construction cost elements to account for variations in unit prices or quantity estimates. Programmatic elements include engineering, permitting, legal and administration and are estimated as a percentage of the construction cost.

Table I-3 provides a breakdown of the different assumptions used for project implementation and contingency.

Table I-3 – Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention[1]	2%
	Mobilization and Demobilization[1]	5%
	Contingency[2]	35%
Project Implementation[3]	Feasibility and Site Studies	9% for OPCC ≤ $1M 6% for OPCC of $1M to $10 Mil. 5% for OPCC > $10M
	Preliminary and Final Design	9% for OPCC ≤ $1M 6% for OPCC of $1M to $10M 5% for OPCC > $10M
	Engineering Services During Construction	5%
Additional Project-Related Costs[3]	Outside Construction Management - not used if project value is < $1M	5%
	Outside Project Management - not used if project value is < $1M	3%

[1] Construction Bid Cost costing factors erosion control/stormwater pollution prevention and mobilization and demobilization are added to the subtotal of unit cost items.

[2] Contingency costing factor is 35% of the subtotal of the unit cost items and contractor born costs determined by costing factors.

[3] Project Implementation and Additional Project-Related Cost categories are determined as a percentage of the construction cost and part of the total CIP project costs.

<u>Project Erosion Control/Stormwater Pollution Prevention</u>

The Project Erosion Control and Stormwater Pollution Prevention cost element includes the contractors cost to manage the stormwater during construction through best management practices. These best management practices include items such as silt fences, rock socks, vehicle tracking, and silt prevention at storm inlets. This category is assumed as 2% of the OPCC subtotal of the items that have unit costs and is based on estimator's judgement and prior reports. This costing factor is added to calculate project OPCC totals.

Mobilization and Demobilization

The Contractor Mobilization and Demobilization cost element includes the contractor's start-up costs and close-out costs. Start-up costs include items such as moving equipment and personnel to the project location, obtaining permits and bonds, etc. Close-out costs include items such as project cleanup, moving equipment and personnel from the project location, etc. The mobilization and demobilization category is assumed as 5% of the OPCC subtotal of the items that have unit costs and is based on estimator's judgement and prior reports. This costing factor is added to calculate project OPCC totals.

Contingency

During the planning phase, the field work and design have not yet been completed for the projects. Therefore, the cost development relies on estimated quantities for each construction element. Project contingency provides for these uncertainties by adding additional costs to the project total. The contingency at the planning level is typically 35% of the OPCC subtotal, after erosion control and stormwater pollution prevention and mobilization and demobilization costing factors have been included. Project contingency also provides for cost associated with items that are difficult to itemize at a planning level.

Feasibility and Site Studies

The Feasibility and Site Studies cost element includes the planning and field investigations (such as geotechnical, survey, ground sampling, utility locates, etc.) required to implement a project and is estimated as a percentage of the subtotal of the previous elements. The percentage varies based on the OPCC, plus cost contingency.

Preliminary and Final Design

The Preliminary and Final Design cost element includes the cost for engineering services to develop biddable plans and specifications in accordance with applicable standards. This cost is estimated using a percentage of the OPCC, plus cost contingency.

Engineering Services During Construction

The Engineering Services During Construction cost element includes a review of contractor submittals, requested changes, and design adjustments that may be required during construction. A flat percentage of the OPCC is used to estimate this cost element.

Additional Project-Related Costs

Outside construction and project management are estimated for projects that are not directly managed by the City. For purposes of this master plan, only projects in excess of $1M were assigned these cost elements.

Appendix J

Annual Funding Requirements for City NP CIP Projects (2020 – 2043)

Annual funding requirements per identified City NP CIP project and fiscal year totals are shown in the following table. It was assumed that each project stage (planning, design, and construction) will take at least one year with the construction phase taking two, three, or four years if the total CIP cost for a project was greater than $1 million, $5 million, or $10 million, respectively.

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Appendix J – Annual Funding Requirements for City NP CIP Projects (2020-2043)

W/S Expense

Project Names	Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park	2020	2021	2022	$ 167,819	$ 167,819	$ 1,050,140	$ 1,050,140	$ 1,050,140	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional PS	2021	2021	2022	$ -	$ 21,239	$ 66,637	$ 66,637	$ 66,637	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 2	2021	2021	2022	$ -	$ 9,980	$ 33,089	$ 33,089	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Greeley West PS	2021	2022	2023	$ -	$ 296,110	$ 296,110	$ 1,855,015	$ 1,855,015	$ 1,855,015	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upper Equalizer	2022	2023	2024	$ -	$ -	$ 2,002,000	$ 1,001,000	$ 5,653,000	$ 5,653,000	$ 5,653,000	$ 5,653,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tech Center Supply	2024	2025	2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Prom Park Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA38 1st Ave Pond	2024	2025	2026	$ -	$ -	$ -	$ -	$ 244,011	$ 133,243	$ 1,251,763	$ 1,251,763	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Twin Rivers Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 25,607	$ 25,607	$ 298,748	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Monfort Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 246,259	$ 134,412	$ 842,610	$ 842,610	$ 842,610	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA-25 Westgate Reg. Phase 1	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA60 Lake Bluffs	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 1,205	$ 1,205	$ 11,339	$ 11,339	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA25 Westgate Reg. PS	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 390,887	$ 213,003	$ 1,337,312	$ 1,337,312	$ 1,337,312	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA34 30st 17Ave	2027	2028	2029	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 92,599	$ 92,599	$ 871,972	$ 871,972	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA4 35 Ave Ost	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,457	$ 13,457	$ 117,747	$ 117,747	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 3	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 21,654	$ 11,803	$ 74,100	$ 74,100	$ 74,100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA3 35 Ave AA st	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bittersweet Park Exp.	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 82,245	$ 82,245	$ 774,669	$ 774,669	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA35 44ave Fst	2030	2031	2032	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,980	$ 7,980	$ 74,909	$ 74,909	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA36 59 ave 10st	2031	2032	2033	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 182,863	$ 182,863	$ 1,148,049	$ 1,148,049	$ 1,148,049	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA16 95ave 16st	2034	2035	2036	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 17,365	$ 9,482	$ 59,391	$ 59,391	$ 59,391	$ -	$ -	$ -	$ -	$ -
SA14 Tech Cent Exp	2035	2036	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA15 37st SH257	2036	2037	2038	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA12 Cobblestone	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,128	$ 1,161	$ 10,875	$ 10,875	$ -	$ -	$ -
Glenmere Park Exp	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 234,308	$ 127,863	$ 1,199,450	$ 1,199,450	$ -	$ -	$ -
SA25 Westgate Reg. Phase 2	2038	2039	2040	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 94,171	$ 60,438	$ 350,683	$ 350,683	$ -	$ -
SA42 23ave Cst	2039	2040	2041	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 212,568	$ 115,870	$ 727,038	$ 727,038	$ 727,038
Total				$ 167,819	$ 495,147	$ 3,447,976	$ 4,005,882	$ 9,140,670	$ 8,193,370	$ 8,260,329	$ 9,188,622	$ 2,318,971	$ 2,316,788	$ 1,154,044	$ 1,157,360	$ 1,106,541	$ 1,222,958	$ 1,165,414	$ 1,157,532	$ 59,391	$ 295,828	$ 282,587	$ 1,483,331	$ 1,676,878	$ 1,077,721	$ 727,038	$ 727,038

Parks

Project Names	Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park	2020	2021	2022	$ 66,361	$ 66,361	$ 415,257	$ 415,257	$ 415,257	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional PS	2021	2021	2022	$ -	$ 66,595	$ 208,945	$ 208,945	$ 208,945	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 2	2021	2021	2022	$ -	$ 31,292	$ 103,754	$ 103,754	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Greeley West PS	2021	2022	2023	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upper Equalizer	2022	2023	2024	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tech Center Supply	2024	2025	2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Prom Park Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA38 1st Ave Pond	2024	2025	2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Twin Rivers Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 7,934	$ 7,934	$ 92,564	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Monfort Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 76,301	$ 41,646	$ 261,075	$ 261,075	$ 261,075	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA-25 Westgate Reg. Phase 1	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA60 Lake Bluffs	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA25 Westgate Reg. PS	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 121,113	$ 65,997	$ 414,355	$ 414,355	$ 414,355	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA34 30st 17Ave	2027	2028	2029	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,472	$ 13,472	$ 126,865	$ 126,865	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA4 35 Ave Ost	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 3	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67,899	$ 37,008	$ 232,347	$ 232,347	$ 232,347	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA3 35 Ave AA st	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bittersweet Park Exp.	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 22,584	$ 22,584	$ 212,722	$ 212,722	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA35 44ave Fst	2030	2031	2032	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,639	$ 31,639	$ 296,997	$ 296,997	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA36 59 ave 10st	2031	2032	2033	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 123,299	$ 123,299	$ 774,098	$ 774,098	$ 774,098	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA16 95ave 16st	2034	2035	2036	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 51,630	$ 28,193	$ 176,586	$ 176,586	$ 176,586	$ -	$ -	$ -	$ -	$ -
SA14 Tech Cent Exp	2035	2036	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA15 37st SH257	2036	2037	2038	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA12 Cobblestone	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Glenmere Park Exp	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 98,984	$ 54,016	$ 506,711	$ 506,711	$ -	$ -	$ -
SA25 Westgate Reg. Phase 2	2038	2039	2040	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA42 23ave Cst	2039	2040	2041	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 120,194	$ 65,518	$ 411,095	$ 411,095	$ 411,095
Total				$ 66,361	$ 164,247	$ 727,957	$ 727,957	$ 708,438	$ 170,693	$ 419,637	$ 688,902	$ 756,801	$ 600,812	$ 413,435	$ 600,007	$ 865,365	$ 1,071,095	$ 825,728	$ 802,291	$ 176,586	$ 275,570	$ 230,602	$ 626,905	$ 572,229	$ 411,095	$ 411,095	$ 411,095

Development

Project Names	Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park	2020	2021	2022	$ 7,820	$ 7,820	$ 48,935	$ 48,935	$ 48,935	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional PS	2021	2021	2022	$ -	$ 576,166	$ 1,807,751	$ 1,807,751	$ 1,807,751	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 2	2021	2021	2022	$ -	$ 270,729	$ 897,657	$ 897,657	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Greeley West PS	2021	2022	2023	$ -	$ 62,890	$ 62,890	$ 393,985	$ 393,985	$ 393,985	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upper Equalizer	2022	2023	2024	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tech Center Supply	2024	2025	2026	$ -	$ -	$ -	$ -	$ 36,000	$ 36,000	$ 420,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Prom Park Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 202,000	$ 110,000	$ 1,034,500	$ 1,034,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA38 1st Ave Pond	2024	2025	2026	$ -	$ -	$ -	$ -	$ 59,989	$ 32,757	$ 307,737	$ 307,737	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Twin Rivers Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 18,659	$ 18,659	$ 217,688	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Monfort Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 179,440	$ 97,942	$ 613,982	$ 613,982	$ 613,982	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA-25 Westgate Reg. Phase 1	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 126,000	$ 81,000	$ 472,500	$ 472,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA60 Lake Bluffs	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 126,795	$ 126,795	$ 1,192,661	$ 1,192,661	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA25 Westgate Reg. PS	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA34 30st 17Ave	2027	2028	2029	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,929	$ 31,929	$ 300,663	$ 300,663	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA4 35 Ave Ost	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,543	$ 46,543	$ 407,253	$ 407,253	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 3	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 587,447	$ 320,189	$ 2,010,219	$ 2,010,219	$ 2,010,219	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA3 35 Ave AA st	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 152,000	$ 152,000	$ 1,424,000	$ 1,424,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bittersweet Park Exp.	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA35 44ave Fst	2030	2031	2032	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 84,381	$ 84,381	$ 792,094	$ 792,094	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA36 59 ave 10st	2031	2032	2033	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 86,838	$ 86,838	$ 545,186	$ 545,186	$ 545,186	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA16 95ave 16st	2034	2035	2036	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 376,005	$ 205,324	$ 1,286,023	$ 1,286,023	$ 1,286,023	$ -	$ -	$ -	$ -	$ -
SA14 Tech Cent Exp	2035	2036	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 293,000	$ 160,000	$ 1,503,000	$ 1,503,000	$ -	$ -	$ -	$ -	$ -
SA15 37st SH257	2036	2037	2038	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 186,000	$ 186,000	$ 1,751,500	$ 1,751,500	$ -	$ -	$ -	$ -
SA12 Cobblestone	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 184,872	$ 100,839	$ 944,625	$ 944,625	$ -	$ -	$ -
Glenmere Park Exp	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 27,708	$ 15,120	$ 141,839	$ 141,839	$ -	$ -	$ -
SA25 Westgate Reg. Phase 2	2038	2039	2040	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 39,829	$ 25,562	$ 148,317	$ 148,317	$ -	$ -
SA42 23ave Cst	2039	2040	2041	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 177,238	$ 96,612	$ 606,201	$ 606,201	$ 606,201
Total				$ 7,820	$ 917,606	$ 2,817,234	$ 3,148,328	$ 2,746,759	$ 942,137	$ 2,801,701	$ 3,653,309	$ 2,945,062	$ 819,395	$ 2,954,516	$ 4,012,691	$ 4,313,151	$ 1,337,280	$ 921,192	$ 1,043,511	$ 1,632,023	$ 3,187,602	$ 4,696,311	$ 3,040,764	$ 1,331,393	$ 754,518	$ 606,201	$ 606,201

Totals

Project Names	Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park	2020	2021	2022	$ 242,000	$ 242,000	$ 1,514,333	$ 1,514,333	$ 1,514,333	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional PS	2021	2021	2022	$ -	$ 664,000	$ 2,083,333	$ 2,083,333	$ 2,083,333	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 2	2021	2021	2022	$ -	$ 312,000	$ 1,034,500	$ 1,034,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Greeley West PS	2021	2022	2023	$ -	$ 359,000	$ 359,000	$ 2,249,000	$ 2,249,000	$ 2,249,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upper Equalizer	2022	2023	2024	$ -	$ -	$ 2,002,000	$ 1,001,000	$ 5,653,000	$ 5,653,000	$ 5,653,000	$ 5,653,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Monfort Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 36,000	$ 36,000	$ 420,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Twin Rivers Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 202,000	$ 110,000	$ 1,034,500	$ 1,034,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA38 1st Ave Pond	2024	2025	2026	$ -	$ -	$ -	$ -	$ 304,000	$ 166,000	$ 1,559,500	$ 1,559,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Prom Park Exp	2024	2025	2026	$ -	$ -	$ -	$ -	$ 52,200	$ 52,200	$ 609,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tech Center Supply	2024	2025	2026	$ -	$ -	$ -	$ -	$ 502,000	$ 274,000	$ 1,717,667	$ 1,717,667	$ 1,717,667	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA-25 Westgate Reg. Phase 1	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 126,000	$ 81,000	$ 472,500	$ 472,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA25 Westgate Reg. PS	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 128,000	$ 128,000	$ 1,204,000	$ 1,204,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA60 Lake Bluffs	2025	2026	2027	$ -	$ -	$ -	$ -	$ -	$ 512,000	$ 279,000	$ 1,751,667	$ 1,751,667	$ 1,751,667	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA34 30st 17Ave	2027	2028	2029	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 138,000	$ 138,000	$ 1,299,500	$ 1,299,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA4 35 Ave Ost	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 60,000	$ 60,000	$ 525,000	$ 525,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Boomerang Regional Phase 3	2028	2029	2030	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 677,000	$ 369,000	$ 2,316,667	$ 2,316,667	$ 2,316,667	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bittersweet Park Exp.	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 152,000	$ 152,000	$ 1,424,000	$ 1,424,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA3 35 Ave AA st	2029	2030	2031	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 105,000	$ 105,000	$ 989,000	$ 989,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA35 44ave Fst	2030	2031	2032	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 124,000	$ 124,000	$ 1,164,000	$ 1,164,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA36 59 ave 10st	2031	2032	2033	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 393,000	$ 393,000	$ 2,467,333	$ 2,467,333	$ 2,467,333	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SA16 95ave 16st	2034	2035	2036	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 445,000	$ 243,000	$ 1,522,000	$ 1,522,000	$ 1,522,000	$ -	$ -	$ -	$ -	$ -
SA14 Tech Cent Exp	2035	2036	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 293,000	$ 160,000	$ 1,503,000	$ 1,503,000	$ -	$ -	$ -	$ -	$ -
SA15 37st SH257	2036	2037	2038	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 186,000	$ 186,000	$ 1,751,500	$ 1,751,500	$ -	$ -	$ -	$ -
Glenmere Park Exp	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 187,000	$ 102,000	$ 955,500	$ 955,500	$ -	$ -	$ -
SA12 Cobblestone	2037	2038	2039	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 361,000	$ 197,000	$ 1,848,000	$ 1,848,000	$ -	$ -	$ -
SA25 Westgate Regional Phase 2	2038	2039	2040	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 134,000	$ 86,000	$ 499,000	$ 499,000	$ -	$ -
SA42 23ave Cst	2039	2040	2041	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 510,000	$ 278,000	$ 1,744,333	$ 1,744,333	$ 1,744,333
Grand Total				$ 242,000	$ 1,577,000	$ 6,993,167	$ 7,882,167	$ 12,595,867	$ 9,306,200	$ 11,481,667	$ 13,530,833	$ 6,020,833	$ 3,737,167	$ 4,522,167	$ 5,771,667	$ 6,286,667	$ 3,631,333	$ 2,912,333	$ 3,003,333	$ 1,868,000	$ 3,759,000	$ 5,209,500	$ 5,151,000	$ 3,580,500	$ 2,243,333	$ 1,744,333	$ 1,744,333

[1] Refer to 5- and 20-year recommended improvements map in Section 5 for project locations

[2] Construction span was set based on total CIP cost estimates per project: $10M – 4 years, $5M – 3 years, $1M – 2 years, < $1M – 1 year

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Appendix K

Comprehensive Plan Action Item List

The City adopted the *Imagine Greeley Comprehensive Plan* in 2018, which is a policy guide that provides framework for public and private growth and development decisions made by the City over the next ten to twenty years. As a part of the Comprehensive Plan, a list of recommended actions was identified in Section 5 to assist in implementation of this plan. A summary of action items addressed with the development of this NPMP to ensure implementation of the Comprehensive Plan is summarized in the following table.

INFRASTRUCTURE (IN)

IMPLEMENTATION ACTION	NON-POTABLE MASTERPLAN ACTION ITEM RESPONSE
Goal IN-1: Ensure developed areas in Greeley are served by adequate public facilities and services.	
IMP IN-1.1 Annually review and update the City's Adequate Public Facilities Area (APFA) concurrent with annual growth and development projections to assist in the planning and funding of municipal infrastructure to accommodate growth. Prepare maps depicting the boundaries of existing and budgeted service areas for infrastructure included in the APFA requirements.	**While the NPMP does not review or update the APFA, it identifies the critical infrastructure needed to serve all major developable areas within the LREGA (Section 5) and the anticipated CIP cost (Section 6). This masterplan will assist in planning and funding of municipal infrastructure and determine the anticipated infrastructure to meet the APFA requirements.**
IMP IN-1.2 Continue to support timely and effective development in the Long Range Expected Growth Area as it relates to 208 Wastewater planning and treatment. Where possible and practical, look for opportunities to share and/or coordinate such capital improvements with other jurisdictions to efficiently use public resources.	**Not Applicable**
IMP IN-1.3 Through the annual Population Growth and Projections and Capital Improvements Plan, identify the location for new fire stations, parks and other public facilities commensurate with the City's expected growth.	**Not Applicable**
IMP IN-1.4 Complete and implement a basin-wide study that addresses drainage improvements through larger, shared, facilities which could also achieve an attractive, functional community or regional park use.	**Not Applicable**
IMP IN-1.5 Evaluate existing capacity within established areas of the city to understand where investments in expanding infrastructure will be needed in order to support the type and/or intensity of development envisioned in the Land Use Guidance Map	**This masterplan has evaluated existing infrastructure to confirm sufficient capacity with the existing conditions, with future development of infill and densification of parcels, and full buildout as envisioned by the Land Use Guidance Map.**

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IMPLEMENTATION ACTION	NON-POTABLE MASTERPLAN ACTION ITEM RESPONSE
IMP IN-1.6 Update existing functional master plans for infrastructure and services as needed to account for changes in land uses and intensities that result from the adoption of this Comprehensive Plan and completion of implementation actions.	**This masterplan incorporates improvements made to the NP water distribution system from the most recent masterplan completed in 2004. This masterplan has incorporated recent land use applications, utilized the Comprehensive Plan to update land uses and anticipated densities, and addressed areas outside of the 20-year plan through guidance and coordination with the Planning department.**
IMP IN-1.7 Develop functional master plans detailing the maintenance, operation, and expansion of infrastructure and public facilities where such documents do not currently exist.	**Not Applicable**
IMP IN-1.8 Consider the extension of water lines to serve larger groups of users and along primary roadways to provide non-potable water to landscaped medians and parkways.	**Not Applicable**

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Appendix L

Greeley Policy for Non-Potable Irrigation

[Final NP policy will be appended here when approved by the City.]

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