Integrated Water Resource Plan

Draft Final

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Prepared for:

City of Greeley Water and Sewer Department

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EXECUTIVE SUMMARY

The Integrated Water Resources Plan (IWRP) for the City of Greeley Water and Sewer Department (Greeley) is a long-term strategic water resources master plan that ensures sustainable and affordable water supplies for their customers now and into the future. This comprehensive plan integrates Greeley's water supply system and projected demands with possible future conditions around hydrology, climate change, and risks to Greeley's water supply system. The IWRP establishes a plan for triggering the Terry Ranch Project (a new aquifer storage and recovery project), a process for evaluating and strategically acquiring water rights, a 10-year Capital Improvement Plan (CIP), and an Adaptive Plan for Greeley to follow.

INTRODUCTION AND PROCESS

Historically, many water resource planning efforts focused on developing a firm yield based on a single set of historical conditions. Projects were selected and prioritized based solely on their ability to improve firm yield under this one set of conditions. Recent events have shown that future conditions are highly uncertain and planning for a single future increases the risk of water supply failure. Greeley, building off a history of effective and prudent planning efforts, elected to complete an integrated planning process for this IWRP to better plan for an increasingly uncertain future.

In implementing an integrated planning process, the IWRP developed "Planning Scenarios" that capture a range of possible future conditions for Greeley's water supply system. These were applied at key points in time (e.g., "Planning Horizons") for Greeley's water supply system. **Figure ES-1** shows the three IWRP Planning Horizons – the first defined what water resources projects are required in the next 10 years, the second identifies when to integrate the Terry Ranch Project, and the third established how to best use the Terry Ranch Project once fully integrated and if that use is sustainable.

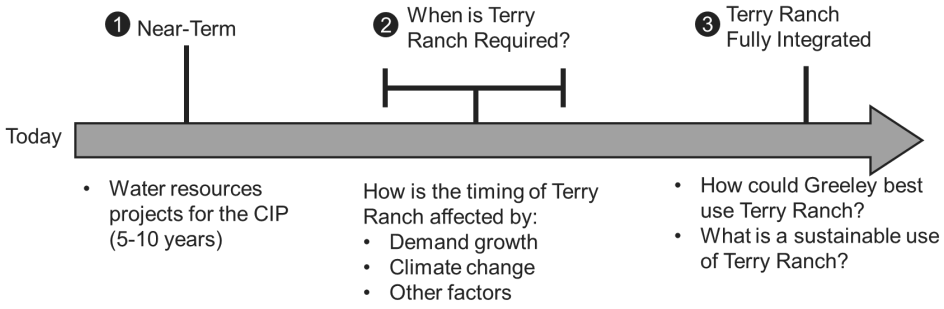

Figure ES-1. Planning Horizons Used in the IWRP

Due to the significant uncertainty around what the future could look like, the IWRP did not predict what future condition is most likely to occur. Instead, a Planning Scenario methodology was applied that captures a range of possible future conditions for Greeley's water supply system. The Planning Scenarios and their associated conditions are shown graphically in **Figure ES-2**. The *Unbearable* Planning Scenario

was the reasonable high-bookend for Greeley's water supply system and combines the hottest climate, the highest demand projections, and significant risk impacts. The *Stressed* Planning Scenario assumes the hottest climate, a lower demand projection, and moderate risk impacts. The *Continued Trends* Planning Scenario assumes a warmer climate, continued decreases in per capita water use, and moderate risk impacts. The *Optimistic* scenario assumes a warmer climate, the lowest demand projections, and least risk impacts. Finally, the *No Climate Change* planning scenario includes no climate change, a higher demand projection than *Optimistic* as the lack of climate change would likely encourage higher Greeley growth, and low risk impacts.

Figure ES-2. Planning Scenarios used in the IWRP

Planning Scenario Name	Climate Warming	CO River Basin Risk Impacts	Water Supply System Yields	Demands
Unbearable		High		
Stressed		Moderate		
Continued Trends		Moderate		
Optimistic		Low		
No Climate Change		Low		

An important element in the IWRP was defining when future water supply system performance was acceptable, which the IWRP set using 'planning performance criteria'. **Figure ES-3** presents the planning performance criteria and their acceptability definitions.

Figure ES-3. Planning Performance Criteria Used in the IWRP

Performance Criteria	Acceptable Performance
Are Greeley customers being significantly impacted?	Drought Restrictions used at any level no more than 20% of years and no more than 10% of years in Level 3
Greeley maintains sufficient emergency reserve.	April 1 storage volume has at least 6 months of indoor demands in 100% of years
Greeley meets critical water needs for public health.	Indoor demands are met 100% of the time.

FUTURE CONDITIONS ASSESSMENT

The IWRP completed a risk assessment that identified, prioritized, and evaluated a comprehensive list of events that could impact Greeley's water supply system. This assessment identified four risk "drivers", defined as major events or conditions that are outside Greeley's control that could impact their ability to provide sustainable water supply to their customers. The drivers identified for the IWRP were:

- The **Climate Change Impacts on Hydrology** driver captures risks that could change what Greeley's existing water rights yield and the timing of that yield compared to what has been experienced historically. This is due to a combination of droughts of increased intensity, duration, and/or frequency compared to the historical record, runoff impacts, and the overall hydrograph from a warmer climate.
- The **Future Demand Uncertainty** driver captures risks that affect how much water demand Greeley's system would need to meet in the future and how water is used compared to historical usage. This includes population growth, outdoor water use variability, and climate change impacts to demands.
- The **Water Rights Administration Complexity and Uncertainty** driver captures risks that affect Greeley's ability to change currently owned water rights, acquire new water rights, and yields from existing and future water rights. This includes increased competition for new water rights, the legal complexity of changing water rights, and uncertainty related to how water rights administration may change under a different hydrograph than historical.
- The **Colorado River Basin Issues** driver captures risks to Greeley's yields from the Colorado River Basin which could result in a variety of short- and long-term supply reductions or curtailments.

The *Climate Change Impacts on Hydrology* driver was further evaluated by developing new climate change hydrology that captures the potential impacts of long-term climate change and droughts of increasing intensity, duration, and frequency. An advanced modeling process was completed that quantified the impacts of long-term changes in temperature and precipitation to Greeley's entitlements (e.g., water legally and physically available to Greeley). **Figure ES-4** summarizes the conclusions from this analysis and the confidence of those conclusions.

Figure ES-4. Conclusions from the Climate Change Hydrology Analysis

Conclusion Statement	Confidence	Comment
Droughts of greater duration, frequency, and severity than observed droughts are possible under current climate.	**High**	*Results show these conclusions are consistent with other studies and make logical sense.*
Climates with less precipitation and or warmer climates will decrease Greeley's water supply system yields.	**High**	
Yields from Greeley's junior water rights and certain water supply systems could be vulnerable to changing agricultural demands.	**Moderate**	*It is likely that agricultural demand changes will impact Greeley's entitlements. It is unknown how agricultural demands will change.*
Climates with increased precipitation could increase Greeley's water supply system yields.	**Low**	*Impacts from hydrograph changes cannot be confidently modeled with existing tools.*

The *Future Demand Uncertainty* driver was further evaluated by developing new total demand projections (potable and non-potable) for Greeley at 2030, 2050, and 2070 under four demand scenarios. These four scenarios varied population growth, the extent to which irrigation increases in response to hotter and drier future climate conditions, the extent of future conservation, and the proportion of new housing units that are multifamily apartments and condominiums. **Figure ES-5** shows the new demand projections.

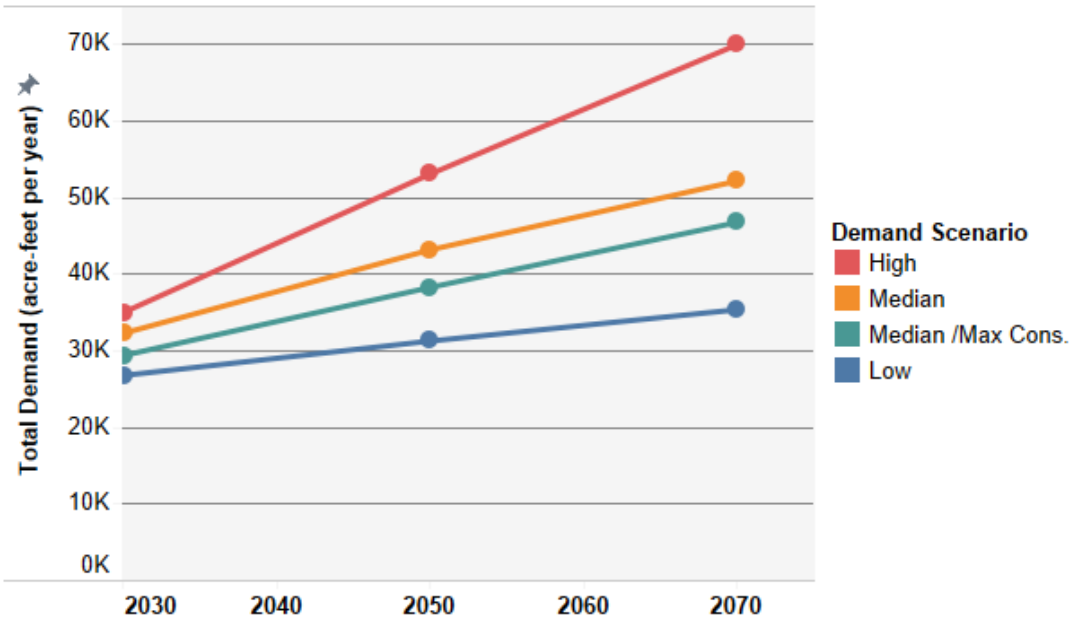

Figure ES-5. Greeley's Projected Future Water Demands

These demand projections are highly variable between the scenarios, with the difference between the high and low scenario increasing from 8,200 acre-feet per year at 2030 (33% of current demands) to 34,600 acre-feet per year at 2070 (137% of current demands). These demand projections assumed demand growth occurs immediately. However, Greeley's total demands have not grown significantly over the last 10 years.

TERRY RANCH TIMING AND INTEGRATION EVALUATION

The *Terry Ranch Timing* analysis determined that Greeley's water supply system without Terry Ranch can meet near-term Planning Scenario conditions. For example, in the *Continued Trends* Planning Scenario, Greeley's system without the Terry Ranch Project can accommodate an additional 10,000 acre-feet per year of demand growth – approximately 40% more demand than current. The IWRP could not confidently time the Terry Ranch Project implementation due to the lack of recent demand growth and the significant variability of future demand projections. In-lieu of assigning a timetable to Terry Ranch Project implementation, Greeley will monitor demands and water supplies as part of the Adaptive Plan.

The *Terry Ranch Integration* analysis determined if Terry Ranch operations would be sustainable long-term under the different Planning Scenarios. The IWRP defined Terry Ranch operations as sustainable if it can deliver sufficient supplies during drought to minimize drought restrictions while maintaining at least 80% of the 1.2 million acre-foot initial aquifer storage volume long-term. **Figure ES-7** shows the results of the Terry Ranch Integration Analysis by Planning Scenario. This table indicates what (if any) additional water resources were included, the percent of years Greeley drought response actions were used, the average annual Terry Ranch "Delta" (average injection minus average extraction), and the percent of the native aquifer remaining at the end of an 86-year simulation period.

Results from the *Terry Ranch Integration* analysis show that the Terry Ranch Project can be operated sustainably in the *Continued Trends*, *Optimistic*, and *No Climate Change* Planning Scenarios. Sustainable operation in these Planning Scenarios will require some additional water supplies and retiming storage. Results from the *Unbearable* and *Stressed* Planning Scenarios show that under the hottest climate change projections and significant demand growth conditions, Terry Ranch Operations are not sustainable. Greeley can monitor climate and demand growth conditions as part of the Adaptive Plan and, if the most impactful future conditions emerge, can adjust the long-term water supply strategy.

Figure ES-6. Tabular Summary of Terry Ranch Integration Results

Planning Scenario	Additional Water Resources	% Years with Drought Response	Annual Terry Ranch Delta (acre-feet per year)	Ending Aquifer Volume (% of 1.2 million acre-foot Volume)
Unbearable	Retiming Storage + Moderate Water Acquisitions	100%	**-10,700**	**23%**
Stressed	Retiming Storage + Moderate Water Acquisitions	64%	**-6,500**	**53%**
Continued Trends	Retiming Storage + Moderate Water Rights	35%	**-1,200**	**91%**
Optimistic	None	12%	**+1,900**	**113%**
No Climate Change	Retiming Storage + Low Water Acquisitions	36%	**-1,900**	**86%**

Color Key Indicates Terry Ranch Sustainability Criteria: **Blue** has sufficient remaining aquifer storage percentage, **Orange** has insufficient remaining aquifer storage percentage

IWRP OUTCOMES AND RECOMMENDATIONS

The IWRP showed that Greeley is well-positioned to provide sustainable and affordable water supplies through an uncertain future. The IWRP's important outcomes and conclusions regarding Greeley's current, near-term, and long-term water supply system are summarized below. **Figure ES-8** shows the recommendations for Greeley to take upon IWRP completion.

- Greeley's current water supply system is resilient against the most likely near-term conditions, but additional water supplies are required to meet projected demands and to mitigate impacts from warmer climate conditions under current Terry Ranch sustainability criteria.
- With the Terry Ranch Project fully integrated, Greeley's water supply system is likely resilient against many possible future conditions including warmer climates, higher demands, and reduced yields. Greeley can sustainably utilize the Terry Ranch Project as a water supply source during droughts long-term when the Terry Ranch Project is coupled with some additional water resources.
- If impacts from climate change are severe and tracking with the hottest projections, Greeley may need to consider additional long-term solutions (i.e., in addition to Terry Ranch).
- The most impactful drivers to Greeley's water supply system – demand growth and climate change impacts – will have long lead times that Greeley can monitor and adapt to.
- Terry Ranch cannot be confidently timed until Greeley sees sustained, significant demand growth.

Figure ES-7. Summary of IWRP Recommendations Used to Develop 10-year CIP and Adaptive Plan

Recommendation	Action
Change Water Rights	Greeley should continue changing existing water rights to municipal use as these will improve the reliability of the existing water supply system before the Terry Ranch Project is integrated.
Continue Strategic Acquisitions	Greeley should acquire water supplies that can be integrated into the current system and the Terry Ranch Project. These water supplies are required to meet projected demands, mitigate climate, and risk impacts to the current water supply system, and improve Terry Ranch operations.
Develop Priority Terry Ranch Infrastructure	The Terry Ranch Project needs to be efficiently integrated into Greeley's water supply system once it is required. Greeley should continue incrementally implementing project components (pipelines, right of way, water rights) to ensure this project is readily available to Greeley.
Study Potential Conceptual Retiming Storage Options	The IWRP identified a retiming storage project as a potentially beneficial project to improve the sustainability of Terry Ranch operations. As the IWRP only included a conceptual definition of the project, Greeley should further define this project and align the concept with real facilities.
Implement Adaptive Planning to Monitor Drivers and Trigger Terry Ranch	While the IWRP showed Greeley's water supply system is resilient against warmer futures and increased demands, it is still vulnerable to significantly stressful future conditions. Additionally, the IWRP could not confidently define when Terry Ranch is required due to uncertainty in demand growth. Greeley should implement an Adaptive Planning process that regularly updates IWRP outcomes and re-evaluates the Terry Ranch timing.