Water 2120: Securing Our Water Future

Volume I: Main Text and Appendices

Water 2120:
Securing
Our Water
Future

Executive Summary ES

Executive Summary

The Albuquerque Bernalillo County Water Utility Authority works to provide reliable, high-quality, affordable, and sustainable water supply, wastewater collection treatment, and reuse systems to support a healthy, environmentally sustainable, and economically viable community. ***Water 2120*** *outlines a plan to ensure success over the next century.*

Key Findings and Recommendations

- Resilience in the face of uncertainty in both future supply and demand requires preparing for a range of possible water supply and demand scenarios.
- Conservation and a shift to direct use of surface water over the last decade have enabled substantial recovery in Albuquerque's depleted aquifer, providing flexibility in planning for the future.
- Under the baseline scenario, Albuquerque has sufficient supplies in its current portfolio of groundwater and surface water to serve a growing community, even in a drier future, through at least the 2060s under the worst-case scenario; and well into the 2080s under the Medium Demand/Medium Growth scenario (see Table ES-1).
- Prudent future investments in conservation, aquifer storage, stormwater capture, wastewater reuse, and other supply portfolio and water storage options can extend existing supplies for decades longer under a variety of scenarios, providing a reliable water supply for our community's future while preserving our aquifer as an emergency reserve.

Table ES-1. Summary of Metrics for Evaluating Current Practices under the Baseline Scenario

Metric	Measure	LH	MM	HL	Unit
Aquifer Drawdown	Average production well drawdown, year 2120	137	203	234	ft
Supply Gap	First year new supply needed	--[1]	2088	2062	year
Supply Gap	Average annual new supply needed, 2100-2120	0	38,000	65,000	ac-ft
Available Return Flow	Average annual available return flow, 2040-2120	13,195	7,323	9,358	ac-ft

Notes:

[1] Under the LH scenario, no additional water supplies are needed during the planning period ending 2120

LH = "Low" water demand, "High" water supply planning scenario

MM = "Medium" water demand, "Medium" water supply planning scenario

HL = "High" water demand, "Low" water supply planning scenario

ft = feet

ac-ft = acre-feet

Managing the Present

The Albuquerque Bernalillo County Water Utility Authority (Water Authority), New Mexico's largest municipal water utility, serves 660,000 customers in the City of Albuquerque and surrounding areas of Bernalillo County area with water and wastewater services.

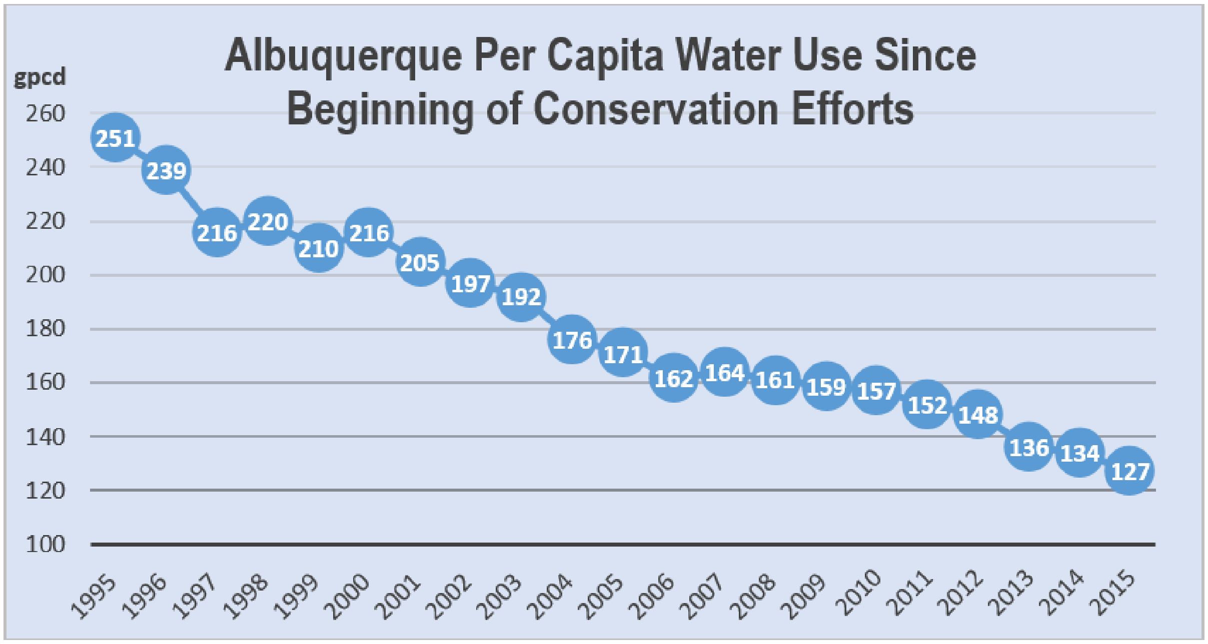
Formed in 2003 as the successor to the City of Albuquerque's municipal water utility, the Water Authority inherited an ambitious agenda laid out by city leaders in the 1990s to ensure a sustainable water supply future by reducing the community's reliance on a rapidly declining aquifer.

Albuquerque's drinking water comes from two sources: the aquifer beneath the city, and San Juan-Chama surface water which is imported from the Colorado River basin into the Rio Grande Basin from the headwaters of the San Juan River in southern Colorado.

Until recently, Albuquerque could only make direct use of its groundwater, reducing management flexibility and leaving the community's long-term water sustainability at risk. The 2008 completion of Albuquerque's $500 million San Juan-Chama Drinking Water Project along with two water reuse and reclamation projects allowed direct use of surface water for the first time since Albuquerque residents in the 1800s hauled river water to their homes in barrels. A diversion near Alameda on Albuquerque's northern end moves river water to a treatment plant at Renaissance Center where it is purified for distribution across the metropolitan area.

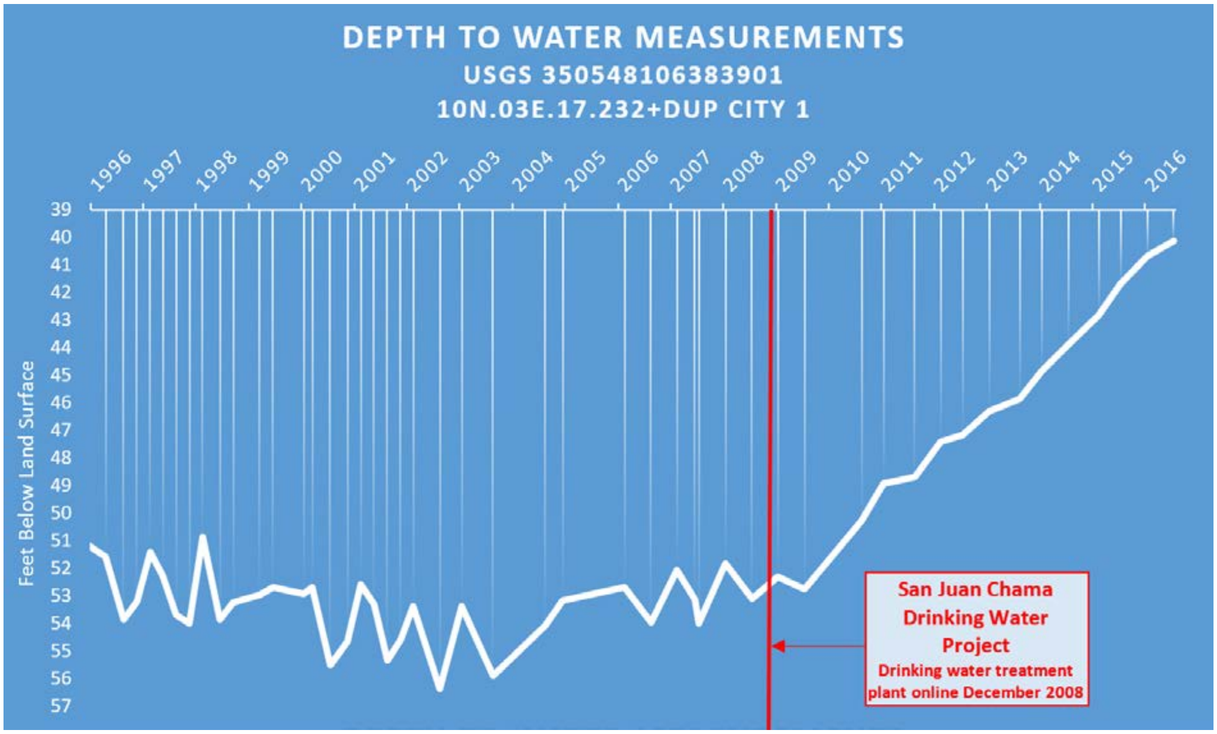
In addition to the diversification of our water resources, conservation efforts begun in the mid-1990s cut per capita water use nearly in half (Figure ES-1), one of the most successful conservation programs in the arid western United States.

Figure ES-1. Albuquerque Per Capita Water Use, 1995-2015



Note: gpcd = gallons per capita per day

Figure ES-2. Depth to Water Measurements for USGS location 350548106383901, within Albuquerque city limits. Note the steady increase in level after the start-up of the San Juan-Chama Drinking Water Project's water treatment plant.



With the success of those initiatives, Albuquerque dramatically reduced groundwater pumping – from 128,000 acre-feet (ac-ft) per year (afy) in 1990 to just 41,000 afy in 2015, a two-thirds reduction in the amount of groundwater used.

Together, conservation and use of surface water reversed the aquifer's decline. Groundwater levels are rising and to date have risen an average of 15 feet since 2008 (Figure ES-2).

Modeling done for **Water 2120** suggests the aquifer will continue to rise well into the 2020s. Those successes and the learning experiences in both aquifer management and conservation programs that went with them have opened Albuquerque's range of policy options to meet our future water needs.

Planning for the Future: Water Demand

With no agricultural use or major water-using industries, the majority of the Water Utility's supply goes to Albuquerque residents' homes and the offices where they work. As a result, estimating population growth is central to long-range water supply planning.

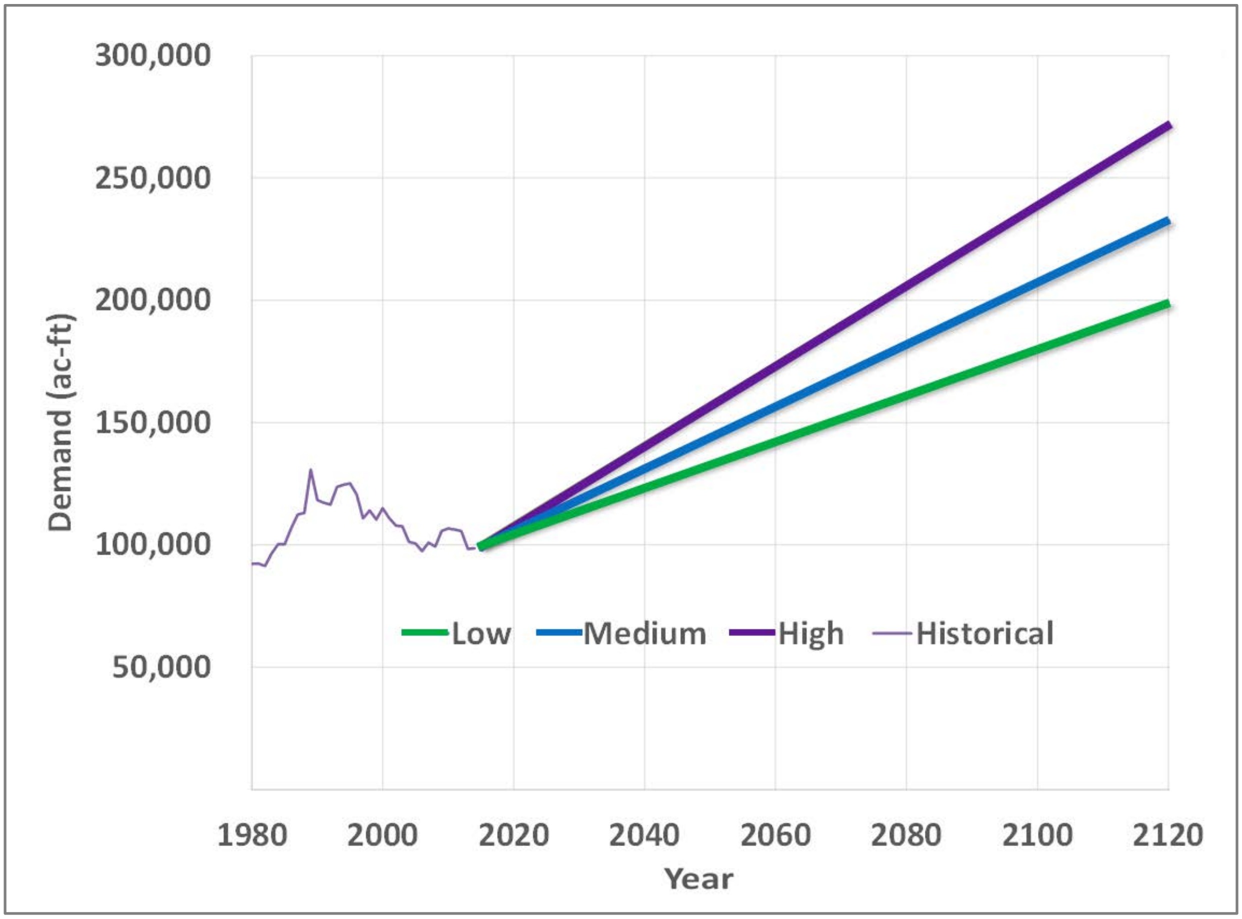
The economic downturn that began in 2008 demonstrated the uncertainty in any such projections, significantly reducing growth in the Albuquerque metropolitan area. Recognizing the inherent uncertainty in picking a number, **Water 2120** developed Low Demand, Medium Demand, and High Demand scenarios, based on population growth, as inputs to its long-term water demand models.

The result is an estimated population of between 943,000 and 1.15 million in 2060, and between 1.3 million and 1.8 million in 2120. Forecasts of per capita water use also are inherently uncertain.

New homes and businesses generally use less water because of efficiency improvements in appliances and changes in landscaping practices, driving per capita use down over time. A warming climate may increase outdoor irrigation requirements, driving it up. New businesses and industries also may place increased demand on water supplies.

Combining those uncertainties in both population and per capita use yields an estimated baseline total water demand in 2120 of between 200,000 and 270,000 afy (Figure ES-3).

Figure ES-3. Actual and Projected Annual Total Water Demand



Note:
ac-ft = acre-feet

Planning for the Future: Water Supply

Planning for a sustainable and resilient Albuquerque water supply for the future begins with an assessment of current water supplies. Albuquerque's water comes from three basic sources:

- Surface water flowing through New Mexico's Middle Rio Grande Valley, including
  - Colorado River Basin water, imported across the continental divide via the San Juan-Chama Project
  - Native Rio Grande water rights
- Wastewater from the Water Authority's reclamation facilities, the result of "non-consumptive" indoor water use in Albuquerque homes
- Groundwater pumped from the aquifer beneath the city

Diversity of sources and adaptability in managing them is one of the keys to a resilient community water supply. Surface and groundwater provide the Water Authority with that capacity. The two supplies are managed conjunctively, with surface water now Albuquerque's primary water source and the aquifer a secondary resource that provides security in times of surface water scarcity. The aquifer rises in times of sufficient surface supplies (as has happened from 2008 to the present), with groundwater providing the necessary supplies during times of surface water scarcity (See Chapter 4, Albuquerque's Groundwater Reserve Management Plan).

Surface water supplies will be affected by natural variability and climate change. Because of uncertainties in projecting both, **Water 2120** analyzes high-, medium-, and low-flow projections for Albuquerque's future water supply. Building resilience into Albuquerque's water management future requires planning that takes into account the possibility of wet periods and the water storage opportunities they represent while also being prepared for sustained dry periods, which would reduce the available surface water supplies and require greater reliance on groundwater reserves.

Based on climate simulations done by the United States Bureau of Reclamation (Reclamation), **Water 2120**'s High Supply, Medium Supply, and Low Supply estimates of San Juan-Chama water supply range from 100 percent of Albuquerque's annual allocation to 75 percent. Modeling also considered the impact of reduced native Rio Grande flows to determine the need to return to groundwater use to meet community water needs under various scenarios.

Managing the Aquifer

Groundwater is a highly valuable resource to the Water Authority and an integral part of its water supply portfolio. A key attribute of groundwater is its resilience: groundwater availability does not significantly change in response to drought. As such, it is a critical and relatively low-cost supply during times of reduced surface water availability.

The response of the aquifer to historical groundwater pumping has provided valuable information about the dynamic nature of the aquifer. **Water 2120** includes a Groundwater Reserve Management Plan (GRMP) that utilizes this new information to ensure that the Water Authority relies on renewable groundwater. The GRMP lays out a strategy for utilizing this renewable resource over the next century by

- setting a limit on how much water can be safely pumped to avoid irreversible subsidence caused when too much water is removed from the aquifer;
- defining a safety reserve to ensure we have an adequate water supply in a worst-case scenario, such as a multi-year interruption in surface water supplies;
- defining a management level – a target aquifer elevation that allows use of the

aquifer as a working reserve that can be drawn down during dry times and refilled when adequate surface water supplies are available while protecting the safety reserve and irreversible subsidence limit.

The first limit represents the worst-case scenario – approximately 300 feet below the level of the groundwater, similar to when Albuquerque first began using wells to provide municipal water more than a century ago. Below that approximate 300-foot mark, irreversible subsidence may set in as the aquifer begins to compress (Figure ES-4).

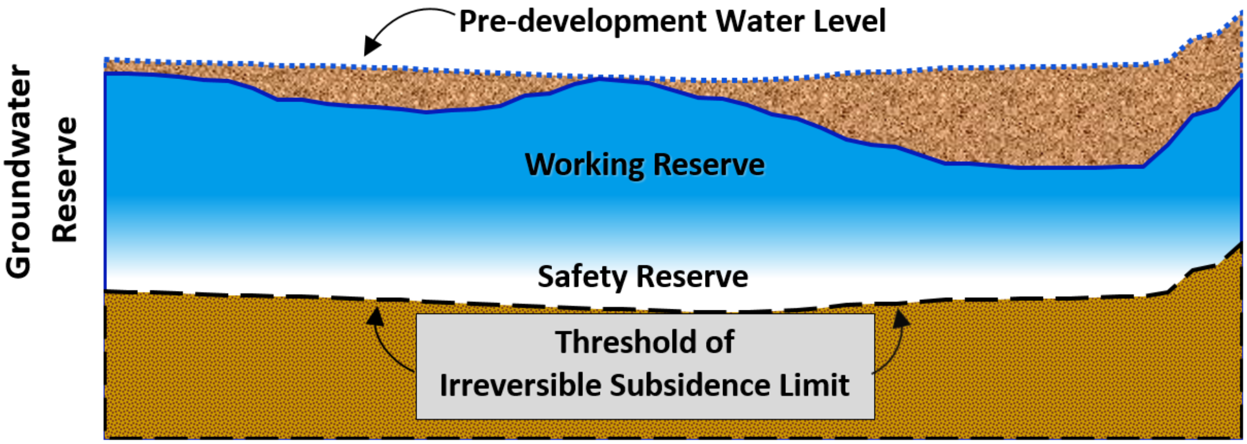
Subsidence can damage roads and buildings on the surface. Equally importantly, irreversible subsidence renders the aquifer unusable, because recharging the compressed sands and gravels that make up the aquifer becomes impossible. Irreversible subsidence would damage Albuquerque's most important water management asset.

Establishing a safety reserve 50 feet above that level – 250 feet below the pre-development aquifer condition – would ensure that Albuquerque would have a water supply in an unplanned-for crisis—chemical spills, institutional conflicts, or catastrophic drought beyond the conditions modeled in the water supply planning scenarios, while still protecting against irreversible subsidence. Above that threshold, **Water 2120** will set the groundwater management level at 110 feet below the pre-development aquifer surface level. This is the level at which the community's water use and water rights are in balance.

Put another way, the **Water 2120** policy objective is for *groundwater to be managed such that there is no long-term net removal of water from storage once a set management level is reached, while utilizing the working reserve to respond to changing hydrologic conditions.*

This allows the community to establish action/decision points regarding new supply that are clearly defined and objective. This type of groundwater management is more conservative than the previous 1997 and 2007 Water Resource Management Strategies and sets a new precedent for water management not seen before in the western United States. Modeling of hypothetical most-extreme-case scenarios for the GRMP (a population of 1.8 million people and drastically reduced surface water supplies in New Mexico) suggests that this approach should ensure a reliable supply of water well into the 21st century.

Figure ES-4. The Groundwater Reserve and Its Components



Water Supply Alternatives

The supply and demand projections discussed above raise the possibility that at some point in the 100-year planning horizon discussed in **Water 2120**, Albuquerque may need to pursue additional supplies of water. While the analysis suggests we are not likely to need additional supplies before the 2060s, it is important to be prepared with a portfolio of options to ensure the community's long-term water supply sustainability.

Water 2120 considers the viability, costs, benefits, and risks associated with a range of other options, including:

- use of existing supplies (groundwater and surface water),
- conservation,
- wastewater reuse, including aquifer storage and recovery (ASR) and/or new storage,
- stormwater capture,
- indirect potable reuse, and
- watershed management.

Water 2120 uses a matrix of criteria to analyze each option across a range of important variables, including reliability, environmental impacts, and cultural values. The goal is not to specify ahead of time which alternative Albuquerque might pursue, but rather to provide a menu of options to help guide future water managers in ensuring the right steps are taken with sufficient lead time to meet any long-term water supply gaps.

Filling Future Gaps in Supply

Linking demand and supply projections with the GRMP goal of maintaining Albuquerque's aquifer around the management level of 110 feet below pre-development conditions allows the community to anticipate future gaps in community water supply, when the current portfolio of groundwater and surface water might be insufficient to meet Albuquerque's needs.

Simulations done for this study suggest the soonest such new supply is needed would be the early 2060s. Depending on growth rates and the region's climate in coming decades, it is possible Albuquerque may not need new supplies for the next century.

To capture the full range of possibility, the supply gap analysis focused on three supply-demand combinations:

- High Demand and Low Supply, representing a future of rapid population growth while drought and climate change simultaneously reduce our available supplies
- Medium Demand and Medium Supply, which includes a projected average amount of climate change
- Low Demand and High Supply, with slow growth and high water supply

Modeling those combinations allowed estimates of when, under varying conditions, Albuquerque's aquifer might drop below the management level of 110 feet below pre-development conditions – the level at which new supply sources would be needed to meet the policy goal of no net depletion of the aquifer.

Under the High Demand/Low Supply scenario, that could happen as early as about 2060. Under the Medium Demand/Medium Supply scenario, no new water would be needed until about 2090. Under the Low Demand/High Supply scenario, no additional supply would be needed through at least 2120 – the entire planning period modeled.

Three portfolios based on the alternatives studied in Chapter 5 were considered to help guide decisions about response to future shortfalls. Just as no single supply or demand projection is correct, no specific portfolio is necessarily the one the Water Authority will pursue. Rather, the portfolios are intended to provide future decision-makers with a broad range of options to consider in both the near term and the long term as an approach to meeting or avoiding a supply gap.

Some options, called no-regret options, will likely be used no matter what supply or demand scenarios Albuquerque faces. No-regret options require little expense or time to act on, and can be used opportunistically at any time. These include purchase and use of additional San Juan-Chama water when available. Low-regret options, such as additional conservation and ASR (we will have to utilize these to take advantage of our existing resources first), are likely to be used as part of any future water supply portfolio, putting off the need for additional water supplies.

The portfolios also include less-likely supply options, including the desalination of brackish groundwater and interbasin transfers, both of which would require implementation time and higher costs, making them less likely under many future scenarios, but important as backstops.

Three portfolios of supply options were created to simulate options to meet Albuquerque's long-term water needs, if and when the aquifer drops below the 110-foot management level. Under the worst-case High Demand/Low Supply scenario, the modeling shows additional water would not be needed until about 2060. However, early implementation of the supply portfolio options would put off the need for additional water to the 2080s or beyond.

Under the Medium Demand/Medium Supply and Low Demand/High Supply scenarios, the portfolios would be sufficient to keep the aquifer at or above the management level through the planning period – through 2120.

Conclusions

- With two decades of conservation success and a shift to surface water, Albuquerque's aquifer is rebounding and will continue to rise well into the 2020s.
- Preserving the aquifer creates the opportunity to use it as a working reserve to help manage fluctuations in surface supplies, while retaining an emergency safety reserve to draw from in worst-case scenarios.
- Establishing a management level in the aquifer is a more conservative approach to long-term use of the aquifer and provides opportunities for using that portion of the working reserve for future generations.
- Conjunctive aquifer management including ASR, additional conservation, and reuse and recycling options can help ensure Albuquerque has a reliable water supply for the next century.
- Using the water resources the Water Authority already owns along with optimizing the use of available wastewater in the future sets the stage for a long-term water supply.
- Acquiring additional pre-1907 water rights is not part of the long-term water supply alternatives in this plan.
- Watershed protection and restoration will provide insurance against catastrophic fires and damage to the forests from which we get our existing water supply.

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Volume I: Main Text and Appendices

Acronyms and Abbreviations

1997 and 2007 Strategies	The 1997 Water Resources Management Strategy and 2007 updated Water Resources Management Strategy
1997 WRMS	The original Water Resources Management Strategy (Water Authority, 1997)
2007 WRMS	The updated version of the Water Authority's Water Resources Management Strategy (Water Authority, 2007)
ac-ft	acre-feet
afy	acre-feet per year
ASR	aquifer storage and recovery
ASR	aquifer storage and recovery
Basin	Middle Rio Grande groundwater basin
BBER	Bureau of Business and Economic Research, University of New Mexico
cfs	cubic feet per second
City	City of Albuquerque
CMIP3	Coupled Model Intercomparison Project Phase 3, World Climate Research
County	Bernalillo County
CRSP	Colorado River Storage Project
DPR	direct potable reuse
DPV	discounted present value
DWP	Drinking Water Project, San Juan-Chama
ENR CCI	Engineering News Record Construction Cost Index
GCM	General Circulation Model
gpcd	gallons per capita per day
GRMP	Groundwater Reserve Management Plan
HDe	hybrid delta ensemble method
IPCC	Intergovernmental Panel on Climate Change
IPR	indirect potable reuse
MRCOG	Middle Rio Grande Council of Governments
MRGCD	Middle Rio Grande Conservancy District

Acronyms and Abbreviations continued

NADA	North American Drought Atlas
NMISC	New Mexico Interstate Stream Commission
NMOSE	New Mexico Office of the State Engineer
NMU	New Mexico Utilities
NOAA	National Oceanic and Atmospheric Administration
NPP	North I-25 Non-Potable Project
O&M	operations and maintenance
RCP	representative concentration pathway
Reclamation	Bureau of Reclamation
SJC Project	San Juan-Chama Project: U.S. Bureau of Reclamation interbasin water transfer project located in the states of New Mexico and Colorado
State	State of New Mexico
TCAC	Technical Consumer Advisory Committee
URGSIM	Upper Rio Grande Simulation Model
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
Water Authority	Albuquerque Bernalillo County Water Utility
WRMS	Water Resources Management Strategy
WTP	water treatment plant

Water 2120:
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CHAPTER 1

Introduction

1

CHAPTER 1

1.1 Water 2120 Overview and Purpose

Albuquerque's water supply planning efforts in their current form began with the development of the 1997 Water Resources Management Strategy (WRMS), originally developed by the City of Albuquerque's Public Works Department. The 1997 WRMS and its 2007 update supported one of the most successful water conservation efforts in the western United States; including the $500 million construction of a surface water treatment and distribution system along with two water reuse and recycling systems, and a two-thirds reduction in Albuquerque's annual groundwater pumping.

With the success of the 1997 and 2007 Strategies, it became clear that Albuquerque was in a position to incorporate lessons learned from its conservation programs and new approach to conjunctive management of groundwater and surface water (Figure 1.1).

This document, entitled **Water 2120**, sets forth the Albuquerque Bernalillo County Water Utility Authority's (Water Authority's) strategy to carry on that work by ensuring a safe and sustainable water supply for the next century, through the year 2120.

Water 2120 continues and expands the water management policies and strategies adopted by the community beginning in the mid-1990s, in response to research showing Albuquerque's dependence on groundwater was unsustainable. By evaluating a range of water supply and demand projections, the Water Authority staff, community advisory committee members, local scientists, and other experts began developing a plan for ensuring a sustainable and resilient water supply.

Water 2120 is the result of these efforts: 14 meetings of the Water Authority's Technical Customer Advisory Committee (TCAC) over a two-year period, five presentations to the Governing Board, a series of public meetings and customer conversations, and a Town Hall meeting.

Building on the community's successes over the last two decades in reducing water use and reversing the decline in our aquifer, **Water 2120** ensures a sustainable water supply in an uncertain future. Calculations made in the **Water 2120** effort show that even if the climate dries in coming decades and Albuquerque's population grows, our current water supplies will reliably meet community needs through the 2060s.

With the addition of prudent steps in coming decades to increase water storage, conservation, and proper management of our aquifer, the City of Albuquerque (City) and the surrounding areas of Bernalillo County (County) served by the Water Authority can be assured a reliable water supply into the 21st century and beyond.

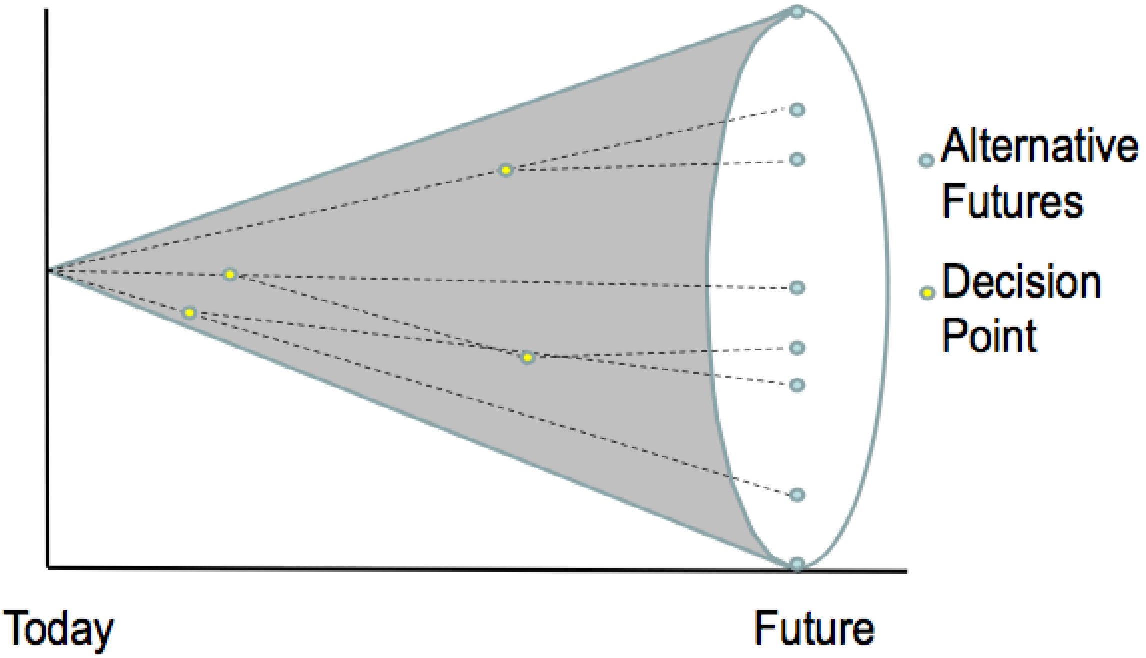
Figure 1.1 The Rio Grande. A major source of Albuquerque's surface water

In the chapters that follow, **Water 2120**

- evaluates water demand under a variety of population growth projections;
- considers the Water Authority's current supply portfolio of surface water, groundwater, and reuse;
- provides a range of scenarios regarding possible impacts of drought and a changing climate;
- lays out a groundwater management strategy that sets limits on how much water can be safely pumped to avoid irreversible subsidence caused when too much water is removed from the aquifer;
- defines a safety reserve to ensure we have an adequate water supply in a worst-case scenario, such as a multi-year interruption in surface water supplies;
- defines a management level – a target aquifer elevation that allows use of the aquifer as a working reserve that can be drawn down during dry times and refilled when adequate surface water supplies are available while protecting the safety reserve and irreversible subsidence limit;
- evaluates future water supply options and establishes a decision framework for future policymakers to determine when those supplies might be needed;
- provides a recommended portfolio of future water supply alternatives, which if implemented when necessary would meet future demand projections for at least the next 100 years.

The purpose of **Water 2120** is not to predict the future, but rather to open up the options available for future water managers to respond to changing situations. The range of uncertainty can be described as a cone, where near events are relatively well known and uncertainty grows further out in time (Figure 1.2).

Figure 1.2. The Cone of Uncertainty



By documenting a range of alternative futures – including future climates, a range of population projections, a variety of different water demands and conservation behaviors – **Water 2120** provides future decision makers with templates for action: What are the metrics, such as available surface water supply or groundwater levels, that determine when decisions must be made; and what are the options available for water storage, new conservation measures, or the steps needed to secure new water supplies?

The goal of **Water 2120** is to ensure resilience, the ability for our community to absorb a water-supply shock and retain its basic function and character. This plan pursues that goal in two ways. First, it preserves a large portion of the working reserve of groundwater that will provide water, even if Albuquerque experiences the most extreme climate projections. Second, it strengthens the flexible water management tools needed to adapt to ever-changing circumstances, allowing us to define our own future rather than having water scarcity define the future for us.

1.2 The Water Authority

The Water Authority was created by the New Mexico Legislature in 2003, having previously been a component of the City of Albuquerque.

The Water Authority is a political subdivision of the State of New Mexico, (State) established pursuant to Section 72-1-10 et seq. NMSA 1978; with specific responsibility for public water, wastewater, and reuse in the greater Albuquerque area. The Water Authority was created to better serve the residents and manage the water resources in Albuquerque and Bernalillo County.

The Water Authority has been governed by an eight-member Governing Board consisting of three Albuquerque City Councilors, three Bernalillo County Commissioners, the Mayor of Albuquerque, and an ex-officio member from the Village of Los Ranchos.

1.3 Overview of the Albuquerque Water System

Albuquerque is a desert to semi-arid community, varying in elevation from 5,000 feet in the Rio Grande Valley to 6,300 feet in the foothills of the Sandia Mountains. Annual precipitation varies from less than 9 inches at the Albuquerque International Sunport to more than 15 inches in the foothills. July through September are Albuquerque’s wettest months, a summer rainy season dominated by afternoon thunderstorms. Snow is common in winter months, but rarely lingers. Rain and snowfall are highly variable. Annual precipitation at the National Weather Service office, which has the longest continuous record, has varied from 3.29 inches in 1917 to 15.88 inches in 1941.

In Albuquerque’s early days, the Rio Grande was our primary source of water. Residents would haul it to their homes in barrels, letting the mud settle before they used it. Beginning with the first well in 1875 in the area of what is now the Old Town Plaza, groundwater over time became Albuquerque’s primary municipal water source. By 1910, Albuquerque had drilled nine wells seven hundred feet or more beneath the city. The population of Albuquerque and surrounding communities in Bernalillo County was just 24,000 people in 1910.

As the city grew, spreading across mesas flanking the Rio Grande on the east and west, the community drilled new groundwater wells to supply its growing water demands. Albuquerque grew rapidly during the years after World War II. Growth has slowed in the past decade, with little growth over the last ten years, consistent with a shrinking population as a whole in New Mexico. Today, the population of Albuquerque and Bernalillo County is approaching 700,000.

Albuquerque's 20th century municipal water needs were met entirely with groundwater, pumped from an aquifer stretching from north of Bernalillo to south of Belen and shared by many communities. Most of the water is found in extensive sand and gravel deposits left behind by the evolution of the ancestral Rio Grande.

Until 2008, nearly all of the Water Authority's some 100,000 acre-feet (ac-ft) of water used each year was pumped from a network of 90 wells. The wells are grouped in 26 well fields across the metropolitan area, each with its own chlorination treatment system to ensure the water meets safe drinking water standards.

The Water Authority has permits from the New Mexico Office of the State Engineer (NMOSE) allowing the Water Utility over time to pump 165,000 ac-ft per year (afy) of water, well above current pumping levels. This permitted right is critical to ensuring the reliability of the community's future water supply with the potential fluctuations that are anticipated with climate variability.

The aquifer is one of the community's most important water system assets because of its ability to store water over time and must be protected against irreversible subsidence, which can happen when too much water is removed. In that situation, the ground above sinks, damaging the city's streets, buildings, and other infrastructure. Equally importantly, the compaction renders the aquifer itself unusable for future water storage.

The Water Utility also has right to the use of surface water through the San Juan-Chama (SJC) Project and other sources. Authorized by Congress as part of the Colorado River Storage Project (CRSP) Act of 1956, the SJC Project provides the majority of Albuquerque's surface water. CRSP provided federal funding through the United States Bureau of Reclamation (Reclamation) for the dams and diversions needed by the states of the Upper Colorado River Basin – Wyoming, Colorado, Utah, and New Mexico – to put their shares of the Colorado River's water to use.

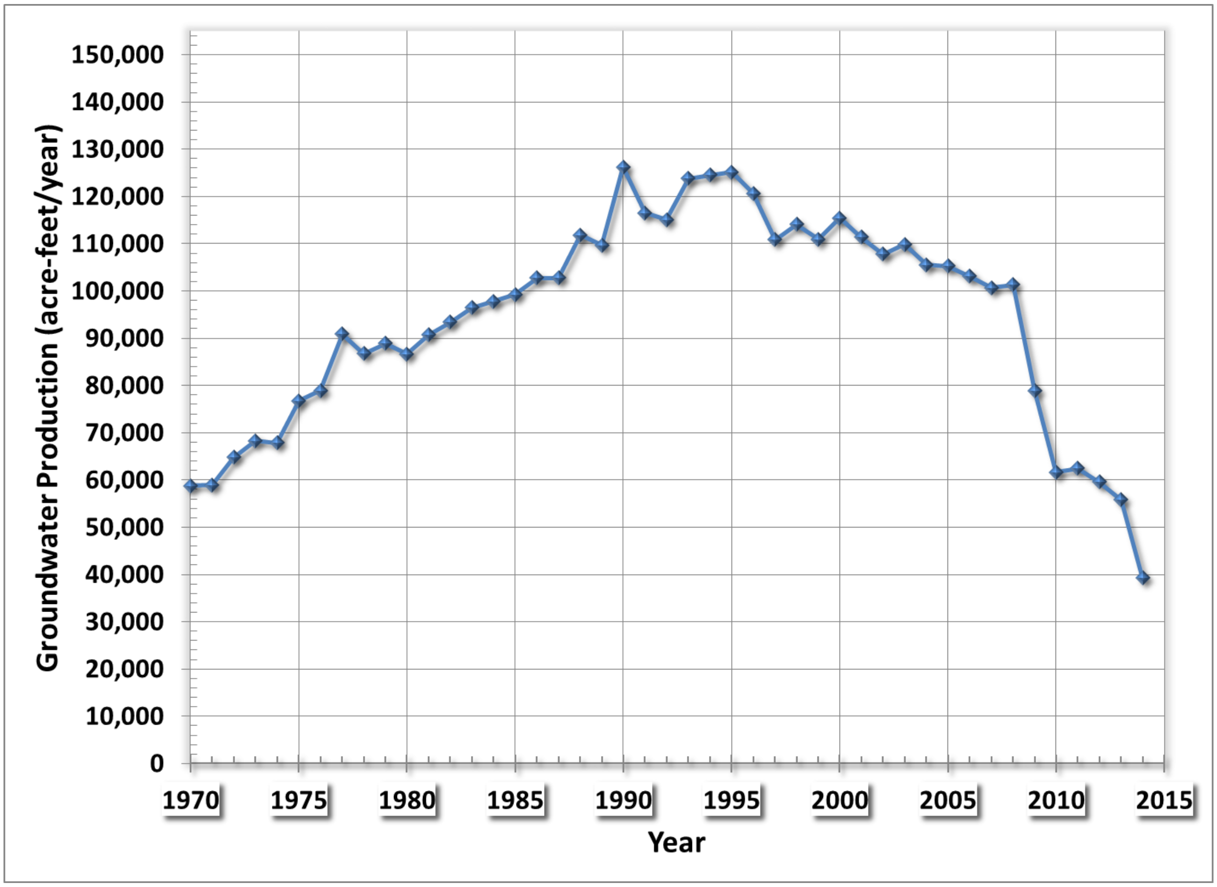
For New Mexico, it was a chance to move water from the San Juan Basin, home to the state's largest river, to the more populous Rio Grande Basin. The SJC Project diverts water from three high mountain tributaries in southern Colorado through more than 25 miles of concrete-lined tunnels dug beneath the continental divide. From the Azotea Tunnel, the water is delivered in the headwaters of the Rio Chama, where its flow is regulated by a series of three large dams for later use downstream.

Albuquerque purchased rights from the federal government for 48,200 afy of SJC Project water in 1965. Prior to 1997, Albuquerque's plan was to use SJC Project water to offset the impacts of its groundwater pumping on the Rio Grande.

With the 2008 completion of the SJC Drinking Water Project (DWP), along with two reuse and recycling projects (a $500 million program), Albuquerque for the first time was able to use its imported water directly, pumping it the length and breadth of the metro area for use in businesses and homes.

After reaching a peak of 128,000 ac-ft in 1990, Albuquerque's groundwater use began declining in response to conservation programs. Since the 2008 shift to direct use of surface water, groundwater pumping dropped to 40,000 ac-ft in 2015 (Figure 1.3).

Figure 1.3. Historical Groundwater Production (1970 to 2014)



The Water Utility's water rights portfolio also includes rights to so-called "native" surface water as a result of rights granted by the State when it began managing Rio Grande Basin water supplies in the 1950s. Albuquerque also has purchased surface water rights from Rio Grande Valley farmers over the years. Together, those native surface water rights total 26,390 afy.

Albuquerque's surface water supplies, both native Rio Grande and imported SJC water, are subject to climate-related impacts. Those impacts are felt in two ways. First, when there is insufficient snowpack in the mountain watersheds that feed the SJC Project, Albuquerque may receive less than its full allotment of 48,200 ac-ft of water. Second, when flows in the Rio Grande pass below designated thresholds, operating rules require the Water Authority to stop diverting river water to ensure an adequate flow in the river for environmental use and other purposes.

While groundwater in general is not directly affected by year-to-year climate variability, there is an indirect effect. When SJC water runs short or diversions must be curtailed, Albuquerque water managers turn to groundwater pumping to make up the shortfall.

Planning for the future requires modeling of the impacts of drought and climate change on SJC and native Rio Grande supplies directly, as well as the indirect impact those factors could have on the aquifer should Albuquerque need to shift to groundwater use to make up for surface water shortfalls. By doing this analysis ahead of time, **Water 2120** creates a framework for pursuit of alternative supplies to offset future groundwater pumping should surface supplies run short.

Wastewater also provides a critical component of the Water Authority's surface water rights portfolio. While some 40 percent of the water used by Water Authority customers is used consumptively outdoors, primarily for irrigation of yards, parks and golf courses; the remaining 60 percent, used indoors, is non-consumptive use, meaning that water can be treated at the Southside Wastewater Reclamation Facility and then made available for other uses. Its primary use currently is as return flow to the Rio Grande, where it offsets some of the impacts of the Water Authority's groundwater pumping and is available for downstream use by farms, cities, and the riparian vegetation. Some 2,000 ac-ft of that wastewater is now treated to higher standards and is then reused for outdoor irrigation of public facilities on Albuquerque's south side.

1.4 A Guide to Water 2120

In the chapters that follow, the results of detailed technical analyses of the Water Authority's supply future are examined.

Chapter 2 details the community's water demands, analyzing in detail Albuquerque's conservation success and population trends; and how those affect how much water we may need in the future.

Chapter 3 incorporates the latest climate modeling to determine the range of risks we face because of droughts and climate change, and how that might affect available water supplies.

Chapter 4 lays out new analyses of our aquifer: how it has responded to reduced pumping in recent years, how it might respond to various pumping levels in the future, and how it might use the concept of renewable groundwater to provide a flexible working reserve to store water to better allow Albuquerque to manage year-to-year water supply variability, while holding water in reserve as a backup to provide an emergency reserve for a worst-case scenario. Our new approach is to use less groundwater over the long-term to save groundwater for the future. This new approach is more conservative than the previous 1997 and 2007 Strategies.

Chapter 5 evaluates a range of future supply options, from wastewater reuse and conservation to desalination of brackish groundwater.

Chapter 6 incorporates the results of the previous chapters to lay out water supply portfolio options to ensure a reliable water supply for Albuquerque and the surrounding areas of Bernalillo County served by the Water Authority through 2120.

1.5 Conclusions

Steps taken in the last two decades to conserve water and build infrastructure have ensured a more diverse supply portfolio and provided the Water Authority with new water management flexibility to respond to changing climate, water supply, and water demands in an uncertain future.

When the City of Albuquerque adopted its 1997 WRMS, it made preservation of the community's groundwater a central policy goal. At the time, the then city-owned water utility was entirely dependent on groundwater to meet municipal needs. Spread in layers of sand and gravel beneath the length and breadth of the metropolitan area, Albuquerque's groundwater for much of the 20th century had provided a reliable source of water to support the community's growing needs. But by the 1990s, the aquifer beneath the metro area was dropping rapidly, and a new scientific understanding of its decline made it clear that continued reliance on that single source of water was not sustainable.

In response, the community undertook two major initiatives – an aggressive conservation program and a shift to the direct use of water imported to the Rio Grande Basin via the SJC Project.

The conservation program, begun in 1995 before the 1997 WRMS was finished, included formal incentives like rebates for lawn removal and xeriscaping, as well as support for the removal and replacement of old indoor plumbing like toilets with new, more water-efficient models.

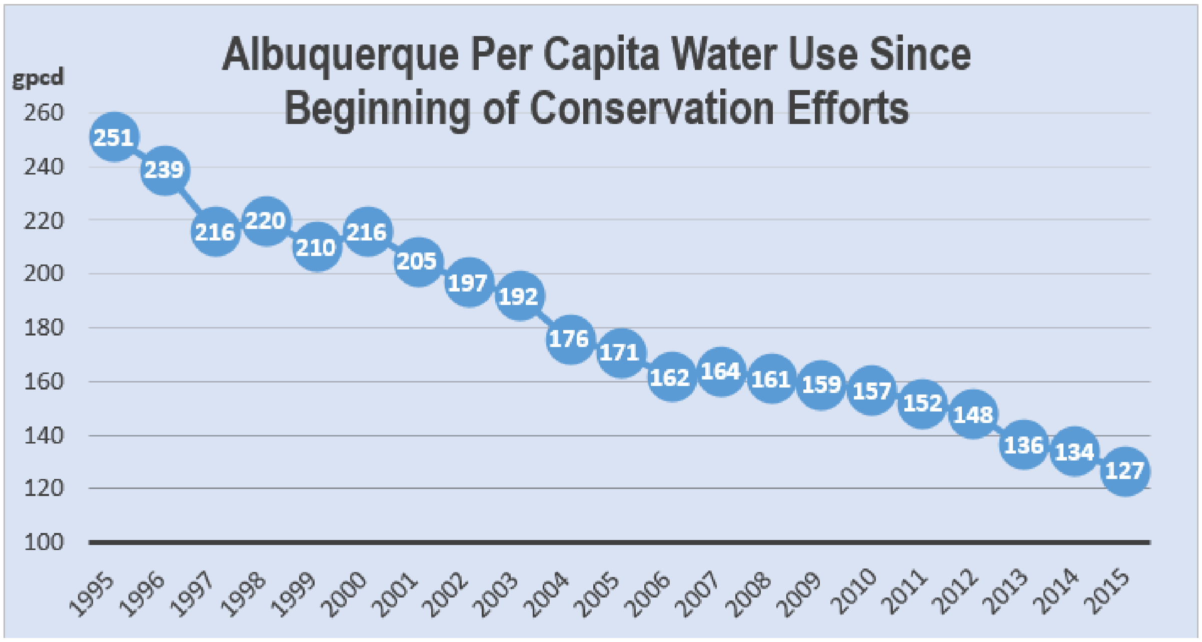
The effort also included major public education efforts that helped capitalize on a growing water ethic among its customers. The result: per capita municipal water use cut nearly in half between the mid-1990s, when the program began, and 2015 (Figure 1.4).

While city-to-city comparisons are difficult because of different accounting methodologies, a 2015 Reclamation study found that per capita water conservation reductions in and around the Albuquerque metro area were greater than in any other major metro area in the seven western states that use water from the Colorado River (Reclamation, 2015).

In parallel with the conservation program, the Water Authority launched a $500 million construction effort that included a diversion dam on the Rio Grande near Alameda on the community's northern end, a water treatment plant, a new transmission system and two water reuse and reclamation projects. This allowed the Water Authority to begin direct use of our SJC water supply and begin the transition to using non-potable water for turf irrigation.

Built in the 1970s, the SJC Project imports water from the San Juan River, a tributary of the Colorado River, for use in central New Mexico. Since the project was first envisioned in the 1950s, it was intended to bolster scarce supplies on the Rio Grande and central New Mexico's aquifers.

Figure 1.4. Albuquerque Per Capita Water Use, 1995-2015



Note: gpcd = gallons per capita per day

In the past, Albuquerque's plan was to use the water to offset the impact of the community's groundwater pumping on the Rio Grande, as water leaked from the river's sandy bottom to refill the cone of depression left by aquifer pumping.

The construction of the DWP allowed the Water Authority, beginning in 2008, to use the water directly from the river, allowing a significant reduction in groundwater pumping. The combination of conservation and an alternative supply of surface water have allowed the community to dramatically reduce its groundwater pumping – from 125,000 ac-ft in 1995 to just 41,000 ac-ft in 2015, a two-thirds reduction in the amount of water taken from the aquifer.

The results have been significant. Across the metropolitan area, groundwater has risen 15 feet or more in response to reduced pumping. The rising aquifer means that the Water Authority's service area now has more total water available than it had 20 years ago, when the first WRMS was adopted, despite a persistent drought and warming temperatures that have left Rio Grande flows well below average for the last 15 years, and a population increase of 48 percent. The aquifer is anticipated to continue to rise for at least another decade.

The result, as evidenced in **Water 2120**, is a new flexibility in the community's portfolio of water management strategies, with less risk to the aquifer and a wider range of options for the future.

With the maturity of the DWP and the possibility of expanded aquifer storage and recovery, the community can now move beyond simply treating the recovering aquifer as a drought reserve, as contemplated in the 1997 WRMS, to a flexible working reserve that provides the community with the resilience necessary to respond to a wide range of climate, water supply, and population futures.

1.6 References

Reclamation, United States Bureau of. 2015: Moving Forward: Phase 1 Report, Chapter 3, Municipal and Industrial Water Conservation and Reuse.

Water 2120:
Securing
Our Water
Future

CHAPTER 2

Water Demand

2

CHAPTER 2

2.1 Introduction and Purpose

Future water demand is a key component of any water resources plan. **Water 2120** includes an update to prior estimates of future water demand. Water demand projections developed as part of this effort will be used in subsequent WRMS development.

As part of previous efforts, the Water Authority used projected population growth along with water use efficiency goals to estimate future water demand through 2060. More recently, the Water Authority recognized the importance of considering uncertainty in population projection and future water demand; and, subsequently, the need to plan for a range of possible futures. As such, the Water Authority is developing multiple water demand projections. Each of these projections is represented as a variation in future population and resulting water demand.

However, while these projections were developed around variations in population, they should be considered to represent a range of future water demands; which could result from uncertainty in forecasting population, the addition of new industrial or commercial customers, changes in population density, or other potential changes in customer class or use pattern.

For example, a high water demand in 2040 could result from greater than expected population growth, or medium growth and the addition of a new industrial water user. For reference, the current areas served by the Water Authority are shown in Figure 2.1.

This document summarizes both historical and recent projected water demands and other considerations related to future water demand for projection through 2120.

2.2 Historical Projections

Historically, the 1997 WRMS was developed with the growing realization that the previous strategy of pumping an unlimited supply of groundwater was unsustainable and was based on a faulty understanding of the aquifer and its connection to the Rio Grande. The 1997 WRMS was a landmark document, which marked a fundamental philosophical shift to sustainability and resiliency. This shift lives on today with the 2007 WRMS and informs this strategy update process.

As part of the 1997 and subsequent 2007 WRMS, population and water demand projections were developed. Population projections were based on historical Water Authority customer growth with changes in water demand between the 1997 WRMS and 2007 WRMS reflecting different water usage rate goals.

Water usage rate is defined as the total water produced from all sources divided by the population (Water Usage Rate = Total water produced / Population) and is expressed in gallons per capita per day (gpcd). A conservation goal of a 30 percent reduction to achieve 175 gpcd by 2006 was established in 1995. This goal coupled with population projection resulted in a projected 2060 water demand of about 204,000 ac-ft. Once this conservation goal was achieved, a new conservation goal was adopted in 2004[1],

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[1] Adopted R-04-12.Section 3

reflecting a 40 percent reduction in water usage rate to 150 gpcd by 2014[2]. This goal coupled with the original population projections resulted in a new projected 2060 water demand of about 175,000 ac-ft.

Table 2.1 presents the historical Water Authority customer population, water usage rate, and resulting water demand associated with historical WRMS development. Figures 2.2 and 2.3 show the projected water demand over time with the historical strategies.

From Figures 2.2 and 2.3, it can be seen that the change in conservation goal alone resulted in a reduction in the projected amount of new supply needed (~20,000 ac-ft) and a delay in the need for new supply.

Additional discussion of the 2007 WRMS is found at the Water Authority Website: http://www.abcwua.org/Water_Resources_Management_Strategy.aspx.

The remainder of this chapter summarizes development of updated population projections, conservation goals, and water demand projections for Water 2120.

Table 2.1. Historical Water Authority Customer Population, Water Usage Rate, and Water Demand Projections for the year 2060 from 1997 and 2007 Strategies

	1997 WRMS	**2007 WRMS**
2060 Population	1,041,566	1,041,566
Water Usage Rate (gpcd)	175	150
Water demand (ac-ft)	204,000	175,000

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[2] This goal was achieved in 2011 and a new goal of 135 gpcd by 2024 was adopted and initially reached in 2014.

Figure 2.1. Water Authority Area Served

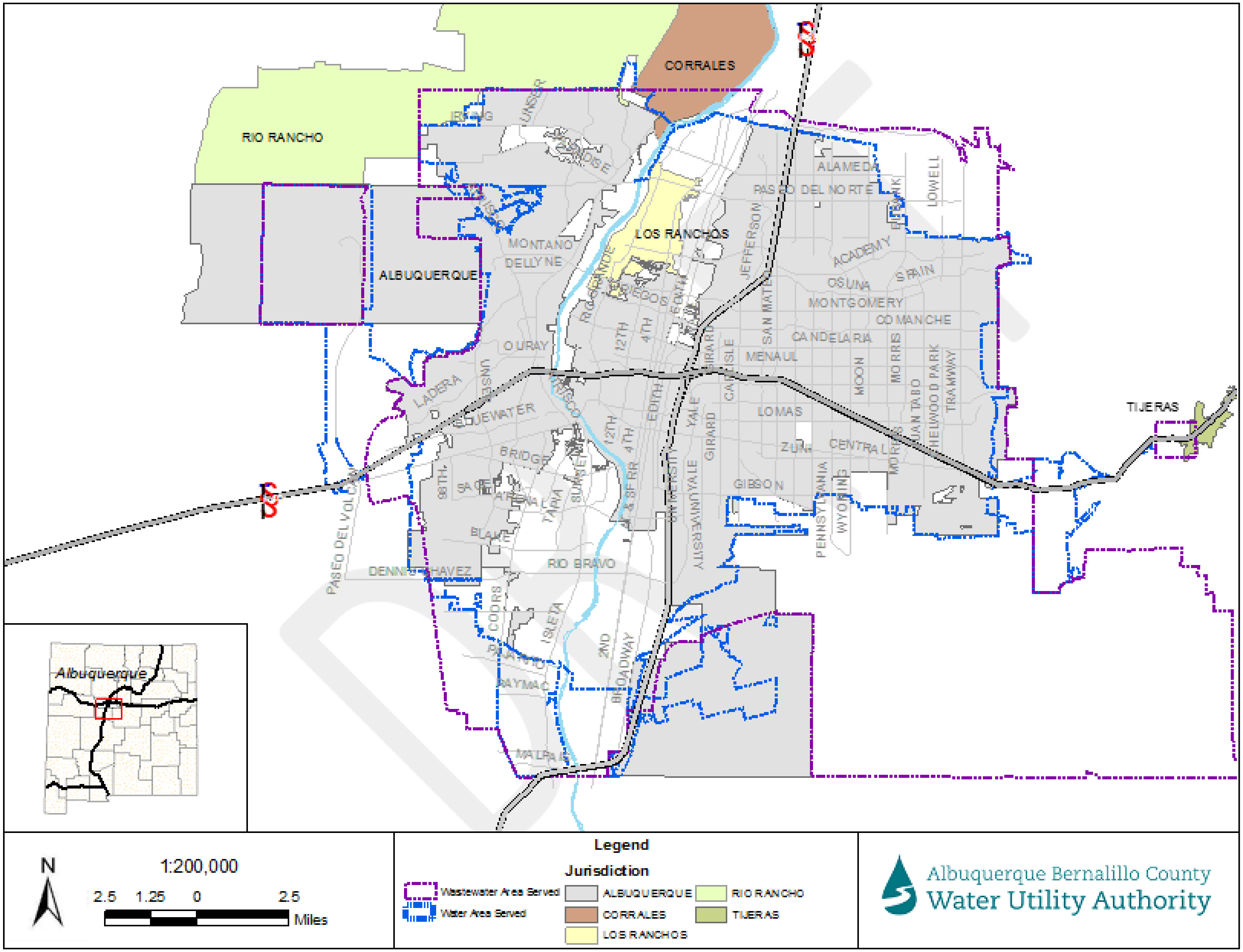


Figure 2.2. Historical WRMS Water Demand, 1997

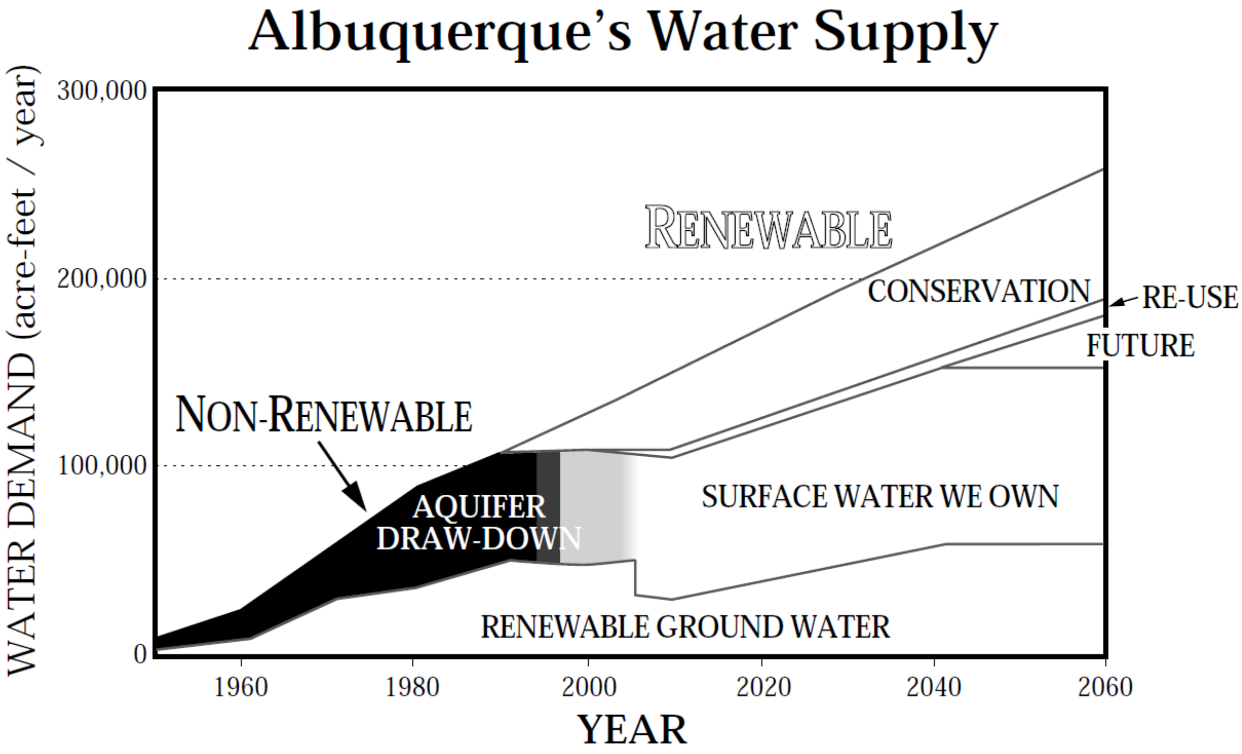
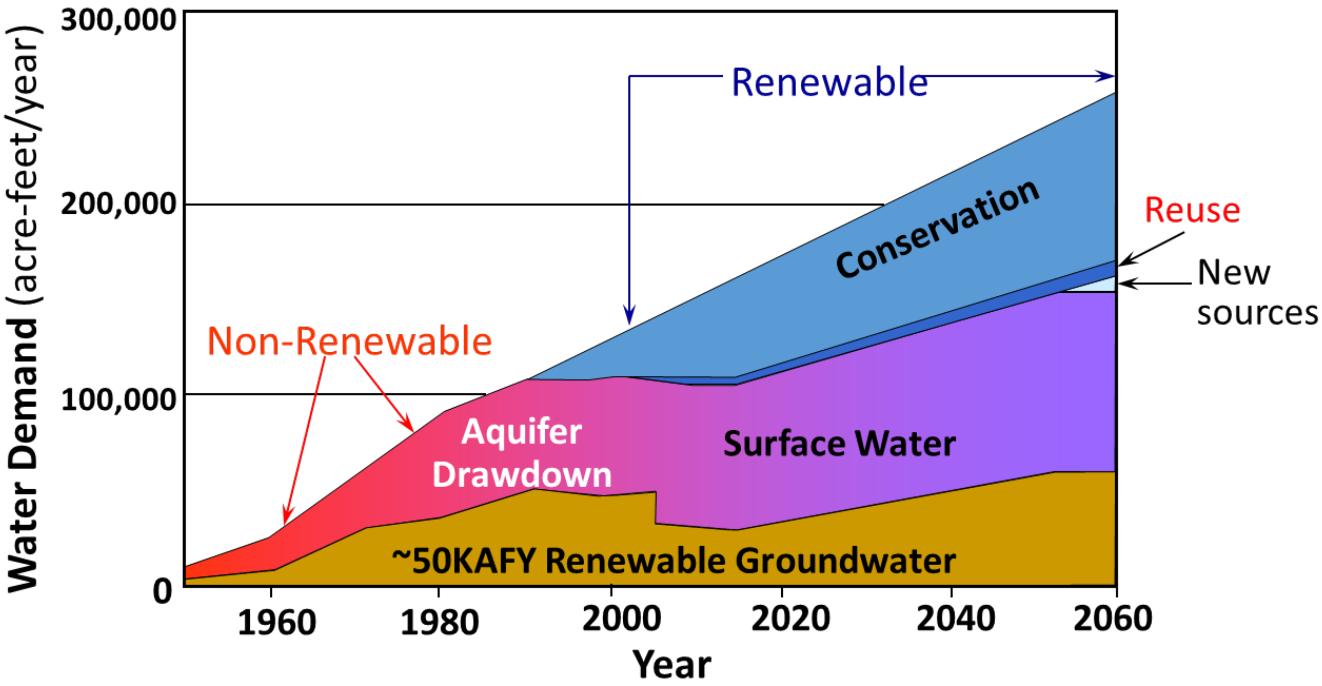


Figure 2.3. Historical WRMS Water Demand, 2007



2.3 2017 WRMS, Water Demand Projections

For this update, three water demand projections were developed: “Low,” “Medium,” and “High.” The Medium projected water demand reflects recent population projections that take into account recent and historical economic conditions, natural growth, and net migration. This projection can be considered the most “expected” based on current and historical information, although not necessarily more likely than other projections. Deviations from expected growth or water usage rates result in alternative Low or High projections. The Low and High projections are developed to capture a broad range of potential future water demands.

Projected water demand is calculated from projected population multiplied by the currently planned water usage rate (per capita water demand). To provide an ability to examine the impact of future supplies and conservation, water demand is broken out into the following water use sectors: residential, commercial, institutional, industrial, multi-family, non-revenue, and miscellaneous; as well as indoor and outdoor water demand for each sector.

2.3.1 Population Growth

2.3.1.1 BACKGROUND AND ASSUMPTIONS

For the purpose of planning, it is assumed that water system growth will correlate to population growth through 2120. As such, projected water system growth was evaluated by examining population growth projections. The following assumptions were made for the evaluation of the water system growth:

- Projection methods are generally consistent with the Water Authority’s most recent 40-Year Water Development Plan (CH2M, 2012).
- Population projections include the Northwest Service Area (Corrales Trunk), consistent with adopted city and county land use plans.
- Low, Medium, and High projections should be developed to mitigate uncertainty in the estimates.
- Water system growth will correlate to population growth.

2.3.1.2 POPULATION GROWTH RESULTS

Historical Water Authority population projections were made as part of the 1997 WRMS and 2007 WRMS. These projections suggested a population of just over 1 million persons in 2060. This estimate was based on linear interpolation of historical water system growth through 1995, projected through 2060. This projection was utilized because historical system growth trends had been remarkably consistent; and because system population growth tended to exceed County or City growth rates. Likewise, this estimate roughly corresponded to the University of New Mexico’s Bureau of Business and Economic Research (BBER) medium growth projections for Bernalillo County, adjusted to reflect the portion of Bernalillo County served by the Water Authority.

If similar methods are employed for this update, utilizing historical Water Authority system population growth from 1980 through 2014, a population of roughly 1 million persons in 2060 is expected (see Figure 2.4). Note, however, that this estimate includes the 2009 acquisition of New Mexico Utilities (NMU).

As such, while the 2060 population projection is similar between current and historical projections, the overall growth rate is reduced from previous estimates due to slowed growth over the last decade. Because historical water system growth is a good indicator of future growth, this linear trend is considered the most expected, or Medium growth projection.

Projected population growth is presented in Table 2.2 and Figure 2.4. The Medium growth projection results in an increase in population from approximately 658,238 in 2015; to 1,038,000 in 2060; and 1,537,000 in 2120. As part of the State's water planning process, this population growth projection was compared to recent estimates for Bernalillo County; including BBER (2012), Middle Rio Grande Council of Governments (MRCOG, 2012), and New Mexico Interstate Stream Commission (NMISC, 2014); as well as previous Water Authority estimates (CH2M, 2007) and estimates made by BBER (2008).

In general, recent BBER and MRCOG projections roughly correspond with the Medium growth populations when they are adjusted to reflect the portion of Bernalillo County served by the Water Authority. These estimates range from annual growth rates of 0.8 percent to 1.2 percent from 2030 to 2040, while the Medium projection reflects 1 percent annual growth over the same period. The BBER (2008) projection suggests population growth much greater than other sources and does not appear to reflect recent trends. Recent NMISC work (2014) developed high and low population projections for Bernalillo County through 2060 with growth rates through 2040 ranging from 0.7 to 0.9 percent.

A High population growth projection is proposed that reflects historical growth rates from the 1997 WRMS. As noted above, this projection reflected average growth rates over time through about 1995. As such, it reflects actual high growth rates previously experienced by the Water Authority and can be considered an upper bound of what is likely. For comparison, this projection results in a 1.2 percent annual growth rate from 2030 to 2040.

A Low population growth projection was developed that is 85 percent of Medium projection growth through 2120. This projection was developed to define the lower bound of expected growth and reflects an annual growth rate of 0.8 percent from 2030 to 2040. This rate is similar to the minimum annual growth experienced by the Water Authority in recent years. This rate is slightly greater than the recent NMISC (2012) low projection. However, the NMISC projection assumes a relatively severe loss of employment base. Growth rates of the various projections are shown in Figure 2.5.

As shown in Figure 2.4, the Low, Medium, and High projections generally reflect the range of available population projections.

The estimates presented in Table 2.2 reflect:

- Low – Based on 85 percent of the Medium projection (0.8 percent growth).
- Medium – Linear fit of Water Authority population from 1980 through 2014 (1 percent growth).
- High – Historical projection from 1997 WRMS projected with linear interpolation through 2120 (1.2 percent growth)

Population projections are an estimate based on historical growth patterns as well as current and projected economic activity. As such, these projections are uncertain. Actual population will vary in magnitude and timing from projections based on future economic conditions. Likewise, overall water demand will vary based on actual population as well as other factors, such as mix of future industry, population density, and overall water usage rates.

Table 2.2. Historical and Projected Albuquerque Bernalillo County Water Utility Authority Population through 2120

Year			**Historical Population**		**Annual Growth Rate**	
1990			423,371			
2000			476,285		1.2%	
2005			522,937		2.0%	
2010			606,780		3.2%	
2015			658,238		1.7%	
	Low Population		**Medium Population**		**High Population**	
2020	*695,478*		*706,180*		*718,752*	
2030	*757,477*	*0.9%*	*789,305*	*1.2%*	*827,020*	*1.5%*
2040	*819,477*	*0.8%*	*872,430*	*1.1%*	*935,288*	*1.3%*
2050	*881,476*	*0.8%*	*955,555*	*1.0%*	*1,043,556*	*1.2%*
2060	*943,475*	*0.7%*	*1,038,680*	*0.9%*	*1,151,825*	*1.0%*
2070	*1,005,475*	*0.7%*	*1,121,805*	*0.8%*	*1,260,093*	*0.9%*
2080	*1,067,474*	*0.6%*	*1,204,929*	*0.7%*	*1,368,361*	*0.9%*
2090	*1,129,473*	*0.6%*	*1,288,054*	*0.7%*	*1,476,629*	*0.8%*
2100	*1,191,473*	*0.5%*	*1,371,179*	*0.6%*	*1,584,898*	*0.7%*
2110	*1,253,472*	*0.5%*	*1,454,304*	*0.6%*	*1,693,166*	*0.7%*
2120	*1,315,472*	*0.5%*	*1,537,429*	*0.6%*	*1,801,434*	*0.6%*

Notes:

[A] 2010 population includes acquisition of New Mexico Utilities, artificially increasing the apparent annual growth rate.

[B] Projected values for 2020 to 2120.

[C] Historical population based on number of customers multiplied by persons per household (from census data).

Figure 2.4. Historical and Recent Population Projections

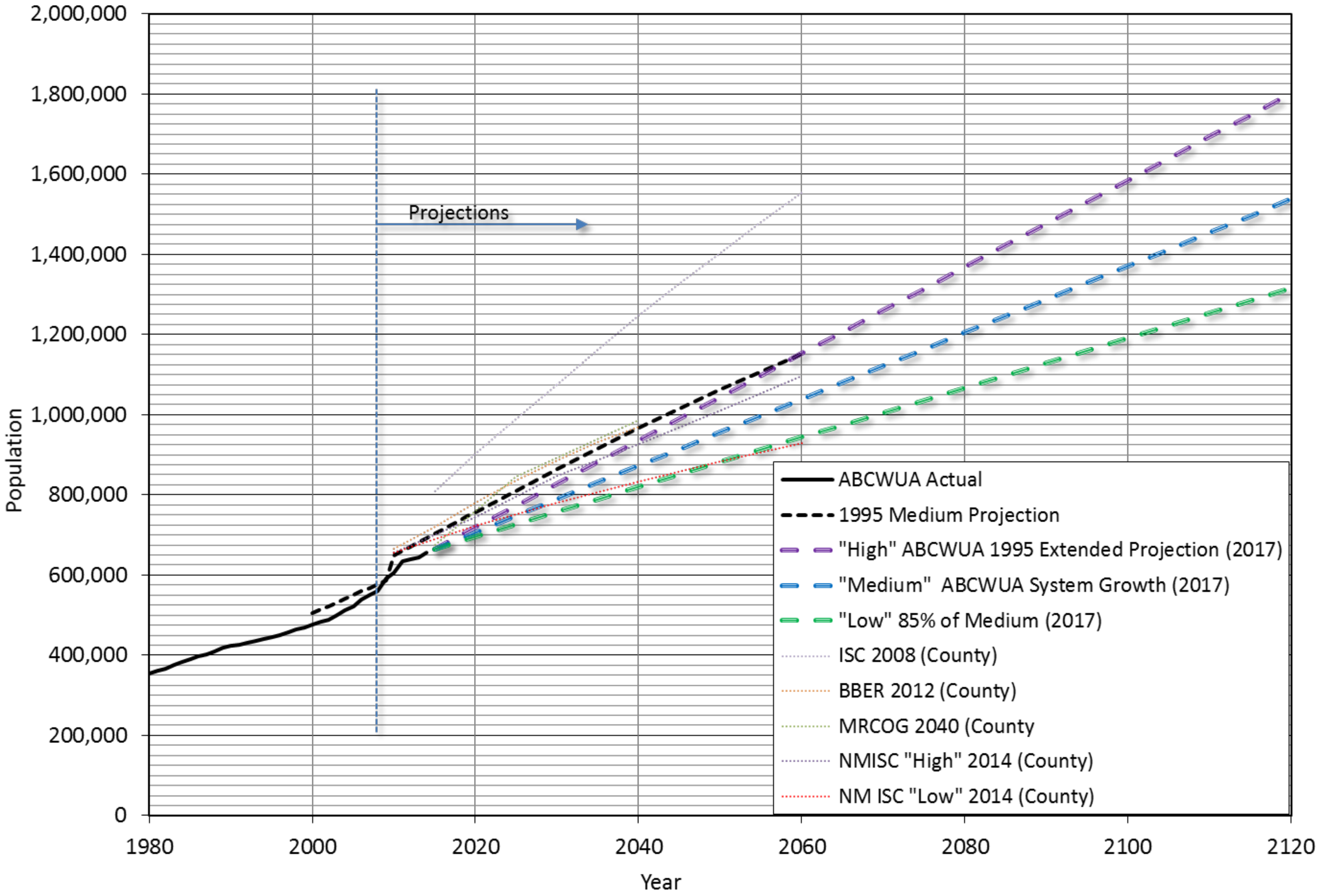
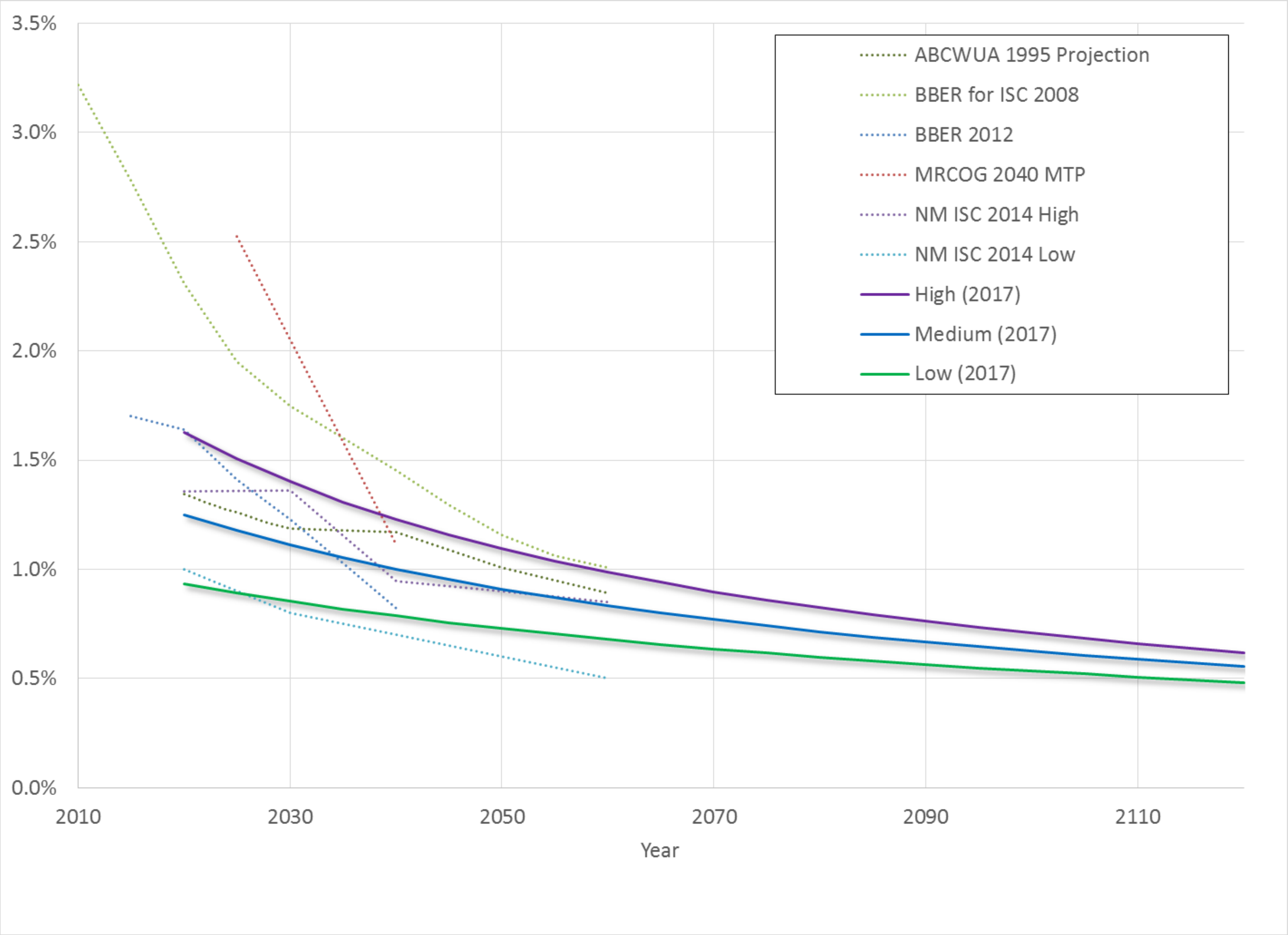


Figure 2.5. Population Projection Growth Rates



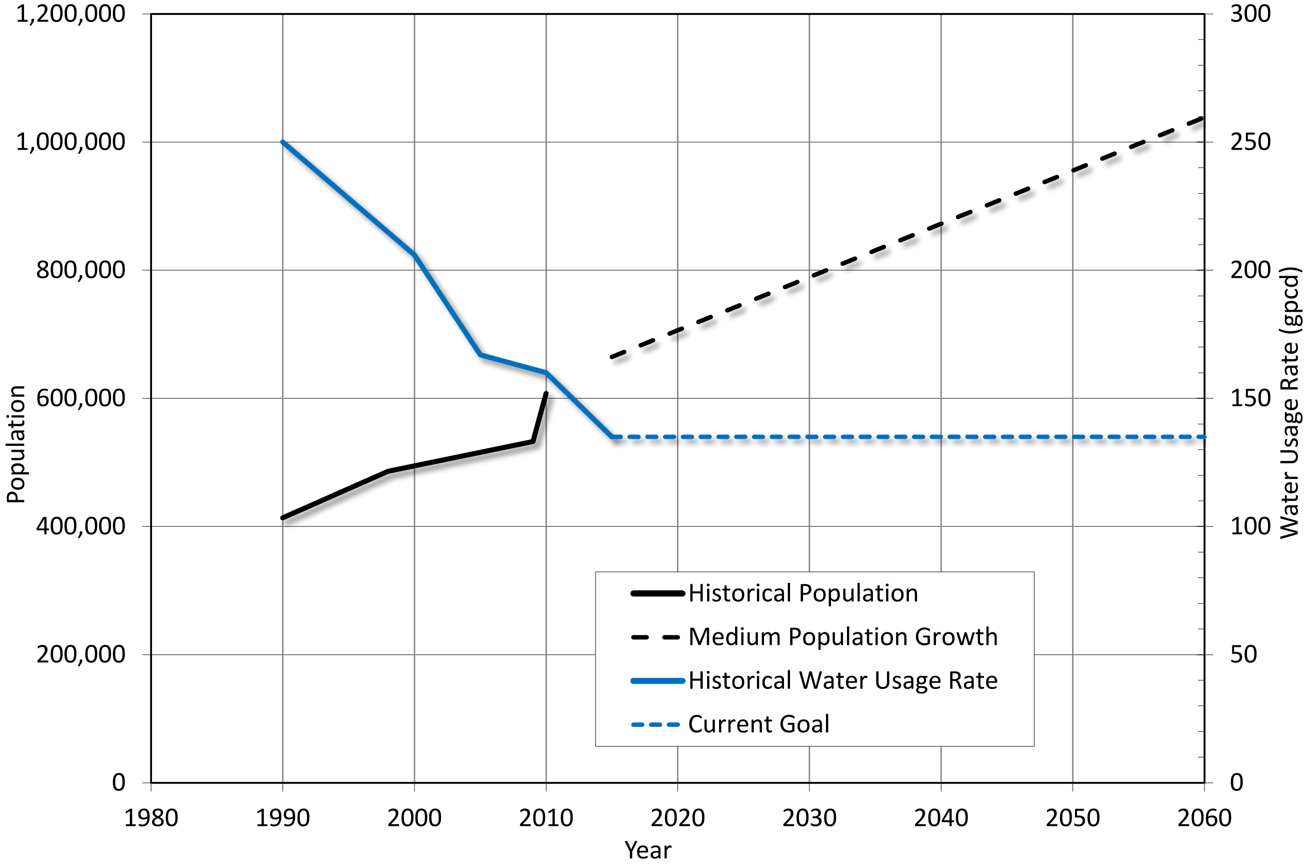
2.3.2 Water Usage Rate

Projected per capita water demand is based on the Water Authority's 2011 conservation goal of reaching 135 gpcd by 2024 (Water Authority, 2013). This goal was reached in 2014 (Yuhas, 2015, pers. comm.). However, water usage rate is likely to fluctuate over time, and a new goal has not been adopted. As such, for projection, this conservation goal remains constant at 135 gpcd through 2060 and beyond (Figure 2.6).

New development will accommodate a significant portion of population growth, and this new growth will likely be more water efficient than more mature areas (see Appendix 2.A for water usage requirements for new development).

To be conservative with respect to future water demand and to allow for evaluation of new conservation goals, the current goal of 135 gpcd is kept constant. Likewise, while residential usage rates are likely to decline, new industry or a change in the mix of customer classes could result in an increase in overall water usage rate. In addition, outdoor irrigation water demand per acre is likely to increase with increasing temperatures expected under climate change, potentially affecting water usage rates (see Section 2.4.6).

Figure 2.6. Baseline Population and Conservation Goal Projections



2.3.3 Projected Water Demands

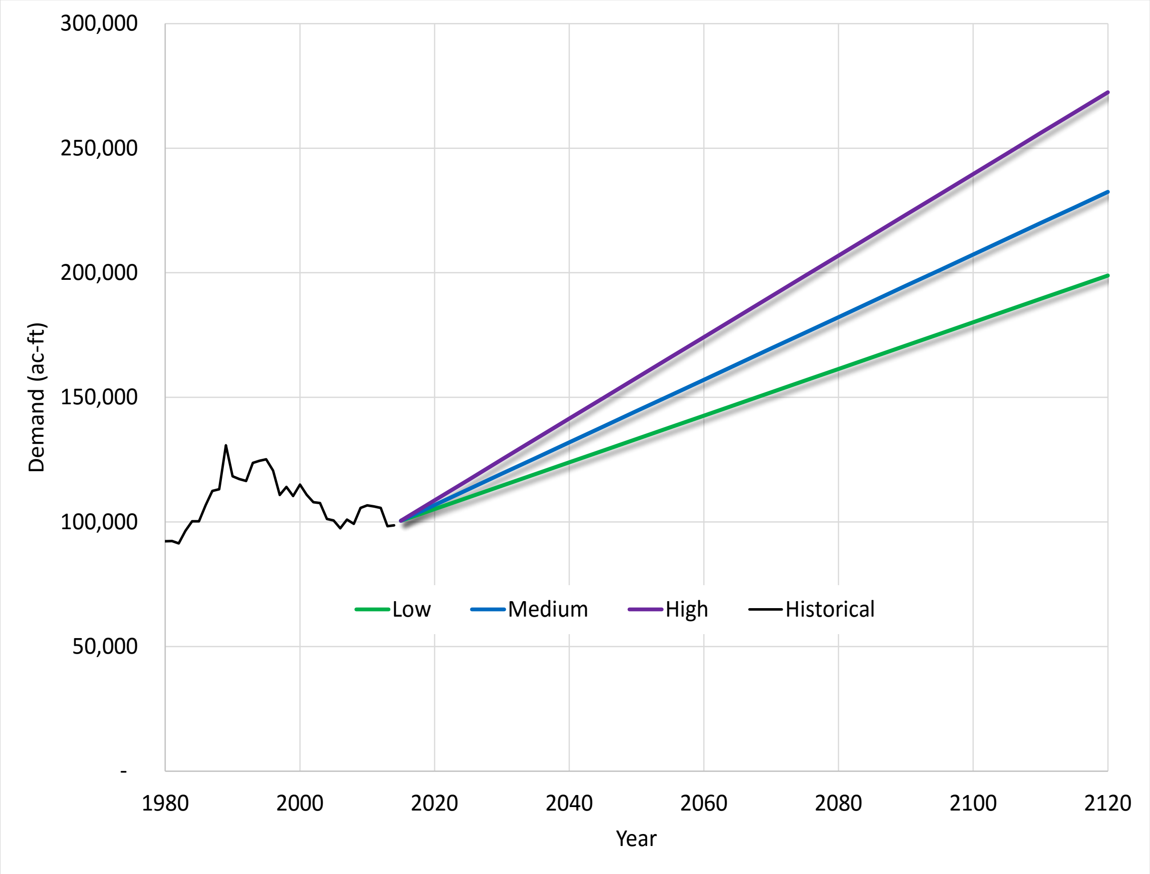
The total annual water demand is estimated by multiplying the projected population by the conservation goal.

For the purpose of tracking and examining the impacts of new supplies and conservation on water demand, water demand is disaggregated into seven sectors (residential, commercial, institutional, industrial, multi-family, non-revenue, and miscellaneous) and further into indoor and outdoor use by sector. Historical sector water demand is known through total produced water and metered customer billing data. Indoor or non-consumptive use by customer class can be estimated based on average winter (December through March) wastewater production. Outdoor or consumptive use can then be calculated as the total water demand minus the indoor portion.

2.3.3.1 PROJECTED ANNUAL WATER DEMAND

For the Low, Medium, and High growth projections, water demand increases from a recent estimate of approximately 100,000 afy in 2015[3] to 200,000, 232,000 and 270,000 afy, respectively, by 2120, as shown in Figure 2.7. These projections represent a relatively broad range of potential future water demands for planning purposes.

Figure 2.7. Actual and Projected Annual Total Water Demand



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[3] This number reflects approximate water demand in 2014 including system and non-system groundwater wells, surface water, and non-potable water demand. Non-system groundwater wells are not connected to collection or distribution and supply at individual locations.

2.3.3.2 WATER DEMAND BY SECTOR

Water demand was evaluated relative to the seven water use sectors:

- residential
- commercial
- industrial
- institutional
- multi-family
- non-revenue
- miscellaneous uses

It was assumed that each sector will grow in equivalent proportion to the total population growth. Data on water usage by sector was available from 2010 to 2014, and is presented in Table 2.3 and Figure 2.8. Trends in water demand by sector were projected using these data.

A further breakdown of non-revenue water is also shown in Figure 2.8, and the 2014 Water Audit is presented in Appendix 2.B. Average gpcd by sector is presented in Figure 2.9. There is no substantial increasing or decreasing trend in these data that is expected to hold up over the long term, so average water use percentages by sector from 2010 to 2014, weighted for more recent data, are expected to be appropriate for planning purposes.

Table 2.3. Actual Water Demand Percentage by Sector, 2010 to 2014

	Water Use Sector						
Year	**Commercial**[A]	**Industrial**[B]	**Institutional**[C]	**Multi-Family**	**Non-revenue**	**Miscellaneous**[D]	**Residential**
2010	14%	1%	4%	13%	10%	11%	46%
2011	14%	1%	4%	13%	11%	10%	47%
2012	14%	1%	5%	13%	8%	12%	47%
2013	15%	1%	5%	13%	8%	12%	46%
2014	15%	1%	5%	13%	7%	14%	45%
Average	14%	1%	5%	13%	9%	12%	46%

Notes:

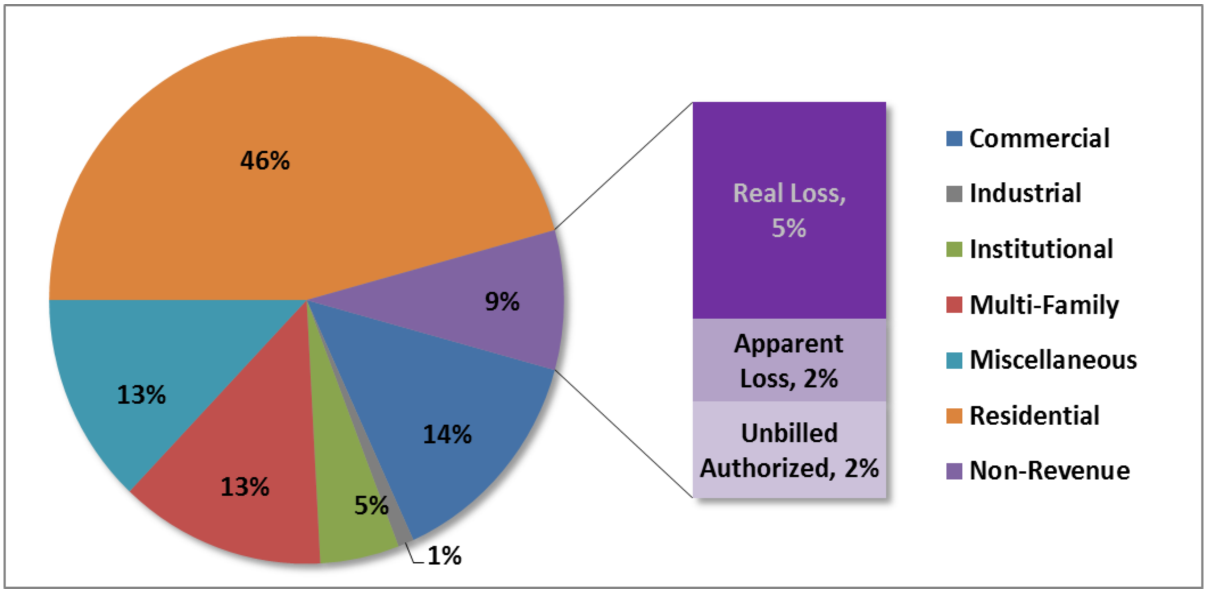
[A] Note that commercial use includes office space, restaurants, and other business.

[B] Industrial includes manufacturing, mining, etc.

[C] Institutional includes parks, schools, athletic fields, city, county, and federal offices

[D] Miscellaneous includes irrigation-only accounts, reuse, and non-potable; as well as a small amount of billed unmetered consumption. The bulk of the water use in this category comes from approximately 1,350 potable and non-potable irrigation-only accounts that meter the large turf areas around the city, such as parks, golf courses and athletic fields.

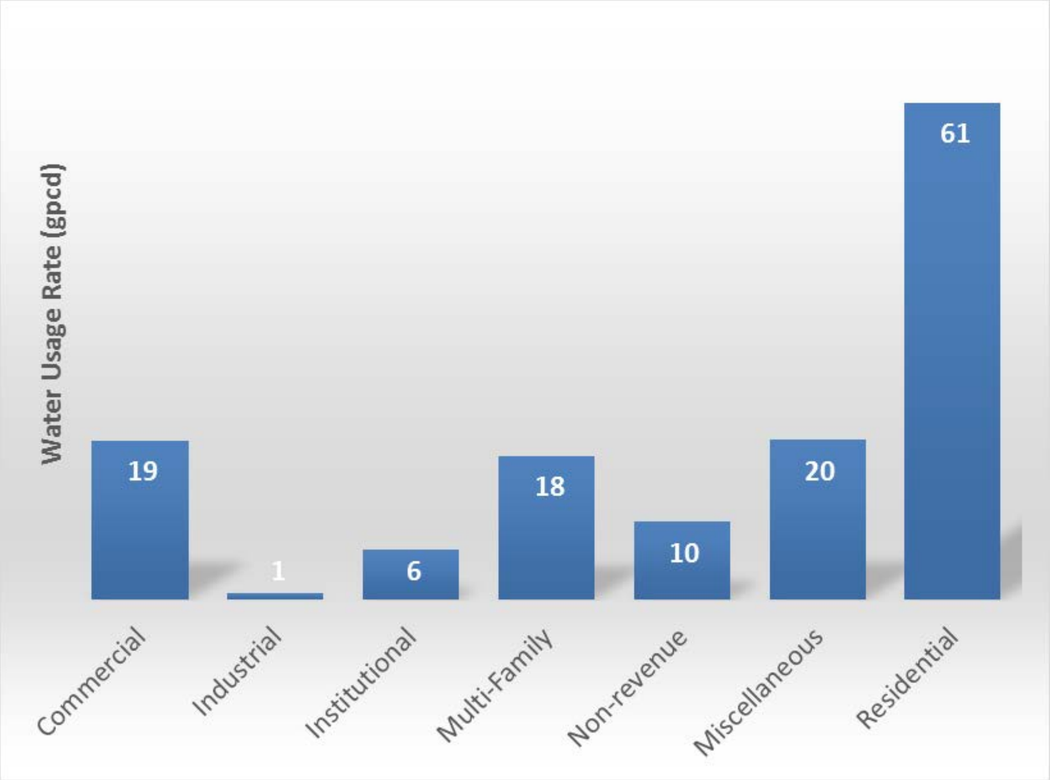
Figure 2.8. Average Water Demand Percentage by Sector



Note:

[A] Non-Revenue water is divided into three components: Real Loss, Apparent Loss, and Unbilled Authorized. Real Loss is physical water lost from distribution up to the point of customer meters. Apparent loss includes metering inaccuracies, data handling errors, and theft. Unbilled Authorized incudes uses such as firefighting and well wash operations.

Figure 2.9. Water Use in Gallons per Capita per Day (2014) by Sector



2.3.3.3 CONSUMPTIVE AND NON-CONSUMPTIVE WATER DEMAND

Water demand can be broken into non-consumptive (indoor/return flow) and consumptive (outdoor) water use by evaluating wastewater return flow relative to the total water demand. The percentage of non-consumptive use has increased from 49 percent in the early 1990s to just under 60 percent since the mid-2000s. It can be expected that this percentage will continue to increase slightly, since population growth is expected to occur through new construction; which, based on current building codes, will use less outdoor water relative to older residences. Likewise, infill or higher density growth would likely result in a decrease in consumptive use and an increase in return flow percentage. However, to be conservative, a consumptive water use ratio that is an average of 2012 to 2014 (59 percent non-consumptive, 41 percent consumptive) is utilized. Table 2.4 presents historical return flow percentage from 1993 to 2014. Figure 2.10 shows the resulting indoor and outdoor (non-consumptive and consumptive) use by sector.

2.3.3.4 MONTHLY WATER DEMAND

Evaluation of the Water Authority's water demand on a monthly basis from 2000 to 2014 resulted in a bell-shaped water demand curve with the highest water demand (approximately 12 percent of annual water demand) occurring in June and July, and the lowest water demand (about 5 percent of annual water demand) occurring from December to February, as shown on Figure 2.11.

Estimates developed as part of the 1997 WRMS indicated summer-month peaks that averaged about 14 percent of annual water demand. Water Authority conservation efforts have clearly cut these peak summer water demands by about 2 percentage points in recent years. This reduction is also demonstrated by the reduction in peak day water production, from about 200 million gallons in 1995 to 150 million gallons in 2014.

Table 2.4. Wastewater Effluent, 1993 to 2014

Year	Return flow to river (ac-ft)	Return flow percentage
1993	58,934	49.7%
1994	60,763	50.7%
1995	60,260	50.6%
1996	58,107	50.3%
1997	58,590	55.2%
1998	60,690	55.6%
1999	59,759	56.1%
2000	58,127	52.3%
2001	57,311	52.8%
2002	56,066	53.7%
2003	55,538	53.1%
2004	55,821	54.3%
2005	57,670	55.5%
2006	57,864	57.2%
2007	56,702	57.4%
2008	57,046	57.5%
2009	58,079	57.6%
2010	58,025	56.3%
2011	57,695	56.4%
2012	59,834	59.1%
2013	55,862	59.2%
2014	52,896	56.6%

Notes:

[A] Return flow to river reflects the quantity of water discharged to the Rio Grande for which the Water Authority receives credit.

[B] Return flow percentage was calculated as return flow to the river divided by the total water produced from all sources.

Figure 2.10. Consumptive and Non-Consumptive Portion of Use by Sector (Average 2012-2014)

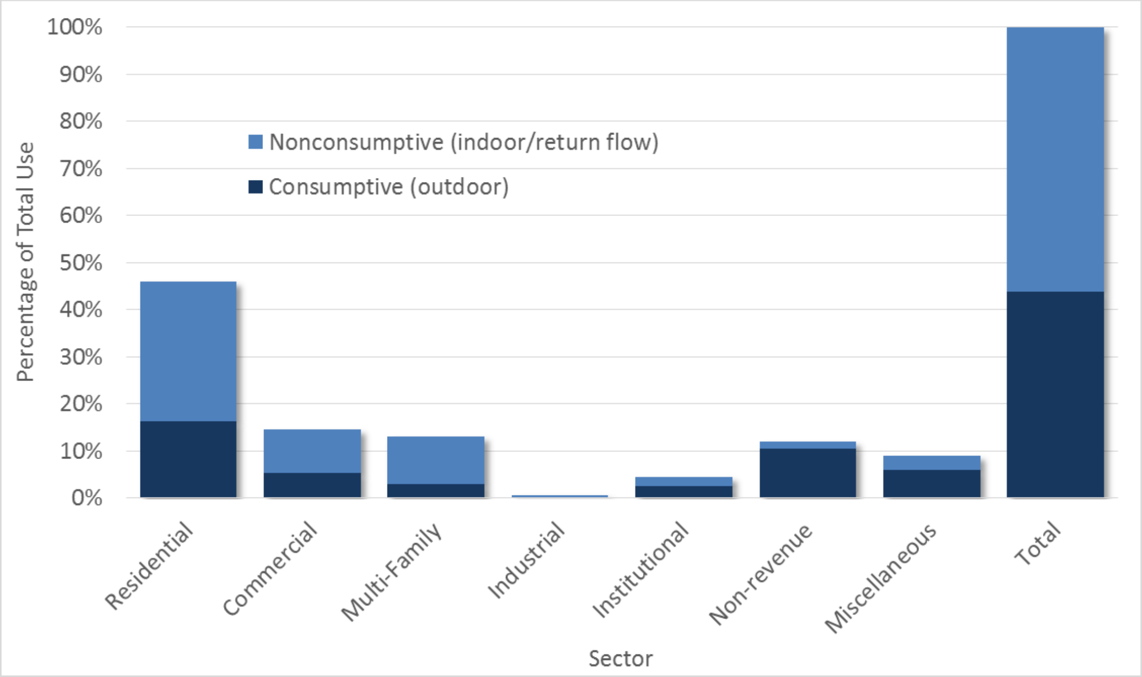
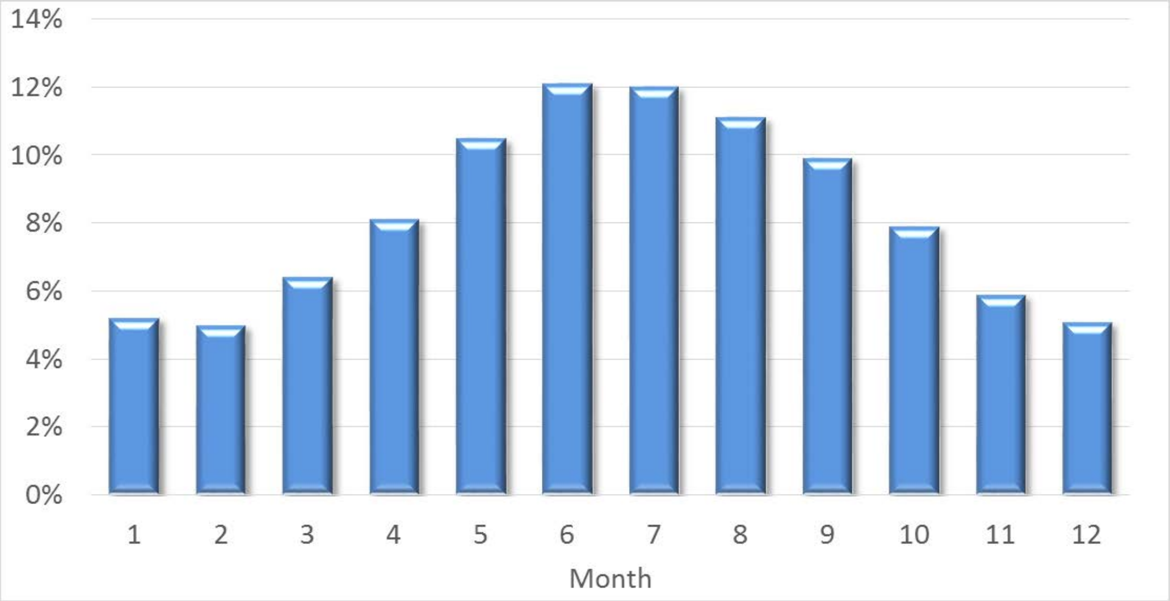


Figure 2.11. Percentage Water Demand by Month, 2000 -2014



2.4 Alternative Water Demand Projection Conditions

Presented below are conditions that would affect the water demands described above, creating either an increase or decrease in water demand.

2.4.1 Conservation Goals

As noted, the assumed conservation goal of 135 gpcd has been achieved. For planning, this rate remains in place through 2120. However, it is expected that using 135 gpcd through 2120 may over-predict water demand, since it is expected that population growth will be supported through new construction, which will have a lower per capita water use rate than existing residential properties. Likewise, existing users are also expected to have a downward conservation trend as older indoor fixtures get replaced by newer, more efficient fixtures, and as outdoor use declines from conversion to lower water use landscaping.

2.4.2 Acute Change in Demand

The Low, Medium, and High projections also do not explicitly account for large jumps in water demand by sector that may occur if, for example, a high water use industrial or commercial development were to locate in Albuquerque. It is unknown what changes in commercial, industrial, and institutional water demands may take place in the future, but changes would have an impact on the overall water demand. Whether the new demand is consumptive or largely non-consumptive will also impact the water supply portfolio. For example, an industry that locates in Albuquerque with largely non-consumptive (indoor) use could be served largely through recycling and reuse. Whereas, a large increase in consumptive use may warrant additional consideration of supply sources.

2.4.3 Change in Indoor/Outdoor Use Ratio

As described in Section 2.3.3.3, the current indoor to outdoor water usage ratio is about 60 percent to 40 percent, respectively; however it is expected that this ratio will change over time, with a decrease of outdoor water use relative to indoor usage. It is expected that population growth will be supported by new residential development, which will use less outdoor water relative to indoor water use through increased xeriscape and low water use irrigation methods. It is also expected that existing properties will continue to transition to lower water use landscaping over time as well, though at a much slower overall rate relative to new construction. Likewise, infill or higher density growth would likely result in a decrease in consumptive use and an increase in return flow percentage.

Using Medium population growth estimates, approximately 44 percent of residential properties by 2060 will be new construction, relative to 2010. It is expected that new construction will use between 25 and 50 percent less water, relative to existing residential properties. For example, homes in the relatively recent Mesa del Sol development use about 30 percent less than the current residential average. Based on this estimate, the indoor usage percentage may increase to between 65 and 70 percent by 2060.

2.4.4 Change in Peaking Factors

Peaking factors are the ratio between the maximum water and average water demand. Based on historical change, it is anticipated that peaking factors may change. Peak day water demands are driven primarily by outdoor water use. As the proportion of outdoor water use declines, it is anticipated that peak day usage will also decline. As noted in Section 2.3.3.4, these changes also potentially impact the monthly distribution of water demand. Use of alternative peaking factors should be evaluated over time.

Also note that the Water Authority's North I-25 Non-Potable Project (NPP) and Southside Reuse systems also reduce the potable system peak day water demands. These systems provide a portion of outdoor water demand (possibly as much as 6%). Additional non-potable reuse projects are currently planned, which could result in additional reductions to the potable system peaking factors.

2.4.5 Change in Population Density

Current water usage rates reflect the mix of current housing and development patterns. A significant shift to more high density development and infill would likely reduce overall per capita use significantly. At present, over half of all use is associated with single-family residential housing. Of this more than 40 percent is outdoor use. Greater population density typically results in more high-rise type living with little to no outdoor use. Population growth that results in greater population density will likely result in less outdoor/consumptive demand and an overall reduction in water usage rate.

2.4.6 Climate Variability Effects

Current predictive models of climate variability indicate that temperature will likely increase and rainfall will be more variable, which is expected to have an effect on future water demand.

Climate variability is expected to increase outdoor water demand. This increase in evaporative and irrigation water demand may be mitigated to some extent by reductions in turf area and overall outdoor water demand, due to conservation trends noted in previous sections.

Data available from the West-wide Climate Risk Assessments (Reclamation, 2011) reflect predicted evapotranspiration at regional climate stations. These data were used to predict the increase in outdoor irrigation water demand based on various future climate projections. See Appendix 2.C for a discussion of how climate change estimates were used to adjust predicted outdoor use.

2.4.7 Additional Considerations

It is likely that new conservation goals will be developed over time to help fill gaps in supply. The nature and extent of these goals may also impact or be impacted by a number of the factors noted in this section.

For example, new pricing models could be employed as a component of conservation that result, as intended, in a reduction in water usage rate. But this method may drive consumers to modify behavior and preferences in ways that are unforeseen in the current analysis – such as specifically targeting landscape changes, resulting in changes to peaking factors.

These changes on a large scale could result in overall cultural and/or quality of life changes that ultimately affect water usage and the economic base. Likewise, changes in the economic base could result in either more or less disposable income, which could result in changed behaviors.

Ultimately, a number of the potential actions and/or external forces are interrelated, resulting in feedback to the system and potential compounding of effects. For simplicity, this analysis examines potential changes from a stable base range of future demands.

It is intended that this range will capture many of these possibilities, though not necessarily represent them explicitly. Future efforts may consider developing scenarios in an explicit economic framework.

2.5 References

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Appendix 2.A

Water Conservation Regulations for New Development

Albuquerque Bernalillo County Water Utility Authority

BILL NO. R-05-13

RESOLUTION

ENHANCING THE WATER CONSERVATION PROGRAM.

WHEREAS, the Authority's high desert environment receives an average of eight inches of rainfall per year, it is appropriate to increase conservation measures; and

WHEREAS, the Albuquerque Bernalillo County Comprehensive Plan requires that "water resources of the metropolitan area shall be managed to ensure a permanent adequate water supply"; and

WHEREAS, conservation has been found to extend the Authority's water supply at a fraction of the cost of other alternatives and that further measures will help to ensure adequate supply of water; and

WHEREAS, dishwashers account for approximately 2% of home water use and are therefore not likely to produce significant water savings; and

WHEREAS, funds currently allocated to the dishwasher rebate program could be better spent on a program with a higher potential for water savings; and

WHEREAS, the voluntary Toilet Rebate Program has been in effect for more than ten years and it is appropriate to require the conversion of low-flow toilets prior to re-sale of a residential and commercial property; and

WHEREAS, the Water Utility Authority has achieved the conservation goal of 30% water usage reduction from 250 gallons per capita per day to 175 gallons per capita per day; and

WHEREAS, the Water Utility Authority has achieved a 38% water usage reduction from 489 gallons per household per day to 303 gallons per household per day; and

WHEREAS, the Water Utility Authority adopted bill R-04-12 which increased the water conservation goal from a 30% to a 40% savings, or a goal of approximately 150 gallons per person per day; and

WHEREAS, there is a need to enhance the water conservation rebate program in order to reach the 40% savings; and

WHEREAS, the Water Resources Advisory Committee established by the Water Utility Authority has recommended water conservation programs to implement in order to reach the 40% savings.

BE IT RESOLVED BY THE AUTHORITY:

Section 1. The toilet rebate program, washing machine rebate program, dishwasher rebate program, hot water recirculation rebate program, rain barrel rebate program, sprinkler timer rebate program and xeriscape rebate program are all authorized by the Authority.

Section 2. The dishwasher rebate program will be rescinded at the end of 2005. A public education program shall be initiated to inform customers that this program will be rescinded.

Section 3. Beginning November 1, 2005, the Xeriscape Rebate Program shall be expanded to include an increased rebate for landscapes that are supported without supplemental irrigation. These landscapes will be supported through a rainwater collection system and/or by natural rainfall. The increased amount of the rebate shall be $0.80 per square foot. Only plants on the Water Conservation Program's extremely low water use plant list will be eligible to be planted in these areas. In addition, in order to receive the rebate, these areas must be approved by the Water Utility's Xeriscape Inspector. In order to allow root establishment, supplemental irrigation shall be allowed for a two-year period for shrubs and grasses and a three-year period for trees.

Section 4. The Water Utility shall work with the City of Albuquerque and Bernalillo County to draft an ordinance requiring that all toilets on both commercial and residential properties be converted to low-flow prior to re-sale. Once this Ordinance has been established by the City of Albuquerque, the toilet rebate program will be phased out.

Section 5. The Water Utility shall develop water conservation best management practices for new residential development and shall work with the City of Albuquerque and Bernalillo County to change the building code or other regulations in order to achieve 180 gallons per household as a goal for new residential homes. The Water Utility Authority shall incorporate the 180 gallons per household goal into development agreements for new services of water.

Section 6. The recommendations of the Water Resources Advisory Committee on water conservation programs to reach the Authority's 10% savings goal will be incorporated in the Authority's strategic planning, budgeting and improvement process. They include the following:

A. Initiate and maintain an aggressive policy to reduce unaccounted for water from 11% to 7% over the next four years. In four years, review the program and set a new goal.

B. Continue to change the rate structure to encourage water conservation and penalize water waste.

C. Develop audit programs to target nursing homes, hospitals, fitness centers, apartments, high schools, hotels, motels and restaurants. These areas should be targeted because they are non-residential high water users and the audit program has been shown to be very effective at reducing water use.

D. Implement an Irrigation Efficiency Rebate. This program will include rain barrels, cisterns, rain sensors for irrigation systems, upgrades to sprinkler heads, movement of sprinklers away from sidewalks and curbs, conversion to low-flow and drip irrigation systems and soil amendments. Incentives for these options should be based upon the potential water savings.

E. Work with local governments to develop an ordinance requiring that irrigation systems be installed by a licensed contractor trained in efficient irrigation. Provide training for irrigation system installers to become licensed in the region.

F. Establish a rebate for non-residential customers that is strictly results based. If you reduce your use by X amount, you will receive a rebate of Y dollars.

G. Develop an ordinance requiring that multiple cycles of water be used in cooling towers.

H. Develop an ordinance requiring sub-metering of multi-family residential accounts (apartments, mobile home parks and some home-owner associations).

I. Expand partnerships with educators, neighborhood representatives, master gardeners and others interested in developing water conservation awareness.

J. Develop a Rain Water Harvesting Ordinance that requires use of water harvesting for all commercial projects over a certain size and all residential developments with more than a certain number of units.

City of Albuquerque

Albuquerque Code of Ordinances

ARTICLE 1: WATER

PART 1: WATER CONSERVATION LANDSCAPING AND WATER WASTE

§ 6-1-1-1 SHORT TITLE.

This article shall be known as the "Water Conservation Landscaping and Water Waste Ordinance."

(Ord. 18-1995)

§ 6-1-1-2 INTENT.

(A) To implement the outdoor water use recommendations of the Water Conservation Task Force, as called for in Resolution Bill No. R-58, Enactment No. 49-1992, adopted by the Council in May of 1992.

(B) To assist in reducing overall per capita water use in the city by 30%.

(C) To reduce yard irrigation and irrigation-related water waste, which comprise over 40% of the city's total annual water usage. To reduce peak summer usage, which is two to three times winter usage and determines the need for capital facilities to adequately meet system water demand. To reduce irrigation water usage without sacrificing landscape quality by using lower water use plants, improved design and planting practices, different watering practices, and better irrigation system design and maintenance.

(D) To reduce water waste; i.e., overwatering, inefficient watering, or release of excess water which generates fugitive water in the public right-of-way. To reduce damage to publicly owned streets and the public expenditures necessary to repair the damage caused by this wasted water. To increase street safety by reducing the potential of frozen water on public right-of-way.

(E) To initially encourage voluntary water conservation for existing single-family residences while requiring conservation on all other properties. To apply more stringent requirements to city-owned facilities to set an example.

(Ord. 18-1995)

§ 6-1-1-3 DEFINITIONS.

For the purpose of this article, the following definitions shall apply unless the context clearly indicates or requires a different meaning.

ATHLETIC FIELD. A turf area used primarily for organized sports.

AUTOMATIC CONTROLLER. A solid state timer capable of operating valve stations to set the days and length of time water is applied.

BUBBLERS. Irrigation heads which deliver water to the soil adjacent to the heads.

CITY OWNED. Property owned by the City of Albuquerque.

COVENANTS. Agreements entered into by property owners, leaseholders, and renters which set conditions for the use, maintenance, and/or sale of property.

DEVELOPMENT. The construction, erection, or emplacement of one or more buildings, structures, or surface improvements on land which is a premises in order to establish or expand a principal residential or nonresidential use.

DISTURBED SLOPES. Slopes that have been altered from their natural configuration or vegetative cover by human activity.

DRIP IRRIGATION. Low pressure, low volume irrigation applied slowly, near or at ground level to minimize runoff and loss to evaporation.

EVAPOTRANSPIRATION. The quantity of water evaporated from adjacent soil surfaces and transpired by plants during a specific time.

EVEN-NUMBERED PROPERTIES. Properties whose official address ends in an even number, excluding city parks and golf courses. Landscaped areas associated with a building will use the number of that building as their address. Only one address shall be used for a large landscaped area associated with one building or activity, even if the landscaped area is broken into many separate subareas.

FLOW RESTRICTION DEVICE. Device applied by the water utility to the customer's meter that restricts the volume of flow to the customer.

FUGITIVE WATER. The pumping, flow, release, escape, or leakage of any water from any pipe, valve, faucet, connection, diversion, well, or any facility for the purposes of water supply, transport, storage, disposal, or delivery onto adjacent property or the public right-of-way.

HAND WATERING. The application of water for irrigation purposes through a hand-held hose, including hoses moved into position by hand and left to flow freely or through a shut-off nozzle.

HARVESTED WATER. Precipitation or irrigation runoff collected, stored and available for reuse for irrigation purposes.

HIGH WATER USE TURF. A surface layer of earth containing regularly mowed grass, with its roots, which requires large volumes and/or frequent application of water throughout its life. High water use grasses include but are not limited to varieties of Bluegrass, varieties of Ryegrass, varieties of Fescue, and Bentgrass.

INFILTRATION RATE. The amount of water absorbed by the soil per unit of time, usually expressed in inches per hour.

INSPECTION. An entry into and examination of premises for the purpose of ascertaining the existence or nonexistence of violations of this article.

LANDSCAPE AREA. The entire parcel less the building footprint, driveways, non-irrigated portions of parking lots and required off-street parking. Includes the public right-of-way.

LOW WATER USE PLANTS. Plants which are able to survive without supplemental water once established as specified in the “Albuquerque Plant List”, published by the city.

MAYOR. The Mayor of Albuquerque or his/her designated representative.

MEDIUM AND LOW WATER USE TURF. A surface layer of earth containing regularly mowed grass, with its roots, which requires moderate or low volumes and/or frequency of application of water once established as specified in the "Albuquerque Plant List" published by the city. Low and medium water use grasses include but are not limited to Bermuda and Bermuda hybrids, Zoysia, blue grama, and Buffalo grass.

MEDIUM WATER USE PLANTS. Plants which require some supplemental watering throughout the life of the plant as specified in the “Albuquerque Plant List” published by the city.

MISTER. A device that produces a cooling effect by emitting fine particles of water into the air in the form of a mist.

MULCH. Any material such as leaves, bark, straw, or other materials applied to the soil surface to reduce evaporation.

NEW DEVELOPMENT. Any development approved by the Albuquerque Planning Department on or after October 1, 1995. For development for which landscaping is required, which is all development except single family residential, only that portion approved by the Albuquerque Planning Department on or after October 1, 1995 shall be considered new development. Development approved by the Albuquerque Planning Department prior to October 1, 1995, but not completed by October 1, 1998 shall also be considered new development.

NON-CITY OWNED. All property which is not owned by the City of Albuquerque.

ODD-NUMBERED PROPERTIES. Properties whose official address ends in an odd number, excluding city parks and golf courses. Large landscaped areas associated with a building will use the number of that building as their address. Only one address shall be used for a large landscaped area associated with one building or activity, even if the landscaped area is broken into many separate subareas.

PRECIPITATION RATE. The amount of water applied per unit of time, usually expressed in inches per hour.

PROPERTY HOLDER. An owner or leaseholder, whose landscaping is governed in whole or in part by rules applied to all property holders within a property holders' association.

PROPERTY HOLDERS ASSOCIATION. An association of property owners, leaseholders, or renters whose landscaping is governed in whole or in part by rules applied to all property holders within the development.

PUBLIC RIGHT-OF-WAY. The area of land acquired or obtained by the city, county, or state primarily for the use of the public for the movement of people, goods, vehicles, or storm water. For the purposes of this article the public right-of-way shall include curbs, streets, and storm water drainage inlets.

RESPONSIBLE PARTY. The owner, manager, supervisor, or person who receives the water bill, or person in charge of the property, facility, or operation during the period of time the violation(s) is observed.

RESTRICTED PLANTS. Plants which, as specified in the "Albuquerque Plant List" published by the city, are classified as restricted due to their high water use requirements and their potential for extensive use in landscaping. Restricted plants include high water use turf, clover, and Dichondra.

RUNOFF. Water which is not absorbed by the soil or landscape to which it is applied. Runoff occurs when water is applied too quickly (application rate exceeds infiltration rate), particularly if there is a severe slope. This article does not apply to stormwater runoff which is created by natural precipitation rather than human-caused or applied water use.

SHUT-OFF NOZZLE. Device attached to end of hose that completely shuts off the flow, even if left unattended.

SINGLE-FAMILY RESIDENTIAL. A lot or premises upon which is established one dwelling only. Of the allowable principal uses, such use shall be the only use on that lot or premises.

SPRAY IRRIGATION. The application of water to landscaping by means of a device that projects water through the air in the form of small particles or droplets.

SPRINKLER HEAD. A device that projects water through the air in the form of small particles or droplets.

STATIC WATER PRESSURE. The pipeline or municipal water supply pressure when water is not flowing.

TEMPORARY IRRIGATION SYSTEMS. Irrigation systems which are installed and permanently disabled within a period of 36 contiguous months.

VALVE. A device used to control the flow of water in the irrigation system.

WATER WASTE. The nonbeneficial use of water. Nonbeneficial uses include but are not restricted to:

(1) Landscape water applied in such a manner, rate and/or quantity that it overflows the landscaped area being watered and runs onto adjacent property or public right-of-way;

(2) Landscape water which leaves a sprinkler, sprinkler system, or other application device in such a manner or direction as to spray onto adjacent property or public right-of-way;

(3) Washing of vehicles, equipment, or hard surfaces such as parking lots, aprons, pads, driveways, or other surfaced areas when water is applied in sufficient quantity to flow from that surface onto adjacent property or the public right-of-way;

(4) Water applied in sufficient quantity to cause ponding on impervious surfaces on non-city owned property.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 42-2001; Am. Ord. 13-2004)

§ 6-1-1-4 APPLICABILITY.

(A) Section 6-1-1-8, Water Budgets and Planting Restrictions, applies to all new development and to existing golf courses, city owned parks, and city owned athletic fields.

(B) Section 6-1-1-9, Design Regulations, applies to all new development and to major renovations of existing golf courses, city owned parks, and city owned athletic fields originally constructed after 1971.

(C) Section 6-1-1-10, Irrigation System Standards, applies to all new development and to expansions or major renovations of existing golf courses, city owned parks, and city owned athletic fields originally constructed after 1971. Single family residential shall be exempt from this section.

(D) Section 6-1-1-11, Inspection Requirements, applies to all new development.

(E) This article does not apply to water provided through the Middle Rio Grande Conservancy District for irrigation purposes. Water obtained through non-city water system sources, however, will be included in the calculation of inches per year for the water budgets for golf courses and parks, as described in Section 6-1-1-8.

(F) Certificates of occupancy for all new development except single family residential shall depend upon compliance with all requirements of this article.

(Ord. 18-1995; Am. Ord. 24-1998)

§ 6-1-1-5 WATERING RESTRICTIONS.

These restrictions apply to all properties within the city limits and/or served by the municipal water utility.

(A) All spray irrigation during the period beginning on April 1 and ending on October 1 of each year must occur between 6:00 p.m. and 10:00 a.m. beginning April 1, 2000. This restriction serves as a guideline for landscape watering on non-city owned property during 1999. This restriction shall not apply to drip irrigation and low precipitation bubblers, hand watering, or watering of containerized plants and plant stock.

(B) All spray irrigation on city owned property during the months of December through March must occur between 10:00 a.m. and 2:00 p.m. This restriction serves as a guideline for landscape watering on non-city owned property. This restriction shall not apply to drip irrigation and low precipitation bubblers, hand watering, or watering containerized plants and plant stock. This restriction shall not apply to golf courses or parks that are in regular use or in use for a special event during these hours.

(C) Shutoff nozzles are required on any hoses used for hand watering, car washing or other outdoor uses, excepting hoses on single-family residential.

(D) All city owned properties other than parks and golf courses shall water no more than every other day. All even-numbered properties shall water only on even-numbered dates. All odd-numbered properties shall water only on odd-numbered dates. This restriction serves as a guideline for landscape watering on non-city owned property.

(E) Restrictions in divisions (A), (B) and (D) above do not apply to the following:

(1) Outdoor irrigation necessary for the establishment of newly sodded lawns and landscaping within the first 30 days of planting or watering of newly seeded turf within the first year of planting;

(2) Irrigation necessary for one day only where treatment with an application of chemicals requires immediate watering to preserve an existing landscape or to establish a new landscape;

(3) Water used to control dust or compact soil;

(4) Visually supervised operation of watering systems for short periods of time to check system condition and effectiveness.

(F) The city shall undertake an aggressive public information campaign to address the requirements of the spray irrigation restrictions for the remainder of 1999 and each year thereafter.

(G) 6-1-1-1 through 6-1-1-99 Water Conservation Landscaping and Water Waste shall be reviewed in its entirety in FY/04 as to its effectiveness and for necessary revisions. This evaluation will be incorporated into the FY/04 budget process.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 54-1999) Penalty, see § 6-1-1-99

§ 6-1-1-6 WATER WASTE.

These restrictions apply to all properties within the city limits and/or served by the municipal water utility.

(A) No person, firm, corporation, or municipal or other government facility or operation shall waste, cause or permit to be wasted any water.

(B) No person, firm, corporation, or municipal or other government facility or operation shall cause or permit the flow of fugitive water onto adjacent property or public right-of-way.

(C) The restrictions in divisions (A) and (B) of this section do not apply to the following:

(1) Storm runoff allowed under provisions of the city's Drainage Ordinance as currently adopted or subsequently amended;

(2) Flow resulting from temporary water supply system failures or malfunctions. These failures or malfunctions shall be repaired as quickly as possible;

(3) Flow resulting from firefighting or routine inspection of fire hydrants or from fire training activities;

(4) Water applied as a dust control measure as may be required under Chapter 9, Article 5 of this code;

(5) Water applied to abate spills of flammable or otherwise hazardous materials, where water is the appropriate methodology;

(6) Water applied to prevent or abate health, safety, or accident hazards when alternate methods are not available;

(7) Flow resulting from routine inspection, operation, or maintenance of the municipal water supply system;

(8) Flow resulting from routine inspection or maintenance of irrigation systems;

(9) Water used by the Traffic Engineering Division, City of Albuquerque, in the course of installation or maintenance of traffic flow control devices;

(10) Water used for construction or maintenance activities where the application of water is the appropriate methodology and where no other practical alternative exists.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-7 SPECIAL PERMITS

These requirements apply to all properties within the city limits and/or served by the municipal water utility.

(A) Use of Misters

(1) The use of misters shall require a special permit, issued by the city. The Mayor shall develop regulations and administrative procedures for the issuance and conditions of such permits. The Mayor shall have the authority to limit the number of permits or revoke permits as deemed necessary to protect the public interest.

(2) Effective April 1, 1999, the use of misters without a permit, or in violation of permit conditions, shall constitute a violation of this article and shall be subject to the fee assessment processes described in §§ 6-1-1-13 and 6-1-1-99.

(3) Any person, firm, corporation, or municipal or other government facility selling, leasing, renting, installing or otherwise making misters available to any other person, firm, corporation, or municipal or other government facility shall provide notification to their customers of the special permit requirement for mister use. Notice may be delivered by prominently posting a sign at the point of purchase or by providing a document to each individual customer. The city shall provide approved language for such notification.

(Ord. 24-1998)

§ 6-1-1-8 WATER BUDGETS AND PLANTING RESTRICTIONS

Subsection (A) of this section applies to all city and non-city owned golf courses, and to all city owned parks and athletic fields. Subsection (B) of this section applies to all new development.

(A) Water Budgets for Parks and Golf Courses.

(1) Parks and golf courses shall use medium and low water use plants as much as possible. High water use turf or other restricted plants shall be allowed only in those areas with heavy usage or foot traffic, such as athletic fields, playgrounds, and golf course tees, greens, and fairways.

(2) All golf courses existing prior to October 1, 1995 will be allowed up to 40 inches of water per acre of landscape area per year. Golf courses using wells must report well usage to the city on a monthly basis. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual golf course basis and shall include municipal and non-municipal water supplies.

(3) All new golf courses or existing golf course expansions permitted by the city after October 1, 1995 will be allowed up to 37 inches per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual golf course basis and shall include municipal and non-municipal water supplies. The landscaped area for new golf courses shall not exceed 90 acres per 18 holes or 45 acres per 9 holes.

(4) All parks will be allowed up to 35 inches of water per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6)

of this section. Usage will be calculated on a per individual park basis and shall include municipal and non-municipal water supplies.

(5) Athletic fields will be allowed up to 45 inches per acre of landscape area per year. Any usage over the allowable amount will be subject to the excess use surcharge(s) described in division (A)(6) of this section. Usage will be calculated on a per individual athletic field basis and shall include municipal and non-municipal water supplies.

(6) Any usage over the approved water budget will be subject to the excess use surcharge(s) defined in the Water and Sewer Rate Ordinance as currently adopted or subsequently amended (see Ch. 6, Art. 4), and established by the Mayor's rules and regulations. This surcharge(s) will be calculated on an annual basis and applied to the February water bill for the property. If two different surcharges are defined in the Water and Sewer Rate Ordinance or the Mayor's rules and regulations, the surcharge for excess usage up to 10% of the water budget shall be the lower of the surcharges. The surcharge for excess usage over 10% of the water budget shall be the higher of the surcharges.

(7) For all parks, golf courses and other facilities with greater than ten acres of restricted plants, and developed after the effective date of this section, the owner or developer shall, when available and economically feasible, use reclaimed wastewater, shallow groundwater or other alternative water supplies, as specified by the policies of the Albuquerque Water Resources Management Strategy.

(B) Planting Restrictions.

(1) All city owned new development other than parks, golf courses, and housing shall use medium and low water use plants on 100% of the landscape area.

(2) All city owned housing and all non-city owned properties other than golf courses shall not use high water use turf or other restricted plants on more than 20% of the landscape area, except that for single family residential properties;

(a) In the event that 20% of the landscape area is greater than 3,000 square feet, high water use turf and other restricted plants shall not be used on more than 3,000 square feet of the landscape area;

(b) In the event that 20% of the landscape area is less than 300 square feet, high water use turf and other restricted plants may be used on up to 300 square feet of the landscape area.

(C) Certain Restrictive Covenants Prohibited.

(1) A property holders' association shall not enforce a provision in a covenant that prohibits or restricts a property holder from: (a) Removing turf grass and installing xeriscape landscaping in compliance with the restrictions for new development in subsection (B) of this section; (b) Installing efficient irrigation systems, including underground drip systems; or

(c) Using rain barrels or other water harvesting devices, provided such devices adequately protect the public's health, safety, and welfare.

(2) A property holders' association may establish criteria for relandscaping to improve water use efficiency but cannot require a higher percentage of high water use turf than allowed in subsection (B) of this section except that it may require that the maximum percentage of high water use turf allowed in subsection (B) of this section be maintained.

(3) A property holders' association may establish criteria regarding type and placement of rainwater collection/harvesting. (Ord. 18-1995; Am. Ord. 1-1998; Am. Ord. 24-1998; Am. Ord. 13-2004; Am. Ord. 41-2004; Am. Ord. 41-2004) Penalty, see § 6-1-1-99

§ 6-1-1-9 DESIGN REGULATIONS

The following regulations apply to all new development, and to expansions or major renovations as existing city owned parks, city and non-city owned golf courses, and city-owned athletic fields originally constructed after 1971.

(A) With the exception of temporary irrigation systems needed to establish low water use plants, spray irrigation shall not be used on slopes greater than four feet of horizontal distance per one foot vertical change (4:1).

(B) All existing disturbed slopes and all man-made slopes shall receive erosion control from plantings and/or terracing. Concrete, asphalt, or any other water and air impervious paving/cover will be allowed only where it is the most appropriate methodology and where no other practical alternative exists.

(C) Plants that require spray irrigation or a mowing frequency of more than three times per year shall not be used in street medians, except that spray irrigation may be used in street medians for up to 36 months where the primary objective is to reclaim disturbed areas with low water use plants.

(D) Spray irrigation shall not be used to apply water to any area within eight feet of a street curb or storm sewer inlet. These areas may be irrigated by drip, bubbler, soaker, or sub-surface irrigation systems.

(E) Sprinkler heads shall be installed at least eight inches away from impermeable surfaces.

(F) No spray irrigation shall be used in areas less than ten feet in any dimension excepting within back or side yards of residential properties, or where such an area is contiguous with adjacent property so that the dimension totals ten feet minimum. Within parking lots no spray irrigation shall be used on any area less than 15 feet in any dimension. These areas may be irrigated by drip, bubbler, soaker, or sub-surface irrigation systems.

(G) Any existing features should be evaluated for incorporation in design to include natural drainage, rock outcroppings, stands of native vegetation which can be protected, or detention areas where vegetation has grown and is being supported by nuisance flows or harvested water.

(H) The potential for using harvested water should be evaluated and, when practical, incorporated into landscape design. Such design shall be consistent with the requirements of the city's Flood Hazard Control Ordinance and the Drainage Ordinance as currently adopted or subsequently amended.

(I) Ponds, fountains, wetlands, marshes, water features for wildlife habitat, functional holding ponds or other reservoirs that are supplied in whole or in part by the municipal water supply shall not exceed 500 square feet or surface area unless approved by the Mayor. Multiple water features on the same property will be considered together to determine surface area. Flowing water used in fountains, waterfalls and similar features shall be recirculated.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-10 IRRIGATION SYSTEM STANDARDS

The following standards apply to all expansions or major renovations at existing parks, golf courses and athletic fields originally constructed after 1971, and to all new development except single family residential. The standards serve as voluntary guidelines for single-family residential development. In general, irrigation systems shall be designed to be site-specific, reflecting plant type, soil type, infiltration rates, slopes, and prevailing wind direction.

(A) Irrigation systems shall be designed to be in conformance with all provisions of this article. Temporary irrigation systems shall not be required to meet these standards.

(B) Application equipment for which the manufacturer specifies flow rates in gallons per minute (gpm) shall not share a control valve with equipment for which the manufacturer specifies flow rates in gallons per hour (gph). Irrigation systems shall be controlled by an automatic controller equipped with the following features:

(1) Two or more independent programming schedules;

(2) Capable of programming run times in one-minute increments and displaying the programmed run time as a numeric display;

(3) Total program memory retention;

(4) Ability to be fitted with an external rain switch interrupter and soil moisture sensor.

(C) No intentional overspray is allowed where it may obstruct pedestrian traffic on a city-required pedestrian walkway, as defined by the city's Sidewalk, Drive Pad, Curb and Gutter Ordinance as currently adopted or subsequently amended.

(D) Irrigation systems shall be designed such that water pressure at the sprinkler or emitter is not more than 20% in excess of the manufacturer's maximum recommended pressure range for that device. Pressure may be regulated by design or by the installation of a pressure regulating device or devices.

(E) Irrigation systems shall be designed to minimize low head line drainage.

(F) All new development with new spray irrigated landscaped areas totaling one-half acre or more shall have a Landscape Irrigation Audit performed by a Certified Landscape Irrigation Auditor, certified by the Irrigation Association. The auditor shall be independent of the property owner and of all contractors associated with the property. The audits will be conducted in accordance with the current edition of the Landscape Irrigation Auditor's Handbook. The minimum efficiency requirements to meet in the audit are a 60% distribution uniformity for all fixed spray systems and a 70% distribution uniformity for all rotary systems. The results of the audit shall be provided to the city in a letter or other form acceptable to the city and shall be signed by the Auditor. Compliance with this provision is required before the city will issue a Certificate of Occupancy or, in the case of park development, a Letter of Final Acceptance.

(G) All new development with spray irrigated landscapes greater than ten acres shall have the sprinkler heads tested for uniformity of performance using the Center for Irrigation Technology's (CIT) Sprinkler Profile and Coverage Evaluation (SPACE) program, or a comparable assessment acceptable to the city. The sprinkler heads shall have a scheduling coefficient of 1.3 or less for full circle heads and 1.5 or less for partial circle heads, with a rating of 1.0 being perfect. The sprinkler heads shall be installed in the spacing and pressure range tested. The results of this test shall be provided to the city in a form acceptable to the city. Compliance with this provision is required before the city will issue a Certificate of Occupancy or, in the case of park development, a Letter of Final Acceptance.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-11 INSPECTION PROCEDURES

The following procedures apply to all new development:

(A) Inspection by Consent.

(1) Within the scope of his authority, the Mayor may conduct an inspection, with the voluntary consent of an occupant or custodian of the premises to be inspected who reasonably appears to be in control of the places to be inspected or otherwise authorized to give such consent.

(2) Before requesting consent for an inspection, the Mayor shall inform the person to whom the request is directed of the authority under and purposes for which the inspection is to be made and shall exhibit an identification card or document evidencing his authority to make such inspections.

(3) Inspections undertaken pursuant to this section shall be carried out with due regard for the convenience and privacy of the occupants, and during the daytime, unless, because of the nature of the premises, the convenience of the occupants, the nature of the possible violation or other circumstances, there is a reasonable basis for conducting the inspection at night.

(4) Notice of the purpose and approximate time of an inspection of an area not open to the general public shall be sent to the occupants or custodians of premises to be inspected not less than seven days before the inspection is undertaken.

(B) Inspection without Consent.

(1) Upon sufficient showing that consent to an inspection has been refused or is otherwise unobtainable with a reasonable period of time, the Mayor may make application for an inspection order/search warrant. Such application shall be made to a court having jurisdiction over the premises to be inspected. Such application shall set forth:

(a) The particular premises, or portion thereof sought to be inspected;

(b) That the owner or occupant of the premises has refused entry;

(c) That inspection of the premises is necessary to determine whether they comply with the requirements of this article;

(d) Any other reason necessitating the inspection, including knowledge or belief that a particular condition exists on the premises which constitutes a violation of this article; and

(e) That the Mayor is authorized by the city to make the inspection.

(2) The application shall be granted and the inspection order/search warrant issued upon a sufficient showing that inspection in the area in which the premises in question are located, or inspection of the particular premises, is in accordance with reasonable legislative or administrative standards, and that the circumstances of the particular inspection for which application is made are otherwise reasonable. The court shall make and keep a record of the proceedings on the application, and enter thereon its finding in accordance with the requirements of this section.

(3) While executing the inspection order/search warrant the Mayor shall, if the premises in question are unoccupied at the time of execution, be authorized to use such force as is reasonably necessary to effect entry and make the inspection.

(4) While conducting the inspection the Mayor shall, if authorized by the court on proper showing, be accompanied by one or more law enforcement officers authorized to serve search warrants who shall assist the Mayor in executing the order at his direction.

(5) After execution of the order or after unsuccessful efforts to execute the order, as the case may be, the Mayor shall return the order to the court with a sworn report of the circumstances of execution or failure thereof.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-12 VARIANCES AND APPEALS

The Mayor shall be responsible for the enforcement of this article. The Mayor may prescribe policies, rules, or regulations to carry out the intent and purposes of this article.

(A) Variances to § 6-1-1-5 (Watering Restrictions) and § 6-1-1-6 (Water Waste), and § 6-1-1-7 (Special Permits).

(1) Administrative variances to the restrictions in §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 may be issued by the Mayor or his/her designee, only for the purposes of installing or retrofitting landscaping, provided that the general intent of this article has been met, compliance with this article is proven to cause practical difficulties and unnecessary hardship, and all options for abatement through modified water management have been exhausted. The criteria to determine hardship shall include level of capital outlay and time required to be in compliance with this article.

(2) Variances may be issued for a period not to exceed one year and shall stipulate both short-term corrective measures and a schedule for completion of long-term corrective measures. Variances issued to accommodate the installation or retrofitting of landscaping are only applicable to the site where the construction that will increase the possibility of wasted water is to occur. The variance shall apply only for the period of construction. As of the date of this legislation any existing variances shall be subject to these provisions. Variances must be renewed on an annual basis if long-term corrective measures cannot be completed within one year.

(B) Appeal of § 6-1-1-5 (Watering Restrictions), § 6-1-1-6 (Water Waste), and § 6-1-1-7 (Special Permits). Any responsible party may appeal fees for violations of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 to the City Hearing Officer by filing an appeal within seven calendar days of receiving a notice of violation. Such request shall be made in writing and filed in the Office of the City Clerk. The appeal shall identify the property and state the grounds of appeal together with all material facts in support thereof. A filing fee of $20 shall be added to the water bill in the event the violation is upheld by the Hearing Officer. When a hearing is requested, the Hearing Officer shall send written notice by certified mail, return receipt requested, to the appellant of the time and place of the hearing. At the hearing the appellant shall have the right to present evidence as to the alleged fact upon which the Mayor based the determination of the need for assessment of fee or restriction of service and any other facts which may aid the Hearing Officer in determining whether this article has been violated. The Hearing Officer shall, within seven working days following the hearing, issue a written decision specifying the fee, if appropriate, and the action that must be taken to avoid additional penalty. Fees will be void and service will not be restricted if the written decision is not issued within seven working days.

(C) Judicial Review. The exclusive remedy for parties dissatisfied with the action of the City Hearing Officer on §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be the filing of a petition for a writ of certiorari with the State District Court. The petition for review shall be limited to the record made at the administrative hearing held pursuant to this article.

(D) Variances to §§ 6-1-1-8 through 6-1-1-10 requirements. A variance to the regulations in §§ 6-1-1-8 through 6-1-1-10 may be issued by the Mayor, through the Zoning Hearing Examiner, provided that the general intent of this article has been met and compliance with this article is proven to cause practical difficulties and unnecessary hardship. The variance procedure for this article will comply with the variance procedure in the Zoning Code as currently adopted or subsequently amended. (This procedure is described in § 14-16-4-2.) Appeals of decisions of the Zoning Hearing Examiner are to the Environmental Planning Commission. Appeals of decisions of the Environmental Planning Commission are to the City Council. Appeal is made by filing written notice with the Planning Department within 15 days after the request for variance has been denied. Appeal procedures will comply with those in the Zoning Code, § 14-16-4-4.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 49-2003)

§ 6-1-1-13 FEES; ASSESSMENT

(A) Fees and Restriction of Service. Any responsible party who violates any of the provisions of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be subject to progressively higher fees and flow restriction until the violation ceases or a variance is granted. The assessment of fees and application of flow restriction shall be consecutive for violations separated by less than three calendar years. Fees and flow restriction shall be suspended pending the outcome of an appeal or variance request.

(B) Assessment of Fees. Assessment of fees for violations of the regulations in §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 will be through the city utility bills for the responsible party's billing account. Fees shall be assessed to the account within 15 days following expiration of the appeal period or issuance of appeal findings and shall be listed as separate line item on the utility bill. Responsible parties shall be notified of the fee through certified mail within 15 days of the violation. Fees must be paid within the normal payment period allowed by the city utility billing system.

(C) In lieu of fees for violations of §§ 6-1-1-5 and 6-1-1-6, the responsible party may have a landscape water audit performed by an authorized landscape irrigation auditor, certified by the Irrigation Association. The audit will be conducted in accordance with the current edition of the Landscape Auditor's Handbook. The audit must be performed within 30 days of notification of violation and the audit recommendation must be implemented within 60 days of the audit. If these deadlines are not met, the fees for violation will apply.

(Ord. 18-1995; Am. Ord. 24-1998) Penalty, see § 6-1-1-99

§ 6-1-1-99 PENALTY.

(A) The schedule for assessment of fees and application of flow restriction for a violation of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7 shall be as follows:

(1) First observed violation – $20;

(2) Second observed violation – $50;

(3) Third observed violation - $100;

(4) Fourth observed violation - $300;

(5) Fifth observed violation - $400;

(6) Sixth observed violation - $600;

(7) Seventh observed violation - $800;

(8) Eighth observed violation - $1,000;

(9) Ninth or more observed violation: Either a $1,000 fee per violation plus application of a flow restriction device at meter or a $2,000 fee per each violation. The flow restriction device cannot be removed by the responsible party and will not be removed by the utility until the responsible party adequately demonstrates to the city that the violation has ceased or until a variance is granted.

(B) For the purpose of assessing fees or flow restriction for violations of §§ 6-1-1-5, 6-1-1-6, and 6-1-1-7, any previous violation shall not be considered if:

(1) A period of five years has elapsed since the violation was incurred; or

(2) The property is acquired by a new owner; or

(3) The violation occurred prior to July 1, 1998.

(C) Any responsible party who violates any provision of §§ 6-1-1-8 through 6-1-1-10 shall be deemed guilty of a misdemeanor, and upon conviction thereof, shall be punished by a fine not to exceed $500 and/or imprisonment for a period not to exceed 90 days. Application of fines for violations of the regulations in §§ 6-1-1-8 through 6-1-1-10 will comply with the Zoning Code as currently adopted or subsequently amended. (See §§ 14-16-4-1 through 14-16-4-12, and 14-16-4-99).

(D) Any person who violates the provisions of this article for which no other penalty is set forth, shall be subject to the general penalty provision of this code set forth in § 1-1-99.

(Ord. 18-1995; Am. Ord. 24-1998; Am. Ord. 42-2001; Am. Ord. 49-2003)

PART 2: FLUORIDATION OF WATER

§ 6-1-2-1 DECLARATION OF PURPOSE OF INTENT.

The City Council, based on information supplied to it by various sources, finds and declares that:

(A) The addition of fluorides to public water supplies is a process which has been adopted and used in many parts of the United States as a measure for improving the permanent condition of the teeth, in particular the teeth of children, and is a means of benefitting the population generally at a minimal cost and difficulty.

(B) The New Mexico Department of Public Health and the United States Public Health Service recommend and encourage the addition of fluorides to public water supplies so as to maintain an optimum fluoride level in such water supplies of 0.9 parts of fluoride per million parts of water to 1.2 parts of fluoride per million parts of water as public health measures.

(C) It has been found and determined on the basis of study and investigation that the minimum optimum level of 0.9 parts of fluoride per million parts of water does not exist in the present water supply of the city.

(D) Long term studies and the use of water fortified by addition of fluorides to a point where the optimum level of 0.9 parts of fluoride per million parts of water to 1.2 parts of fluoride per million parts of water has been maintained in public water supplies have demonstrated that such process does reduce the incidence of dental caries and tooth decay in the permanent teeth of children and does not produce deleterious effects to any persons; and also is of benefit to adults.

('74 Code, § 8-3-1) (Ord. 151-1970)

§ 6-1-2-2 AUTHORITY TO PROCEED WITH FLUORIDATION OF WATER SUPPLY.

(A) The Mayor is directed to acquire the necessary facilities and supplies for the fluoridation of the city public water supply as soon as practicable to the end that the fluoride content of the water supply can be raised to and maintained at the optimum fluoride level of 0.9 parts of fluoride per million parts of water to 1.2 parts of fluoride per million parts of water no later than January 1, 1972.

(B) The Mayor is hereby authorized to cause the addition of fluorides to the city public water supply in controlled amounts to reach and maintain the optimum fluoride level as soon as the facilities and supplies have been acquired and made operational.

('74 Code, § 8-3-2) (Ord. 151-1970)

PART 3: PUBLIC USE OF FIRE HYDRANTS

§ 6-1-3-1 PERMIT REQUIRED.

(A) No person, individual, firm, partnership or corporation (hereinafter called "User") shall obtain water from any fire hydrant located within the city for any purpose other than public emergency use without obtaining a permit from the city as provided herein.

(B) A User may obtain such a permit upon application to the city as provided in § 6-1-3-2. The permit shall designate the fire hydrants from which the User may obtain water.

(C) A permit may be revoked at any time for cause, such as, but not limited to:

(1) User's failure to pay for water at the specified time;

(2) User's interference with emergency use of designated fire hydrant;

(3) User obtaining water from other than designated fire hydrant;

(4) Conviction of the User for any violation of §§ 6-1-3-1 et seq.;

(5) Compelling need of the city.

(D) The granting of a permit under this section does not grant any right of privilege to the User to interfere with the city's duty to the public. Emergency use for fire protection supersedes and takes precedence over all other uses.

('74 Code, § 8-2-1) (Ord. 234-1972) Penalty, see § 1-1-99

§ 6-1-3-2 METER REQUIRED.

The user shall use a meter owned by the city in order to keep a record of the water used. The User is required to deposit $300 for each meter. This deposit shall be reimbursed to the User upon the return of the water meter in good condition and certification by the Water Division that the fire hydrant concerned is in good condition. The user is responsible for any damage incurred to fire hydrant or water meter. The deposit shall be applied toward the payment for any such damage and may be applied to any unpaid charges for water obtained pursuant to the provisions of § 6-1-3-1 et seq.

('74 Code, § 8-2-2) (Ord. 234-1972) Penalty, see § 1-1-99

§ 6-1-3-3 CROSS-CONNECTIONS.

Unprotected cross-connections (as defined within the Cross-Connection Prevention and Control Ordinance set forth in § 6-2-1 et seq.) are prohibited.

('74 Code, § 8-2-3) (Ord. 234-1972; Am. Ord. 26-1976; Am. Ord. 88-1978; Am. Ord. 39-1987) Penalty, see § 1-1-99

PART 4: WATER CONSERVATION LARGE USERS

§ 6-1-4-1 SHORT TITLE.

This article shall be known as the "Water Conservation Large Users Ordinance."

(Ord. 18-1998)

§ 6-1-4-2 INTENT.

(A) To implement the recommendations related to large water users called for in Resolution Bill No. R-173, Enactment No. 40-1995, adopted by the Council in March of 1995.

(B) To assist in reducing overall per capita water use in the city by 30% from 250 to 175 gallons per person per day.

(C) To require development, adoption, and implementation of water conservation plans for customers using large amounts of water through a cooperative process with the city.

(D) To assist large users in identifying ways to reduce water use.

(E) To formalize monitoring and feedback for large users on meeting approved goals for water use reductions.

(Ord. 18-1998)

§ 6-1-4-3 DEFINITIONS.

For the purpose of this article, the following definitions shall apply unless the context clearly indicates or requires a different meaning.

ATHLETIC FIELD. Physically defined high water use turf area used regularly for athletic practices and/or games.

EXISTING CUSTOMER. Any city water system customer for which a water meter was installed prior to the effective date of this article.

LANDSCAPED AREA. The entire parcel less the building footprint, driveways, and non-irrigated portions of parking lots.

LARGE USER. Any city water system customer which used or uses in excess of 50,000 gallons per day in 1997 or any calendar year thereafter in which annual use is averaged over the year (50,000 gallons per day equals 18.25 million gallons or 24,398 units annually). Usage for multiple meters serving the same geographic facility will be added together and considered one customer.

LOW FLOW FIXTURES. Plumbing fixtures as follows: 1.6 gallons or less per flush toilets, 1.0 gallon or less per flush urinals, 2.5 gallons or less per minute shower heads, 2.5 gallons or less per minute faucets and/or aerators.

NEW CUSTOMER. Any city water system customer for which a water meter was not installed prior to the effective date of this article.

VERY LARGE USER. Any city water system customer which used or uses in excess of 300,000 gallons per day in 1997 or any calendar year thereafter in which annual use is averaged over the year (109.5 million gallons or 146,390 units annually). Usage for multiple meters serving the same geographic facility will be added together and considered one customer.

(Ord. 18-1998)

§ 6-1-4-4 APPLICABILITY.

All sections of this article apply to all large and very large users within the city limits and/or served by the municipal water utility, excepting customers which receive over 80% of their water from sources other than the city and public and private golf courses and parks, which are regulated by the Water Conservation Landscaping and Water Waste Ordinance. Compliance with this article is a condition of service from the utility. Private well usage will be included in the calculation of total usage and surcharges.

(Ord. 18-1998)

§ 6-1-4-5 WATER USE REQUIREMENTS.

(A) All new and existing large users shall use proven, economically feasible, most effective technology to minimize the amount of water used, including but not limited to water used for cooling, heating, processing, and operations.

(B) New large users shall:

(1) Comply with the landscaping requirements for new development in the Water Conservation Landscaping and Water Waste Ordinance;

(2) Use low flow fixtures in all kitchen facilities and bathrooms.

(C) Existing large users shall:

(1) Reduce water use for landscaped area to 35 inches per acre by 2004, excluding athletic fields at schools;

(2) Reduce water use for school athletic fields to 45 inches or less per acre per year;

(3) Use or convert to low flow fixtures in all kitchen facilities and bathrooms by 2004;

(4) For multi-family residential large users, be exempted from fully complying with divisions (C)(1) and (3) if usage equals or averages, on an annual basis, less than 180 gallons per day unit;

(5) For mobile home parks, be exempted from fully complying with divisions (C)(1) and (3) if usage equals or averages, on an annual basis, 260 gallons per day per unit.

(Ord. 18-1998)

§ 6-1-4-6 USAGE PROJECTIONS.

(A) All large users shall assess their projected usage, in cooperation with the city, by developing the following:

(1) Description of all uses of water within the facility;

(2) A plan for improvements to be implemented prior to 2004;

(3) Projections of average annual, monthly, and daily water use through 2004;

(4) Projections of annual water costs, based on current rates;

(5) Projections of annual sewer costs, based on current rates;

(6) Projections of annual energy savings through 2004 related to reduced water use, if applicable, based on current rates;

(7) Projections of changes in annual pretreatment costs through 2004 related to reduced water use, if applicable.

(B) Existing large users shall also include the following, based on information provided by the city:

(1) Average annual, monthly, and daily water use over the last three years;

(2) Last three years' annual water and sewer costs.

(Ord. 18-1998)

§ 6-1-4-7 WATER CONSERVATION PLAN REQUIREMENTS.

(A) All large users shall develop a water conservation plan, in cooperation with the city, which includes:

(1) A policy statement reflecting the commitment of the large user to conservation;

(2) Findings from § 6-1-4-6;

(3) Improvements to be implemented by 2004, listed by year and specific type of improvement;

(4) Annual goals and water budget for water usage from the year plan is proposed through 2004 and any significant changes after 2004;

(5) A plan for promoting water conservation to employees and/or residents;

(6) A contact person with the city for implementation of this article.

(B) Existing large users' water conservation plans shall also include:

(1) Conservation-related improvements already made;

(2) A schedule for converting to low water use plumbing and landscaping.

(C) Large users shall also:

(1) Work with the city to evaluate and, if feasible, implement utilization of appropriately treated industrial sewage return flow to the city's system in alternate ways, such as for deep injection well recharge and for irrigation purposes; sharing of costs to implement these solutions will be negotiated;

(2) Communicate with similar water users, keep informed of new developments to reduce water use, and implement new processes as feasible;

(3) Work in partnership with the city, agencies, companies, and/or universities involved in research to facilitate development and sharing of more efficient ways to use water.

(Ord. 18-1998)

§ 6-1-4-8 PLAN APPROVAL.

(A) Large users and very large users shall develop and seek approval of a water conservation plan within five months of notification by the city of the applicability of this article to the customer.

(B) The city will issue a plan approval, based on the customer's water conservation plan, as negotiated by the city and the customer. For new customers, approval must occur prior to issuance of a city water meter. For existing customers, plan approval must occur within eight months of notification by the city of the applicability of this article to the customer, unless the plan is being mediated or appealed. Plan approval will be based on compliance with § 6-1-4-6(A)(1)-(3), § 6-1-4-6(B)(1), § 6-1-4-7(A)(1)-(6), and § 7(B)(1)-(2) of this article and any additional commitments by the customer to make improvements to use water more efficiently.

(Ord. 18-1998)

§ 6-1-4-9 PLAN REVISIONS.

Either the customer or the city may initiate a plan revision at any time except during the months of November through February to alter inaccurate projections, reflect growth or decline at the facility, or accommodate other significant changes. Plan revisions will not be made to accommodate minor, short-term fluctuations caused by line breaks, leaks, fire flow delivery, and weather. No more than two revisions may be initiated by the customer during any 12 month period. The city will notify customers prior to making plan revisions. Revisions will be made only if the projections/goals will be changed by at least 5%.

(Ord. 18-1998)

§ 6-1-4-10 VERY LARGE USERS.

(A) Very large users are subject to the same requirements as large users.

(B) In addition, prior to plan submittal, existing very large water users must provide an audit of their uses of water by a qualified expert accepted by both the city and the customer. Implementation of the auditor's recommendations will be subject to negotiation with the city. The city may terminate water service to any very large user refusing to implement improvements the city considers reasonable, subject to the provisions described in § 6-1-4-14.

(Ord. 18-1998)

§ 6-1-4-11 NOTIFICATION.

(A) The city will notify all existing large users of the requirements in this article and its applicability within 18 months of the final adoption of the article, starting with the largest users and moving downward. Large users are not required to submit plans prior to their notification in order to allow time for adequate staff review and approval.

(B) All large water users with approved plans will be informed of their annual usage relative to their projected usage every year prior to March 31. Notification to customers who have achieved their final goal for two consecutive years will not continue unless usage exceeds the reduction goal in a subsequent year. Notification to customers who exceed their goal will continue indefinitely.

(Ord. 18-1998)

§ 6-1-4-12 VARIANCES.

(A) The Mayor shall be responsible for the enforcement of this article. The Mayor may prescribe policies, rules, or regulations to carry out the intent and purposes of this article.

(B) Administrative variances to the restrictions in § 6-1-4-5 through § 6-1-4-7 may be issued by the Mayor or his/her designee, provided that the general intent of this article has been met, compliance with this article is proven to cause practical difficulties and unnecessary hardship, and all reasonable options for abatement have been exhausted. The criteria to determine hardship shall include level of capital outlay and time required to be in compliance with this article.

(Ord. 18-1998)

§ 6-1-4-13 MEDIATION AND APPEALS.

(A) In the event that the customer and the city cannot agree on the customer's plan and annual goals, a mediation will be scheduled through the city's Dispute Resolution Office. The goal of the mediation is to create a mutually acceptable plan with the help of a third party mediator. The mediation will be scheduled by the Dispute Resolution Office within three weeks of the request. Follow-up mediations, if necessary, will be scheduled as quickly as possible. Costs for the mediation will be split equally between the city and the customer. Based on the mediation(s) and any subsequent discussions between the city and the customer, a plan will be proposed for approval within ten working days of the final mediation. In the event agreement is not reached through the mediation process, the city will propose a plan for approval within 12 working days of the final mediation.

(B) Any large user dissatisfied with the plan proposed by the city following the mediation may appeal the plan to the City Hearing Officer by filing an appeal within seven calendar days of receipt of the proposed plan. Such request shall be made in writing and filed in the Office of the City Clerk. The appeal shall include the proposed plan and state the customer's disagreement with the proposed plan, together with all material facts in support thereof. When a hearing is requested, the City Hearing Officer shall send written notice by certified mail, return receipt requested, to the appellant of the time and place of the hearing. At the hearing, the appellant and the city shall have the right to present evidence to aid the City Hearing Officer in determining whether the proposed plan should be approved. The City Hearing Officer shall, within seven working days following the hearing, issue a written decision specifying any modifications to the plan that must be made prior to plan approval. If no modifications are required by the City Hearing Officer, an appeal filing fee of $20 shall be added to the customer's water bill.

(C) The exclusive remedy for parties dissatisfied with the decision of the City Hearing Officer shall be the filing of a petition for a writ of certiorari with the State District Court. The petition for review shall be limited to the record made at the hearing held by the City Hearing Officer pursuant to this article.

(Ord. 18-1998)

§ 6-1-4-14 COMPLIANCE; NONCOMPLIANCE.

(A) Failure to comply with the provisions of this article to develop and seek approval of a water conservation plan within five months of notification by the city of the applicability of this article to the customer will result in city assignment of annual water usage goals, based on the customer's past usage, estimated potential for reductions, and the 30% reduction goal adopted in Resolution 40-1995.

(B) Compliance with this article is a condition of service from the utility.

(C) Water conservation staff or consultants authorized for this purpose by the Mayor may conduct an inspection of a customer's property for the purpose of assessing proposed plan validity and/or compliance with this article or approved plan. Inspections shall be conducted with the voluntary consent of the customer or the customer's representative. Inspection is deemed a condition of service. Customer refusal of an inspection for these purposes will result in city assignment of goals as described in division (A) above.

(Ord. 18-1998)

§ 6-1-4-15 EFFECTIVE DATE.

This article shall become effective five days after publication in full.

(Ord. 18-1998)

PART 5: WATER CONSERVATION WATER BY REQUEST

§ 6-1-5-1 INTENT.

The public purpose of this ordinance is to:

(A) Assist in reducing overall per capita water use in the city, thereby helping to ensure a sustainable supply of water;

(B) Eliminate unnecessary use of water in restaurants by serving water to customers only when requested, thereby reducing water served and water used to wash glasses;

(C) Educate water system customers and hospitality industry clientele about and eliminate the unnecessary use of water by reducing the frequency of washing of sheets, towels, and other linens; and

(D) Encourage government facilities and businesses to eliminate waste and use water efficiently.

(Ord. 2-2001)

§ 6-1-5-2 SHORT TITLE.

This ordinance shall be known as the "Water Conservation Water by Request Ordinance."

(Ord. 2-2001)

§ 6-1-5-3 DEFINITIONS.

For the purpose of this article, the following definitions shall apply unless the context clearly indicates or requires a different meaning:

BUSINESS. Retail facility, office, shopping center or other facility in the commercial water billing class, other than multi-family or mobile home residential facilities.

GOVERNMENT FACILITY. Facility operated by the City of Albuquerque, Bernalillo County, State of New Mexico, United States, or other governmental entity.

LODGING ESTABLISHMENT. A motel, hotel, or bed and breakfast establishment which provides private rooms for overnight stay and provides towels and/or sheets and/or other linens.

RESTAURANT. A food service facility which serves meals to customers, including those food service facilities in lodging establishments and schools and drive-in food facilities, and excluding health and frail elderly care facilities.

(Ord. 2-2001)

§ 6-1-5-4 APPLICABILITY.

All sections of this article apply to all restaurants, lodging establishments, government facilities, and businesses within the city limits and/or served by the municipal utility. Compliance with the ordinance is a condition of service from the utility.

(Ord. 2-2001)

§ 6-1-5-5 DRINKING WATER SERVICE.

All restaurants shall provide drinking water only as specifically requested by the customer.

(Ord. 2-2001)

§ 6-1-5-6 LINEN WASHING SERVICE.

All lodging establishments shall offer customers the option of not changing sheets and towels in private rooms for stays of less than five days. Lodging establishments shall encourage this practice, at a minimum, through posting of signs in every room instructing customers how to avoid linen service for stays less than five days. Lodging establishments with less than ten rooms may encourage this practice through brochures or other general promotional materials rather than signs in each room.

(Ord. 2-2001)

§ 6-1-5-7 EDUCATING EMPLOYEES, CLIENTS, AND CUSTOMERS.

The city shall work cooperatively with government facilities and businesses to post signage informing and educating employees, clients, and customers about the need to and how to save water.

(Ord. 2-2001)

§ 6-1-5-8 ASSESSMENT OF FEES.

Any responsible party who violates the provisions of this ordinance shall be subject to progressively higher fees until the violation ceases. The schedule for assessment of fees is as follows.

First violation $20 Second violation $50 Third and additional violation $100

Assessment of fees for violations of this ordinance will be through city utility bills and placed on the responsible party's billing account. The responsible party may appeal fees for violation of this ordinance and the appeal process shall follow the process set forth in § 6-1-1-12(B) of the Water Conservation Landscaping and Water Waste Ordinance. Fees shall be assessed to the responsible party's billing account within 15 days following expiration of the appeal period or issuance of appeal findings and shall be listed as a separate line item on the utility bill. Responsible parties shall be notified of the fee through certified mail within 15 days of the violation. Fees must be paid within the normal payment period allowed by the city utility billing system. Fees shall be suspended pending the outcome of an appeal. Each day in which a violation occurs shall constitute a separate offense. The responsible party will be given seven days to comply with this ordinance before another fee may be assessed.

(Ord. 2-2001)

PART 6: [RESERVED]

PART 7: PLUMBING FIXTURE RETROFIT FOR CITY OWNED PROPERTY

§ 6-1-7-1 SHORT TITLE.

Sections 6-1-7-1 et seq. shall be cited as the "The Plumbing Fixture Retrofit Ordinance for City Owned Property."

(Ord. 2-2009)

§ 6-1-7-2 DEFINITIONS.

For the purpose of §§ 6-1-7-1 et seq., the following definitions shall apply unless the context clearly indicates or requires a different meaning:

EXISTING PLUMBING FIXTURE.

(1) Any toilet manufactured to use more than 1.6 gallons of water per flush.

(2) Any urinal manufactured to use more than 1.0 gallon of water per flush.

(3) Any showerhead manufactured to have flow capacity of more than 2.5 gallons of water per minute.

(4) Any faucet that emits more than 2.5 gallons of water per minute.

FAUCET. A fixture commonly known as a faucet but only when located at a kitchen or bathroom sink.

LOW WATER USE PLUMBING FIXTURE. Plumbing fixtures as follows: 1.6 gallons or less per flush toilets, 1.0 gallon or less per flush urinals, 2.5 gallons or less per minute shower heads, 2.5 gallons or less per minute faucets and/or aerators.

PLUMBING FIXTURE. A faucet, showerhead, urinal or toilet.

RETROFIT. Means to replace any existing plumbing fixture with a low water use plumbing fixture.

(Ord. 2-2009)

§ 6-1-7-3 DUTY OF CITY TO RETROFIT.

All plumbing fixtures in all city owned property over which the city has control shall be low water use plumbing fixtures no later than December 31, 2014. The City Council may, by Resolution, extend this deadline to complete the installation of low water use fixtures.

(Ord. 2-2009)

§ 6-1-7-4 RETROFIT EXEMPTIONS.

The following conditions and circumstances shall exempt property from the provisions of this part:

(A) Where a low water use plumbing fixture would be installed in an existing building that has been identified by a local, state, or federal government entity as an historical site, and an historically accurate water- conserving plumbing fixture is not available.

(B) Where installation of a low water use plumbing fixture would require modifications to plumbing system components located beneath a finished wall, floor or other surface.

(C) Where the unique configurations of a building drainage system or portions of a public sewer, or both, require a greater quantity of water to flush the system in a manner consistent with public health.

(D) Where the existing building will be demolished or rehabilitated within 90 days of the purchase of such existing building.

(Ord. 2-2009)

Bernalillo County

Sec. 30-249. - Design and construction regulations for new development.

This section applies to all new development.

(1) *Single-family and small multifamily development requirements.* All new single-family and small multifamily development shall use one of the three alternatives listed to select water conservation measures that will be incorporated into the design and construction of the new dwelling.

a. *Alternative number 1.* Bernalillo County Water Conservation Measures Worksheet.

1.Building permit applications for all single-family and small multifamily development using alternative number 1 shall include a fully and properly completed water conservation measures worksheet certifying that:

(i)Measures selected on the worksheet will reduce indoor water use by at least 20 percent using plumbing fixtures which are more water efficient than those required in the 2006 Uniform Plumbing Code; and

(ii)All of the selected measures shall be incorporated into the design and construction of the new dwelling; and

2.All new single-family and small multifamily development using alternative number 1 shall comply with the planting restrictions in subsection (4); and

3.Before obtaining a certificate of occupancy, all single-family and small multifamily development using alternative number 1 may be subject to inspection and approval by a water conservation compliance officer or other designated staff.

b. *Alternative Number 2.* Build Green New Mexico Bronze Certification.

1.Building permit applications for all single-family and small multifamily development using alternative number 2 shall submit a copy of a fully and properly completed Build Green New Mexico property registration form and applicant's affidavit; and

2.All new single-family development using alternative number 2 shall comply with the planting restrictions in subsection (4) or any subsequent modifications to the outdoor requirements of the Build Green New Mexico program whichever are more stringent; and

3.Before obtaining a certificate of occupancy all single-family and small multifamily development using alternative number 2 must submit certification from Build Green New Mexico which shows that the dwelling meets a minimum of the Build Green New Mexico bronze certification and provide independent verifiers name and address.

c. *Alternative number 3.* EPA watersense fixtures.

1.Building permit applications for all single-family and small multifamily development using alternative number 3 shall include a fully and properly completed water conservation measures form certifying that:

(i)All toilets installed shall meet EPA watersense specifications; and (ii)All bathroom faucets installed shall meet EPA watersense specifications; and

(iii)If a dishwasher is installed by the home builder, it shall be energy star qualified; and

(iv)If a clothes washer is installed by the home builder, it shall be energy star qualified; and

(v)Hot water distribution systems should be designed and built to minimize the volume of water between the plumbing fixture and hot water source. This may be accomplished by minimizing pipe runs and reducing diameter of hot water pipes, using water demand initiated hot water systems, or other efficient system designs.

2.All new single-family and small multifamily development using alternative number 3 shall comply with the planting restrictions in subsection (4); and

3.Before obtaining a certificate of occupancy all single-family and small multifamily development using alternative number 3 will be subject to inspection and approval by a water conservation compliance officer or other designated staff.

(2) *Requirements for commercial and large multifamily development.*

a. Building permit applications for all new commercial, large multifamily and institutional development shall include a fully and properly completed commercial indoor water conservation measures worksheet certifying that:

1. Indoor water use will be reduced by at least 20 percent using plumbing fixtures which are more water efficient than those required in the 2006 Uniform Plumbing Code; and

2. All of the measures selected on the commercial indoor water conservation measures worksheet shall be incorporated into the design and construction of the new building.

b. Building permit applications for all new commercial and large multifamily development on more than one acre shall include a fully and properly completed commercial outdoor water conservation plan and site plan that includes three of the following seven outdoor water conservation measures related to landscaping. One of the three options completed must include option (i), (ii), or (iii). After January 1, 2016, all new development shall comply with four of the following seven water conservation measures. One of the four options completed must include option (i), (ii) or (iii). All new development shall comply with the planting restrictions in subsection (4) of this section. The commercial outdoor water conservation plan shall be reviewed for approval by the county geohydrologist or other designated county official. Approval of commercial outdoor water conservation plan and site plan by the county will be based on the water conservation plan criteria below unless the applicant proposes alternative methods that provide equivalent or greater water conservation.

1.*Water conservation plan criteria.* The plan shall include three of the following seven outdoor water conservation measures related to landscaping. One of the three options completed must include option (i), (ii), or (iii). After January 1, 2016, all new development shall comply with four of the following seven water conservation measures. One of the four options completed must include option (i), (ii) or (iii). All new development shall comply with the planting restrictions in subsection (4) of this section.

(i)At least 25 percent of the landscape area shall be precipitation supported plant material. Irrigation may be used for establishment of the precipitation supported plant material, but the area shall be zoned separately from any other landscaped area. If this option is chosen, then option (vii) must also be completed and the irrigation to the area should be shut off within two years and identified in the EMP. After January 1, 2013, 35 percent of the landscape area shall be provided by precipitation supported plant material. After January 1, 2016, 45 percent of the landscape area shall be provided by precipitation supported plant material.

(ii)Passive water harvesting shall occur on at least 25 percent of the landscape area. The irrigation system shall be designed so that the water harvesting areas are zoned separately from nonwater harvesting areas. After January 1, 2013, passive water harvesting shall occur on 35 percent of the landscape area. After January 1, 2016, passive water harvesting shall occur on 45 percent of the landscape area.

(iii)One hundred percent of the irrigation water supply shall be from a non-potable municipal, private or well source. Non-potable water supplies will need to be officially documented and confirmed.

(iv)A smart irrigation controller (smart controller) shall be designed and installed to control all of the irrigation system for the landscape area. The smart controller must be from a list approved by Bernalillo County.

(v)An approved soil amendment program is used during installation of the landscape to improve the nutrient and water holding capacity of the soil.

(vi)Non-potable water shall be collected and stored for use as the primary water source for landscape irrigation. Storage capacity shall be a minimum of 50 percent of the peak month landscape water demand for the property.

(vii)An exterior management plan (EMP) shall be developed and submitted to the county with other project documents. The EMP is a two-year commitment to employ best management practices that significantly reduce water use, chemical use, and water runoff as compared with standard practices.

c. All new commercial development less than one acre may follow the guidelines for outdoor water use in [subsection] (2)b. above, or use a smart controller for all landscape areas, use only low and medium use plants, and have no spray irrigation.

d. All new large multifamily residential development including mobile home parks with more than eight units shall have separate meters or submetering for water service to all dwelling units.

(3) *Remodels and additions.*

a. All remodels and additions for single-family and small multifamily development shall use EPA Watersense-labeled fixtures for any new plumbing fixture installed. Existing plumbing fixtures not included in the remodel shall be evaluated for replacement using incentive programs from Bernalillo County or the West-wide.

b. All remodels on commercial and large multifamily development shall use EPA Watersense-labeled fixtures for any new plumbing fixture installed. All remodels on commercial and large multifamily development which affect more than 50 percent of the existing plumbing fixtures shall use EPA Watersense-labeled plumbing fixtures for any new fixture installed and upgrade any existing fixtures using EPA Watersense-labeled fixtures. All additions on commercial large multifamily development which increase the floor area of the existing building by more than 50 percent of the existing square footage shall use EPA Watersense-labeled plumbing fixtures for any new fixture installed and upgrade any existing fixtures using EPA Watersense-labeled fixtures.

c. All landscaping plantings that are added or replaced as part of a remodel or addition on commercial large multifamily development shall be from the low-water-use approved plant list. Any existing landscaping may remain.

(4) *Restrictions on landscape planting, ponds, and irrigation systems.*

a. All properties other than county-owned parks, golf courses and athletic fields shall not be designed and constructed to use high-water-use turf or plants on more than ten percent the landscape area, except:

1. For single-family and small multifamily development, the use of high-water-use plants shall not exceed 1,500 square feet of the landscape area;
2. In the event that ten percent of the landscape area is less than 300 square feet, high-water-use turf and other high-water-use plants may be used on up to 300 square feet of the landscape area;
3. Large multifamily development may use high-water-use turf on up to 30 percent of the landscape area as long as no dimension of the turf area is less than ten feet. Swimming pools will be considered the same as high-water-use turf for the purposes of this limitation;
4. Properties zoned A-1 Agricultural with access to water provided through the Middle Rio Grande Conservancy District or community acequia systems for irrigation purposes may use high-water-use turf or other high-water-use plants in the landscape area supplied by irrigation water;
5. Private parks may have up to ten percent of the landscape area in high-water-use turf or other high-water-use plants. If grading and drainage plan details demonstrate that water harvesting will support up to 30 percent high-water-use turf or plants then up 30 percent of the landscape area may be high-water-use turf or plants;
6. Private parks which are supplied by 100 percent utility-provided, non-potable water may have up to 30 percent of the landscape area in high-water-use turf or plants.

b.S treet medians, streetscapes, ornamental landscapes and common areas of subdivisions shall not be designed and constructed with high-water use turf and other high-water use plants. Street medians, streetscapes, ornamental landscapes and common areas of subdivisions that are included in a grading and drainage plan shall be evaluated for water harvesting opportunities during the grading and drainage plan review.

c. Ornamental ponds shall not be designed and constructed to exceed 500 square feet of surface area. Ornamental fountains shall not be designed and constructed to exceed 250 square feet of surface area. Multiple water features on the same property will be considered together to determine surface area. Flowing water used in fountains, waterfalls and similar features shall be recirculated. Ponds and fountains shall be designed to be consistent with the requirements of all applicable local and state regulations.

d. The list of low, medium, and high-water-use plants maintained by the ABCWUA will be the approved plant list for landscape planting. Exceptions and additions to this list may be approved if documented proof of water use can be demonstrated for the area of intended use.

e. The list of precipitation only plants maintained by the ABCWUA will be the approved plant list for precipitation Supported landscape planting. Exceptions and additions to precipitation only plant list may be approved if documented proof of water use can be demonstrated for the area of intended use.

(5) *Irrigation systems.*

a. All irrigation systems shall be designed and installed to meet all minimum standards established by the current editions of uniform plumbing code and uniform mechanical code. All irrigation systems should use currently accepted water conservation design principals to maximize efficiency of the irrigation system.

b. Spray irrigation systems shall not be designed and constructed for use on slopes greater than four feet of horizontal distance per one-foot vertical change (4:1).

c. Spray irrigation systems shall not be designed and constructed to apply water to any area within eight feet of a street curb or storm sewer inlet. These areas may be irrigated by drip, bubbler, soaker or subsurface irrigation systems.

d. Spray irrigation systems shall not be designed and constructed using sprinkler heads that are closer than eight inches to impermeable surfaces.

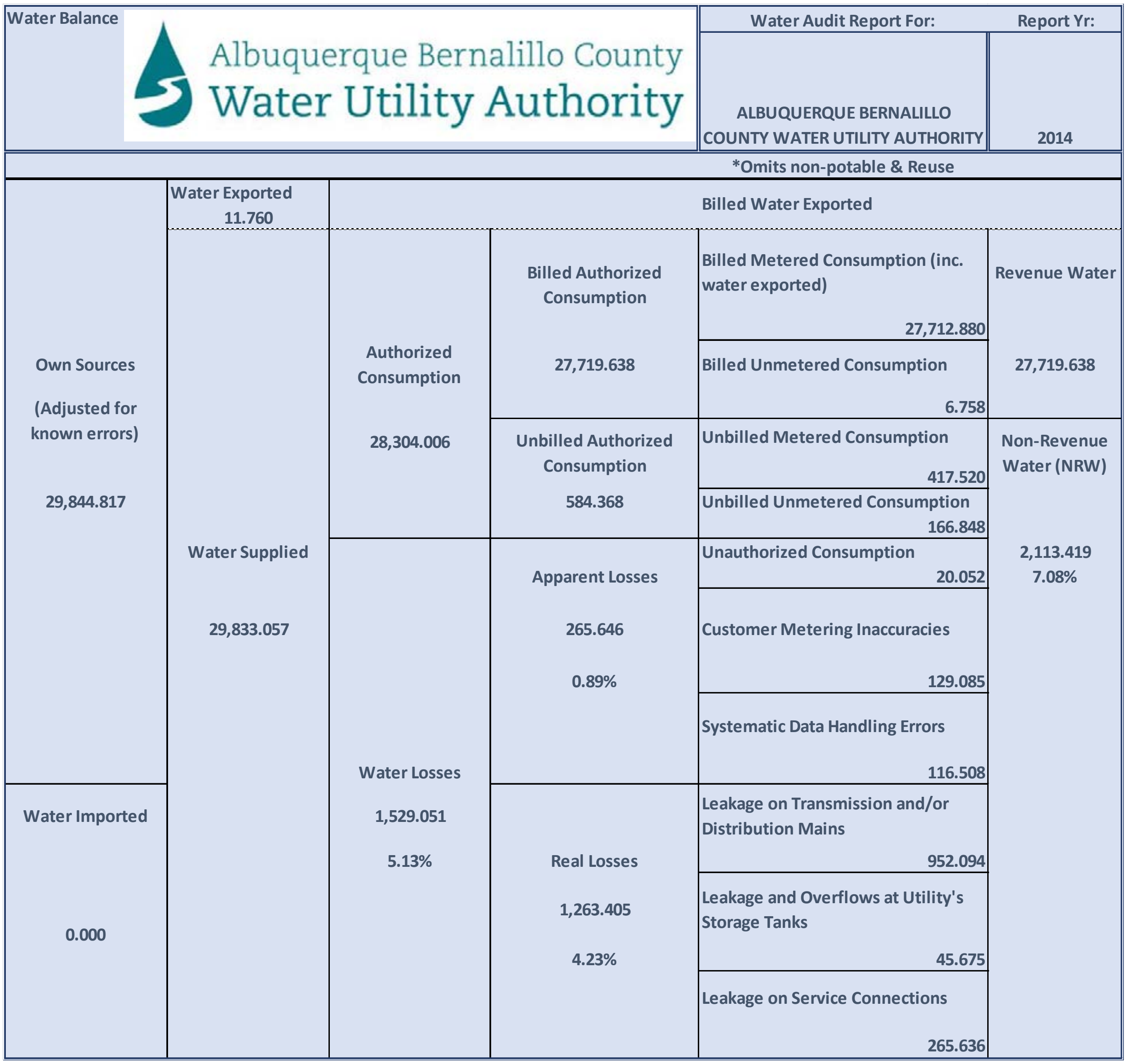
e. Spray irrigation systems shall not be designed and constructed to be used in areas less than ten feet in any dimension excepting within back or side yards of residential properties, or where such an area is contiguous with adjacent property so that the dimension totals ten feet minimum. Spray irrigation systems shall not be designed and constructed to be used on any area less than 15 feet in any dimension within parking lots. These areas may be irrigated by drip, bubbler, soaker or subsurface irrigation systems.

(Ord. No. 2010-13, § 9, 5-25-10, eff. 10-1-10)

Appendix 2.B

Water Authority Water Audit Report for 2014

Figure 2.B1. Screen Capture from Water Authority Water Audit



Water Balance

Albuquerque Bernalillo County
Water Utility Authority

Water Audit Report For:	Report Yr:
ALBUQUERQUE BERNALILLO COUNTY WATER UTILITY AUTHORITY	2014

*Omits non-potable & Reuse

Own Sources (Adjusted for known errors) 29,844.817	Water Exported 11.760	Billed Water Exported			
	Water Supplied 29,833.057	Authorized Consumption 28,304.006	Billed Authorized Consumption 27,719.638	Billed Metered Consumption (inc. water exported) 27,712.880	Revenue Water 27,719.638
				Billed Unmetered Consumption 6.758	
			Unbilled Authorized Consumption 584.368	Unbilled Metered Consumption 417.520	Non-Revenue Water (NRW) 2,113.419 7.08%
				Unbilled Unmetered Consumption 166.848	
		Water Losses 1,529.051 5.13%	Apparent Losses 265.646 0.89%	Unauthorized Consumption 20.052	
				Customer Metering Inaccuracies 129.085	
				Systematic Data Handling Errors 116.508	
Water Imported 0.000			Real Losses 1,263.405 4.23%	Leakage on Transmission and/or Distribution Mains 952.094	
				Leakage and Overflows at Utility's Storage Tanks 45.675	
				Leakage on Service Connections 265.636	

Figure 2.B2. Non-Revenue Water as Percent by Volume by Water Provider

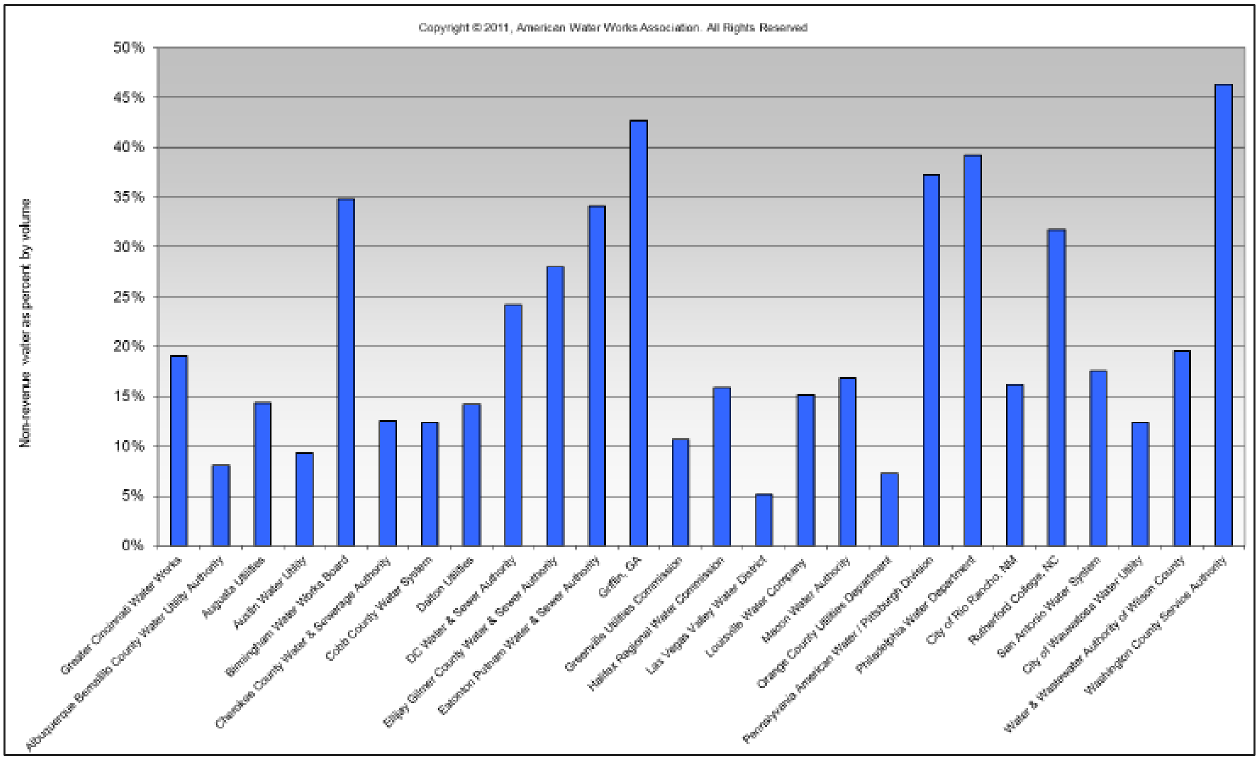


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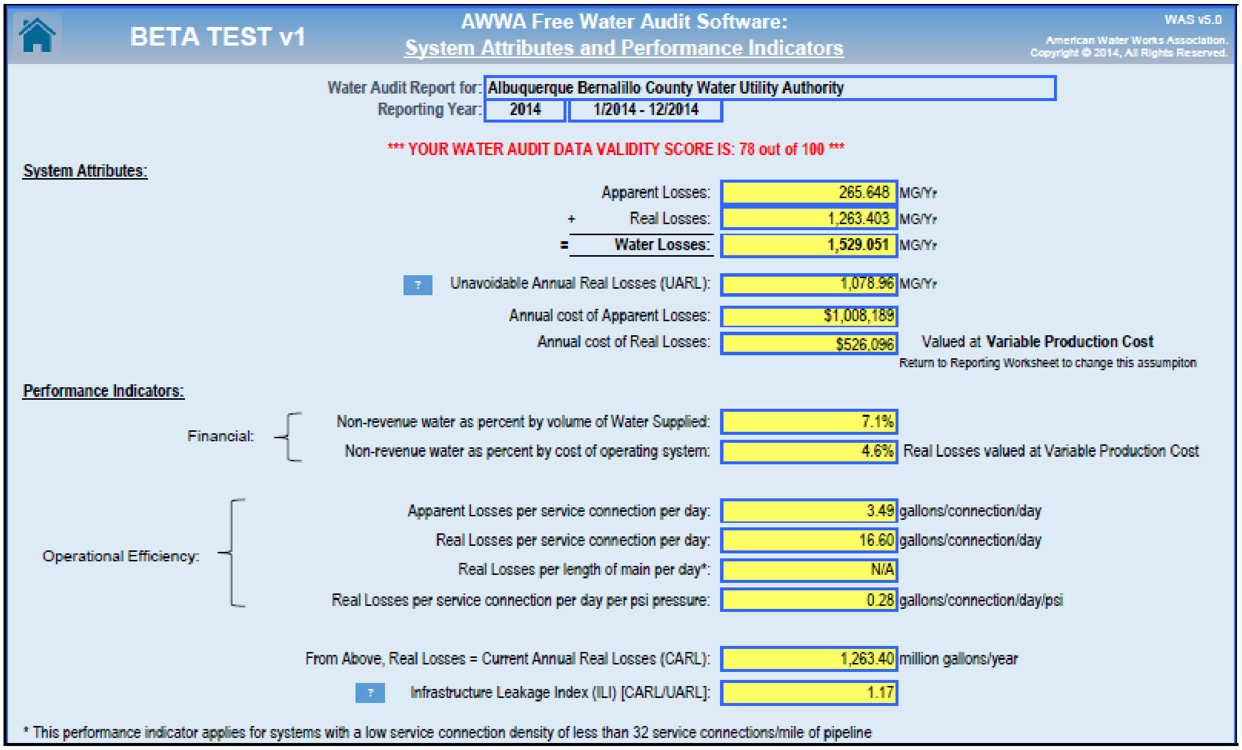
Figure 2.B3. Screen Capture from Water Authority Water Audit



Water Audit Report for: Albuquerque Bernalillo County Water Utility Authority
Reporting Year: 2014 | 1/2014 - 12/2014

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 78 out of 100 ***

System Attributes:

Apparent Losses: 265.648 MG/Yr
+ Real Losses: 1,263.403 MG/Yr
= **Water Losses:** **1,529.051** MG/Yr

Unavoidable Annual Real Losses (UARL): 1,078.96 MG/Yr

Annual cost of Apparent Losses: $1,008,189
Annual cost of Real Losses: $526,096 Valued at **Variable Production Cost**
Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:
Non-revenue water as percent by volume of Water Supplied: 7.1%
Non-revenue water as percent by cost of operating system: 4.6% Real Losses valued at Variable Production Cost

Operational Efficiency:
Apparent Losses per service connection per day: 3.49 gallons/connection/day
Real Losses per service connection per day: 16.60 gallons/connection/day
Real Losses per length of main per day*: N/A
Real Losses per service connection per day per psi pressure: 0.28 gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL): 1,263.40 million gallons/year

Infrastructure Leakage Index (ILI) [CARL/UARL]: 1.17

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

Appendix 2.C

Climate Change Effects on Outdoor Water Demand

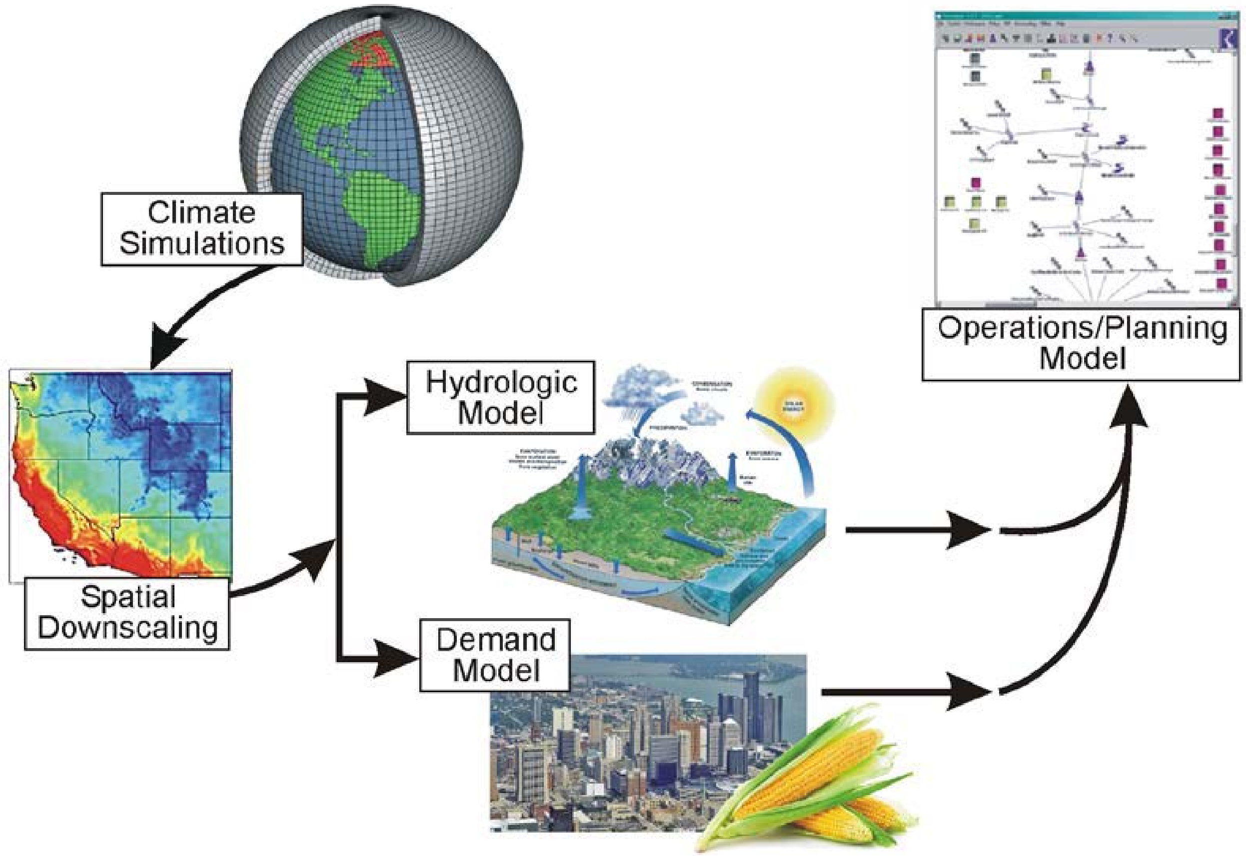
Appendix 2.C

Climate Change

Projections of evapotranspiration at Albuquerque with the effects of climate change for the Western United States were developed by Reclamation as part of the West-wide Climate Assessment (Reclamation, 2011). These projections were derived from work completed by the World Climate Research Program's Coupled Model Intercomparison Project Phase 3 (CMIP3) (Maurer et al., 2007). The CMIP3 data were produced using general circulation models (GCMs) that project global changes in atmospheric temperature and precipitation based on changes in greenhouse gas emissions. These global projections were used to develop the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (IPCC, 2007). For regional planning purposes, the global projections were downscaled by Reclamation using the Bias Correction and Spatial Disaggregation approach.

The approach was used with three different carbon emissions scenarios (B1 [low], A1B [middle], A2 [high]) to produce 112 different equally likely climate traces. The general approach to develop the Downscaled GCM Projected sequences is shown graphically in Figure 2.C1. The downscaled climate information results in temperature and precipitation data that can be used to estimate evapotranspiration.

Figure 2.C1. General Method for Development of Climate Change Hydrologies

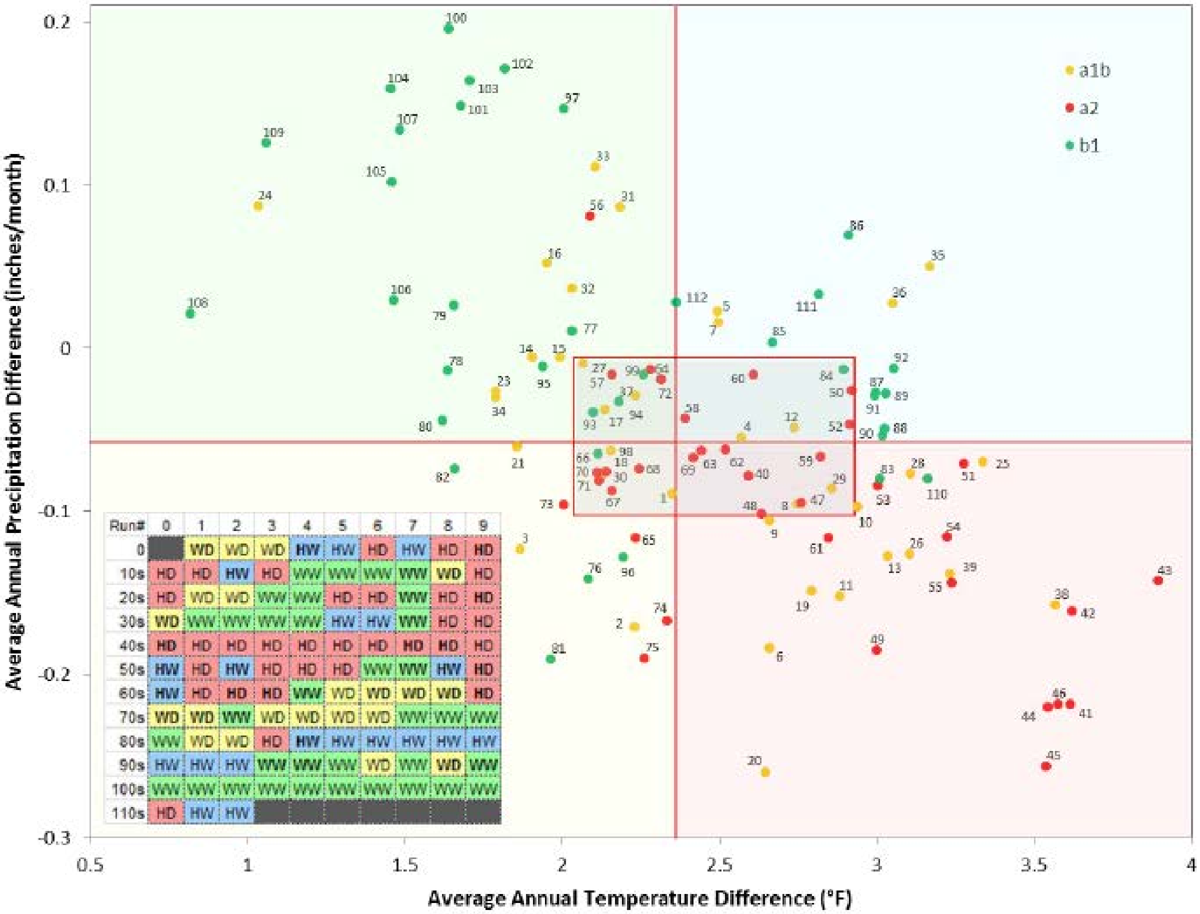


Source: Modified from the URGIA

West-Wide Climate Team Modifications for Local Use

For the purpose of water planning in the Middle Rio Grande, Reclamation organized the 112 climate traces into 5 “ensembles” by percentile of temperature and precipitation using a hybrid delta ensemble method (HDe). The “central tendency” group include all traces which fall within the 25th and 75th percentile for both precipitation and temperature change. The remaining four groups are based on the 50th percentiles of precipitation and temperature change and are referred to as hot-dry, hot-wet, warm-dry, and warm-wet (Figure 2.C2). The HDe method uses the average of temperature and precipitation change across all traces within each ensemble for three projection points in time, 2020s, 2050s, and 2080s.

Figure 2.C2. Grouping of the 112 Climate Traces into Five Ensembles



Run#	0	1	2	3	4	5	6	7	8	9
0		WD	WD	WD	HW	HW	HD	HW	HD	HD
10s	HD	HD	HW	HD	WW	WW	WW	WW	WD	HD
20s	HD	WD	WD	WW	WW	HD	HD	WW	HD	HD
30s	WD	WW	WW	WW	WW	HW	HW	WW	HD	HD
40s	HD	HD	HD	HD	HD	HD	HD	HD	HD	HD
50s	HW	HD	HW	HD	HD	HD	WW	WW	HW	HD
60s	HW	HD	HD	HD	WW	WD	WD	WD	WD	HD
70s	WD	WD	WW	WD	WD	WD	WD	WW	WW	WW
80s	WW	WD	WD	HD	HW	HW	HW	HW	HW	HW
90s	HW	HW	HW	WW	WW	WW	WD	WW	WD	WW
100s	WW	WW	WW	WW	WW	WW	WW	WW	WW	WW
110s	HD	HW	HW							

Source: Santa Fe Basin Study HDe Data Memo

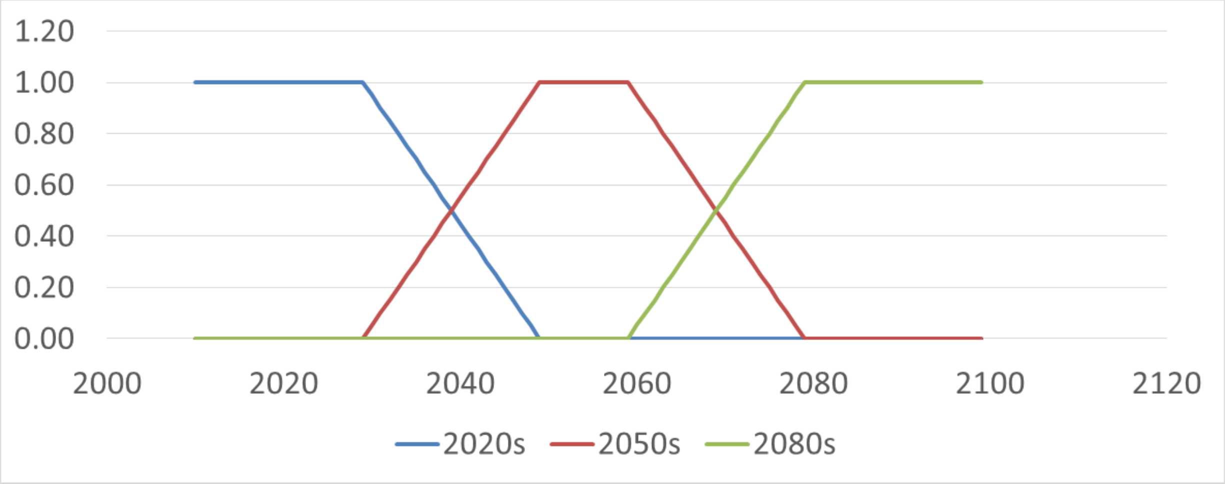
So, for example, for the 2080s period the temperature and precipitation data from the above process were taken from the 2070 to 2099 period and compared to the simulated historical period (1950-1990). The difference in precipitation and temperature for the two periods was taken to create the five ensembles. The average difference for each ensemble was then used as a “delta” to modify the historical precipitation and temperature for each ensemble for the 2080 period.

Modifications Made as Part of this Study

Each sequence developed using the HDe method reflects meteorological data (temperature and precipitation) as if the climate were stable for each time-period. Thus, for a 2080s Hot-Dry ensemble, the resulting sequence reflects a time series of meteorological data for only the 2080s change over the entire sequence. Therefore, time series data in 2000 or 2020 or 2090 all reflect a 2080s climate. As such, when planning using these data, any time prior to the 2080s will over-represent the impact of climate.

Likewise, for a 2020s sequence, any time after the 2020s will under-represent the impact of climate. To alleviate this ambiguity, the sequences were modified to interpolate the data over time. For example, the "Hot-Dry" sequence was interpolated over time between the 2020s, 2050s, and 2080s to result in a single sequence that gradually changes over time. Figure 2.C3 shows the factors used to interpolate the sequences.

Figure 2.C3. Factors Applied to 2020s, 2050s, and 2080s Projections to Arrive at a Single Sequence



This interpolation was applied to the monthly average evapotranspiration data at Albuquerque resulting in monthly average values for each of the five ensembles as well as the base "historical" sequence. The average monthly percent change was then calculated from historical to each ensemble (e.g. "Hot-Dry", "Central", etc.) These percent changes were applied to the outdoor portion of demand when examining climate change to reflect an increase over the base expected demand due to climate change.

Figure 2.C4 shows the monthly evapotranspiration data for the base (historical simulated), Hot-Dry, and Central ensembles. Figure 2.C5 shows the resulting percent changes. These values were interpolated over time using the method depicted in Figure 2.C3 and applied to outdoor demand for the Hot-Dry and Central ensembles.

Figure 2.C4. Monthly Average Reference Evapotranspiration for Albuquerque

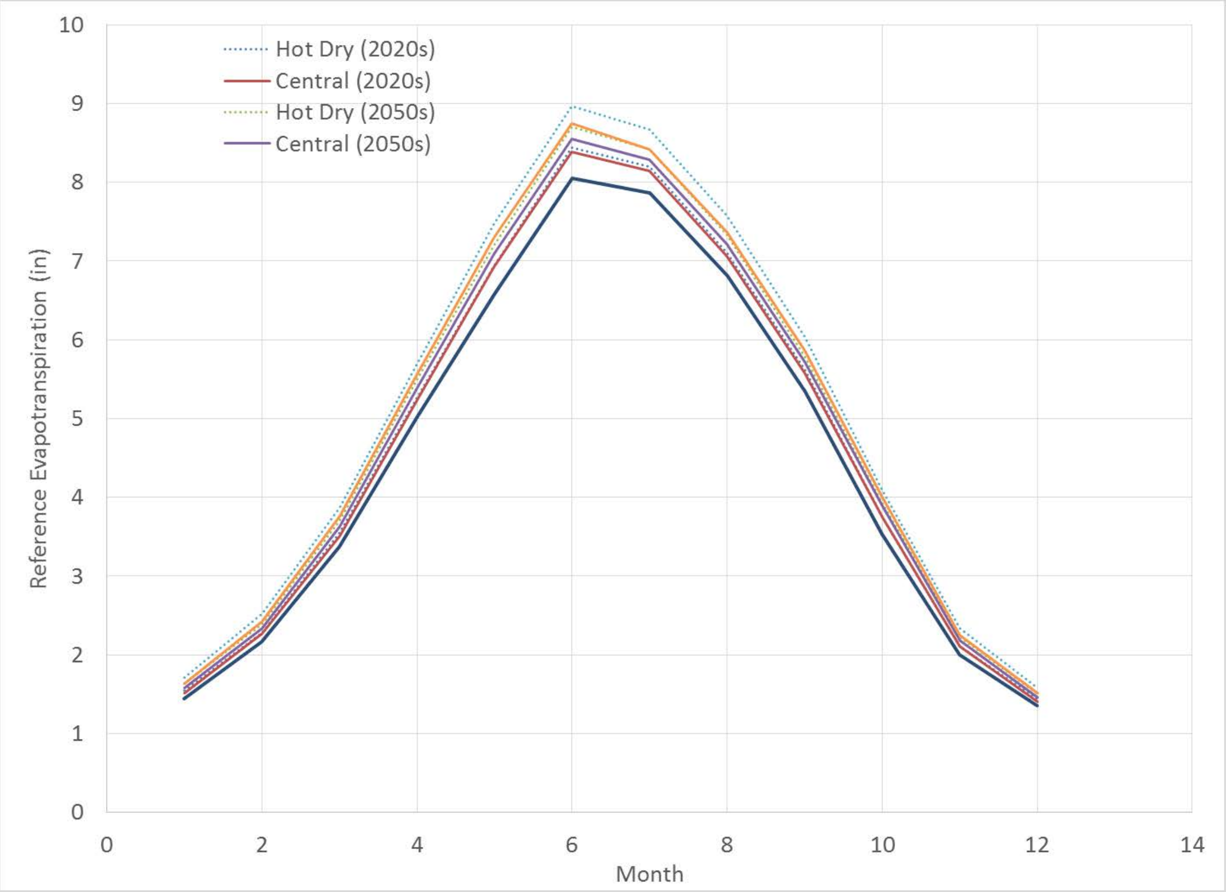
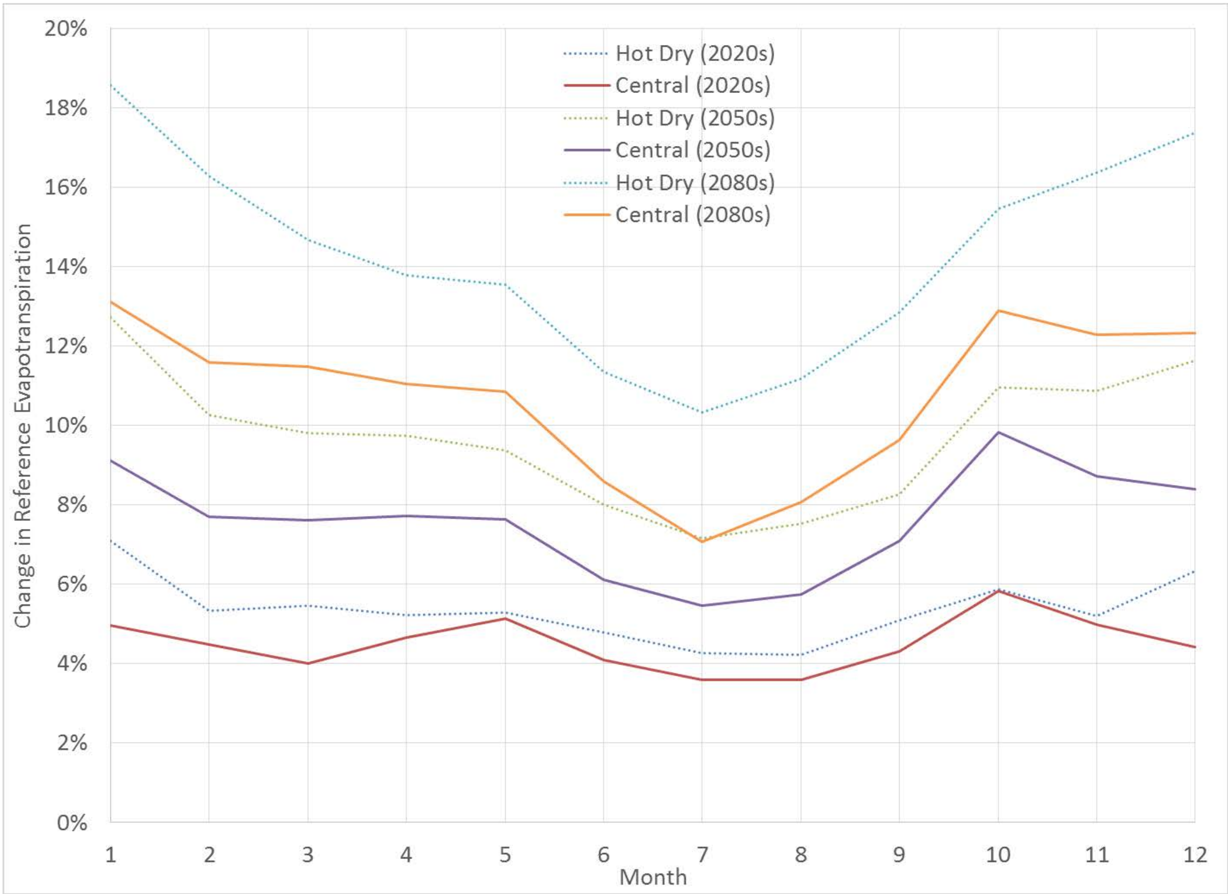


Figure 2.C5. Monthly Percentage Change in Reference Evapotranspiration from Historical



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Water 2120:
Securing
Our Water
Future

CHAPTER 3

Supply

3

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3.1 Introduction and Purpose

An understanding of future water supply is critical to any water resources management strategy. **Water 2120** includes an update to prior estimates of future water supply. Water supply projections developed as part of this effort will be incorporated into the WRMS.

Historically, the Water Authority relied solely on groundwater to meet demands. Implementation of the 1997 and 2007 Strategies has vastly expanded the Water Authority’s supply portfolio with the goal of providing a reliable and sustainable resource for its customers. The portfolio now includes groundwater, surface water through both the DWP and the NPP), non-potable reuse, and aquifer storage and recovery (ASR). Likewise, the Water Authority has drastically reduced its overall water usage rate (measured as gpcd) through conservation.

As part of the 1997 and 2007 Strategies, the Water Authority used historical Rio Grande flow to estimate future surface water availability; and, subsequently, the Water Authority’s ability to utilize SJC water. Surface water availability, when coupled with demand, is the key parameter in estimating the quantity needed of other existing or possible new supplies.

As with demand, the Water Authority recognized the inherent uncertainty in surface water availability and the need to plan for a range of possible futures. Therefore, the Water Authority is considering multiple supply projections. Each of these projections is represented as a variation in future surface water supply, both Rio Grande and SJC.

This chapter summarizes historical and recent projected surface water supplies and other considerations related to current water supply projections through 2120.

While each of these existing and potential supply sources are discussed independently, many are interconnected either through direct or indirect relationships (e.g. demand to wastewater volume, wastewater requirements for surface water use).

Likewise, individual water supply scenarios will be dependent on projected water availability and regulatory limitations on these supply sources, as well as future demand.

3.2 Supply Projections from the 1997 and 2007 WRMS

Historical planning efforts, as well as the NMOSE permitting process for the SJC diversion (SP-4830[1]), used a modified version of the 1971-1998 streamflow sequence at Central Avenue gage (USGS, 2016) as representative of the longer historical record.

As part of the development of the NMOSE permitting process for SP-4830, surface water supply projections were completed for the period from 2006-2060. The 1971-1998 gage record was utilized and repeated over the planning period. The average native[2] flow over this period is roughly equivalent to the longer

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[1] SP-4830 is the Water Authority’s permit with the NMOSE to divert surface water for the SJC DWP.

[2] Water Authority SJC water was removed from the gaged record to arrive at a “native” flow for the 1971 to 1998 record. This removal was completed for comparison to the historical record and to avoid double counting this water in subsequent predictive scenarios.

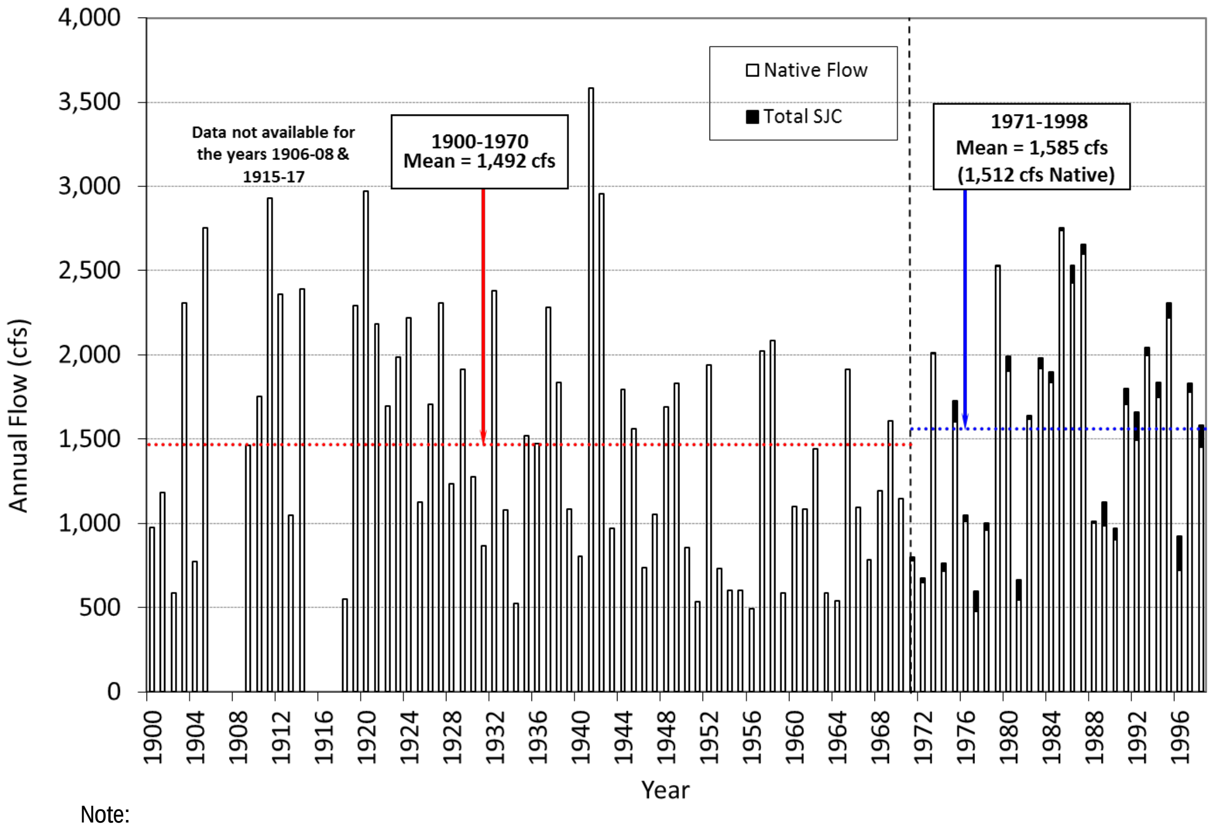
previous historical record (1900-1970, see Figure 3.1).

However, the 1971-1998 period did not include a drought as severe as that of the 1950s. Therefore, a three-year artificial drought was added to the sequence by repeating the 1972 flow record back-to-back (CH2M, 2003).

The resulting sequence was then used to estimate when SJC water could be diverted; and, subsequently, how much groundwater and other supplies would be needed to meet projected demand.

Figure 3.1 shows average annual historical Rio Grande flow at the Otowi gage (near Santa Fe) that was utilized in previous planning efforts. Note that the average native flow of the 1900-1970 period is within about one percentage point of the native flow in the 1971-1998 period, making the two periods roughly equivalent on a surface water supply basis.

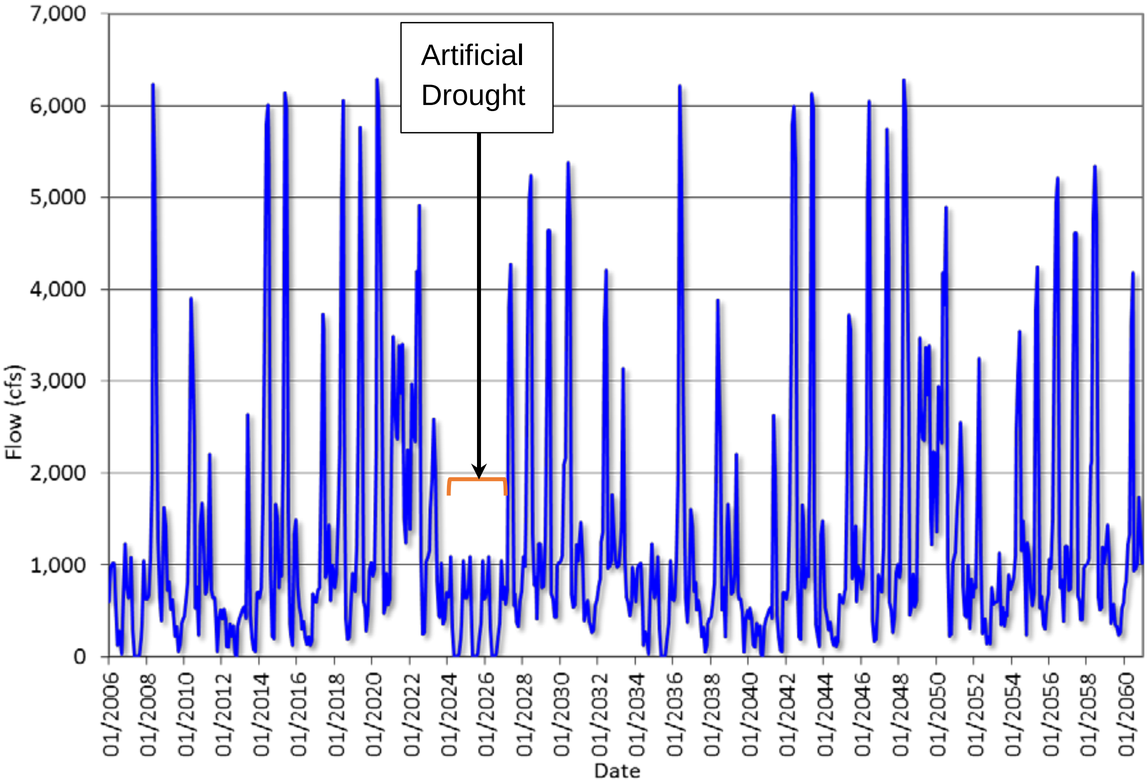
Figure 3.1. Historical Water Rio Grande Flow at Otowi gage 1900-1998



Note:
cfs = cubic feet per second

Figure 3.2 shows the resulting 2006-2060 average monthly Rio Grande flow sequence used in the 1997 and 2007 Strategies. The artificial drought (repeat of 1972 hydrology) occurs in the 2024-2026 timeframe. The remainder of this chapter summarizes development of updated supply projections for **Water 2120**.

Figure 3.2. 1997 and 2007 WRMS Projection of Rio Grande Flow



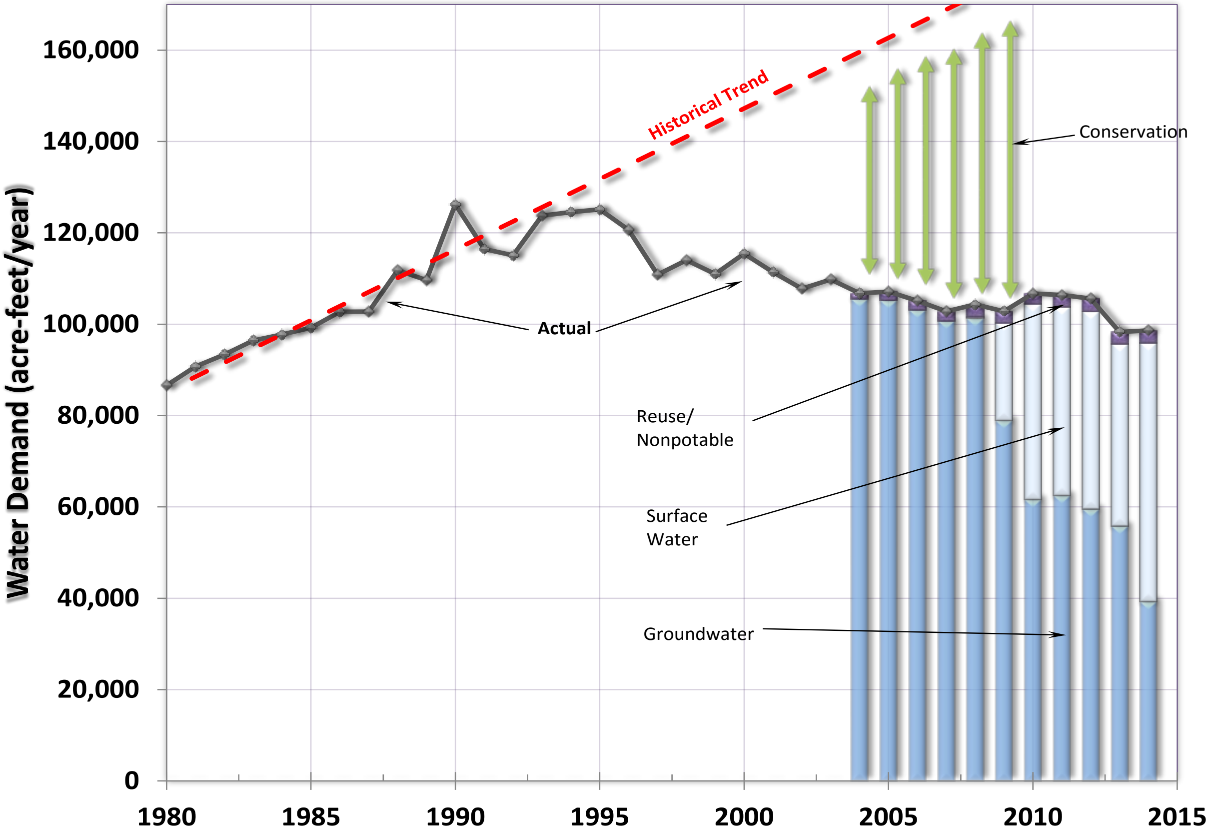
Note:
cfs = cubic feet per second

3.3 Current Sources of Supply

Current supply sources include surface water and groundwater. Surface water includes native Rio Grande water, SJC water, and wastewater; each used directly through diversion or reuse and/or indirectly for offsets of groundwater pumping impacts to the Rio Grande[3].

Surface and groundwater sources are interrelated via both the connection of the aquifer to the river and the return flow of groundwater to the surface water system. The following sections describe all current water supply sources. Figure 3.3 shows the historical makeup of supply sources through 2014. These supply sources, permits, and rights are also summarized in Tables 3.1 through 3.3.

Figure 3.3. Historical Supplies Meeting Demand (1970-2014)



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[3] Groundwater pumping impacts to the Rio Grande are referred to as "river effects." These effects are quantified using the NMOSE Middle Rio Grande Administrative Area Model and require offset. Offsets are made through wastewater return flow, native Rio Grande rights or releases of water from storage.

Table 3.1 describes the consumptive water rights available to the Water Authority. These rights are the total amount of water that can be consumed (diversion – return flow = consumptive use.)

Table 3.2 describes the surface and groundwater permits that facilitate the use of the rights in Table 3.1. So, these are the means that are permitted to utilize the rights in Table 3.1. Table 3.3 describes additional resources, like storage and wastewater, that extend the use of rights.

Accounting for the interaction of rights, permits, and resources is complex and varies based on annual demand, hydrology, historical use, and other factors. In general, the permits noted in Table 3.2 along with wastewater reuse in Table 3.3 are the sources of water supply that are used to meet water demand. These permits require that effects on the Rio Grande must be offset with the rights noted in Table 3.1 or through wastewater return flow or releases from storage noted in Table 3.3.

For example, in 2014 there was about 99,000 ac-ft of water demand. It was supplied by about 39,000 ac-ft of groundwater, 56,000 ac-ft of surface water, and 4,000 ac-ft of non-potable water and wastewater reuse.

This plus residual historical groundwater effects resulted in a reduction in Rio Grande flow on the order of 116,000 ac-ft. This reduction was offset by 26,000 ac-ft in native Rio Grande rights, 52,000 ac-ft of wastewater return flow and 38,000 ac-ft of SJC water. The remaining SJC water was stored in Abiquiu Reservoir through ASR for later use.

3.3.1 Surface Water

Native Rio Grande water rights and SJC Project water are both utilized via the Rio Grande. In addition, because wastewater is currently used to offset effects of groundwater pumping on Rio Grande flow, it is included in this section as a surface water supply.

Table 3.1. Water Authority Permits and Resources – Water Rights

	Description	Consumptive Right (afy)	Comments
Consumptive Water Rights			
Native Rio Grande	Vested rights	17,875	Currently used as offsets to effects on the Rio Grande from current and historical groundwater production (RG-960 and RG-4462).
	Acquired rights	8,521	
San Juan-Chama (SJC)		48,200	Currently directly diverted as part of the DWP (SP-4830), and the Non-potable Project (SP-4819). SJC water stored in Heron, Abiquiu, or Elephant Butte reservoirs is also used for groundwater pumping offsets. SJC water has been stored through SP-4819 for ASR. This water is subject to evaporative and conveyance loss.

Table 3.2. Water Authority Permits and Resources – Surface and Groundwater Permits

	Permit	**Permitted Diversion (afy)**	**Comments**
Surface Water			
DWP	SP-4830	96,400	Total surface water diversion south of Alameda Blvd. This amount is in combination with SP-4819 such that the maximum diversion at the two locations cannot exceed 96,400 for all purposes. Half of this amount, the SJC Water portion, can be consumptively used. The remaining portion must be returned to the Rio Grande.
North I-25 Non-potable project	SP-4819	3,000	Sub-surface diversion of surface water up to 3,000 afy for non-potable use in the northeast quadrant and ASR in Bear Canyon Arroyo. This amount is in combination with SP-4830 such that the maximum diversion at the two locations cannot exceed 96,400 for all purposes. The source of this diversion is SJC Water that can be fully consumptively used.
Groundwater			
Albuquerque Basin	RG-960 et al.	155,000	This permit allows for groundwater production up to 155,000 afy. Surface water effects must be offset with wastewater return, vested and acquired rights, and/or SJC water.
	RG-4462 (Previously New Mexico Utilities)	10,000	This permit allows for groundwater production up to 10,000 afy. Surface water effects must be offset with wastewater return, vested and acquired rights, and/or SJC water.
ASR - Recovery Water	USR-02 (ASR)	varies	This permit utilizes excess winter capacity of the SP-4819 sub-surface diversion for diversion and infiltration in Bear Canyon Arroyo. This stored water can then be recovered at a later time through groundwater production wells.

Table 3.3. Water Authority Permits and Resources – Storage

	Description	Quantity (afy)	Comments
Resources			
Wastewater	Municipal discharge	~60,000 (Varies)	Groundwater and surface water not consumed (indoor use) is returned to the Southside Water Reclamation Plant for treatment, use, and/or discharge to the Rio Grande. This water is currently used for offsets of the effects from groundwater pumping on Rio Grande (RG-960 and RG-4462) and to return the native portion of the DWP diversion (SP-4830). Availability of this resource generally varies with time and tends to increase with increasing population
	Municipal reuse	2,000	Water treated at the SWRP that is used for non-potable irrigation demand in the Southeast quadrant (southside reuse project).
Abiquiu Reservoir	Reservoir storage	170,900	Reservoir where SJC water is delivered. Currently used solely for storage of SJC water.
Elephant Butte Reservoir	Reservoir storage (through agreement with Reclamation)	50,000	Reservoir utilized as the delivery point for Rio Grande Compact water. A storage pool was created under contract by Reclamation for utilization by the Water Authority.
Heron Reservoir	SJC water delivery	varies	This reservoir is the delivery point for SJC water. Storage is allocated annually based on the SJC contract amount. Carry-over storage is not allowed – meaning that the Water Authority can generally only store water in Heron for a year. However, waivers often allow for storage for a few extra months on an annual basis.

3.3.1.1 NATIVE RIO GRANDE WATER RIGHTS

The Water Authority has two types of native water consumptive rights on the Rio Grande: vested and acquired, totaling about 26,396 afy. These water rights, along with treated wastewater flows, are used to offset past and current effects on Rio Grande flows caused by the Water Authority's groundwater pumping. Vested water rights were granted to the City/Water Authority in 1963 after the NMOSE declared the Middle Rio Grande Basin. The amount granted was based on historical groundwater pumping prior to the declaration of the basin in 1956.

Vested rights are a "right to deplete" and have been applied to offset effects of groundwater pumping on the Rio Grande for more than 50 years (vested rights[4] do not allow for direct diversions from the Rio Grande). The Water Authority has 17,875 afy of vested native Rio Grande rights.

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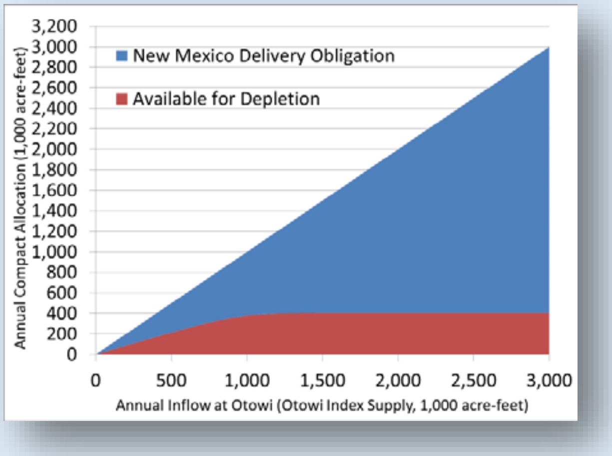
[4] Vested rights were granted based on an estimate of historical pumping and are directly tied to groundwater production. As such, they are not available for direct surface diversion.

The Rio Grande Compact and Water Rights

The State of New Mexico entered into an interstate compact with Colorado and Texas in 1938. This Compact apportioned the amount of Rio Grande flow and established delivery obligations for the States of Colorado and New Mexico. The Rio Grande Compact is a delivery compact, requiring each upstream state to deliver a certain amount of water to the downstream state. The amount of delivery is based on the amount of supply in a given year. For the Middle Rio Grande, New Mexico's delivery obligation is dictated by the native flow passing Otowi gage (see Figure below). Any water entering into the Rio Grande downstream from Otowi gage and upstream of Elephant Butte Reservoir is also available for consumption.

Flows were apportioned based on how much the States were using at the time of signing. As can be seen, for lower inflows, the portion of the inflow that New Mexico must deliver is reduced. Once the inflow exceeds about 1 million ac-ft, New Mexico must deliver all flow in excess of 400,000 ac-ft. Historical Rio Grande Flow at Otowi gage has averaged, from 1895 through 2014 (some data missing), about 1,450 cubic feet per second (cfs) or 1.06 million afy. This volume of flow results in a New Mexico delivery amount of about 600,000 ac-ft. However, since 2011, flows have been below 1,000 cfs with only 755 cfs in 2013; or about 550,000 ac-ft.

This volume of flow resulted in a delivery obligation of about 300,000 ac-ft and the ability to deplete 250,000 ac-ft, in addition to water entering the system below Otowi gage, for all uses in the Middle Rio Grande (defined per the Compact as from Otowi gage to Elephant Butte Reservoir). Depletions come from uses of Rio Grande water by native Rio Grande rights holders, such as agricultural, municipal, and industrial users; but also from evapotranspiration, including evaporation associated with Elephant Butte Reservoir. The Water Authority holds about 25,000 ac-ft of native rights, or just over 5 percent of the maximum depletion.

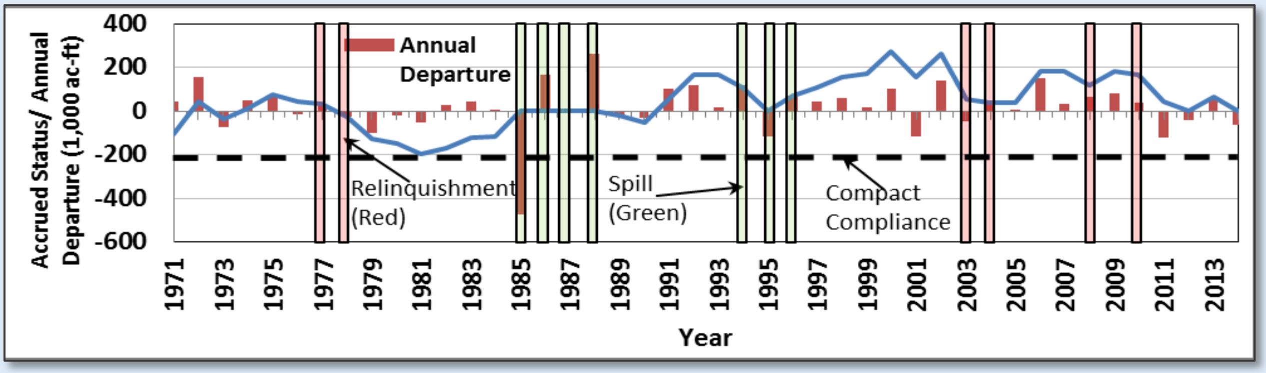


New Mexico delivers water to Elephant Butte Reservoir resulting in "Project Storage." The Compact allows for New Mexico to over- or under-deliver its annual requirement. However, there are limits on how much of a deficit can be accrued (200,000 ac-ft) and annual limits on the amount of credit received (150,000 ac-ft). An operational spill (which can be "actual" [water actually spilled from a full Elephant Butte Reservoir] or "hypothetical" [when water would have spilled had releases not been made]) in system reservoirs resets the accrued status to zero (or reduces the accrued credit proportionally to the amount of the spill). When Project Storage at Elephant Butte drops below 400,000 ac-ft, New Mexico cannot increase the amount of water in storage in upstream reservoirs. Likewise, water in storage can be requested by the downstream state when the state is in accrued debit status.

On occasion, New Mexico has relinquished ("released") some of its stored credit water to Texas. The relinquishment amount is allocated and made available to upstream users who are then able to store a like amount of native water. Relinquishment allows for storage of native water even when Project Storage drops below 400,000 ac-ft. Relinquishment makes water available to New Mexico users and ensures that water is not ultimately lost due to a spill. In total, the State has relinquished almost 400,000 ac-ft of water since 2003. For example, in 2003; 175,500 ac-ft of water were relinquished and allocated to the U.S. Bureau of Reclamation, Middle Rio Grande Conservancy District, and the City of Santa Fe for storage or use (see table on following page for recent history). In the 1950s, the State was judged to be out of compliance with the Compact for a number of years, largely due to structural problems in making deliveries.

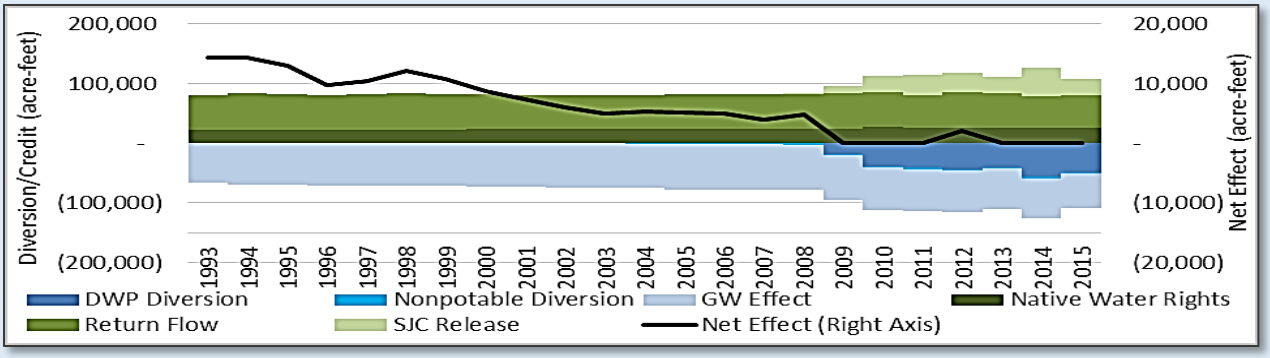
	2003	2008	2010	2011	2012	2013	2015	Total Used/ Stored	Available for Storage
RELINQUISHED	175,500	125,000	80,000	0	0	0			
ALLOCATIONS (afy)									
United States	56,483	25,517	0	9,000	0	0	19,000	82,584	27,416
MRGCD	112,965	37,035	0	21,000	0	20,000	58,000	171,744	77,256
City of Santa Fe	6,052	1,448	0	1,000	0	0	0	1,293	7,207
State of NM	0	0	0	0	6,000	0	7,000	0	13,000
Total Allocated	175,500	64,000	0	31,000	6,000	20,000	84,000	255,621	124,879
Total Unallocated	0	61,000	141,000	110,000	104,000	84,000	0		

The State acted to reduce the structural problems, including construction of a pilot channel through the accumulated sediment at the inlet to Elephant Butte Reservoir. The State has been fully in compliance with the Compact since the late 1960s. The figure below shows the annual compact departure as well as years where spills (green bars) and relinquishment (red bars) have occurred.



To receive a permit for a ground or surface water diversion, the applicant must show that they will not impact the Compact in excess of their rights or their ability to offset impacts. If the State believes that granting a permit is not neutral with respect to its impact on the Compact, the permit may not be granted. The State is able to check for compliance once a permit is issued through reporting, accounting, and administration.

Historically, the net effect of the Water Authority's permits has been positive with respect to the Compact as shown below (providing more water than required, or a surplus). Since 2009, the Water Authority's impact has been neutral or positive as the Water Authority is fully using all of its water rights and return flows in addition to supplemental releases of SJC water stored in Abiquiu Reservoir; thereby keeping the river whole, as per NMOSE Permit requirements. As the groundwater system balances and the aquifer rebounds, projections indicate that the Water Authority may once again surplus the Rio Grande with groundwater.



The remaining 8,515 afy of the Water Authority's Rio Grande rights have been acquired since 1956, including about 1,261 afy acquired through the NMU purchase[5]. All of these vested and acquired rights are currently used to offset groundwater pumping.

3.3.1.2 SAN JUAN-CHAMA PROJECT

Another surface water source is water from the SJC project. The SJC Project consists of a transbasin water transfer from the San Juan River Basin (tributary to the Colorado River) to the Rio Grande Basin. Water diverted from three tributaries of the San Juan River (Navajo River, Little Navajo River, and Rio Blanco) is imported into the Rio Grande through a series of tunnels to Heron Reservoir (401,320 ac-ft capacity) where it is allocated to SJC contractors[6] (see Figure 3.4).

The SJC project has a firm yield (defined as the amount of water that can be drawn annually without shortage based on a historical hydrologic sequence, see Figure 3.5) of about 96,200 afy and a contracted delivery amount of a little over 86,000 afy, with the remaining difference allocated to future settlements but not contracted.

Carry-over storage in Heron Reservoir is not allowed, and as such contractors must take delivery of their annual allotment. In some years, Federal waivers allow storage in Heron Reservoir beginning April 30th and as late as September 30th. Evaporative losses are not accrued in Heron Reservoir for SJC contractors.

Figure 3.5 presents the historical delivery to Heron Reservoir as well as the estimated firm yield[7]. Limitations of SJC deliveries include the following:

- SJC diversions are subject to "minimum bypass"[8] requirements (Table 3.4) to protect Colorado fish and aquatic life.
- There are physical diversion limitations (950 cfs capacity Azotea tunnel).
- SJC diversions are subject to sharing of shortages in addition to Colorado/Upper Colorado River Basin Compact limitations by declaration of the Secretary of Interior.

The Water Authority has consumptive rights to 48,200 afy of SJC water and takes delivery from the outlet of Heron Reservoir. SJC water is typically released from Heron Reservoir to Abiquiu Reservoir where the Water Authority has 170,900 ac-ft of storage capacity.

An additional 50,000 ac-ft of storage is available in Elephant Butte Reservoir and is accessed for use by the Water Authority through exchanges with native Rio Grande water. Transit losses, or estimated losses of water due to evaporation and seepage, are applied as water flows downstream to Elephant Butte Reservoir for storage. The Water Authority is charged evaporative losses for storage in both Abiquiu and Elephant Butte reservoirs.

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[5] NMU was purchased in 2009. NMU formerly served a corridor generally within Albuquerque City limits extending west from Corrales to the Bernalillo County boarder, just south of the Sandoval County border.

[6] SJC Contractors include: the Water Authority, Middle Rio Grande Conservancy District, Jicarilla Apache Tribe, City and County of Santa Fe, County of Los Alamos, Pojoaque Valley Irrigation District, City of Espanola, Town of Belen, Village of Los Lunas, Village of Taos, Town of Bernalillo, Town of Red River, and Twining Water & Sanitation District.

[7] Firm yield is defined as the long-term average supply that a reservoir of a given size could produce every year given the expected input flow. Note that in some years input flow will be greater or less than the firm yield due to natural variability.

[8] Minimum bypass flows are amounts that must pass the diversion point. For example, if a minimum bypass flow is set at 100 cfs and 120 cfs is flowing, then the allowed diversion would be 20 cfs.

Figure 3.4. The San Juan-Chama Diversion and Delivery System

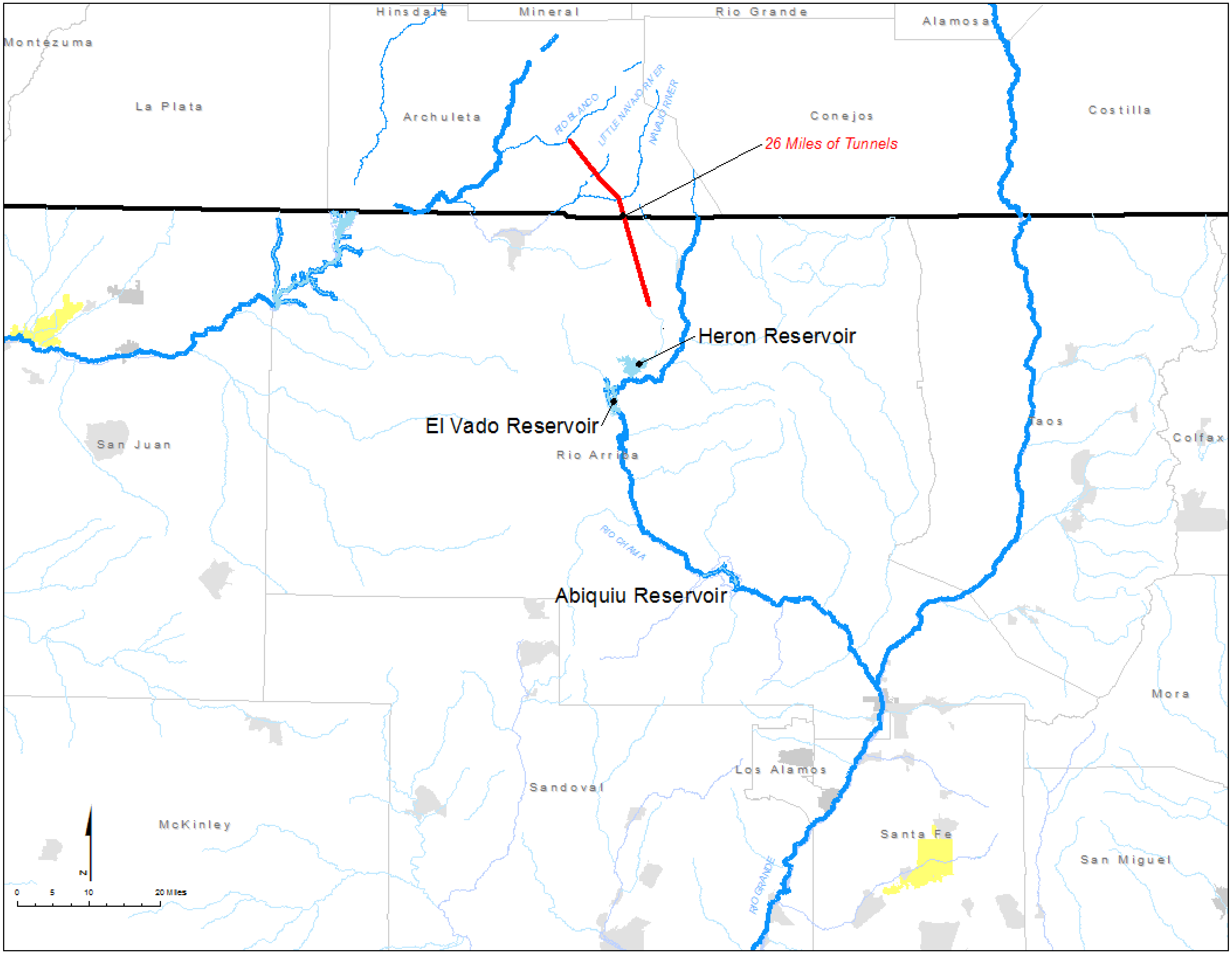

Table 3.4. Minimum Bypass Flows for San Juan-Chama Diversions (cfs)

	Rio Blanco	**Little Navajo River**	**Navajo River**
January	15	4	30
February	15	4	34
March	20	4	37
April	20	4	37
May	40	27	88
June	20	27	55
July	20	27	55
August	20	27	55
September	20	27	55
October	20	4	37
November	20	4	37
December	15	4	37

The Water Authority diverts its SJC water under NMOSE permits SP-4830 and SP-4819 for the SJC DWP and the NPP, respectively. The Water Authority may divert up to 94,000 afy, provided return flows to the Rio Grande are equal to at least half of the total diversion[9] at all times and that native Rio Grande flows are above 122 cfs at the point of diversion. For flows above 122 cfs but below 195 cfs, diversions are curtailed by 1 cfs for every 1 cfs drop in flow. See Appendix 3.A for a copy of the NMOSE permit SP-4830, including a list of conditions.

Figure 3.6 presents monthly Rio Grande flow data at the Central Avenue gage. Figure 3.7 presents low-flow frequency curves for the Rio Grande at Central Avenue gage. The plot shows the 1-, 7-, 14-, 30-, and 60-day average low-flow curves and how often they occur.

For example, an average daily flow of 100 cfs will occur about once every three years; whereas a 60-day average low flow of 100 cfs will occur about every 17 years. Monthly average Rio Grande flow less than 130 cfs occurred approximately 7 percent of the time from 1942 through 2010.A portion of SJC water, up to 3,000 afy, is permitted for diversion as part of the NPP (SP-4819). This diversion permit also provides water to the Bear Canyon Arroyo Aquifer Storage and Recovery Project.

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[9] SP-4830, Condition 9: An amount of water equivalent to the amount of native surface water diverted under this permit shall be simultaneously returned directly to the Rio Grande at the City's SWRP wastewater outfall as verified by accounting methodology acceptable to the NMOSE. The amount of water considered to be return flows of 'native' surface water under this Permit shall not be available for offset purposes, or to increase diversions of ground water, under the City's other permits. In other words, not all of the return flow is available for other uses.

3.3.1.3 WASTEWATER

Less than half (about 45 percent) of the water used by the Water Authority is used consumptively (water that evaporates, is transpired by vegetation, or is otherwise "lost"). The rest – currently about 60,000 afy – is discharged as treated wastewater[10] to the Rio Grande. Part of this wastewater, or "return flow," is currently used, along with native surface water rights, to offset effects on Rio Grande flows due to groundwater pumping.

Figure 3.8 shows historical Water Authority demand (ground and surface water) and return flow. Return flow has remained relatively constant in volume since the mid-1990s, while demand has decreased significantly, due largely to the impact of outdoor conservation.

Since 2012, up to 2,000 afy of return flow is used as part of the Southside Reuse Project to irrigate large turf areas (e.g. parks, athletic fields, etc.) in the southeastern portion of Albuquerque. A small amount[11] of industrial wastewater has also been used as non-potable reuse in the NPP for irrigation of large turf areas.

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[10] Water Authority wastewater is treated at the Southside Water Reclamation Plant near Rio Bravo Blvd. and the Rio Grande. Wastewater is treated using traditional filtration and biological processes and disinfected with ultraviolet light. Wastewater is treated to meet unrestricted urban reuse standards, in addition to Federal Clean Water Act and National Pollutant Discharge Elimination System Permit requirements.

[11] Historically as much as 800 afy has been utilized. Currently, about 30 afy is utilized.

Figure 3.5. SJC Annual Inflow to Heron Reservoir

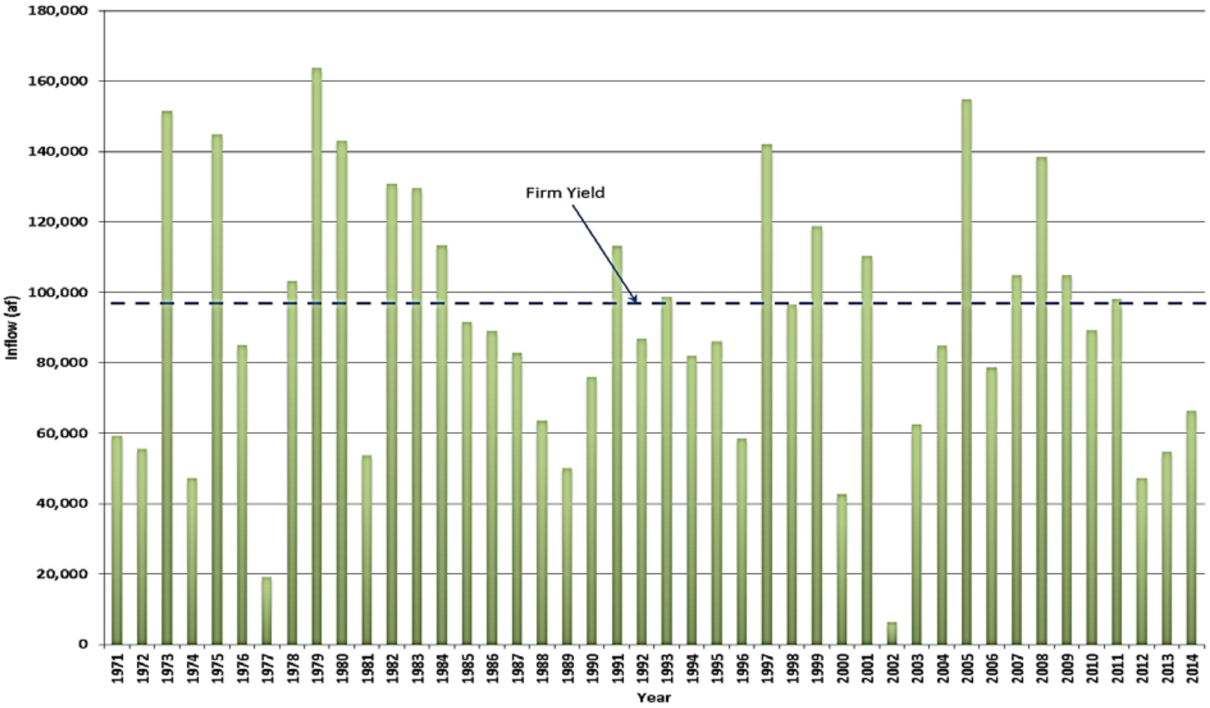


Figure 3.6. Monthly Rio Grande Flow at Albuquerque (1942-2014) (See Appendix 3.E for larger size)

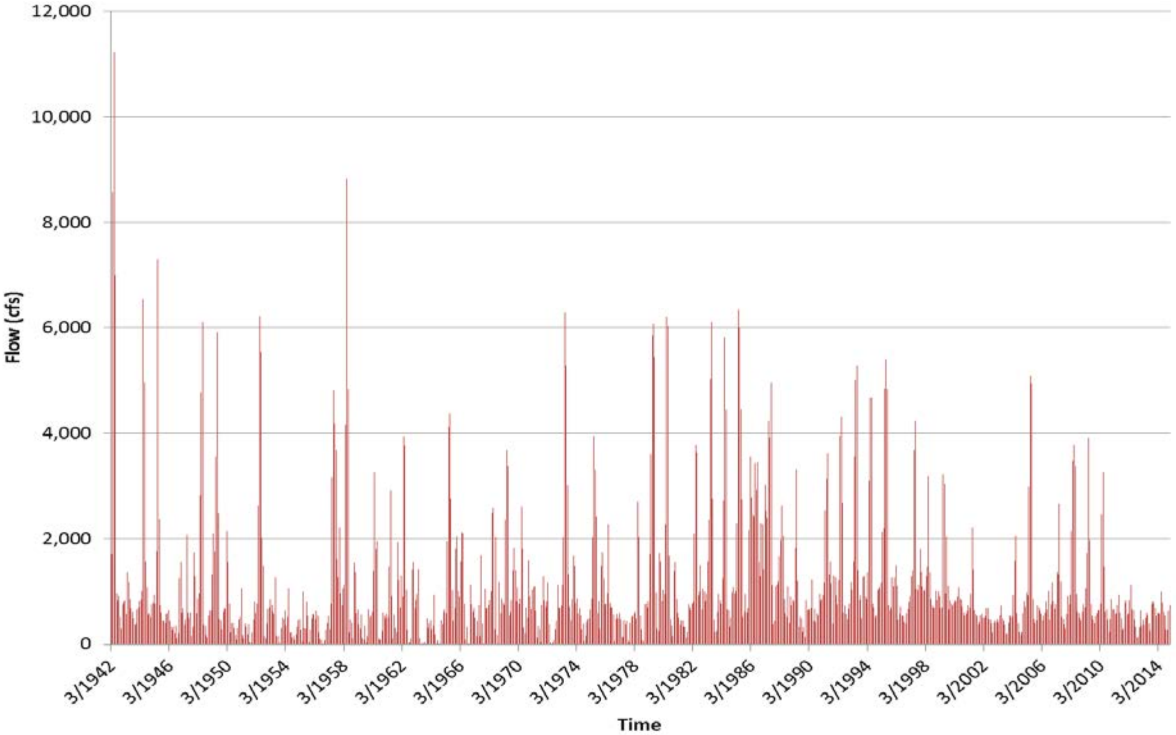


Figure 3.7. Low Flow Frequency at Albuquerque, Based on 1971-2014 Hydrology

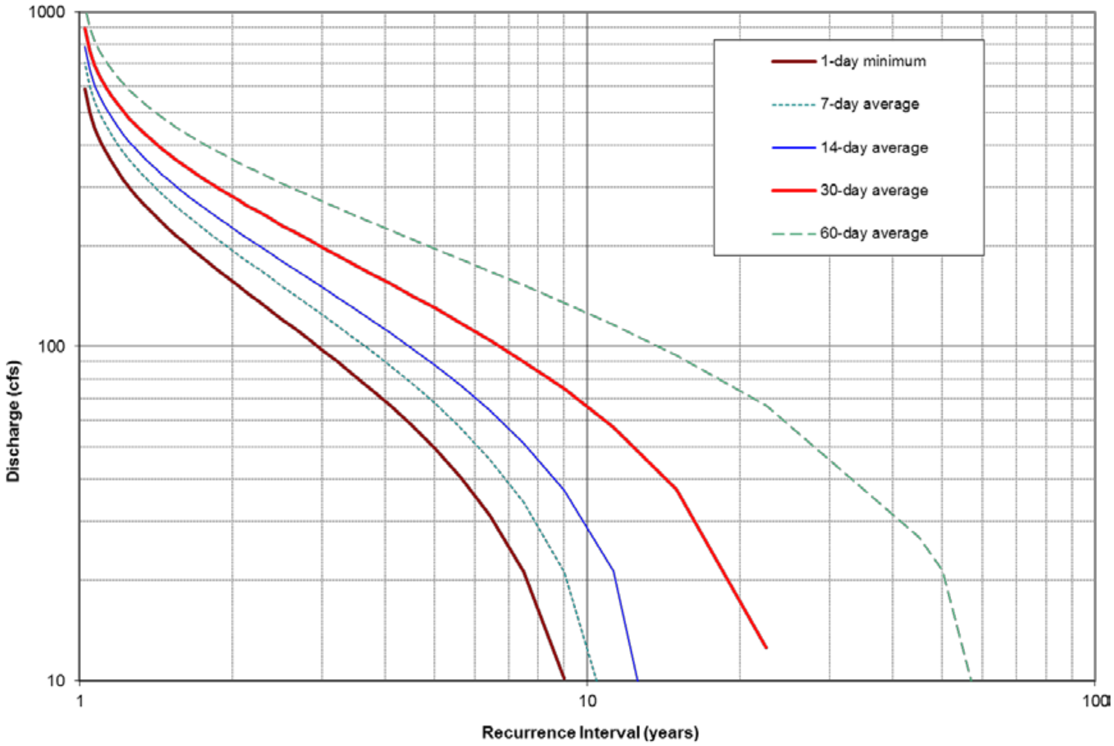
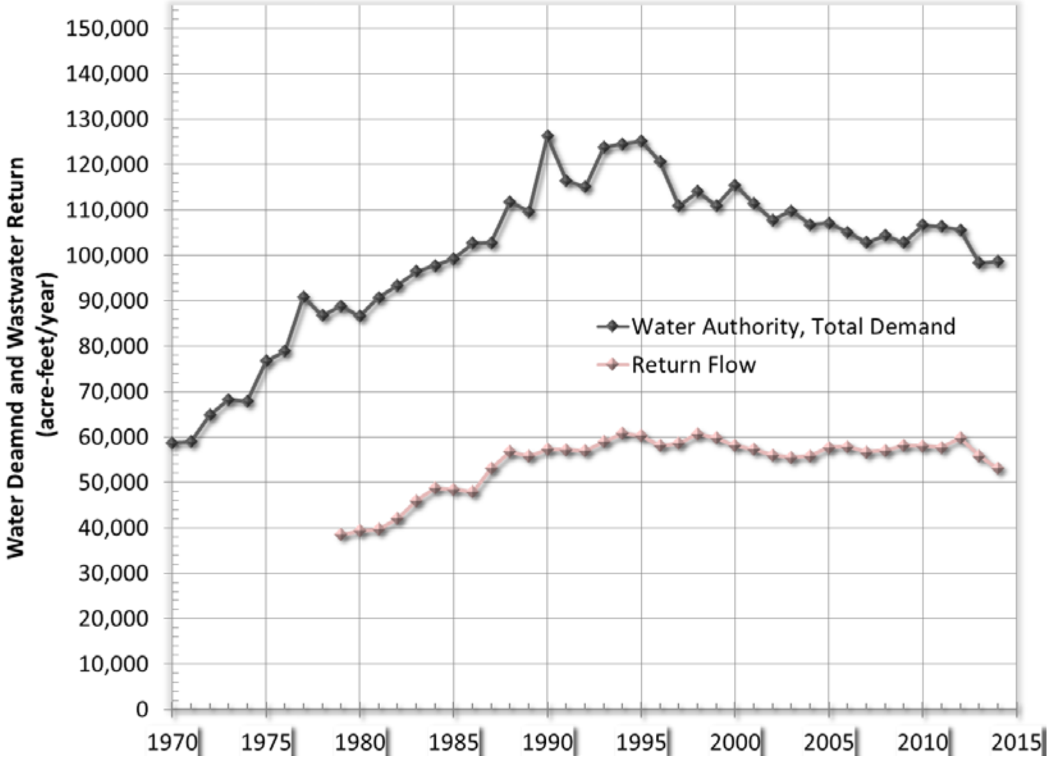


Figure 3.8. Historical Demand and Return Flow for the Water Authority



3.3.2 Groundwater

The Water Authority currently pumps groundwater from the Middle Rio Grande Basin aquifer, comprised of extensive sand and gravel deposits beneath the Rio Grande Valley and adjoining mesas. These deposits extend from north of Bernalillo to south of Belen. A map of the basin extent is shown in Figure 3.9.

In 2015, the Water Authority's total demand was about 93,000 afy. Until December of 2008, demand was met through groundwater pumping. In late 2008, the Water Authority began phasing in surface water. Since December of 2008, groundwater production has steadily declined from near 100,000 ac-ft to about 42,000 ac-ft in 2015 (see Figure 3.3).

The Water Authority has two groundwater permits issued by the NMOSE: one originating from the City of Albuquerque (RG-960 et al.), and one originating from NMU (NMU, RG-4462), which the Water Authority acquired in 2009. The maximum allowed pumping from both permits combined is 165,000 afy. RG-960 allows pumping of up to 155,000 afy[12] of groundwater, as long as the effects of that pumping on the flow of the Rio Grande are offset. Table 3.5 lists the permitted maximum groundwater pumping over time. Existing well capacity from the Water Authority's more than 90 wells is sufficient to pump the full amount of its groundwater diversion rights.

Table 3.5 RG-960 Diversion Limits

Years	**Diversion Limit (ac-ft)**
Through 2015	132,100
2016 through 2029	142,900
2030 and thereafter	155,000

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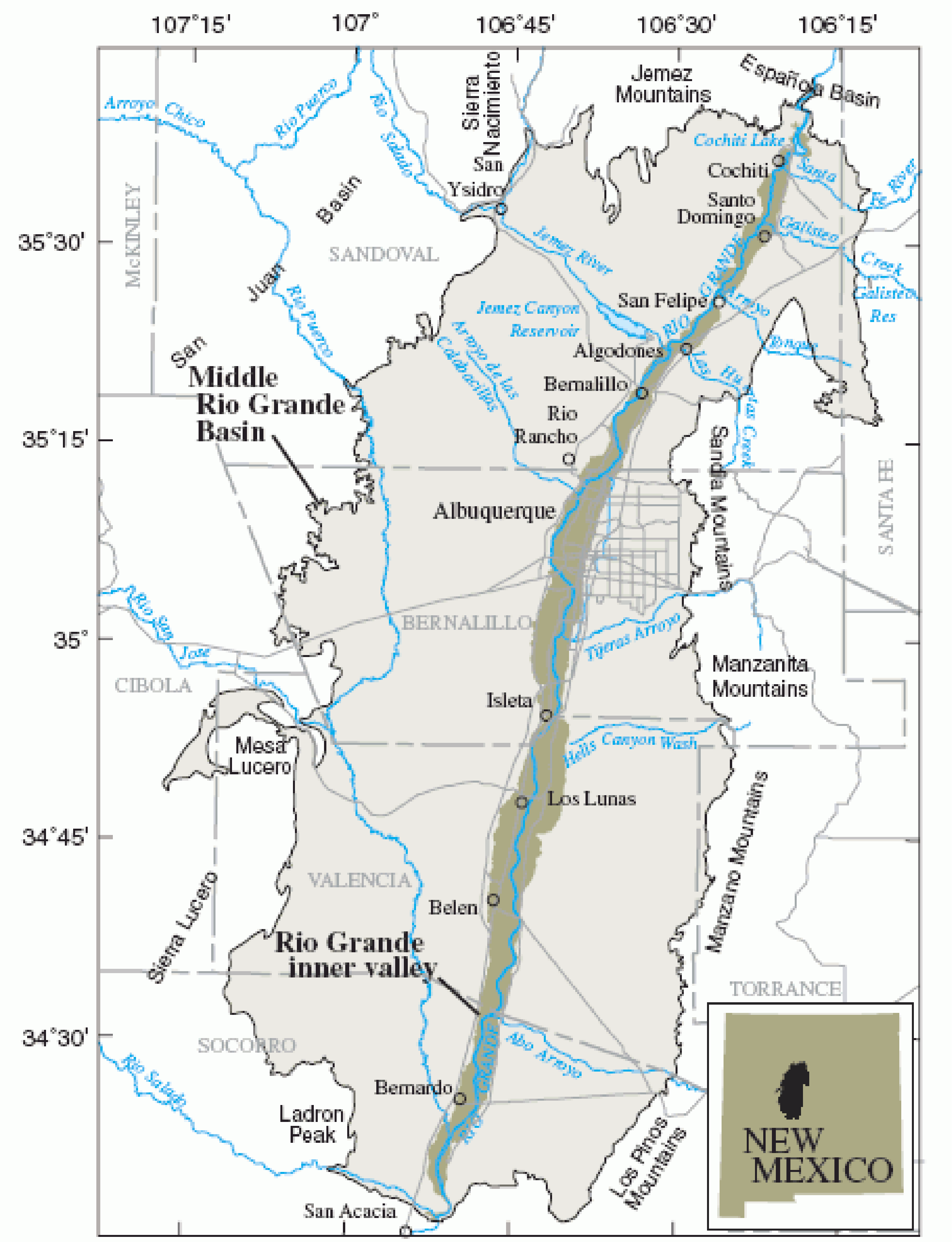
[12] The maximum amount of allowable pumping under RG-960 is pro-rated over time from 132,000 afy, currently, to the eventual maximum of 155,000 afy.

Figure 3.9. Middle Rio Grande Basin



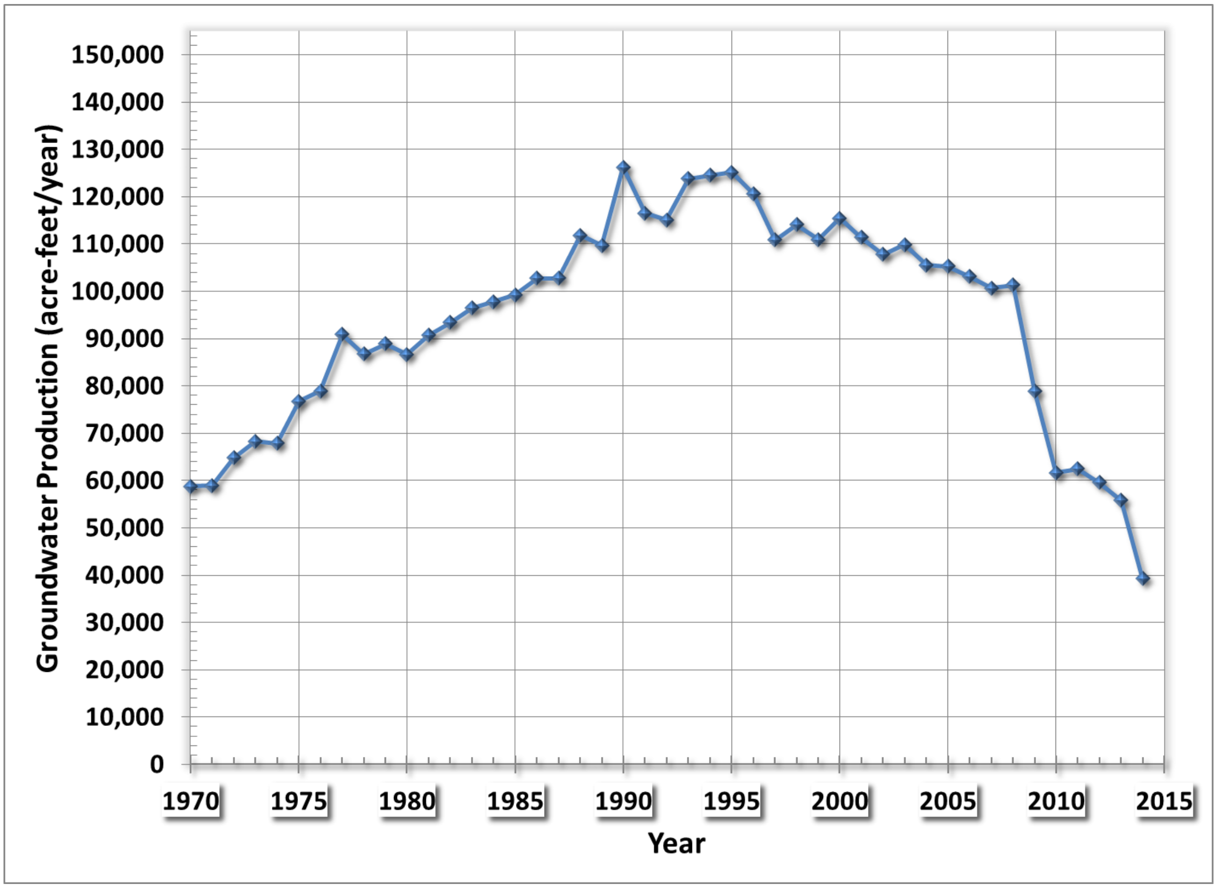
Source: USGS, http://nm.water.usgs.gov/projects/middleriogrande/images/basin.gif

Historical groundwater production is shown in Figure 3.10. The required surface water offset for groundwater pumping varies over time, depending on historical and current pumping. Offset requirements are determined by the NMOSE utilizing its Administrative Area Model for the Middle Rio Grande. Offsets are met through a combination of treated wastewater effluent discharged to the Rio Grande, native surface water rights, and, if necessary, releases of stored SJC water. There is a significant lag time between groundwater production and when this production affects the Rio Grande.

The NMU acquisition included 10,000 afy of groundwater diversion rights (RG-4462), and historical production nearly reached this amount. Offsets associated with exercise of these rights are computed using the Glover-Balmer method[13]. Offsets are met through a combination of treated wastewater effluent discharged to the Rio Grande and native surface water rights.

Since acquisition, the NMU system has historically discharged wastewater to the Water Authority system, but diversions and return flow credits under permit RG-4462 are administered separately from RG-960. The former NMU system is interconnected with the Water Authority's distribution system.

Figure 3.10. Historical Groundwater Production (1970-2014)



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[13] The Glover-Balmer method is an analytical approach that utilizes the "average" transmissivity between the production well and the river along with the distance to the river to calculate the impact to the river.

3.4 Supply Projections

Previous strategies utilized historical Rio Grande flow to represent future potential for supply variability. While this sequence is appropriate for capturing the variability associated with the observed record, it does not include the greater variability associated with either the paleo record or with more recent work on anticipated climate change.

For the current WRMS, the Water Authority is mitigating this uncertainty in future streamflow by considering a range of future conditions. A series of "Low," "Medium," and "High" streamflow/supply projections were developed based on:

1. Updating the historical Rio Grande flow sequence from 1971-1998 to 1971-2014 (which includes the recent drought)
2. Utilizing modified Reclamation-provided flow sequences (see Appendix 3.B) for the Rio Grande and San Juan River to reflect projected climate variability (Llewellyn, 2013).

This variability is focused entirely on surface water availability. Note that other supply sources are generally immune from variability and are either dependent on surface water availability (groundwater - demand increases directly with reduction in surface water) or completely independent of surface water (reuse/wastewater sources).

The remainder of this chapter presents selected surface water sequences and provides a discussion of how groundwater is potentially impacted by the projected hydrologic variability.

3.4.1 Surface Water Projections

Average and median flow over the planning period were compared with the historical record and the five Reclamation climate sequences (see Table 3.6). Three sequences were selected from these that describe the range of potential flows for Low, Medium, and High projections.

Table 3.6. Available Hydrologic Sequences, Flow in cfs 2015-2120

Climate Sequence	Average Flow	Median Flow
Warm-Dry	910	583
Warm-Wet	1,216	745
Hot-Dry	778	513
Hot-Wet	952	607
Central	961	613
Historical (1971-2014)	1,251	766

Note that while the Warm-Wet sequence from Reclamation is roughly equivalent to the historical record, it was appropriate to utilize the historical record as it is relatively wet and can be easily compared to past experience. The following sections discuss the Low, Medium and High projections for both Rio Grande and SJC flows and ultimately supply.

3.4.1.1 HIGH SUPPLY - HISTORICAL HYDROLOGY (1971-2014)

Rio Grande

As part of previous planning efforts, the 1971-1998 hydrologic record was analyzed and, subsequently, chosen as representative of the longer hydrologic record (CH2M, 2003). This record was chosen because it is representative of the long-term (>100-year) record, and the current operational regime for reservoirs, river facilities, and SJC water importation and use began in 1971.

The 1971-1998 streamflow record was adjusted and aligned so that 1971 became 2006, 1972 became 2007; etc., to simulate future hydrologic conditions. Adjustments to the historical record included:

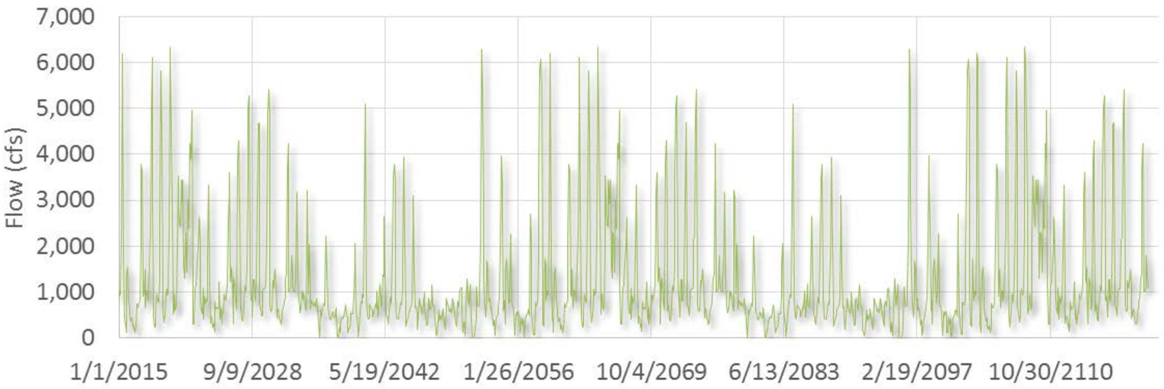
- Removal of the historical (1971-1998) Water Authority SJC water that was in the river at Central Avenue gage based on a detailed evaluation of Federal, State, and Water Authority records.

- Addition of a simulated 3-year drought to the record based on three drought years (1972 repeated) placed 'back-to-back' in the baseline so as to depict an extended drought similar to that experienced in the 1950s. Such a drought is otherwise missing from the 1971-1998 period.

As described in detail in Appendix 3.C, this process was utilized to update the historical sequence through 2014, resulting in a High supply sequence consistent with the recent historical record (1971-2014). Note that because of recent drought, an artificial drought was not added to this update.

Figure 3.11 presents the resulting sequence, repeated to cover the period from 2015-2120. Average monthly flows vary significantly from near zero to over 6,000 cfs.

Figure 3.11. High Supply Sequence, 2015-2120



San Juan-Chama

San Juan-Chama water diverted to Heron Reservoir is constrained by minimum bypass requirements and varies from year to year. However, Heron Reservoir has a capacity of over 400,000 ac-ft, compared with the firm yield of about 96,000 afy.

Historically, the capacity of Heron Reservoir has been sufficient to act as a buffer to supply variability (see Figure 3.5). Accordingly, SJC supply is assumed to be 48,200 afy under "High" flow projections, corresponding with historical hydrology.

3.4.1.2 LOW AND MEDIUM-CLIMATE CHANGE PROJECTIONS

Rio Grande

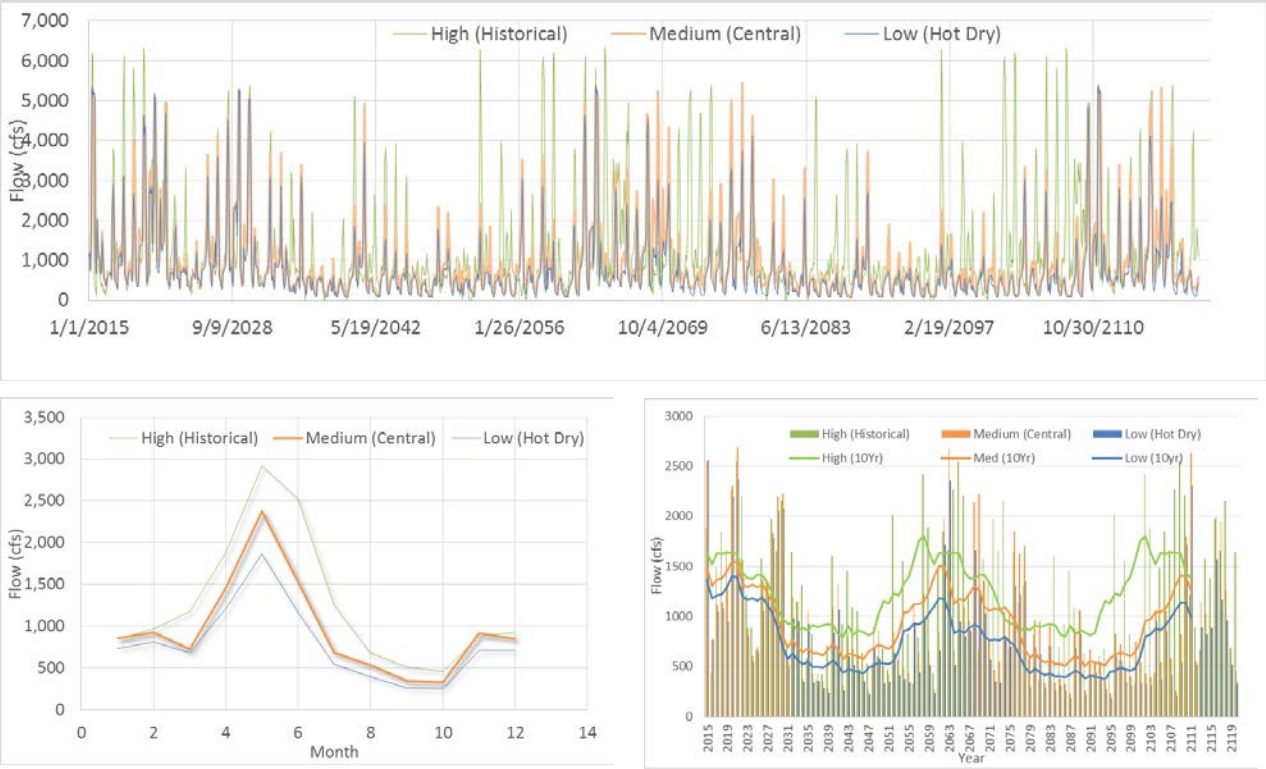
As discussed above, surface water supply is likely to be influenced by climate change. Five climate change sequences have been developed for use in water supply planning in New Mexico by Reclamation. Two of these sequences, "Hot-Dry" and "Central," were chosen to represent Low and Medium supply conditions, respectively.

The Low (Hot-Dry) sequence reflects the average of the upper 25 percent of climate traces for both temperature increase and precipitation decrease.

The Medium (Central) sequence reflects the central tendency of climate traces for temperature and precipitation. Appendix 3.B presents additional detail on the development of the climate change sequences.

Figure 3.12 shows Rio Grande flow under the Low, Medium, and High Supply projections for monthly flow, annual flow (with a 10-year running average), and monthly average flow. Table 3.7 provides summary statistics for flow over the planning period. Appendix 3.D provides a discussion that compares the chosen sequences to the paleo record as reconstructed from tree-ring data.

Figure 3.12. Low, Medium, and High Flow (see Appendix 3.E for larger size)



Note:
These figures are intended to show data trends and not individual data points. For more detail see Appendix 3.E, where larger versions are presented.

Table 3.7. Historical and Updated Annual Rio Grande Flow Projections (cfs)

2015-2120	Average	Median
WRMS 2007^A	1,362	816
High (Historical)	1,251	766
Medium (Central)	1,077	677
Low (Hot-Dry)	973	621

^{A} The 2007 WRMS is averaged over the planning period from 2006 to 2060

San Juan-Chama

For San Juan-Chama supply, each climate change sequence noted for the Rio Grande also results in a sequence of Azotea tunnel inflow.

These projections can be used with evapotranspiration data (also adjusted to reflect warmer temperatures with climate change) to estimate available SJC water for the Water Authority.

Table 3.8 presents the amount of SJC supply available under each of the three projections. As can be seen, even under relatively extreme assumptions about future climate, SJC is still a significant component of future supply.

Table 3.8. Average SJC Supply Projection 2015-2120

Projection	Percentage (%) of normal flows
High Supply (Historical)	100
Medium Supply (Central)	88
Low Supply (Hot-Dry)	75

3.4.2 Groundwater Production Projections

Under the “High” projection (historical Rio Grande hydrology), groundwater usage is expected to be reduced from other projections, due to the increased availability of surface water. It is assumed that groundwater production will increase in drought years, and that the aquifer will continue to be recharged – similar to mountain front recharge and varying river recharge corresponding to groundwater pumping.

For the Low and Medium projections, groundwater production will increase, fluctuating based on available surface water with drought years requiring greater production. While model results suggest that groundwater production clearly remains viable over the planning period, the long-term sustainability of groundwater production could potentially be affected by climate change through changes in local precipitation affecting mountain front recharge and/or through regional changes that impact the amount of water flowing in the Rio Grande.

The Low and Medium projections will generally mean less water flowing in the Rio Grande, resulting in more frequent curtailment of surface water diversions and subsequent greater reliance on groundwater to meet demands. In addition, less water in the river will result in lower seepage rates and, therefore, more reliance on groundwater from storage. That said, additional pumping will result in additional drawdown and ultimately expand river recharge over a larger area, resulting in a similar river recharge.

It is anticipated that the primary impact of climate change to the groundwater supply will be greater reliance on this resource with a small change in reliability over the planning period due to change in recharge. Likewise, it is anticipated that this change in reliability will be small when compared to potential surface water impacts and the buffering capacity of the aquifer (storage) and will not be considered at this time.

3.5 References

CH2M HILL Engineers INC (CH2M). 2003. Hydrologic Effects of the Proposed City of Albuquerque Drinking Water Project on the Rio Grande and Rio Chama Systems. Prepared for City of Albuquerque Public Works Department. October.

U.S. Geological Survey (USGS). 2016. USGS 08330000 RIO GRANDE AT ALBUQUERQUE, NM. USGS Gage Data Central Avenue Bridge. http://waterdata.usgs.gov/nm/nwis/uv/?site_no=08330000&PARAmeter_cd=00065,00060.

Llewellyn, Dagmar. 2013. Personal communication with Abhishek Singh, INTERA..

Appendix 3.A

SP-4830

BEFORE THE NEW MEXICO STATE ENGINEER

IN THE MATTER OF THE APPLICATION BY	**)**	
CITY OF ALBUQUERQUE PUBLIC WORKS	**)**	**Hearing No. 02-017**
DEPARTMENT TO DIVERT SURFACE	**)**	
WATER FROM THE RIO GRANDE BASIN	**)**	**OSE File No. 4830**
OF NEW MEXICO	**)**	

REPORT AND RECOMMENDATION OF THE HEARING EXAMINER

This matter came on for hearing before Victor Kovach, the State Engineer's designated Hearing Examiner, on December 3 through December 6 and December 9 through December 13, 2002, in Santa Fe, New Mexico, and on February 24 through February 27, 2003, in Albuquerque, New Mexico. The parties appeared as follows: Jay F. Stein, Esq., and James C. Brockmann, Esq., represented the Applicant City of Albuquerque Public Works Department; Peter Thomas White, Esq., Mary Humphrey, Esq., and Connie Odé, Esq., represented Protestants Amigos Bravos, Rio Grande Restoration, Sierra Club, New Mexico Public Interest Research Group (NMPIRG), Socorro Soil and Water Conservation District (SSWC), John Carangelo, and the Assessment Payers Association of the MRGCD (hereinafter referred to collectively as the "Coalition Protestants"); and William D. Teel, Esq., represented the Water Resource Allocation Program (WRAP) of the Office of the State Engineer (OSE). An appearance, at the beginning of the hearing, was made by Lester K. Taylor, Esq., for the Pueblo of Isleta, Gary Horner, Esq., for B.J. Resources, Inc., and Ray A. Garcia, *pro se*.

Having considered the pleadings and evidence of record, the Hearing Examiner recommends the following Findings and Order.

FINDINGS

1. The State Engineer has jurisdiction of the parties and subject matter.
2. On May 18, 2001 and again on June 26, 2001, the City of Albuquerque (City) Public Works Department filed Application No. 4830 with the State Engineer for Permit to divert surface water from the Rio Grande for municipal, industrial and related

purposes for the City’s Drinking Water Project (DWP). The City proposes to divert approximately 94,000 acre-feet per year (afy), on a yearly average, at a near constant rate of about 130 cubic feet per second (cfs), with peak diversions of up to 103,000 afy at a rate of up to 142 cfs, generally comprised of 50 percent San Juan-Chama Project water, which will be fully consumed within the City’s water service area, and 50 percent 'native' Rio Grande Water, which will be returned to the Rio Grande. The Application and legal notice identify three alternative diversion points, all of which are located on land owned by the Middle Rio Grande Conservancy District (MRGCD).

3. The City’s preferred diversion alternative, and focus of its presentation at hearing, is a new surface water diversion facility to be located in the vicinity of the Paseo del Norte Bridge in Albuquerque, New Mexico, within a 500-foot radius of a point where X=382,500 feet and Y=1,525,800 feet NMCS Central Zone, NAD 27. The facility would consist of an adjustable-height (from 0 to 3.5 feet) inflatable dam to be installed on the Rio Grande approximately 2,500 feet north (upstream) of the Paseo del Norte Bridge. At Rio Grande stream flow rates up to approximately 10,000 cfs, the adjustable-height crest gates would be raised or lowered as required to maintain an average water surface elevation of approximately 4,992.9 feet, which is about 2.9 feet above the existing river bottom. At flow rates greater than 10,000 cfs, the gates would be maintained in the lowered position. The proposed diversion facilities include a sluice channel, raw water intake and fish screens along the east bank of the Rio Grande, a 50-foot-wide, low gradient, fishway on the west side of the river, and a pump-station and pipeline to convey water to the City’s proposed treatment plant near Chapell and Osuna Roads in northeast Albuquerque. The 'native' Rio Grande water diverted by the City would be returned to the river at the City's Southside Water Reclamation Plant (SWRP) wastewater outfall, located below the Rio Bravo Bridge at a point where X=373,900 feet and Y=1,462,000 feet New Mexico Coordinate System (NMCS), Central Zone, North American Datum (NAD) 27.

4. Affidavits of Publication indicate that legal notice of the Application was published in the following newspapers: *Albuquerque Journal; Las Cruces Sun-News; News Bulletin* of Valencia County, New Mexico; *The Herald*, Truth or Consequences, New Mexico; and, *El Defensor Chieftain*, Socorro, New Mexico. Protests to the granting of the Application were filed by the MRGCD, the City of Farmington, the San Juan Water Commission, the Hammond Conservancy District, the Navajo Nation, the Pueblo of Isleta, the Frankie S. Carruthers Trust, the Alliance for the Rio Grande (by and through Amigos Bravos, Rio Grande Restoration, Sierra Club, NMPIRG and only these entities), SSWC, John Carangelo, Chairman, in his official capacity and as an individual, the Assessment Payers Association of the MRGCD, B.J. Resources, Inc., Robert E. Oxford, Bette J. Oxford, and Ray A. Garcia.

5. Several Protestants objected to the priority date claimed by the City for the San Juan-Chama Project water in the Application and legal notice. San Juan-Chama Project water is imported into the Rio Grande Basin from the San Juan River Basin and is not subject to priority administration within the Rio Grande Basin. Any potential priority administration with respect to such water can only occur in the San Juan River Basin, and not in the Rio Grande Basin. Any priority date for Applicant's San Juan-Chama Project water will properly be adjudicated by the district court for the Eleventh Judicial District in the pending general water rights stream adjudication for the San Juan River. Accordingly, by stipulation, and limiting order of the State Engineer entered on November 8, 2002, the priority date for the City's San Juan-Chama Project water is not an issue for determination in this administrative proceeding and any decision entered in these proceedings shall not be construed as establishing a priority date for said SJCP water.

6. The protests of the MRGCD, the City of Farmington, the San Juan Water Commission, the Hammond Conservancy District, the Navajo Nation and the Frankie S. Carruthers Trust were withdrawn prior to hearing and these entities were dismissed from further proceedings.

7. The protests of Robert E. Oxford and Bette J. Oxford were dismissed by Order entered in this matter on September 23, 2002.

8. The Coalition Protestants moved to dismiss the Application for lack of jurisdiction. The Hearing Examiner's Order, entered on November 7, 2002, denying Coalition Protestants' Motion to Dismiss Application for Lack of Jurisdiction is incorporated herein by reference.

9. On December 3, 2002, at the beginning of the hearing and prior to the presentation of witnesses, the protests of the Pueblo of Isleta, B.J. Resources, Inc., and Ray A. Garcia were withdrawn and these parties were dismissed from the proceedings by order entered on the record.

10. The remaining parties who participated at hearing include the City, the Coalition Protestants and the WRAP of the OSE.

11. San Juan-Chama Project (SJCP) water is diverted from three tributaries of the San Juan River, a tributary of the Colorado River, and imported into the Rio Grande Basin to provide for beneficial consumptive use of a part of New Mexico's entitlement to Colorado River water under the Colorado River Compact, 45 Stat. 1057, 1064 (1928) and the Upper Colorado River Basin Compact, 63 Stat. 31 (1949).

12. The diversion works for SJCP water, located in southern Colorado, are as follows: the Blanco Diversion Dam diverts surface waters from the Blanco River; the Little Oso Diversion Dam diverts surface waters from the Little Navajo River; and, the Oso Diversion Dam diverts surface waters from the Navajo River. The SJCP water is transmitted via approximately 26 miles of tunnels, into Willow Creek, a tributary of the Rio Chama, and stored in Heron Reservoir in northern New Mexico.

13. 48,200 afy of SJCP water is expressly allocated to the City for municipal purposes in accordance with Contract No. 14-06-500-810 between the United States Department of the Interior, Bureau of Reclamation and City of Albuquerque, dated June 25, 1963 and Amendment No. 1, dated July 6, 1965. The City estimates that it has invested more than $45,000,000 to develop its supply of SJCP contract water.

14. The City has a permit to consume up to 3,000 afy of SJCP water under OSE File No. 4819 for its Nonpotable Surface Water Reclamation Project (NSWRP). It wishes to reserve the right to use said 3,000 afy under either the DWP or NSWRP

and proposes to coordinate such use with the OSE.

15. The City takes delivery of its SJCP water at the outlet works of Heron Reservoir. After release from Heron Reservoir, the City's SJCP water is stored in Abiquiu Reservoir. The City has 170,900 acre-feet of storage space leased in Abiquiu Reservoir.

16. The general operating plan for the City's DWP, set forth in Exhibit A, Pages A-4 & A-5, of Application No. 4830, provides for a constant release of about 67 cfs of City SJCP water from Abiquiu Reservoir in most years. The City estimates that after incurring conveyance losses between Abiquiu and Albuquerque, 65 cfs of SJCP water will reach the diversion facility at Paseo del Norte. A constant diversion of 130 cfs, comprised of 65 cfs SJCP water and 65 cfs ‘native’ water, would occur at the diversion facility as long as flows at the diversion works are at or above a specified 'threshold flow' of 200 cfs. The 'threshold flow' level was determined based on the following: a diversion rate of 130 cfs comprised of 65 cfs of SJCP water and 65 cfs 'native’ water; a fishway bypass flow of 50 cfs; and a flow of 20 cfs at the sluiceway outlet to provide for downstream movement of sediment and fish past the intake screens, as follows:

Total Stream Flow Above Diversion Works
200 cfs (Native + SJCP)
Native Stream Flow **SJCP**
135 cfs 65 cfs
At Diversion Works
50 cfs 20 cfs 65 cfs 65 cfs
Fishway Sluiceway DWP --------------> DWP ----------->
Below Diversion Works
70 cfs Native Stream Flow

As proposed, a minimum of 135 cfs of 'native' flow would have to be present in the Rio Grande at the point of diversion for full operation of the DWP.

17. When 'native' flows fall below 135 cfs at the diversion point (total flow of 200 cfs with the 65 cfs SJCP water in the river) the City proposes to begin curtailing the quantity of the diversion, to ensure proper operation of the sluiceway and fishway facilities and to minimize depletion effects in the reach of the Rio Grande between the point

of diversion and return flow at the SWRP. The City will continue to release 67 cfs and divert 65 cfs of SJCP water, but will begin curtailing the total quantity (native + SJCP water) of the diversion by 1 cfs for each 1 cfs drop in native flow below 135 cfs. When 'native' flow drops to 70 cfs at the point of diversion DWP diversions would cease and releases of City SJCP water at Abiquiu would be cut off.

18. The DWP is a primary component of the City of Albuquerque's Water Resources Management Strategy (AWRMS) and 40-Year Water Development Plan (hereinafter "40-Year Plan").

19. Municipalities are allowed a water use planning period not to exceed forty (40) years and applications for appropriation of water by municipalities are to be based upon a water development plan for reasonably projected water demands within the forty-year planning period. The City's population and demand projections are set forth in its 40-Year Plan dated August 2002 (City Exhibit No. 11).

20. Three different population projection data sets for the City's water service area are included in Table 2 of the City's 40-Year Plan as follows: the Bureau of Business and Economic Research (BBER) estimates a population of 752,294 in the year 2040; the Middle Rio Grande Council of Governments estimates a population through 2010 at 603,760; and the City's Continued Current Growth Trends (CCGT) estimates a population of 868,800 in the year 2040. The City's CCGT population projection is based on past water use and the growth in the number of utility accounts. All three projections are reasonable.

21. Based on its population estimate of 868,800 for the year 2040, and its expectation that annual average per capita water use will be reduced from 205 to 175 gallons per capita per day (gpcpd) by 2010, the City projects that demand for its service area in the year 2040 will be approximately 170,000 afy (175 gpcpd x 365 days = 63,875 gallons per capita per year ÷ 325,851 gallons per acre-foot = 0.196 afy per capita x 868,800 = 170,284.8 afy).

22. Estimated demand for the City's service area in the year 2040, based upon the BBER population estimate of 752,294, would be approximately 147,450 afy using similar methodology.

23. Estimated demand for the City's service area in the year 2040, using the City's population estimate and a gpcpd figure of 155 would be approximately 150,800 afy.

24. Andrew Lieuwen, Ph.D., WRAP's expert in water rights, water planning and water conservation, reviewed the City's 40-Year Plan and determined that it was acceptable.

25. The City proposes to meet anticipated water demand through transition from dependence on groundwater as its sole source of supply to conjunctive use of SJCP water under the DWP and groundwater permitted under OSE File No. RG-960 et al. Presumably, the amount of the City's annual groundwater diversions under RG-960 et al., would decrease by an amount commensurate with its annual DWP surface water diversions.

26. The City's prior strategy was to meet water demand by continued and increasing diversion of ground water under its existing Permit No. RG-960 et al., and to use its allocated SJCP water to offset the effects on the flows of the Rio Grande that result from those groundwater diversions. The City now proposes to fully consume its SJCP water through direct surface water diversion. Such transition may be permissible provided that the City can meet its obligations under RG-960 et al., that there will be no impairment to existing water rights, that its proposal will not be contrary to the conservation of water within the state and that its proposal will not be detrimental to the public welfare of the state of New Mexico.

27. As a condition of approval under its existing Permit No. RG-960 et al., the City is required to offset the depletion effects of its groundwater diversions on the surface flows of the Rio Grande. OSE records and testimony of WRAP's witnesses indicate that the City uses what it has termed 'vested' and 'acquired' water rights, return flow credit and SJCP water to do so.

28. Although the City proposes to decrease its diversion of groundwater under RG-960 et al., upon implementation of the DWP, it would nonetheless remain obliged to offset the net surface water depletions on the flow of the Rio Grande associated with past groundwater diversion (residual effects) and to offset the effects of continuing groundwater diversions under RG-960 et al. In Table 4-1 of City Exhibit 23, the City

estimates that it needs to have at least 91,000 acre-feet of SJCP water stored in Abiquiu to offset anticipated residual effects during the years 2006 through 2016, or the first ten years of operation. The City also notes that additional storage of SJCP water would be needed to offset evaporation and seepage losses at Abiquiu (26,000 acre-feet), and to meet other obligations (29,000 acre-feet), during that same ten-year period. The Coalition Protestants' technical expert adjusted the City's calculations upward and estimated that the amount of water needed to offset residual effects for the first ten years of operation could be as high as 132,382 acre-feet (Coalition Exhibit 4, Page A-4).

29. The City's calculation of additional releases of SJCP water, for offset purposes during the first ten years of operation, are derived from Table E2 of its Exhibit 23. Certain discrepancies in the listing of estimated net effects (column 17) and the consequent estimated additional SJCP releases (column 20) were recognized at hearing. The estimates of additional releases of SJCP water are calculated by comparing net effects on Rio Grande flow to the amount of water the City describes as its vested and acquired rights: 23,347 afy. The net effects for the majority of years covered by Table E2 are apparently calculated by subtracting groundwater return flows (column 11) from the river effects calculated using the OSE model (column 16). However, net effects entries for the years 2006 through 2016 are not consistent with this methodology. Adjusted entries for the years in question and the corresponding adjusted figures for additional SJCP releases are as follows:

Col. (1) Year	Col. (16) OSE River Effects	Col. (11) Groundwater Returns	Col. (17) Net Effect	Col. (20) Additional SJCP Releases
2006	65,092	17,287	47,805	24,458
2007	64,451	27,142	37,309	13,962
2008	59,050	11,870	47,180	23,833
2009	57,145	16,741	40,404	17,057
2010	53,676	11,679	41,997	18,650

2011	52,197	16,546	35,651	12,304
2012	52,517	27,385	25,132	1,785
2013	49,402	20,600	28,802	5,455
2014	46,301	15,482	30,819	7,472
2015	43,878	16,433	27,445	4,098
2016	42,203	17,547	24,656	1,309
			Total:	130,383

Based on the adjusted entries above, the City's estimate of the amount of additional releases of SJCP water needed for the period of 2006 through 2016 would be approximately 130,383 acre-feet. Additional releases of SJCP water in the amount of 97,960 acre-feet would be required for offset purposes during the first five years of operation of the DWP, as those operations are described and simulated in City Exhibit 23.

30. Prior to initial diversion of SJCP water for the DWP, the City should have at least 130,000 acre-feet of SJCP water stored in Abiquiu reservoir. Thereafter, the City should maintain SJCP water storage in Abiquiu reservoir at levels sufficient to ensure that its obligations under other permits, including its obligation concerning offset of residual and anticipated upcoming effects to the Rio Grande, resulting from its diversion of groundwater under RG-960 et al., will be met.

31. The City's SJCP water in excess of the amount determined by the State Engineer to be needed for offset purposes under RG-960 et al., would be available for release for the City's DWP. SJCP water released for the City's DWP, less conveyance losses, would be available at the DWP diversion point.

32. For purposes of estimating the annual quantity of SJCP water available for diversion at Albuquerque, the City utilized incremental loss methodology. Incremental loss methodology assumes that non-native water is riding on top of native flows. The SJCP water incurs losses caused by evaporation from the larger surface area of the flowing water, but no seepage or other losses.

33. The City considers a factor of 2.5% appropriate for computing conveyance losses of SJCP water from Heron reservoir to the Paseo del Norte diversion site. The City's

proposed factor is derived from loss factors for SJCP water used by the United States Bureau of Reclamation. Table D-5 of City Exhibit 23 reflects a loss rate of 2.35% from Heron reservoir to the Jemez River (Table D-5 of City Exhibit 23). The City adds an additional conveyance loss rate of 0.15 % for the remaining distance to the Paseo de Norte diversion site. According to the City's calculations, approximately 47,000 afy of SJCP water would be available for appropriation at the diversion point for the DWP ((48,200 afy – (0.025 x 48,200 afy) = 46,995 afy)).

34. More conservative, monthly conveyance loss rates for SJCP water from Heron reservoir to Albuquerque were provided in Tables D-6a & D-6b of City Exhibit No. 23, as follows:

	Table D-6a	Table D-6b
January-March	0.97 (3.00%)	0.97 (3.00%)
April	0.96 (4.00%)	0.94 (6.00%)
May	0.95 (5.00%)	0.91 (9.00%)
June	0.93 (7.00%)	0.88 (12.00%)
July – September	0.92 (8.00%)	0.85 (15.00%)
October	0.95 (5.00%)	0.91 (9.00%)
November – December	0.97 (3.00%)	0.97 (3.00%)

WRAP's experts utilized conveyance loss rates from Table D-6b of City Exhibit 23, in evaluating the subject Application. In order to ensure a conservative analysis of depletion effects on streamflows under the DWP, the City utilized the loss rates in Table D-6a of its Exhibit 23, in model simulations.

35. Underestimation of conveyance losses could result in the diversion of native water without a corresponding accounting for such diversion. Monthly, incremental conveyance losses for SJCP water between Heron reservoir and the City's point of diversion should be determined based upon a study, approved by and acceptable to the State Engineer. The results of said study should be adopted for determination of conveyance loss rates for SJCP water under the DWP. In the interim, for purposes of determining the amount of SJCP water delivered to the proposed point of diversion for the DWP, the monthly conveyance loss factors from Table D-6a of the

City Exhibit 23, referenced in Finding 36, above, should be utilized. Assuming a constant rate of release of SJCP water of 4,017 acre-feet monthly (48,200 afy ÷ 12), and no diversion of SJCP water under the City's NSWRP, total SJCP water available at the proposed point of diversion for the DWP would be 45,792 acre-feet calculated as follows:

Month	CLF	SJC (monthly release)	Available at diversion
January	0.97	4,017	3,896
February	0.97	4,017	3,896
March	0.97	4,017	3,896
April	0.96	4,017	3,856
May	0.95	4,017	3,816
June	0.93	4,017	3,736
July	0.92	4,017	3,696
August	0.92	4,017	3,696
September	0.92	4,017	3,696
October	0.95	4,017	3,816
November	0.97	4,017	3,896
December	0.97	4,017	3,896
Annual		48,200	45,792

The above calculations should be adjusted downward to the extent that SJCP water is diverted for the City's NSWRP under Permit No. 4819.

36. The City proposes to fully consume the available SJCP water diverted under the DWP by diverting an equivalent amount of 'native' Rio Grande water and returning the full amount of that 'native' water to the Rio Grande at its SWRP discharge point.

37. The reach of the Rio Grande between the proposed DWP diversion point at Paseo del Norte and the SWRP return flow point, referred to at hearing as the 'depleted reach', is approximately 15-miles long. There are no existing surface water right holders with diversion works on the Rio Grande within the length of the 'depleted reach'.

38. The first immediate downstream surface water diversion below the SWRP return flow point is the MRGCD's Isleta Diversion Dam used for delivery of water to lands within Isleta Pueblo and to lands of individual members of MRGCD. The MRGCD and Isleta Pueblo entered into settlement agreements with the City and withdrew their protests to the granting of this Application.

39. Provided that 100% of the amount of 'native' water diverted under the DWP is timely returned to the Rio Grande, there should be no decrease in the amount of 'native' water available to existing water right holders downstream.

40. The City submitted expert testimony and exhibits reflecting that, in time, estimated depletions on the Rio Grande under the DWP conjunctive use AWRMS strategy would be less than the effects that would result from continued reliance on groundwater under RG-960 et al., as its sole source of supply.

41. City Exhibit 23 includes an analysis of the hydrologic effects of a baseline scenario, wherein the surface water depletion effects of groundwater diversions under RG-960 et al., are simulated, with annual ground water diversions increasing up to 162,354 afy in 2040 and 194,875 afy in 2060, and an analysis of the surface water depletion effects under the DWP, wherein surface and groundwater are used conjunctively (89,883 afy ground & 72,000 afy surface water in 2040 and 100,777 afy ground & 94,000 afy surface water in 2060).

42. The City's hydrologic baseline was developed in three steps as follows:
    a. Align the 1971-98 streamflow and reservoir gage records for the Middle Rio Grande (MRG) and Rio Chama Basins so that 1971 becomes 2006, 1972 becomes 2007, etc., and adjust the records by removing historic City SJCP water.
    b. Subtract the effects of historical City groundwater pumping from the adjusted 1971-98 record and account for the effects of SWRP returns on river flows. This is based on running the OSE interim groundwater model to estimate historical pumping-induced river seepage and using the City's record of wastewater return flows.

c. Subtract or add to the flows determined in subpart (b), above, the projected future effects (2006 through 2060) of continued, full-scale, groundwater pumping (using the OSE interim model) and SWRP return flows on river flows. Also included in the baseline are: variable SJCP water releases made for existing City leases (up to 2,600 afy) through termination in about 2011, approximately 3,000 afy in SJCP water releases for the NSWRP (through 2060), and beginning in 2050, releases of SJCP water to offset pumping effects (amounts increase from about 220 afy to 6,100 afy over the 2050 to 2060 time period), and a simulated 3-year drought.

43. The 1971-98 period provides an acceptable basis for examining the effects of the DWP and RG-960 alternatives on streamflow conditions in the MRG.

44. The City used the OSE interim groundwater model of the Albuquerque basin aquifer, coupled with an interactive 'spreadsheet model' of Rio Grande flows (built upon the adjusted 1971-98 hydrologic record). The two models, so coupled, are an acceptable tool for evaluation and comparison of the hydrologic effects of the DWP and RG-960 alternatives in this matter.

45. Computer simulations for the period 2006 (City's anticipated DWP start up date) through 2060 reflect that the DWP and RG-960 groundwater diversion alternatives will have similar effects on overall streamflow conditions in the MRG. In general, the simulations indicate that relative to RG-960 groundwater diversions, the DWP alternative results in more water (about 60 cfs) in the river above the diversion point at Paseo del Norte, somewhat less water (10 to 25 cfs) in the reach between the diversion point and the City's wastewater return flow point, and essentially no change in flows at the MRGCD's Isleta Diversion Dam.

46. The overall quality of water discharged to the Rio Grande at the City's SWRP will improve under the DWP.

47. The evidence presented at hearing reflects that if the full amount of 'native' Rio Grande water diverted under the DWP is returned at the SWRP outfall, the effects on existing downstream surface water rights, under the DWP, would be no greater than the projected effects under RG-960 et al.

48. In order to prevent impairment to downstream users, diversions of ‘native’ water under the DWP could never be greater than 50% of the DWP diversion, and said diversion of ‘native’ water would have to cease at any time the City’s return flows to the Rio Grande at its SWRP outfall are less than 50% of the DWP diversion.

49. The amount of the City’s return flows to the Rio Grande that are considered return flows of ‘native’ surface water under its DWP, would not be available to offset depletion effects or to otherwise increase the City’s diversion of groundwater under RG-960 et al.

50. The expert testimony and model simulations reflect that the DWP will have less effect on the Albuquerque area aquifer and upon existing groundwater rights within the basin than the RG-960 alternative. By 2040, estimated drawdowns from pre-development water levels under simulated RG-960 conditions are greater than 200 feet in areas of west, northeast and southeast Albuquerque. Under the DWP alternative, estimated drawdowns in 2040 are generally less than 150 to 175 feet in the same areas.

51. As compared to the RG-960 alternative, the DWP will have a positive effect on the aquifer.

52. The City has taken significant steps with respect to water conservation, beginning with the establishment of a Water Conservation Task Force in July of 1990. In May of 1992, the City passed Resolution R-49-1992 adopting a Short-Term Water Conservation Program that included appointment of a Water Conservation Officer, and research and development of a Long-Term Water Conservation Strategy to include specific per capita consumption goals and water rate modifications. In March of 1995 the City adopted its Long-Term Water Conservation Strategy through Resolution R-40-1995 and the Landscaping and Water Waste Ordinance O-18-1995.

53. The City adopted the following water use reduction goals in R-40-1995: reduction of overall per capita usage of 250 gallons per capita per day (gpcpd) by 30% to achieve 175 gpcpd by 2004; reduction of summer outdoor usage by 25%; reduction of current year-round indoor usage by 33%; and reduction of peak day usage by

20% within six to ten years. Since that time the City has maintained a multi-faceted program to encourage conservation and has reduced water usage within its service area by more than 20% to 205 gpcpd.

54. Other southwestern cities of comparable size and climate have successfully reduced their water usage to significantly less than 175 gpcpd. City Exhibit 17 contains a table at page 2, which reflects a gpcpd of 155 (combined residential & non-residential) for El Paso, Texas and Tucson, Arizona.

55. The City's Exhibit 17, page 3, reflects that, in 1950, water use in the City averaged 148 gpcpd.

56. Jeanne Witherspoon, the City's former Water Conservation Officer and its expert in water conservation, testified that the City has achieved significant reductions in water usage in a relatively short period of time and that with continuing and sustained effort, the City can achieve a gpcpd of 150.

57. By utilizing practically available technology and resources, the City can significantly reduce its per capita water usage. Prior to diverting any ‘native’ water under its DWP, the City should be required to reduce its combined residential and non-residential water usage level to 175 gpcpd. The City should be able to achieve a water usage level of 155 gpcpd or less within a reasonable period of time and continued diversion of ‘native’ water under the DWP should be contingent upon the City’s filing of regular conservation progress reports demonstrating that it is diligently pursuing reductions in water usage levels to the maximum extent practical and showing continuing reductions consistent with achieving a water usage level of 155 gpcpd within twenty (20) years.

58. The City's water conservation program should be modified and updated to include a drought management plan acceptable to the OSE.

59. The Coalition Protestants presented several witnesses who testified about the intrinsic cultural and environmental value of maintaining flows in the Rio Grande throughout the ‘depleted reach’ and related concerns as to the effect that diminution of those flows might have on the riparian ecology and aquatic habitat.

60. A Draft Environmental Impact Statement (Draft EIS), City of Albuquerque DWP, June 2002, was admitted into evidence as Coalition Protestants' Exhibit 9. The Draft EIS reflects that 189 miles of river channel of the Rio Grande is likely to experience average annual flow increases of 65 cfs under the DWP with a 15-mile stretch experiencing depleted flows. Table 3.16-1 of the Draft EIS (Coalition Protestants Exhibit 9) compares the projected effects that the DWP and no action (RG-960) alternatives would have over time to historical flows measured in the Albuquerque reach of the Rio Grande. The projections are based upon an average annual gpcpd of 175. The projected incremental differences in streamflows in cfs at the Albuquerque Central Avenue gage (hereinafter 'Albuquerque gage'), and additional depletions under the DWP as opposed to the no action alternative, are as follows:

Year	No Action	DWP	Additional Depletions
2006	-47	-68	21
2012	-56	-77	21
2020	-61	-94	33
2030	-68	-99	31
2040	-78	-89	11
2050	-85	-109	24
2060	-90	-119	29

The average of the above projected additional depletions on Rio Grande streamflows under the DWP, measured at the Albuquerque gage, is 24.29 cfs (21 + 21 + 33 + 31 + 11 + 24 + 29 = 170 ÷ 7 = 24.29 cfs).

61. The DWP should be operated in a manner that minimizes additional depletions through the 15-mile 'depleted reach' of the Rio Grande, as much as practicable.

62. Table C-3, Appendix C of City Exhibit 23, sets forth historical data on monthly Rio Grande flows measured at the Albuquerque gage. The data reflect that the median of annual average flows for 1943 through 1998 is 1,116 cfs. The median of annual average flows for 1943 – 1970 (pre SJCP) is 936 cfs. The lowest reported median of monthly average flows is 122 cfs and the minimum annual average flow

measured was 293 cfs recorded in 1964.

63. To the extent that ‘native’ flows are available above the proposed point of diversion, the DWP should be operated so that flows in the channel of the Rio Grande between the point of diversion and the Albuquerque gage are no less than the lowest reported median of monthly average flows: 122 cfs. Allowing 130 cfs of flow to pass through the diversion works should be adequate to maintain said flow level.

64. The ‘threshold flow’ level and curtailment strategy, set forth in the general operating plan for the City’s DWP and described in Findings 16 and 17, should be adjusted upward to reflect the difference between the 70 cfs of ‘native’ flow the City originally proposed to pass through the diversion works and the 130 cfs referenced in Finding 63, above. Accordingly, diversion of ‘native’ water would be curtailed when ‘native’ flows fall below 195 cfs (130 cfs that remains in the channel immediately below the point of diversion + 65 cfs DWP diversion), measured immediately above the storage pool at the proposed point of diversion, by 1 cfs for each 1 cfs drop in ‘native’ flow, and would be suspended when ‘native’ flow drops to 130 cfs or lower at the same point.

65. Other regulatory agencies, including the United States Fish and Wildlife Service and the Bureau of Reclamation, have regulatory oversight under the National Environmental Policy Act to ensure that the City’s operation of the DWP complies with environmental requirements.

66. The City's plan for conjunctive use of water resources constitutes a reasonable use and development of water resources, especially as compared to reliance on groundwater as its sole source of supply, that will extend the life of the aquifer, and allow for flexibility of operations during times of low flow or drought.

67. Evidence was also presented at hearing concerning the public benefit that would be realized from the DWP.

68. The United States Environmental Protection Agency (EPA) has promulgated a new maximum contaminant level for arsenic in drinking water of 10 *u*g/L. The City's proposed Surface Water Treatment Plant under its DWP will enable it to meet the arsenic standard in a cost-effective fashion by applicable compliance dates. In

addition to the public health benefits associated with meeting the EPA drinking water standard, cost savings to the City were estimated at approximately $160,000,000 ($200 million for groundwater treatment versus $40 million for surface water treatment).

69. The use of surface water will result in a lower concentration of Total Dissolved Solids (TDS) in the water supply as compared to use of groundwater under RG-960 et al., and in the water discharged to the Rio Grande at the City's SWRP.

70. The overall quality of the water supplied to the public within the City's water service area will improve under the DWP as will the water discharged to the Rio Grande at the City's SWRP.

71. The City's continued reliance on groundwater as its sole source of water supply could result in significant land surface subsidence over large areas of the Albuquerque Basin. The City's transition to conjunctive use of water resources under the DWP will reduce the risk of land surface subsidence.

72. F. Lee Brown, Ph.D., Economic Consultant, estimates that direct economic benefits to the City resulting from the DWP will be approximately $1,371,000,000.00 as follows: $127,000,000.00 reduced well costs + $221,000,000.00 reduced subsidence costs + $260,000,000.00 reduced arsenic and desalinization costs + $763,000,000.00 creation of a drought reserve.

73. The City has demonstrated that it needs a transition from reliance on groundwater under Permit RG-960 et al., as its source of municipal water supply, to conjunctive use of surface and ground water as a matter of public health and welfare.

74. The evidence presented at hearing establishes that granting Application No. 4830 will facilitate the City’s transition to conjunctive utilization of its SJCP water under the DWP and groundwater under RG-960 et al., and that if properly conditioned, there will be no increase in depletions to the Rio Grande, no impairment to existing water rights, no detriment to the public welfare of the state and conservation of water will be enhanced.

75. The hearing adjourned on February 27, 2003. The record was held open through April 25, 2003 for the limited purpose of allowing the parties opportunity to file proposed findings, conclusions and recommended conditions. On April 25, 2003, the Coalition Protestants filed proposed findings and also filed a Motion to Recuse the State Engineer. Said motion should be and is denied.

76. Application No. 4830 should be approved, subject to conditions.

ORDER

THEREFORE, Application No. 4830 for Permit to divert surface water from the Rio Grande is approved, subject to conditions, as follows:

Permittee: City of Albuquerque

OSE File No.: 4830

Date of Application: Application filed May 18, 2001 and June 26, 2001

Point of Diversion: New surface water diversion facility located on the Rio Grande within a 500-foot radii of a point where X=382,500 feet and Y=1,525,800 feet, New Mexico Coordinate System (NMCS), Central Zone, North American Datum (NAD) 27 and approximately 2,500.0 feet north (upstream) of the Paseo del Norte Bridge

Source of Water: Colorado River water apportioned to New Mexico for beneficial consumptive use by the Colorado Compact, 45 Stat. 1057, 1064 (1928) and the Upper Colorado River Basin Compact 63 Stat. 31 (1949) and allocated to the City of Albuquerque by Contract No. 14-06-500-810 between the United States Department of the Interior, Bureau of Reclamation and the City of Albuquerque, dated May 25, 1963, and Amendment No. 1, dated July 6, 1965, for San Juan-Chama Project Water.

Surface waters of the Rio Grande

Amount of Water:

Diversion – Up to 48,200 afy of San Juan Chama Project water, less conveyance losses as determined in accordance with Conditions of Approval, below, measured at the point of diversion. ‘Native’ Rio Grande surface water may be simultaneously diverted, in accordance with the conditions of approval below and in an amount not to exceed the amount of San Juan-Chama Project water diverted at any time, provided such water is timely returned directly to the Rio Grande, in full, at the SWRP outflow.

Consumptive Use – Up to 48,200 afy of San Juan-Chama Project Water less conveyance losses as determined in accordance with Conditions of Approval, below. Diversion of ‘native’ Rio Grande surface waters is for non-consumptive use only and 100% of the amount diverted shall be simultaneously returned to the Rio Grande.

Purpose of Use:	Municipal, industrial and related purposes for the City of Albuquerque Drinking Water Project
Place of Use:	Service area of the City of Albuquerque water system

CONDITIONS OF APPROVAL

1. Permit No. 4830 shall not be exercised to the detriment of valid existing water rights or in a manner that is contrary to the conservation of water within the state or detrimental to the pubic welfare of the State of New Mexico.
2. The total annual combined diversion of surface water under this permit and Permit No. 4819 shall not exceed 96,400 afy, less conveyance losses as determined in accordance with Conditions of Approval 6 and 7 below.
3. Prior to initial diversion of surface water from the Rio Grande for start-up of the DWP, the City shall demonstrate to the satisfaction of the State Engineer that it has 130,000 acre-feet of San Juan-Chama Project water in storage at Abiquiu reservoir available and reserved for offsetting residual and ongoing effects to the Rio Grande as a result of its groundwater diversions under RG-960 et al.
4. The City shall submit to the State Engineer, by the first day of each of the quarterly periods January through March, April through June, July through September, and October through December, or such other time period as may be determined acceptable by the State Engineer, information concerning the upcoming period sufficient to determine that the amount of San Juan-Chama Project water the City has in storage is adequate to meet offset requirements and anticipated DWP diversions, including the following: (a) projected average daily total surface water diversions and projected total ground water diversions from the City's wells; (b) projected return flows from surface water diversions and from ground water diversions from the City's wells; (c) projected deliveries of the City's San Juan-Chama Project water; (d) the amount of the City's acquired Rio Grande surface water rights;(e) the amount of the City's vested and acquired groundwater rights and the amount of the City's dedicated surface water rights; (f) projected amount of

MRGCD or BOR water in storage available for repayment to the City; and, (g) the amount of San Juan-Chama Project water the City has in storage and available to meet its projected obligations, including offsets for residual and ongoing effects under RG-960 et al., and its projected diversion under the DWP.

5. If the information provided pursuant to Conditions of Approval 3 & 4 does not adequately establish that sufficient San Juan-Chama Project water is available in storage, the State Engineer may take such action as he deems necessary, including but not limited to, ordering that the City suspend its diversion of surface water under the DWP.
6. The City shall propose a study of incremental loss rates for delivery of San Juan-Chama Project water to the point of diversion, to be undertaken by the City within two (2) years from the date of approval of this permit, and to be conducted in a manner acceptable to and approved by the State Engineer based on existing and anticipated Rio Grande channel conditions for each month of the year and for all levels of native streamflow.
7. The amount of San Juan –Chama Project water diverted under this Permit shall be determined monthly based upon the amount of water released from upstream storage less conveyance loss rates as determined by the study required by Condition of Approval 6 and accepted by the State Engineer. Until said study is completed and the results accepted by the State Engineer, the monthly conveyance loss rates shall be as follows: January thru March 3.00%; April 4.00%; May 5.00%; June 7.00%; July thru September 8.00%; October 5.00%; and, November thru December 3.00%.
8. The City's total mean daily surface water diversion rate shall not exceed 130 cfs. The amount of native Rio Grande surface water diverted under this Permit shall not exceed 50% of the total amount of water diverted at any time.
9. An amount of water equivalent to the amount of native surface water diverted under this permit shall be simultaneously returned directly to the Rio Grande at the City's SWRP wastewater outfall as verified by accounting methodology acceptable to the State Engineer. The amount of water considered to be return flows of 'native'

surface water under this Permit shall not be available for offset purposes, or to increase diversions of ground water, under the City's other permits.

10. Prior to any diversion of 'native' Rio Grande surface water under this permit, the City shall reduce its average per capita water usage to 175 gpcpd, computed in accordance with standards and methodology described by and acceptable to the State Engineer's Water Conservation Bureau. Continued diversion of 'native' Rio Grande surface water under this permit shall be contingent upon the City's demonstrating to the satisfaction of the State Engineer that it is utilizing the highest and best technology available to ensure conservation of water to the maximum extent practicable to reduce average annual per capita water usage to 155 gpcpd, computed in accordance with standards and methodology described by and acceptable to the State Engineer's Water Conservation Bureau, as soon as practicable and no later than twenty (20) years after initial diversion of 'native' Rio Grande surface water. By March 1st of each year, the City shall submit to the State Engineer a report of its average per capita water usage for the prior calendar year, computed in accordance with standards and methodology described by and acceptable to the State Engineer's Water Conservation Bureau.

11. The City shall submit progress reports on its 40-Year Plan and Water Conservation Plan on or before January 10, 2007, and every 5 years thereafter, showing that the City is diligently pursuing and achieving reduction of its average per capita water usage in accordance with Condition of Approval 10, above.

12. The City shall regulate its surface water diversion rate under this permit and Permit No. 4819 to maintain, in so far as 'native' flow is available at and above the point of diversion, streamflows of not less than 122 cfs in the channel of the Rio Grande between the point of diversion and the Albuquerque Central Avenue gage.

13. Diversion of 'native' water from the Rio Grande under this permit shall be curtailed when 'native' flow in the channel of the Rio Grande is less than 195 cfs, measured immediately above the storage pool at the point of diversion, by 1 cfs for each 1 cfs drop in 'native' flow below 195 cfs. Diversion of 'native' water from the Rio Grande under this permit shall be suspended when any of the following situations exist: the

amount of return flow to the Rio Grande at the City's SWRP outfall is less than the amount of 'native' water diverted; 'native' flow in the channel of the Rio Grande is equal to or less than 130 cfs, measured immediately above the storage pool at the point of diversion or immediately below the point of diversion; streamflows in the channel of the Rio Grande fall below 122 cfs, measured at the Albuquerque Central Avenue gage; or the State Engineer determines that suspension is necessary to meet compact obligations or to protect existing water rights.

14. Prior to diversion of any surface water from the Rio Grande under this permit, the City shall install, in a manner acceptable to the State Engineer, stream gages of a type approved by the State Engineer, at locations acceptable to the State Engineer sufficient to adequately measure and monitor streamflows above the point of diversion and throughout the reach of the Rio Grande from the point of diversion to the Southside Water Reclamation Plant wastewater outfall. The total diversion of surface water under this permit and flows returned directly to the Rio Grande shall be measured with totalizing meters of a type and at a locations approved by and installed in a manner acceptable to the State Engineer. All meters and gages shall have continuous data recorders. The data, on a real-time basis at intervals acceptable to the State Engineer, shall be made available to the public and the State Engineer. The City shall provide in writing, the make, model, serial number, date of installation, initial reading, units, and dates of recalibration of each meter and gage, and any replacement meter or gage used to measure stream flows, diversion of water and return flows to the Rio Grande. At a minimum, all meters and gages shall be calibrated in accordance to industry standards annually and the results shall be submitted to the Office of the State Engineer.

15. The City shall submit final plans for construction of the DWP diversion works and impoundment structures to the State Engineer for approval, prior to construction. Prior to any diversion of surface waters from the Rio Grande under this permit, the City must arrange for the State Engineer's inspection and approval of the diversion works, impoundment structures and the meters and gages required pursuant to Condition of Approval 14.

16. On or before the 10th day of January, April, July and October, or such other times as may be determined acceptable by the State Engineer, the City shall submit to the Office of the State Engineer, a comprehensive report, both in writing and electronically, which includes the following data concerning the preceding three-month period, or such other time period as may be determined acceptable by the State Engineer: the total amount of San Juan-Chama Project water released from Heron and/or Abiquiu reservoir(s) for its DWP and for offset of depletions on the Rio Grande caused by the exercise of permit RG-960 et al.; the total amount of water diverted from all sources; the measured streamflows throughout the reach of the Rio Grande from above the point of diversion to the Southside Water Reclamation Plant wastewater outfall; and the total flow returned directly to the Rio Grande.
17. Proof of Completion of Works shall be filed within four (4) years from the date of this order.
18. The State Engineer shall retain jurisdiction over this permit for the purpose of ensuring that exercise of the permit does not violate the forgoing Conditions of Approval, is not detrimental to existing water rights, is not contrary to the conservation of water within the State and is not detrimental to the public welfare of the State of New Mexico.

Respectfully submitted July 8, 2004.

____________________________	____________________________
Victor Kovach	Louis D. O’Dell
Hearing Examiner	Technical Advisor

I ACCEPT AND ADOPT THE REPORT AND RECOMMENDATION OF THE HEARING EXAMINER THIS _______ DAY OF ______________ 2004.

____

JOHN R. D'ANTONIO, JR., P.E.
NEW MEXICO STATE ENGINEER

Appendix 3.B

Discussion of Climate Change Data

Appendix 3.B

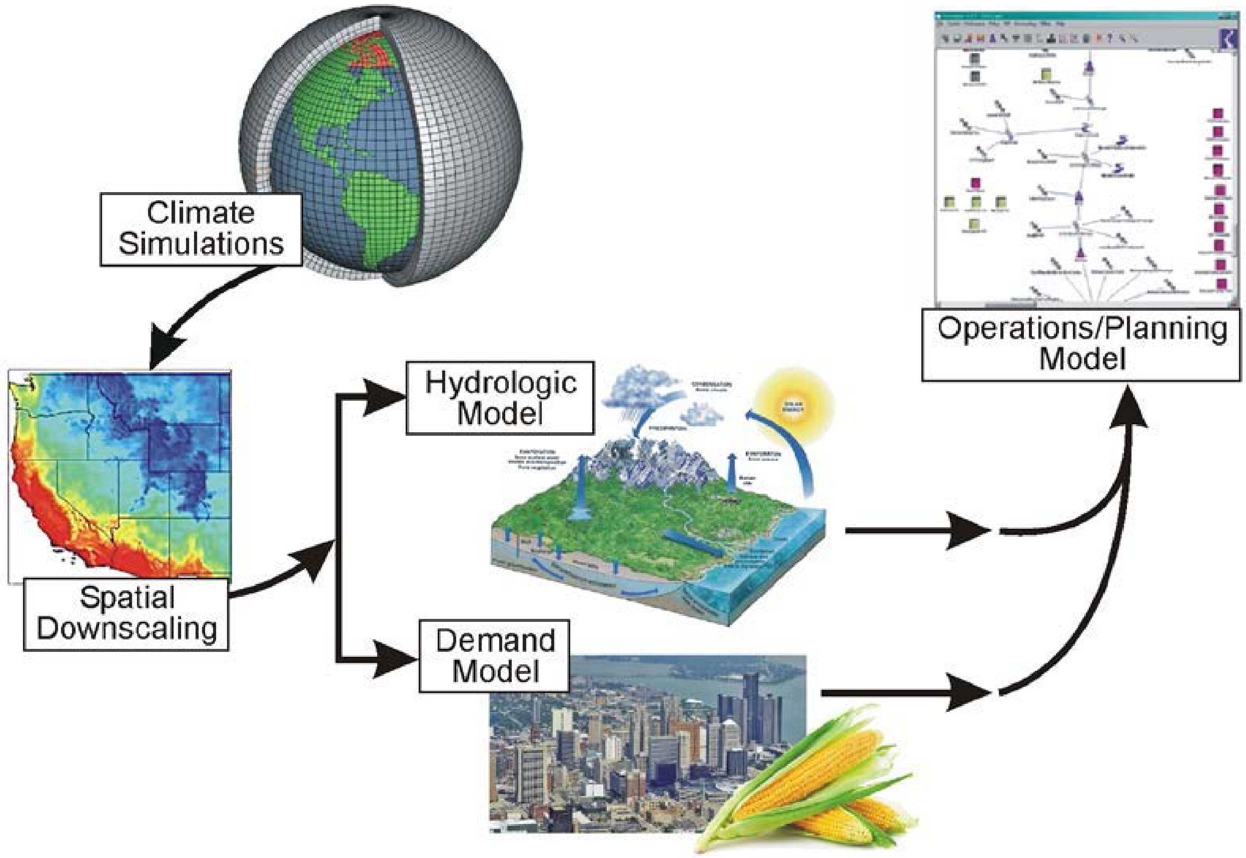
Climate Change

Projections of streamflow with the effects of climate change for the Western United States were developed by Reclamation as part of the West Wide Climate Assessment (Reclamation 2011a). These projections were derived from work completed by the World Climate Research Program's Coupled Model Intercomparison Project Phase 3 (CMIP3) (Maurer et al., 2007). The CMIP3 data were produced using general circulation models (GCM) that project global changes in atmospheric temperature and precipitation based on changes in greenhouse gas emissions. These global projections were used to develop the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (IPCC, 2007). For regional planning purposes, the global projections were downscaled by Reclamation using the Bias Correction and Spatial Disaggregation approach.

The approach was used with three different carbon emissions scenarios (B1 [low], A1B [middle], and A2 [high]) to produce 112 different equally-likely climate traces. The general approach to develop the Downscaled GCM Projected sequences is shown graphically in Figure 3.B1. The downscaled climate information is then fed into the Variable Infiltration Capacity (VIC) model. The VIC hydrology model used the climate projections along with land cover, soils, elevation, and other watershed information to simulate hydrologic fluxes. The result of this approach was 112 unique sequences of natural flow under a range of future climate projections.

The same Downscaled GCM Projected scenario was also employed to develop the results described in the *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011, Report to Congress* (Reclamation, 2011b), the Colorado River Basin Study (Reclamation, 2012), the Upper Rio Grande Impact Assessment (Reclamation, 2013), and other studies.

Figure 3.B1. General Method for Development of Climate Change Hydrologies



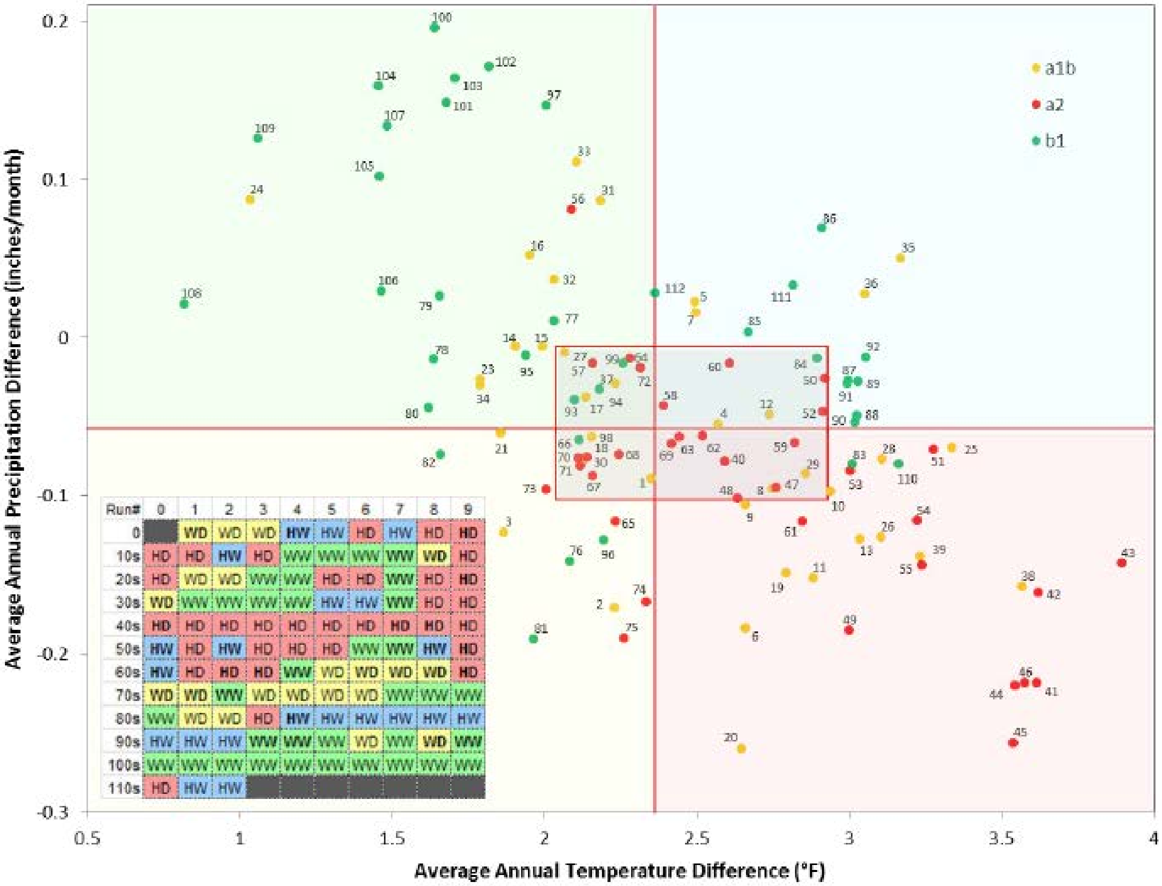
Source: Modified from the CRBS

West-Wide Climate Team Modifications for Local Use

For the purpose of water planning in the Middle Rio Grande, Reclamation organized the 112 climate traces into five "ensembles" by percentile of temperature and precipitation using a hybrid delta ensemble method (HDe).

The "central tendency" group include all traces which fall within the 25th and 75th percentile for both precipitation and temperature change. The remaining four groups are based on the 50th percentiles of precipitation and temperature change and are referred to as Hot-Dry, Hot-Wet, Warm-Dry, and Warm-Wet (Figure 3.B2). The HDe method uses the average of temperature and precipitation change across all traces within each ensemble for three projection points in time: 2020s, 2050s, and 2080s.

Figure 3.B2. Grouping of the 112 Climate Traces into Five Ensembles



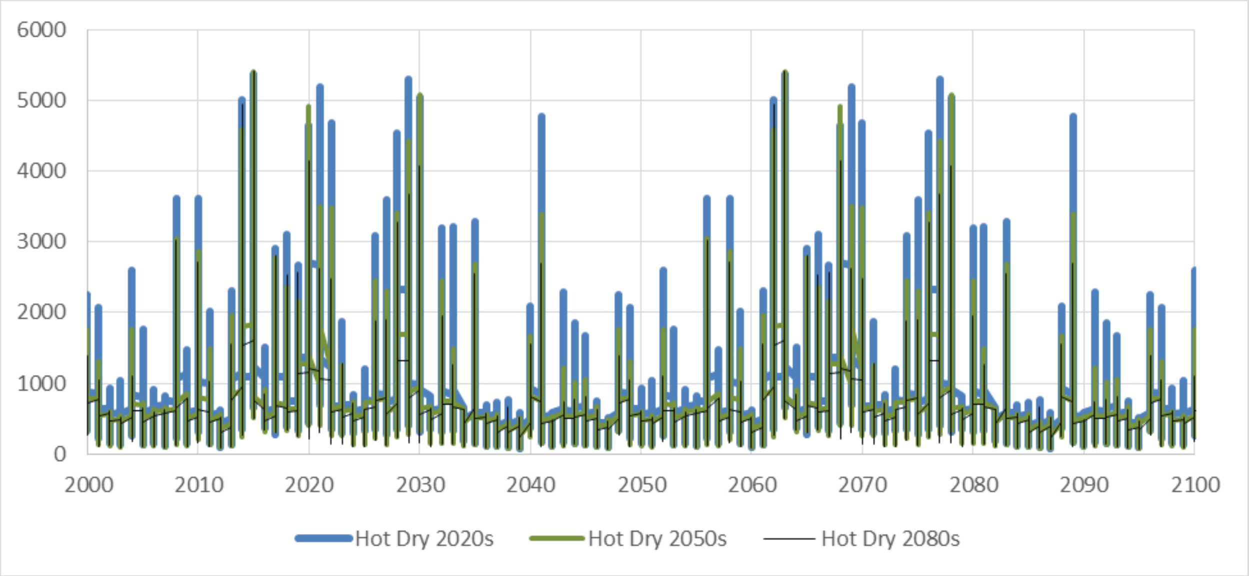
Run#	0	1	2	3	4	5	6	7	8	9
0		WD	WD	WD	HW	HW	HD	HW	HD	HD
10s	HD	HD	HW	HD	WW	WW	WW	WW	WD	HD
20s	HD	WD	WD	WW	WW	HD	HD	WW	HD	HD
30s	WD	WW	WW	WW	WW	HW	HW	WW	HD	HD
40s	HD	HD	HD	HD	HD	HD	HD	HD	HD	HD
50s	HW	HD	HW	HD	HD	HD	WW	WW	HW	HD
60s	HW	HD	HD	HD	WW	WD	WD	WD	WD	HD
70s	WD	WD	WW	WD	WD	WD	WD	WW	WW	WW
80s	WW	WD	WD	HD	HW	HW	HW	HW	HW	HW
90s	HW	HW	HW	WW	WW	WW	WD	WW	WD	WW
100s	WW	WW	WW	WW	WW	WW	WW	WW	WW	WW
110s	HD	HW	HW							

Source: Santa Fe Basin Study HDe Data Memo

So, for example, for the 2080s period the temperature and precipitation data from the above process were taken from the 2070-2099 period and compared to the simulated historical period (1950-1990). The difference in precipitation and temperature for the two periods was taken to create the five ensembles. The average difference for each ensemble was then used as a “delta” to modify the historical precipitation and temperature for each ensemble for the 2080 period. The same method was employed for each of the projection periods and the resulting climate data were run through the VIC model to arrive at runoff and then through the Upper Rio Grande Simulation Model (URGSIM) to arrive at flow sequences.

The resulting monthly HDe hydrologic sequences were developed for the Water Authority by the West Wide Climate Risk Assessment Team, part of the Basin Study Program under the SECURE water act. These sequences have also been provided to the Middle Rio Grande Council of Governments and utilized as part of the Santa Fe Basin Study. Figure 3.B3 shows the resulting hydrologic sequences for the Hot-Dry ensemble. The sequences are plotted so that you can easily see that streamflow clearly reduces from 2020s (blue) to 2050s (green) to 2080s (black).

Figure 3.B3. Example Streamflow Sequence, Hot-Dry



Modifications Made as Part of this Study

Each hydrologic sequence developed using the HDe method reflects streamflow as if the climate were stable for each time-period. Thus, for a 2080s Hot-Dry ensemble, the resulting hydrologic sequence reflects a time series of streamflow for only the 2080s change over the entire sequence. Therefore, time series flows in 2000 or 2020 or 2090 all reflect a 2080s climate.

As such, when planning using these data, any time prior to the 2080s will over-represent the impact of climate. Likewise, for a 2020s sequence, any time after the 2020s will under-represent the impact of climate. To alleviate this ambiguity, the sequences were modified to interpolate the streamflow over time. For example, the “Hot-Dry” sequence was interpolated over time between the 2020s, 2050s, and 2080s to result in a single sequence that gradually changes over time.

Figure 3.B4 shows the factors used to interpolate the sequences. Figure 3.B5 shows an example of the resulting Hot-Dry streamflow used in this study. Note that the red line associated with the interpolated sequence tracks with the blue 2020s line through about 2030, the green 2050s line through about 2060, and the black 2080s line through the rest of the sequence. The same methods were used for each of the ensembles.

Figure 3.B4. Factors Applied to 2020s, 2050s, and 2080s Projections to Arrive at a Single Sequence

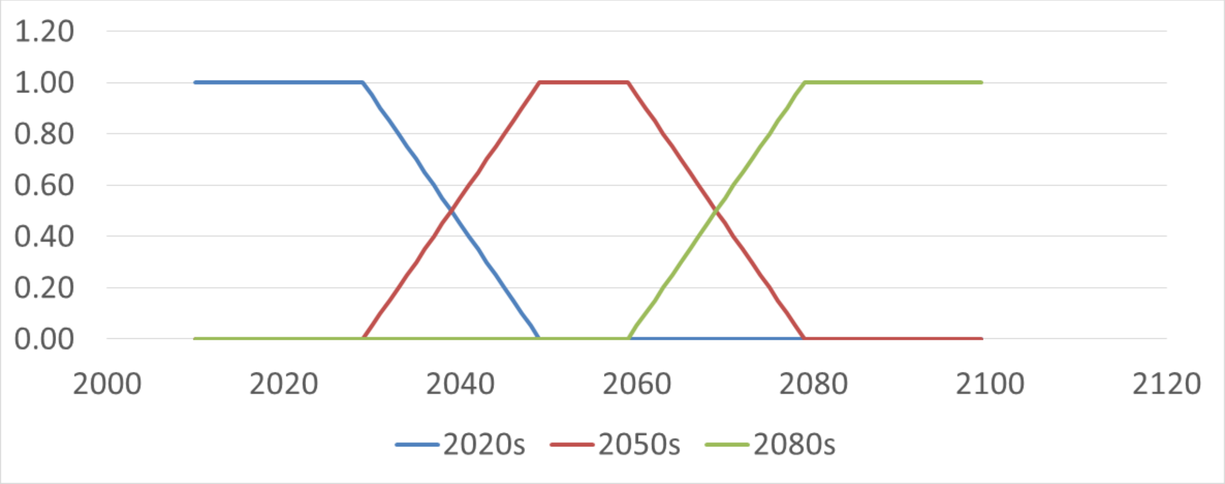
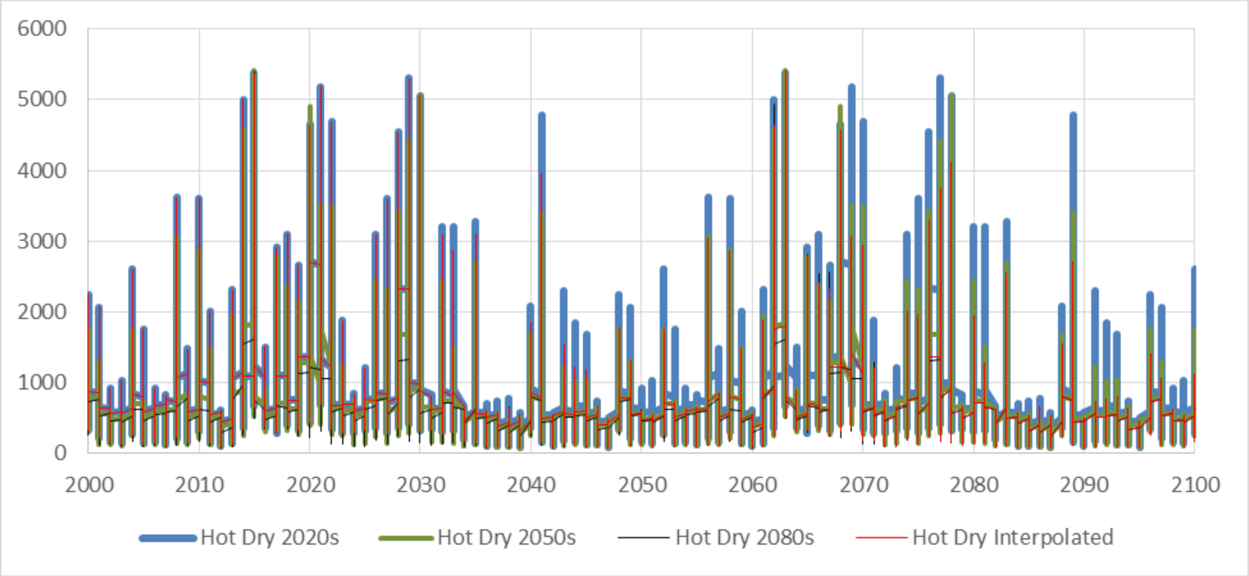


Figure 3.B5. Resulting Hot-Dry Sequence



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Appendix 3.C

Update of the Historical Rio Grande Flow Sequence

Appendix 3.C

Update of the Historical Rio Grande Flow Sequence

Historical Rio Grande Flow (High Supply)

As part of previous planning efforts, the 1971-1998 hydrologic record was analyzed and subsequently chosen as representative of the longer hydrologic record (CH2M, 2003). This record was chosen because it is representative of the long-term (>100-year) record and the current operational regime for reservoirs, river facilities, and SJC water importation. Use began in 1971.

The 1971-1998 streamflow record was adjusted and aligned so that 1971 became 2006, 1972 became 2007, etc., to simulate future hydrologic conditions. Adjustments to the historic record included:

- Removal of the historical (1971-1998) City SJC water that was in the river at Central Avenue gage based on a detailed evaluation of Federal, State, and City records.
- Addition of a simulated 3-year drought to the record based on three 1972s placed 'back-to-back' in the baseline so as to depict an extended drought similar to that experienced in the 1950s. Such a drought is otherwise missing from the 1971-98 period.

A similar process was undertaken to update the streamflow sequence through 2014. Analysis of historical SJC records was undertaken to estimate SJC water at the Central Avenue gage. Water Authority SJC water was removed from the historical record to ensure that SJC water was not "double counted." In this way, historical releases of SJC water for reasons such as supporting the Rio Grande Silvery Minnow would not be reflected in the gaged flow that determines future operating conditions. This process was completed by examining official Reclamation reported "SJC" water at Otowi gage along with Water Authority releases from upstream reservoirs and considering NMOSE permitted loss rates.

Pumping-induced effects on the Rio Grande also affect measured flow at the Central Avenue gage. These effects could be added back into the gage readings to reflect something closer to a "natural" flow. However, unlike SJC releases, these impacts are ongoing and reflect pumping over a number years rather than a discrete event (i.e. a dedicated release). It is anticipated that while the magnitude of the effect will fluctuate, future flows at Central Avenue gage will continue to be affected by groundwater pumping. For future diversion planning purposes, it is assumed that adding the groundwater pumping effects back into the gaged record will over-represent the water available and therefore was not completed as part of this update.

Because the update includes a historic drought period, the simulated 3-year drought used in the previous streamflow sequence was removed.

DWP diversions began in December 2008. As per the NMOSE permit, these diversions remove both the released SJC water and a like amount of native water that is returned at the Southside Wastewater Reclamation Plant. Because this diversion occurs upstream of the Central Avenue gage and return flow occurs downstream of the Central Avenue gage, flows are reduced at the gage by the amount of "borrowed" native water. Diversions since 2008 were added back into the gage reading to reflect the flow at Central Avenue gage without DWP diversion.

Figure 3.C1 shows the raw Central gage data overlain with the adjusted 1971-98 data (including the artificial drought) and the updated adjusted 1971-2014 data. Where there are small amounts of SJC water at the gage there is little if any discernable difference in the lines. However, when significant portions of the total flow are from SJC water, the lines clearly deviate from one another. Note that the artificial drought is clearly shown in the 1989-1991 timeframe. This artificial drought was 1972 repeated over three consecutive years. Also note that this artificial drought is not included in the newly updated 1971-2014 update. The adjusted 1971-2014 line, shown in blue, clearly deviates from the raw data in 2000, 2002, and 2004 when significant quantities of the Water Authority's SJC water were provided for the Rio Grande Silvery Minnow.

Figure 3.C2 shows the individual monthly adjustments that were applied to the raw USGS data for the Central gage. The blue columns represent Water Authority SJC water that was subtracted from the gaged flow. The orange columns represent the total diversion that was added to the gaged flow.

Table 3.C1 presents summary statistics for the original adjusted 1971-1998 period (with artificial drought and resulting model sequence (2006-2060) compared to the updated adjusted 1971-1998 and 1971-2014 sequences as well as the resulting 2006-2120 sequence. Note that the artificial drought resulted in a dryer overall 1971-98 period than the historical period suggested. Whereas, the updated sequence results in a significantly dryer overall model sequence (2006-2120).

Table 3.C1. Historical and Updated Annual Rio Grande Flows (cfs)

	Original WRMS		**Updated**	
	Average	**Median**	**Average**	**Median**
1971-1998	1,326	810	1,390	847
1971-2014	N/A	N/A	1,187	740
2006-2060	1,362	816	1,167	725
2006-2120	N/A	N/A	1,237	763

Figure 3.C1. Raw and Adjusted Monthly Flow at Albuquerque

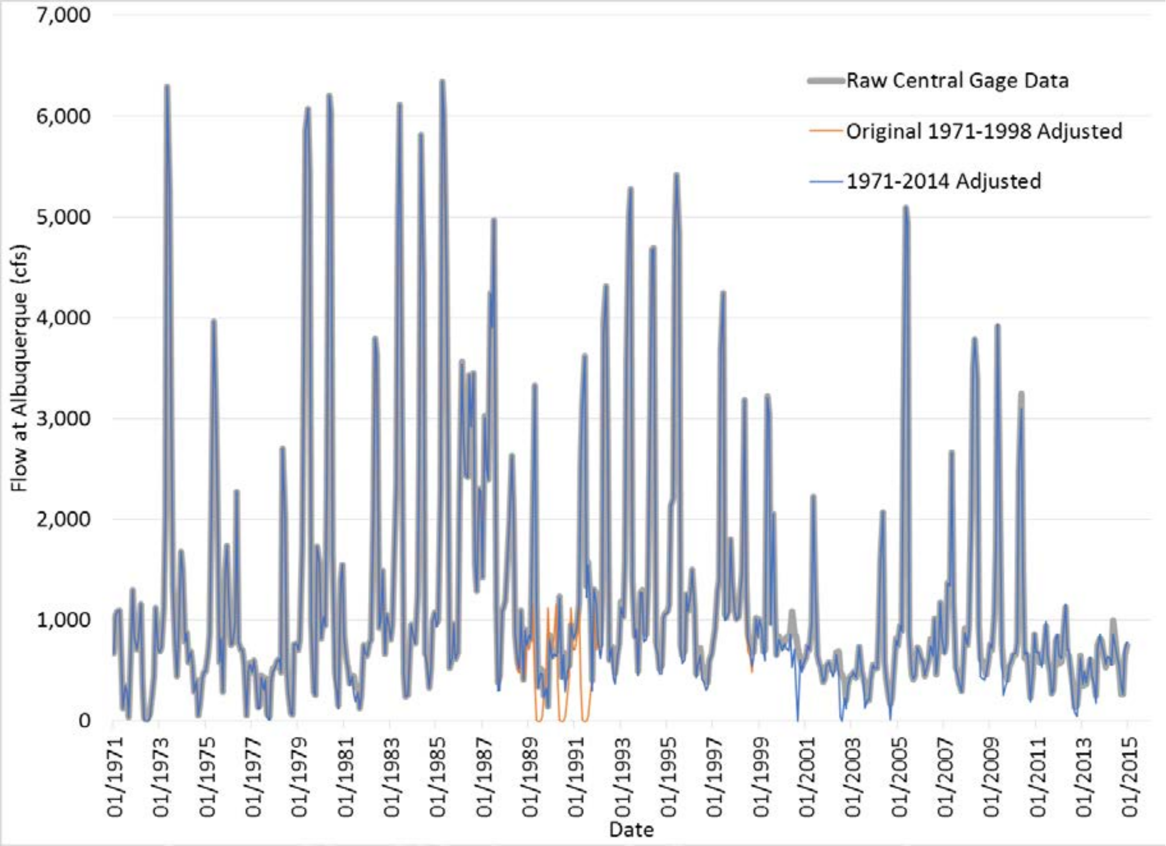
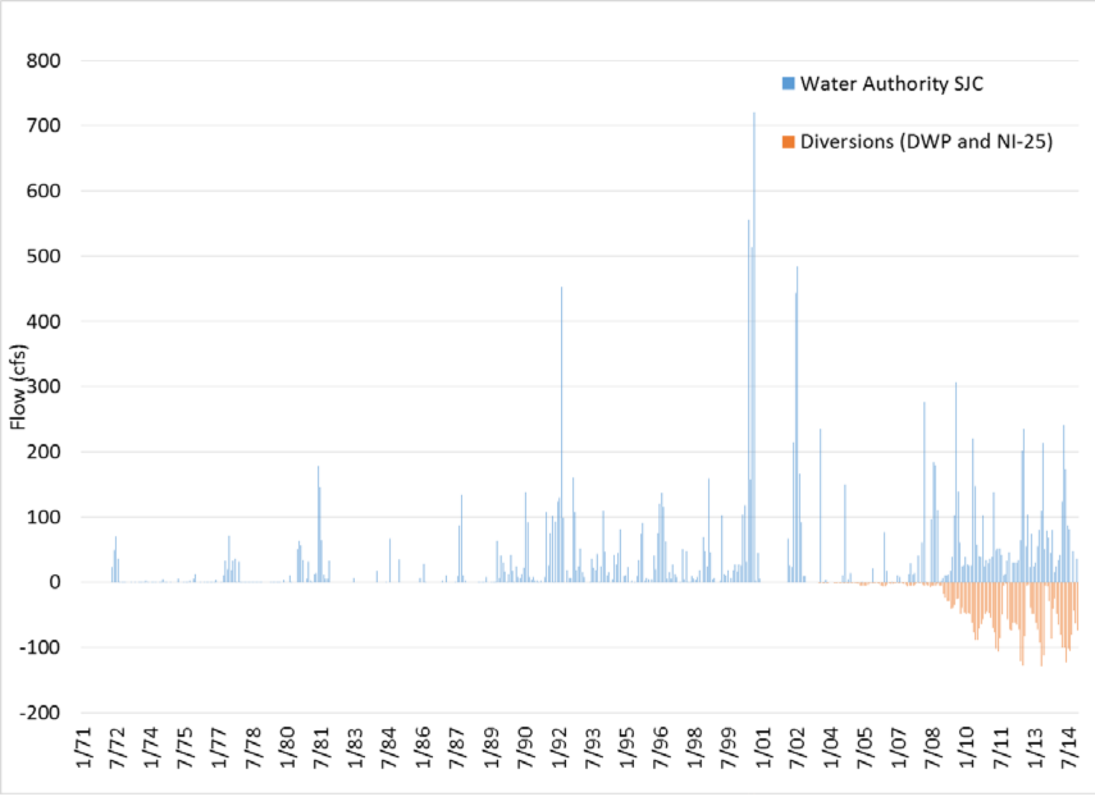


Figure 3.C2. Central Gage Adjustments



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Appendix 3.D

Historical Variability and Drought Compared to Recent Projections

Appendix 3.D

Historical Variability and Drought Compared to Recent Projections

Introduction

Water-supply hydrologies were developed as part of the **Water 2120** update. These hydrologies reflect potential future water availability from the SJC Project and flow of the Rio Grande. The hydrologies are coupled with different demand projections and will ultimately be used to asses supply gaps. These hydrologies consist of observed Rio Grande flows at the Central Avenue gage in Albuquerque and climate-change impacted flows developed for the Water Authority by the West Wide Climate Risk Assessment Team, part of the Basin Study Program under the SECURE Water Act of 2009. This appendix examines recent work on potential drought conditions under climate change, compares the WRMS water-supply hydrologies to historical hydrology reconstructed from tree-ring data, and examines historical and recent climate change datasets.

Development of WRMS Water Supply Hydrologies with Climate Change

The climate-change impacted flows were based on 112 bias-corrected and statistically downscaled projections of temperature and precipitation from 16 GCM run for three different emission scenarios and a variety of boundary conditions, as part of the Phase 3 of the CMIP3. For the purpose of regional-planning, the West Wide Climate Risk Assessment Team used a HDe method (Brekke, 2010; Reclamation, 2015) to create five hydrologic projections that captured both the temperature and precipitation trends of the GCMs as well as historical variability of the Rio Grande. The five projections were completed by first grouping the 112 temperature and precipitation sequences based on percentiles of change in average (over a representative area for the Upper Rio Grande Basin) temperature and precipitation for 3 different periods: 2030s, 2050s, and 2080s. The percentiles of change in average temperature and precipitation were classified into five categories:

- 'Warm-Dry' (WD) – below the 50th percentile for temperature increase and below the 50th percentile for precipitation.
- 'Warm-Wet' (WW) - below the 50th percentile for temperature increase and above the 50th percentile for precipitation.
- 'Hot-Dry' (HD) – above the 50th percentile for temperature increase and below the 50th percentile for precipitation.
- 'Hot-Wet' (HW) - above the 50th percentile of temperature increase and above the 50th percentile of precipitation.
- 'Central' (C) – between the 25th and 75th percentile for both temperature increase and precipitation.

The distribution of changes in monthly precipitation and temperature in each of the above five categories were used to alter historical temperature and precipitation data for 1951-1998. The modified temperature and precipitation time-series were then used as input to a VIC (Variable Infiltration Capacity) model (a macro-scale hydrologic model) to derive hydrologic sequences. The hydrologic and climate sequences were, in turn, input into URGSiM - a monthly mass balance model - to simulate movement of surface and ground water through the Upper Rio Grande Basin under current management practices and demands.

The HDe data assembled (as described above) by the West Wide Climate Risk Assessment Team consisted of Azotea flows (as part of the Drinking Water Project); storage, outflows, evaporation rate, and precipitation rate at Heron Reservoir; storage, outflows, evaporation rate, and precipitation rate at Abiquiu Reservoir; flows at the Central Avenue gage; storage, outflows, evaporation rate, and precipitation rate at Elephant Butte; and reference ET (evapotranspiration) for the Albuquerque region.

Of the five climate change categories, three were chosen for this analysis to represent the range of climate change impacts – Warm-Wet (WW), Central (C), Hot-Dry (HD) – for the three periods (2030s, 2050s, and 2080s). The underlying assumption for the HDe analysis is that the GCMs are consistent and reliable indicators of average changes in temperature and precipitation, while being less consistent and reliable in the prediction of inter-annual variability. To account for inter-annual variability in the climate projections, historical hydrology (1951-1998) is used as a basis for the climate sequences.

Climate Change Driven Droughts

From a planning perspective, the important consideration is whether the hydrologic sequences chosen adequately represent potential hydrologic variability and potential future drought conditions. A recent paper (Cook et al., 2015) compared drought metrics under future climate change to historic droughts.

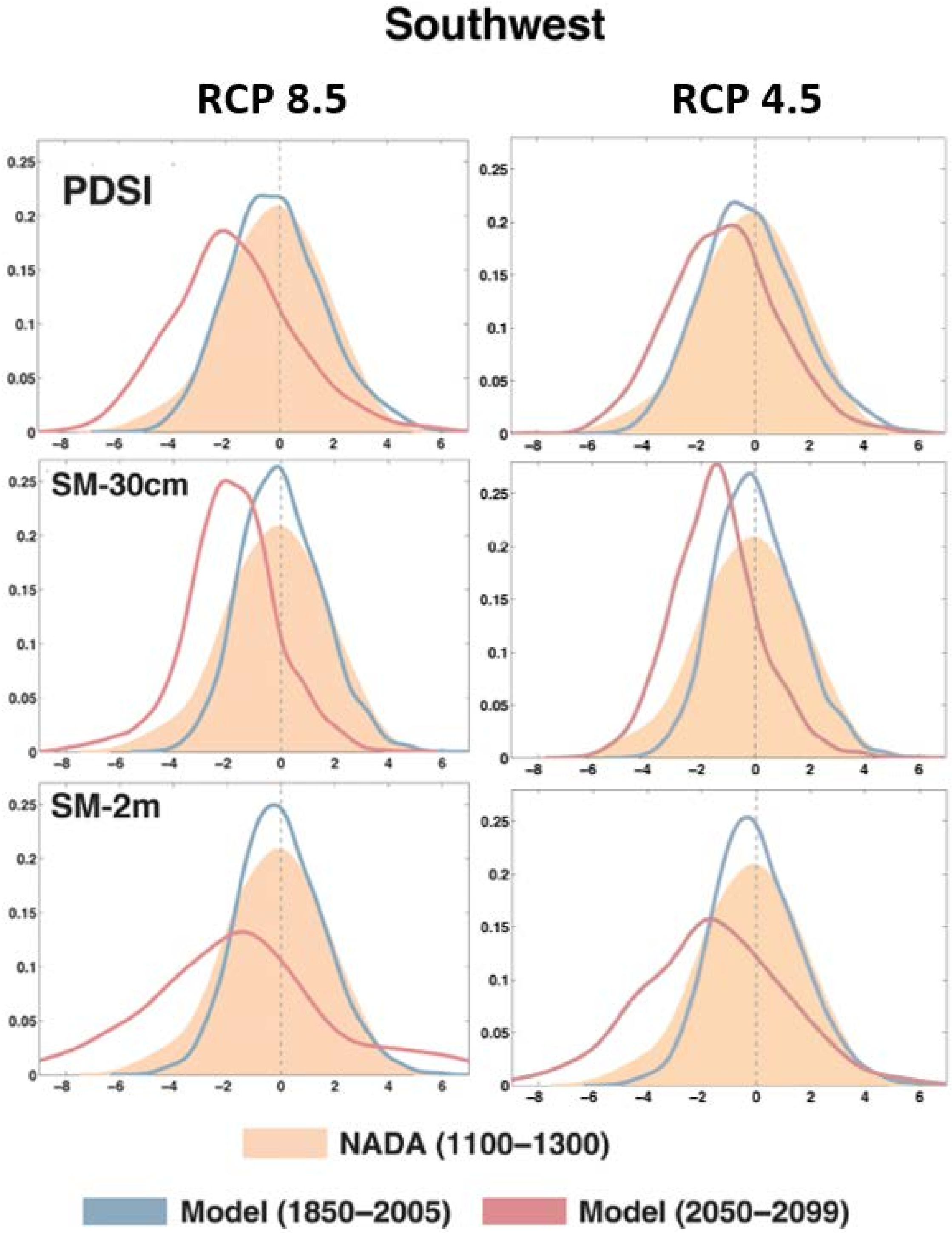
The study is based on the recent CMIP5 GCM ensemble and focuses on representative concentration pathway (RCP) 8.5 “business-as-usual” high emissions scenario and the RCP 4.5, a more moderate emissions scenario. In addition to measured historical data, the study includes tree-ring based hydro-climate reconstructions to represent droughts over the last millennium (1000-2005 CE).

Millennial-length hydro-climate reconstructions feature notable periods of extensive and persistent Medieval-era droughts, which exceed the duration of any drought observed during the historical record (1850-2010 CE). The authors use a modified (incorporating the Penman Monteith equation for estimating evapo-transpiration demands) Palmer Drought Severity Index (PDSI); summer (June–July) integrated soil moisture for shallow (< 30 cm) soils (soil moisture [SM]-30cm); and summer (June–July) integrated soil moisture for deeper (2-3 m) soils (SM-2m).

The study suggests that based on all three metrics the southwest is expected to show markedly consistent drying over the latter half of the 21st century (2050-2099). Projected changes in the Southwest (2050-2099 CE) for all three moisture balance metrics are significantly drier compared to both the modern interval (1850-2005 CE) and reconstructed 1100-1300 CE records.

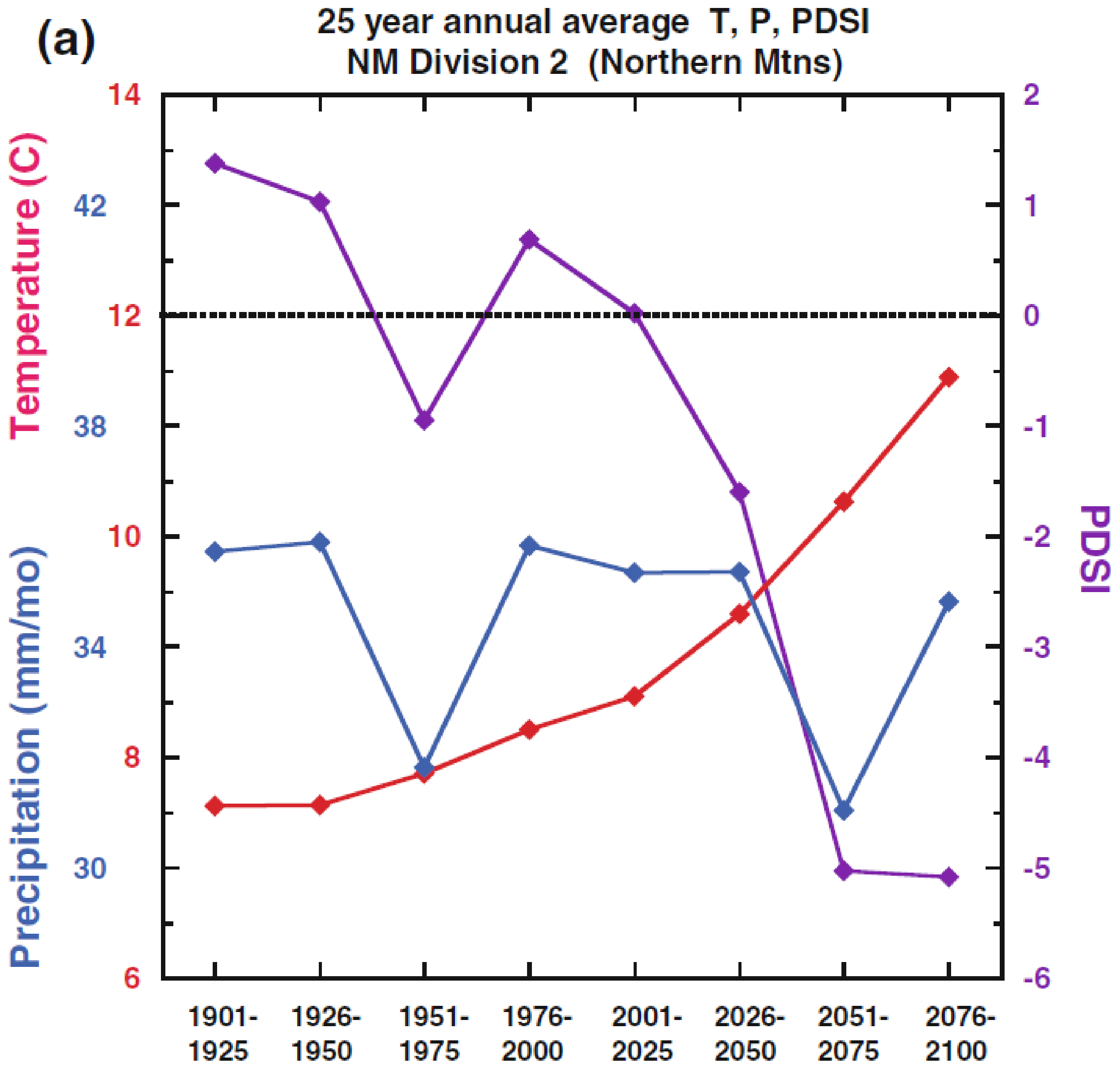
The distribution of the three metrics for the two emission scenarios are compared to historical and reconstructed North American Drought Atlas (NADA) records in Figure 3.D1.

Figure 3.D1: Comparison of three drought metrics (PDSI, SM-30cm, and SM-2m) over three different periods (1100-1300, 1850-2005, and 2050-2099 CE) for the Southwest for two different emission scenarios (RCP 8.5 and RCP 4.5). Drought metrics for 2050-2099 are seen to be worse than those for the two historical periods. (Cook et al., 2015)



These results are consistent with another study (Gutzler and Robbins, 2011) that looked at regional drought statistics under climate change (based on the CMIP3 GCM ensemble) for the western United States. The study also points to a persistent and consistent (across different GCMs) drying in New Mexico. Figure 3.D2 compares average (over 25 years) changes in precipitation and evapotranspiration and PDSI for New Mexico for the 20th and 21st century.

Figure 3.D2: Average change in temperature, precipitation and PDSI for New Mexico from 1900 to 2100 CE.(Gutzler and Robbins, 2011)



Comparison of Water Supply Hydrologies to Historical Tree-Ring/Flow Reconstructions

Tree-ring based climate reconstructions allow us to look at multi-decadal droughts over the millennium. Cook et al. compared drought indices from reconstructed climate records with predictions from GCMs (Cook et al., 2015). Results indicated that future conditions can be expected to be warmer and (in general) drier than conditions observed over the historical period. While, GCMs give us an indicator of the severity of future drought (mostly driven by warmer conditions) they do not provide consistent trends on the frequency and duration of such droughts.

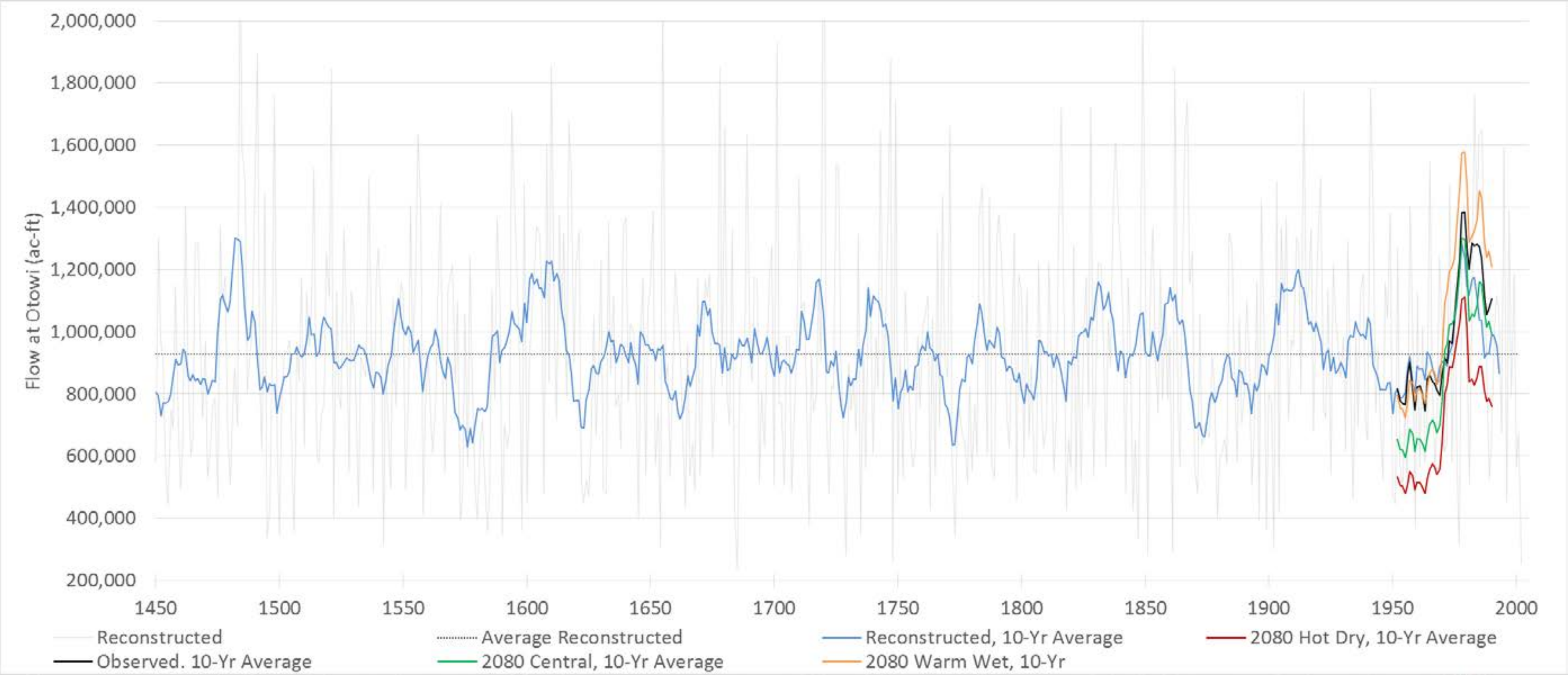
Most climate change impact analyses are conducted by downscaling and transforming historical hydrologic sequences with respect to 'average' future climate conditions. As such, if the historical sequence has a wet period (e.g. 1975 – 2000 CE), the relatively wet period will be part of the climate-impacted time-series. However, historical data is still our most reliable source of information for the duration and frequency of future droughts. Streamflow reconstructions from tree rings have been made available (http://treeflow.info/rio-grande-basin#field-other-hydroclimatic-recons) for various gages in the Rio Grande Basin as part of a NOAA funded project to expand and improve the usability of tree-ring reconstructions for drought planning and water management in the Rio Grande Basin. The reconstructions are based on linear regressions between tree-ring thickness and observed flow records. Figure 3.D3 shows streamflows (annual and 10-year average) at Otowi gage from the reconstructed records compared with flows at Otowi gage from the West Wide Climate Risk Assessment HDe dataset for different future climate scenarios.

As can be seen from the figure, flows under Hot-Dry conditions for 2080 CE (red line), are generally lower than those seen in the reconstructed or historical record. For the sake of this assessment, we assume that persistent below average flows at Otowi gage are indicative of drought conditions. As such, the two longest droughts from the reconstructed periods correspond to a 34-year span from 1877 to 1909 and a 21-year span from 1574 to 1594. The drought of the 1950s is also of note. Based on the Otowi gage flows, this 16-year drought period starts in 1945 and ends in 1966. Since the West-Wide Climate Risk Assessment HDe time-series are based on the 1951-1998 sequence, they too show the same low flow conditions for the 1950s. As such, the drought of the 1950s is exacerbated in the 2080-HD scenario and shows up as a multi-decadal drought more severe (in terms of magnitude) than the multi-decadal droughts of the 1800s and 1500s.

The overall average flow (926,000 afy) over the reconstructed period of is about 7 percent less than the average flow in the observed time period from 1958 to 2000 (note though that the simulated historical period is 3 percent lower than observed). However, the 2080 Hot-Dry and 2080 Central sequences are both lower than the paleo-reconstructed sequence with the Hot-Dry flow reduced by more than 20 percent. Further, both climate change sequences are less than the minimum flow in any 100-year sequence from the paleo record.

Based on this assessment, it can be concluded that the drought of the 1950s as simulated in the West Wide Climate Risk Assessment HDe hydrologic sequences is comparable to historic droughts in the paleo-reconstructed records. Likewise, it appears that the 1950s drought under a Hot-Dry climate is of greater magnitude than any droughts from the tree-ring record and that the average flow for the Hot-Dry sequence is less than paleo-reconstructed records over comparable periods.

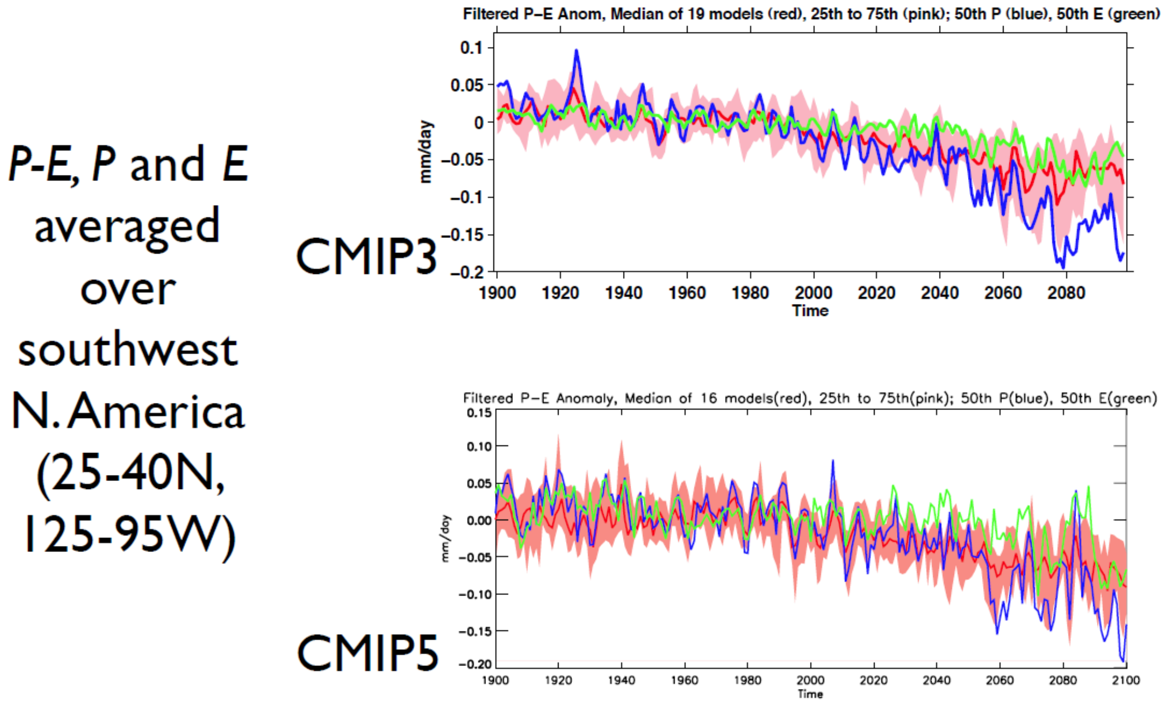
Figure 3.D3: Annual and 10-year average streamflows at Otowi gage from the reconstructed records compared with observed and 10-year average simulated flows from the West Wide Climate Risk Assessment HDe dataset (2080-HD, 2080 WW, 2080 C).



Comparison of Climate Change Projections – CMIP3 and CMIP5

Recently, the IPCC published the CMIP5 dataset, representing the latest in ongoing study and refinement of climate science. However, at the time of development of this update to the WRMS, CMIP5 data have not been downscaled and bias-corrected by Reclamation for use in western water planning. A study conducted by a research group (Seager et al., 2012) from the Lamont Doherty Earth Observatory of Columbia University compared predictions from CMIP3 and CMIP5 for precipitation – evaporation anomalies (used as a surrogate indicator for drought) in the Southwest. Figure 3.D4 shows trends from the model for the calibration (1900–2000 CE) and prediction (2000–2099 CE) periods.

Figure 3.D4: Comparison of trends in precipitation and temperature anomalies for CMIP3 and CMIP5. (Seager et al., 2012)



Seager et al. (2012) point out that while overall trends and range of results are consistent between CMIP3 and CMIP5, there are differences in the inter-annual variability. The CMIP5 ensemble predicts slightly wetter conditions for New Mexico, but overall the P-E anomaly grows over time indicating progressively dryer conditions, for both CMIP3 and CMIP5.

Based on this literature survey, it is indicative that average multi-decadal change in precipitation and temperature are consistent across CMIP3 and CMIP5. These findings are consistent with recommendations from the recent Reclamation (2015) study that released downscaled hydrologic projections for CMIP3 and CMIP5.

The report states that '*while future downscaled climate and hydrology projections based on CMIP5 may inform future analyses, many completed and ongoing studies have been informed by CMIP3 projections that were selected as best information available at the time of study. Even though CMIP5 is newer, it has not been determined to be a better or more reliable source of climate projections compared to existing CMIP3 climate projections. As such, CMIP5 projections may be considered an addition to (not a replacement of) the existing CMIP3 projections until a final decision that CMIP5 is superior is issued by the climate modeling community*.'

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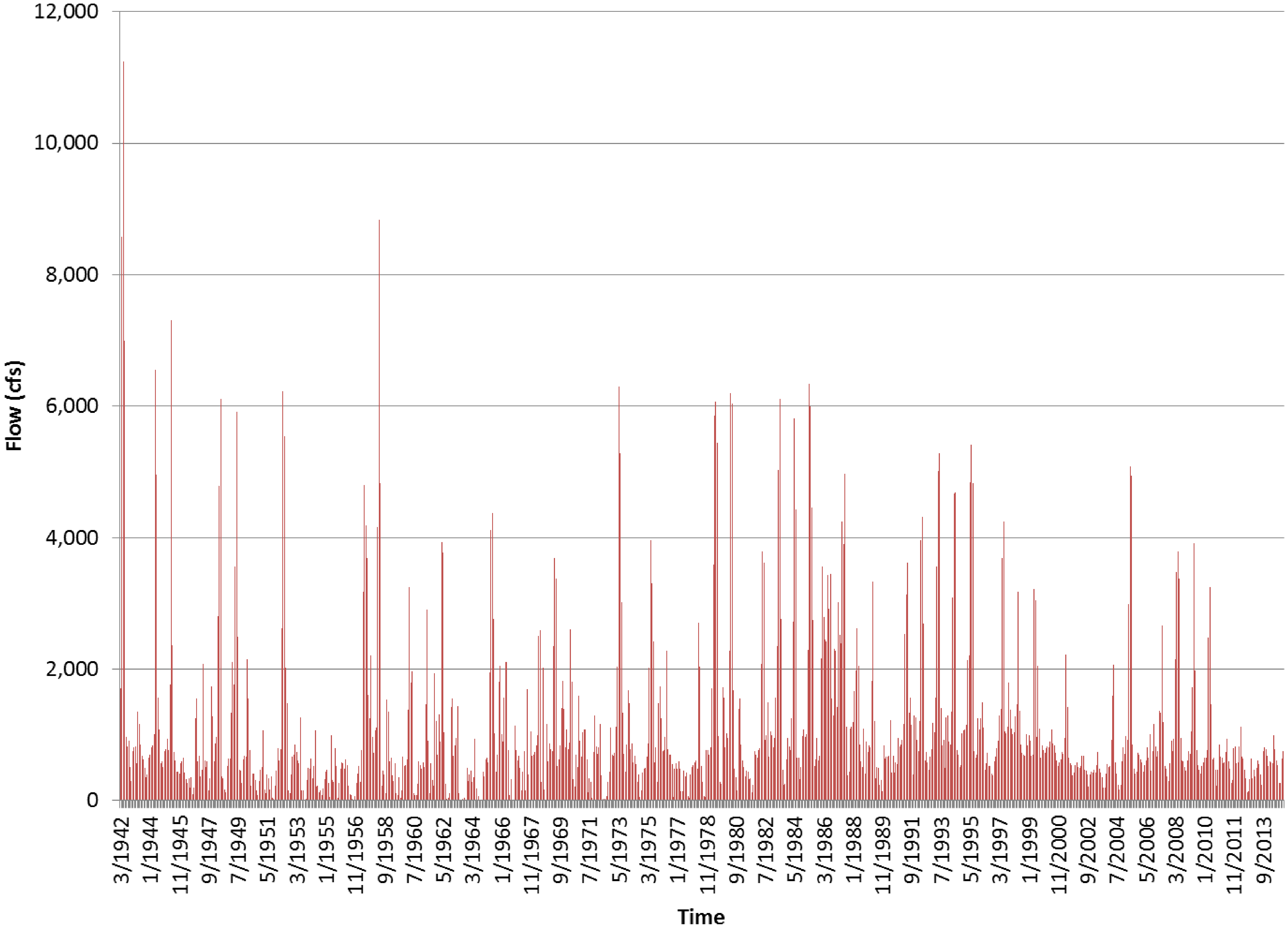
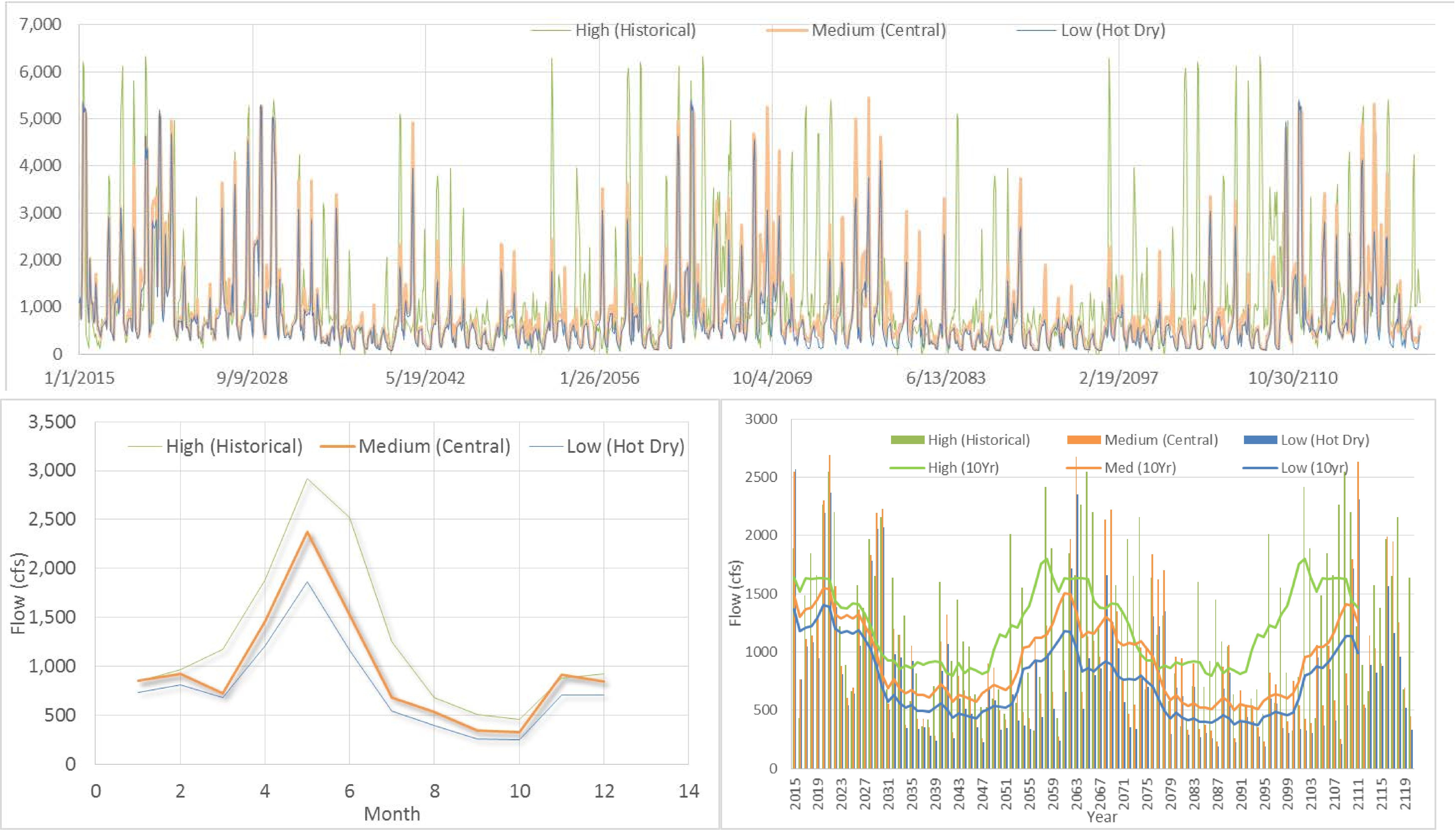
Appendix 3.E

Select Larger Size Figures

From Section 3.3.1.2 - Figure 3.6. Monthly Rio Grande Flow at Albuquerque (1942-2014)



From Section 3.4.1.2 - Figure 3.12. Low, Medium, and High Flow



Water 2120:
Securing
Our Water
Future

CHAPTER 4

Groundwater Management

4

CHAPTER 4

4.1 Introduction and Purpose

As part of **Water 2120**, a groundwater management plan is proposed to limit groundwater use over the long term, which will guide overall policy and decision-making with respect to the timing and need for new water supplies.

Groundwater is a highly valuable resource to the Water Authority and an integral part of its water supply portfolio. Managing and utilizing groundwater supplies while maintaining a Groundwater Reserve is a critical consideration in the effort to update the WRMS.

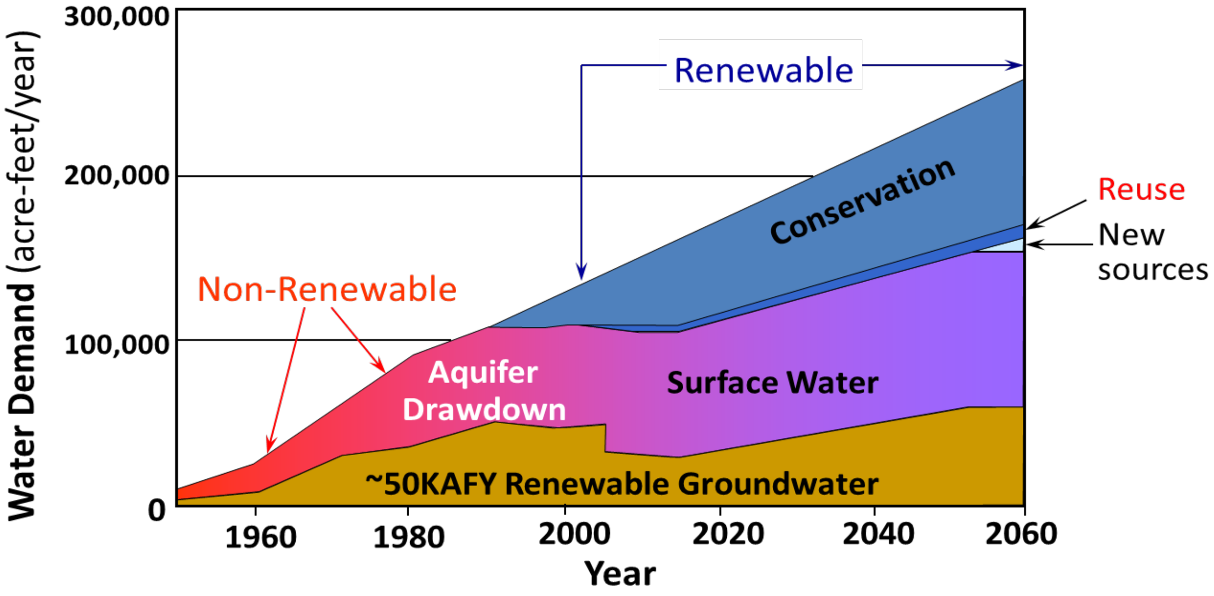
A key attribute of groundwater is its resilience: groundwater availability does not significantly change in response to drought. As such, it is a critical and relatively low-cost supply during times of reduced surface water availability.

The Water Authority's established groundwater management policy (Water Authority, 2007, Policy C) was adopted as part of the 2007 update to its WRMS, and reads as follows:

> *The Authority shall establish a ground-water drought reserve that maintains sufficient water in storage in the aquifer to provide water supply during a prolonged drought. Water levels in the aquifer shall be maintained so that a drought reserve shall be accessible without causing adverse, irreversible impacts to the aquifer*[1].

The 2007 WRMS also states that "groundwater use is limited to the amount of recharge." Based on work done in support of the 1997 and 2007 Strategies, long-term average utilization of the aquifer was estimated to be about 50,000 to 60,000 afy (Figure 4.1).

Figure 4.1. 2007 WRMS Strategy Graphic with Conservation Goal



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[1] Policy C, Water Resources Management Strategy, Albuquerque Bernalillo County Water Utility Authority, October, 2007, p.7.

The existing policy provided for groundwater use that would vary from year to year and exceed the long-term average during periods of limited surface water availability. In other words, groundwater was not limited during periods when surface water was not available, and there was no long-term management level established to limit how much groundwater could be used during the previous 2007 planning period.

Ultimately, the strategy resulted in managing aquifer use in a way that preserved storage for future drought, protected the aquifer from irreversible damage, balanced water rights and recharge, and provided flexibility for future rate payers.

The origin of the 2007 policy dates to the initial 1997 WRMS and more specifically to a 1996 report prepared as input to the 1997 WRMS (Brown et al., 1996). The 1996 report *The Value of Water* identified important services provided by the aquifer distinct from the value obtained by simply extracting water and using it.

The 2007 WRMS also recommended that the analysis in the 1996 report be updated to account for potential changes over the intervening years. Figure 4.1 presents the 2007 WRMS graphically, including updates to the WRMS such as a new conservation goal.

This chapter develops a balanced long-term approach to managing groundwater, utilizing the most recent information and the best available science and modeling tools (NMOSE Administrative Area Model [NMOSE, 2001]), while maintaining the same protections called for in the 1997 and 2007 Strategies.

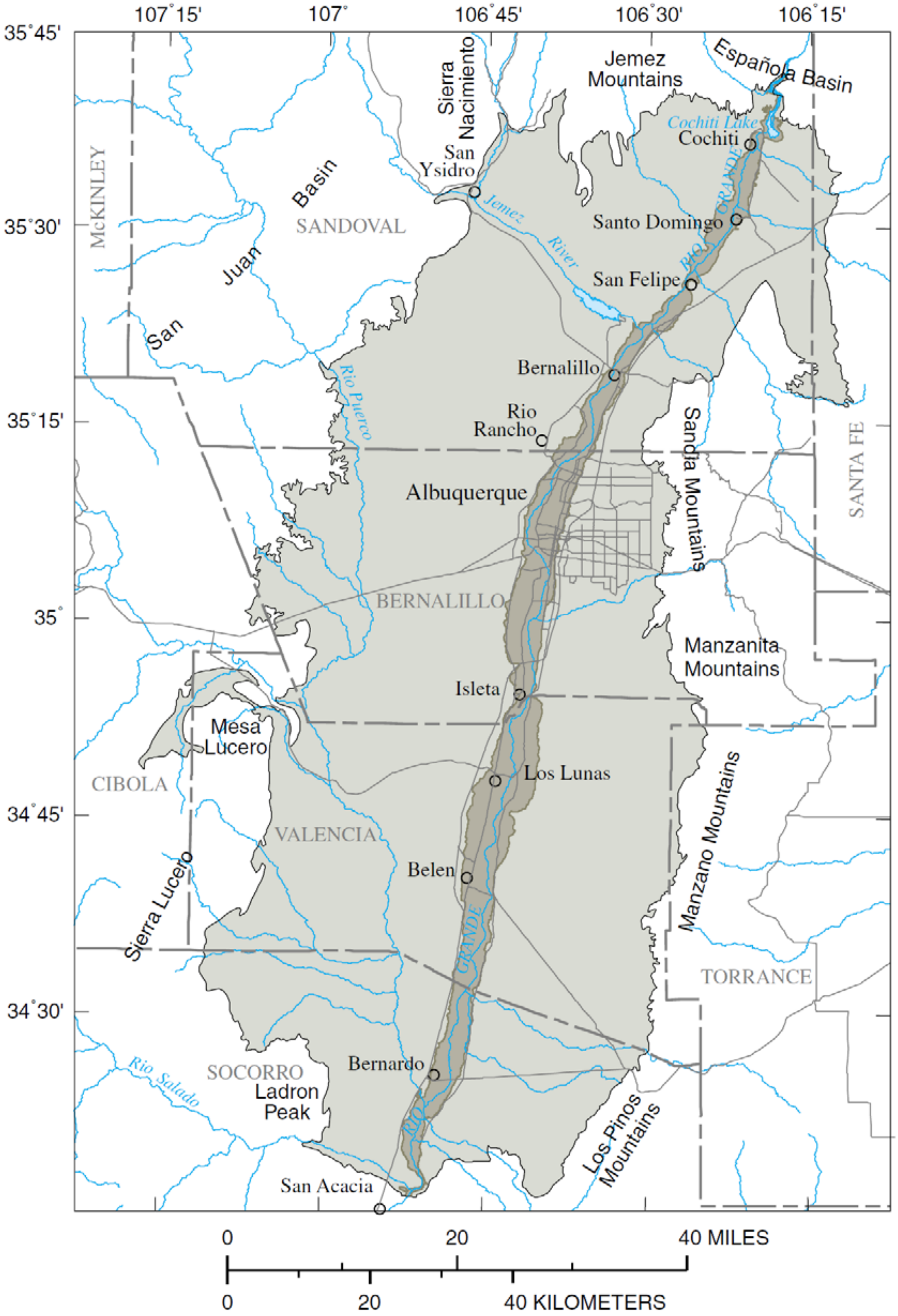
The policies in the 2007 WRMS provide the framework for this Groundwater Reserve Management Plan (GRMP), including using and protecting existing San Juan-Chama and native water rights, and providing for a Groundwater Reserve that does not limit options for future generations.

The GRMP discussed in this chapter, while consistent with previous strategy goals, is a new concept in local groundwater management which can be applied in perpetuity and can serve as a model to other groundwater users in the Middle Rio Grande Basin and beyond. Key components of the GRMP are as follows:

- consistent with 2007 WRMS Policies B and C
- consistent with recent aquifer management experience
- establishes a Groundwater Reserve above a threshold of irreversible subsidence
- broadens the concept of “drought reserve” to a Safety Reserve as protection against all emergency, largely unquantifiable, supply-related events
- defines a Working Reserve, above the Safety Reserve, which can be utilized and replenished depending on hydrologic conditions
- sets a Management Level at 110 feet of drawdown within the Working Reserve as a goal measured by average well drawdown
- barring emergency, it results in no net long-term impact to the aquifer once the Management Level is reached
- utilizes a renewable groundwater supply

The narrative of this chapter is divided into subsections following this introduction which 1) describe the Middle Rio Grande groundwater basin (Figure 4.2) and its dynamic nature, 2) propose principal zones into which the aquifer is divided for purposes of management, and 3) propose an operational plan for managing the regularly used uppermost zone.

Figure 4.2. Middle Rio Grande Groundwater Basin



Source: http://nm.water.usgs.gov/projects/middleriogrande/images/basin.gif

4.2 The Middle Rio Grande Groundwater Basin

This section provides background information about the Middle Rio Grande groundwater basin (Basin) and a description of the dynamic nature of the aquifer – particularly how recharge to the aquifer changes in response to pumping. Understanding the dynamic character of the aquifer is central to conceptual development of a groundwater management plan.

4.2.1 Background

Groundwater from the Basin is a key water supply source for the Water Authority, Rio Rancho, and others. Most of the key water users, including the Water Authority, have participated to varying degrees in the Middle Rio Grande Regional Water Planning process that includes consideration of this key resource.

Because of its importance, the Basin has been studied extensively by the USGS and others. Accordingly, this discussion provides only a brief summary of the Basin needed to support development of the GRMP.

More information on the Basin can be found on the USGS's Middle Rio Grande Basin Study webpage:

http://nm.water.usgs.gov/projects/middleriogrande/).

The Basin extends from Cochiti to San Acacia, a distance along the Rio Grande of about 100 miles (Figure 4.2). Natural recharge to the aquifer is estimated to total about 100,000 afy through mountain-front recharge along the edges of the aquifer and major arroyos and underflow from adjacent basins including the Espanola Basin (Thorne et al., 1993; Kernodle et al., 1995; Tiedeman et al., 1998; McAda and Barroll, 2002).

Under pre-development[2] conditions (no groundwater pumping), natural recharge (about 100,000 afy) was balanced with discharge to the Rio Grande and evapotranspiration from riparian vegetation along the Rio Grande. Pumping of the aquifer for water supply since pre-development has subsequently changed the water balance of the system, as described in the following subsection.

4.2.2 Groundwater: A Dynamic System

This subsection summarizes the dynamic nature of the groundwater system. A more complete description is found in Appendix 4.A. Historical conditions are used to describe the dynamic aquifer response to groundwater pumping. This response can then be applied to potential future conditions and help inform definitions of the Groundwater Reserve and its components, as well as form the basis for managing the aquifer.

Groundwater pumping by the Water Authority and others began in the late 1800s, increased substantially in the 1950s, and continued to increase until the early 1990s. There are two general sources of water pumped from wells historically in the Basin:

1. **Water removed from aquifer storage**. In response to groundwater pumping, water was removed from aquifer storage resulting in aquifer drawdown.
2. **Water from the Rio Grande ("river effect")**. Because the river system is in direct connection with the aquifer, aquifer drawdown also resulted in increased recharge from the river system and/or decreased discharge to the river system (intercepted recharge). Taken

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[2] "pre-development" is generally defined as a period prior to wide-spread groundwater production. In general, groundwater levels and movement would have been solely controlled by natural processes.

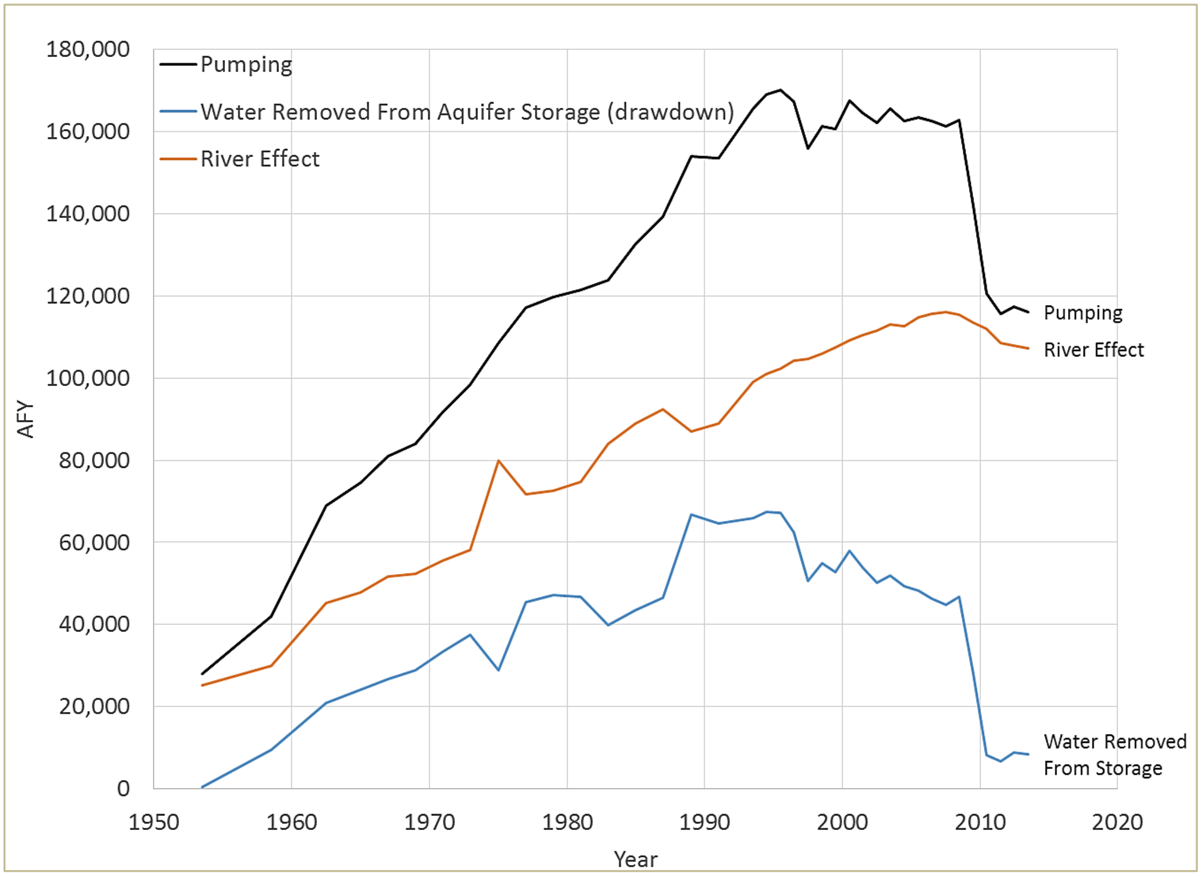
together, the increased recharge and/or decreased discharge are referred to as the “river effect.”

These two sources of water cannot be directly measured. The NMOSE developed a numerical groundwater model of the Basin (NMOSE, 2001), which is used to estimate the river effect. The NMOSE model is used as the administrative tool to quantify river effects from individual water users on the river system.

Historical sources of water pumped by wells (all wells, not just Water Authority wells), based on the NMOSE model, are presented in Figure 4.3. Model results suggest that, recently, river effects have supplied more than 70 percent of water to wells, with aquifer storage providing the remaining 30 percent. The river effect has provided as much as about 100,000 afy to wells.

To put this supply in context, a) natural recharge is about 100,000 afy, and b) average annual river flows are on the order of 1 million afy, indicating that the effect on the river is not large relative to total flow rates. The effect on the river must be offset in the form of treated wastewater returned directly to the Rio Grande, water rights, or surface storage releases to the Rio Grande. The degree to which the river is losing water to the aquifer changes each year given the dynamics of the system.

Figure 4.3. Estimated Sources of Historical Water Pumped from all Wells in the Middle Rio Grande Basin



Based on the NMOSE model

Three important concepts are apparent from Figure 4.3:

1. When aquifer pumping was increasing (e.g. 1950-1990; black line in Figure 4.3), the river effect was also increasing (orange line in Figure 4.3), but there was a time lag – pumping in a given year impacts the river system most in later years. During this time lag, aquifer drawdown continues as withdrawals from aquifer storage (blue line in Figure 4.3) make up the difference between pumping and river effect.
2. When groundwater pumping becomes relatively stable (e.g. 1990 to early 2000's; black line in Figure 4.3), the river effect (orange line in Figure 4.3) continues to increase and water removed from aquifer storage (blue line in Figure 4.3) is reduced as a source of water to the wells.
3. If groundwater pumping is reduced, it is possible for the river effect to exceed the pumping rates. While this last impact has not occurred on a Basin-wide basis, it has happened in the Albuquerque area in recent years, where groundwater production was greatly reduced by the advent of the San Juan-Chama Drinking Water Project. The Water Authority's river effects, which are offset with treated wastewater, native rights, and, if needed, additional San Juan-Chama water, exceed the Water Authority's groundwater pumping, resulting in a net addition of water to the aquifer (observed as rising water levels).

While there is a lag time associated with pumping, drawdown, and river effect, the NMOSE model suggests that, if pumping were relatively stable over a long period, the river effect would approach an equilibrium state in which recharge from the river equals pumping from the aquifer. Timing to reach the equilibrium state depends on how far from equilibrium the system is, and could be on the order of 20 to 75 years.

Once this equilibrium state is attained, groundwater elevations stabilize (i.e. no additional drawdown). The deeper the equilibrium state drawdown, the greater the river effect and the more pumping could be sustained in perpetuity without continued drawdown (as long as river water is available in sufficient quantity). This equilibrium concept, or water balancing approach, is central to the GRMP presented below.

4.3 Defining the Groundwater Reserve

To better manage the Water Authority's groundwater supply, three aquifer zones are defined. This section defines these zones, which include the Groundwater Reserve, Safety Reserve, and Working Reserve.

Due to the dynamic and interrelated nature of aquifer storage and pumping, the zones are defined in terms of drawdown level from pre-development[3] conditions.

4.3.1 Groundwater Reserve

The Groundwater Reserve is defined as the portion of the aquifer that can be used without risking irreversible subsidence. Because this threshold is about 300 feet below pre-development conditions, this level has been defined as the bottom of the Groundwater Reserve (Figure 4.4, also see Appendix 4.B).

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[3] For the purposes of analysis, pre-development is defined through utilization of the NMOSE Administrative Area Model. As developed, the first stress period of this model represents pre-development conditions.

Similar to the 2007 WRMS, avoiding the irreversible subsidence threshold is the initial objective of the proposed GRMP. The Groundwater Reserve is further divided into two parts: the Safety Reserve and the Working Reserve.

4.3.2 Working Reserve

The Working Reserve is the portion of the aquifer that is regularly utilized. The bottom of the Working Reserve coincides with the top of the Safety Reserve, or 250 feet of drawdown below pre-development conditions. Average drawdown[4] from pre-development conditions reached a maximum of about 115 feet in the early 2000s, and is projected to rise to about 50 feet in the 2020s.

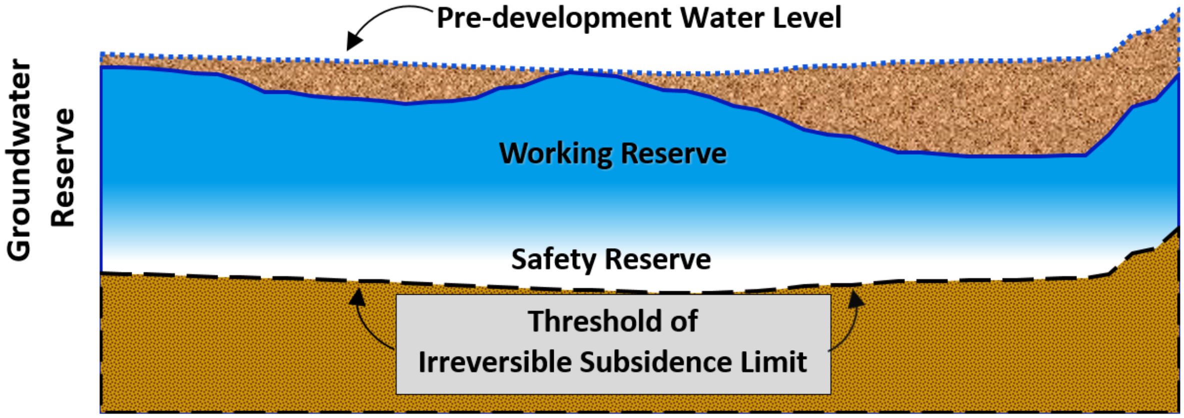
Accordingly, the full range of the aquifer between 50 feet and 250 feet below pre-development conditions is defined as the Working Reserve. The Working Reserve can be utilized to respond to all "normal" or predictable future hydrologies, including drought and climate change.

4.3.3 Safety Reserve

The Safety Reserve is defined as the bottom 50 feet of the Groundwater Reserve, or the interval between 250 feet and 300 feet of drawdown below pre-development conditions. The intent of maintaining a Safety Reserve is to account for unforeseen, largely unquantifiable events not included in the planning scenarios; such as chemical spills, institutional conflicts, physical disruptions, as well as even catastrophic drought beyond levels embedded in historical hydrology or contemplated with climate change. The top of the Safety Reserve is based on a reasonable factor of safety of 50 feet above the irreversible subsidence threshold.

As discussed in Appendix 4.C, under a wide array of extreme hypothetical future conditions, the Safety Reserve could continue to meet all essential water demands, even at the end of the planning period (e.g. 2120, with a population of 1.8 million people), in perpetuity without the risk of irreversible subsidence.

Figure 4.4: The Groundwater Reserve and its Components



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[4] Average drawdown from pre-development conditions, using the NMOSE model for both pre-development and recent water levels, across 78 Water Authority wells with water that does not exceed arsenic drinking water standards. Simulated values are used to provide a consistent reference for projected drawdown used subsequently in this section.

4.4 Managing the Working Reserve

This section summarizes management objectives and background information related to development of a management approach and provides a description of a prescriptive approach to managing the Working Reserve. Utilizing and managing the Working Reserve is critical for a resilient long-term water supply for the Water Authority. It is based on a balanced approach that utilizes the existing water rights owned by the Water Authority (2007 WRMS Policy B), maximizes the use of existing infrastructure, and leaves many options for future generations.

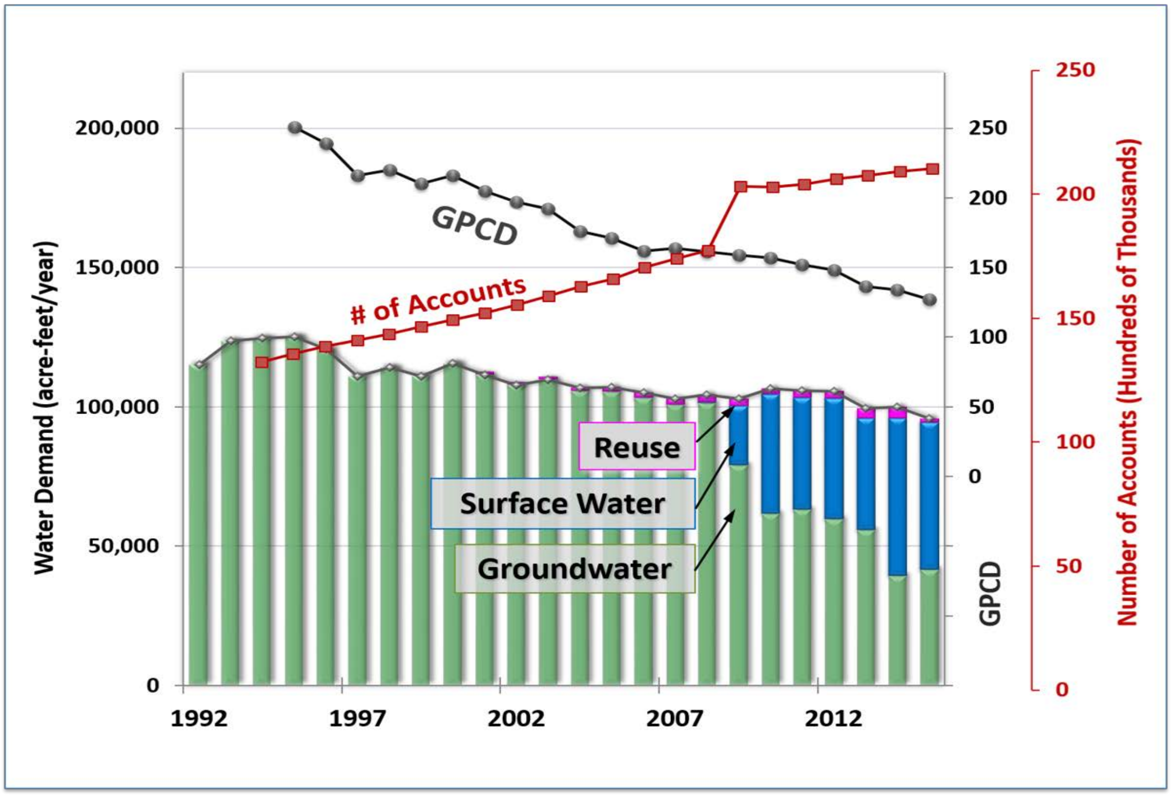
The foundation of the Groundwater Reserve is the 1996 report The *Value of Water* (Brown et al., 1996) which discusses the need to maintain groundwater in reserve for dry times or drought.

4.4.1 Management Objective

Consistent with the concepts adopted in the 1997 and the current 2007 WRMS, the objective of the 2017 WRMS is for *groundwater to be managed such that there is no long-term net removal of water from storage once a set Management Level is reached, while utilizing the Working Reserve to respond to changing hydrologic conditions.*

Water levels in the aquifer in the Albuquerque area are rising and simulations estimate that this will continue into the 2020s. In the 1990s, the aquifer was the sole source of supply for the Water Authority. Groundwater demand peaked at around 125,000 afy in 1995 (Figure 4.5).

Figure 4.5. Historical Water Authority Water Use



Groundwater use caused water level declines throughout the Basin. Since the mid-1990s, the Water Authority has reduced per capita consumption (measured in gallons per capita per day [GPCD]) by more than 40 percent, began reuse and recycling programs, and developed surface water under the San Juan-Chama Drinking Water Project. The combination of these programs has reduced overall demand to about 95,000 afy in 2015, which is about the same as demand in the early 1980s.

Recent history shows that the aquifer can experience periods of drawdown (removal from storage) and recovery (addition of water to storage). Accordingly, the management objectives can be attained by having alternating periods of decreasing groundwater storage (aquifer pumping in excess of recharge, up to the full permitted amount of pumping) and periods of increasing storage in response to reduced groundwater pumping (e.g., a new supply). This approach can be likened to a bank account, in which the balance fluctuates up and down, but over the long-term deposits and withdrawals are about equal.

An objective of no net change in storage inherently results in reliance on renewable groundwater, as there must be a long-term balance between groundwater recharge and withdrawals. This is a progressive approach to groundwater management, and if implemented by all groundwater users in the Basin, would result in the ability to maintain groundwater supply in perpetuity.

4.4.2 Background

To meet the objective of no net removal of storage after a Management Level is reached, an understanding of what conditions result in change in aquifer storage is necessary. In addition, it is necessary to understand how the Water Authority's entire water balance is related to the groundwater balance and change in aquifer storage. Accordingly, this section summarizes the water balance of the groundwater, followed by a summary of the Water Authority's system water balance.

4.4.2.1 GROUNDWATER BALANCE

The amount of groundwater in storage decreases when withdrawals from the aquifer exceed recharge to the aquifer. For the purposes of the Water Authority's management strategy, only the Water Authority's effect on the aquifer is explicitly considered[5]. The Water Authority has two effects on the aquifer, as follows:

1. "Water out" is groundwater pumped from wells.
2. "Water in" is the river effect, which is offset through surface water rights, return flows, and San Juan-Chama Project water.

The Water Authority adds water to storage when the river effect exceeds groundwater pumping, and removes water from storage when pumping exceeds the river effect.

Historical Water Authority groundwater pumping (metered) and river effect (estimated using the NMOSE model) are presented in Figure 4.6. Through 2009, pumping exceeded the river effect, and water was being removed from storage. Since 2010, the river effect has exceeded pumping, and water has been added to storage. As discussed in Section 4.2.2, if pumping remains stable, the river effect will approach an equilibrium with pumping.

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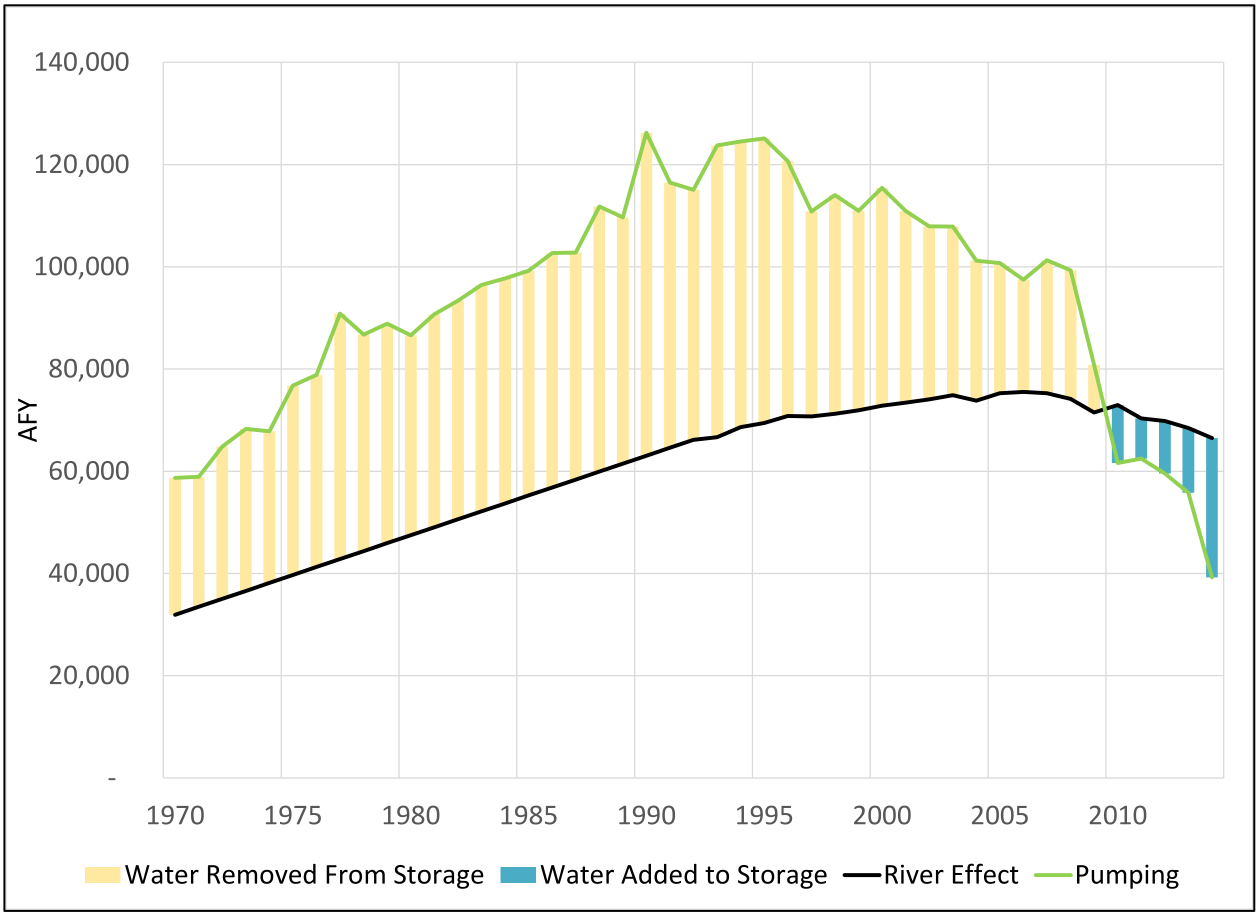
[5] Groundwater pumping of others is out of the control of the Water Authority and is not directly considered in this analysis. However, pumping by others will affect the aquifer levels and is therefore considered indirectly in the implementation of this plan. The Water Authority can set an example for others through its actions and participate in the NMOSE Regional Planning process to help guide future policy.

Figure 4.6. Water Authority Groundwater Balance



Groundwater pumping is based on meter data; river effect and storage estimated using the NMOSE model

However, there is a lag time between pumping and the river effect, as can be seen in Figure 4.6, where pumping fluctuates year to year, whereas change in river effect due to pumping fluctuation is smoothed out over time and delayed when compared to pumping.

4.4.2.2 WATER AUTHORITY SYSTEM WATER BALANCE

Change in Water Authority storage (combined aquifer and surface water reservoirs) is equal to the difference in water availability and water use. Water availability is assumed to equal the Water Authority's consumptive surface water rights of 74,590 afy (26,390 afy of Rio Grande surface water rights plus 48,200 afy of San Juan-Chama water; see Chapter 3: Supply). Accounting for evaporation and transit losses for San Juan-Chama water (on the order of 3,500 afy), total water availability for consumptive use can be assumed to be about 71,000 afy (total available supply = total supply – losses).

Consumptive use of 71,000 afy corresponds to a total water demand of about 165,000 afy, given recent consumptive use of about 43 percent (see Chapter 2, Demand) of diversion. Assuming the DWP operation of about 90,000 afy over the long-term (full permitted use, less evaporative and transit losses), the Water Authority could use a long-term average of about 75,000 afy of groundwater (i.e. 165,000 – 90,000 = 75,000) while maintaining a water balance that results in no change in total system storage, and therefore, no long-term change in groundwater storage.

4.4.2.3 RIVER EFFECTS AND OFFSETS

The ability to offset the river effect is a key consideration in selection of a Management Level. The river effect can be offset with a combination of Rio Grande surface water rights, return flows, and San Juan-Chama water.

Return flows vary from year to year and are a function of non-consumptive demand (wastewater returned to the system). Existing wastewater obligations that affect availability of return flows for offsetting river effects are as follows:

- **Reuse.** The Water Authority uses some reuse water for non-potable needs at the Southside Water Reclamation Plant and turf areas in the Southeast Heights and South Valley, and the reuse amount is not returned to the river and therefore no credit is given.
- **DWP offsets.** The native portion of the Drinking Water Project diversions is required to be returned to the Rio Grande and is not allowed to be used for offsets.

The volume of water available to offset river effects has been estimated under three hypothetical demand scenarios (Figure 4.7), intended to capture a range of possible demands. All hypothetical demand scenarios assume full use of DWP, current reuse, and groundwater use up to the full permitted amount.

Results suggest that the Water Authority could pump a long-term average of about 75,000 afy and still be able to fully offset river effects, if offsets were equal to groundwater pumping. This includes pumping up to the 165,000 ac-ft permitted in drought years and lower groundwater production in full surface water supply years. At lesser long-term average pumping rates, there would be excess available wastewater (about 23,000 afy if long-term average pumping is 20,000 afy). At greater pumping rates there would not be enough wastewater to offset river effects, and San Juan-Chama water would be required to meet offset requirements (about 40,000 afy if long-term average pumping is 165,000 afy).

It is important to distinguish between long-term average pumping and short-term pumping needs during dry years within the context of maintaining the ability to offset river effects. The long-term average of 75,000 afy could still be maintained with drought or dry year pumping equal to the full permitted amount of 165,000 afy (consistent with the overall water availability and water use calculation in the preceding section). During years in which increased groundwater pumping is needed, the river effect is met because

a) the river effect has a lag time and does not respond significantly to short-term changes in groundwater pumping;
b) in dry years when the DWP is not fully utilized, offset requirements for the DWP are less, leaving more wastewater available for offsetting the river effect; and
c) in dry years when the DWP is not fully utilized, although rarely needed, SJC water could be available for offsets.

Figure 4.7. Water Available to Offset River Effect

Available exceeds pumping

With ~75,000 afy of pumping, ~75,000 afy of offsets are available

Pumping exceeds available

	Hypothetical Demand Scenarios			
	Scenario 1	Scenario 2	Scenario 3	Notes
Supplies				
Demand	111,300	165,000	256,300	
DWP	90,000	90,000	90,000	Full permitted use less evaporative and transit losses
Reuse	1,300	1,300	1,300	Current usage
Groundwater	20,000	73,700	165,000	Calculated to meet demand, up to full right
Wastewater Accounting				
Wastewater Generated	63,441	94,050	146,091	Calculated based on 43% consumptive use (recent)
DWP Return Flow	45,000	45,000	45,000	Return flow requirement for native component of DWP
Wastewater for Offset	17,141	47,750	99,791	Total WW minus DWP offsets minus reuse
Offsets Available				
Wastewater	17,141	47,750	99,791	From line above
Native Rights	26,000	26,000	26,000	Full permitted amount
Total Available for Offset	43,141	73,750	125,791	Sum of 2 lines above
Overrelease (-) or Available (+)	**23,141**	**50**	**-39,209**	**If river effect = pumping**

Note: all values in acre-feet per year

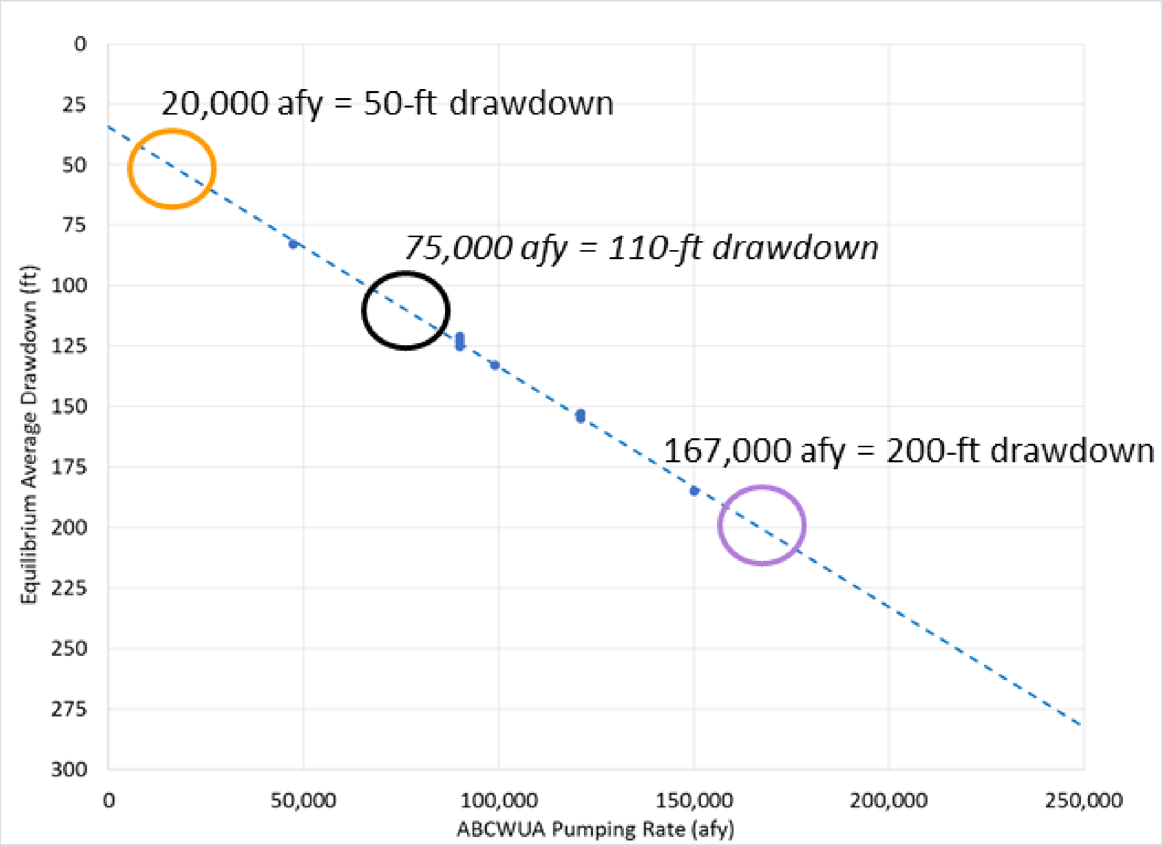
4.4.2.4 GROUNDWATER PUMPING AND AQUIFER LEVELS

The aquifer dynamics described in Section 4.2 suggest that that the deeper the equilibrium state drawdown, the greater the river effect and the more pumping that could be sustained without continued drawdown (as long as river water is available). The NMOSE model was used to develop a relationship between equilibrium Water Authority pumping and drawdown levels (Figure 4.8).

Model results suggest that if long-term groundwater pumping were about 75,000 afy, average drawdown would be about 110 feet. If water levels were drawn down to 200 feet below pre-development conditions, but not below, the aquifer system could produce more than 165,000 afy in perpetuity without continued aquifer drawdown.

Conversely, if water levels were only drawn down to 50 feet below pre-development conditions, the aquifer system could only produce about 20,000 afy for the Water Authority. Note that all of these scenarios examine hypothetical constant pumping over a long timeframe to achieve equilibrium and do not reflect actual or proposed operations.

Figure 4.8. Equilibrium Pumping Rates



Water Authority pumping rates that can be sustained in perpetuity at a particular average drawdown level, based on simulations using the NMOSE model. Colored circles correspond with levels in Figure 4.9.

4.4.3 Groundwater Management Level

This section summarizes the selection of the Management Level, followed by additional information related to alternative Management Levels not selected.

4.4.3.1 SELECTED MANAGEMENT LEVEL

The Management Level was selected to be 110 feet of drawdown from pre-development conditions, based primarily on the water balance and the relationship to historical aquifer levels. As discussed in the preceding sections, with current water supplies and management of those supplies, long-term average groundwater pumping could be about 75,000 afy, which translates to average aquifer drawdown of about 110 feet below pre-development water levels.

In addition to being supported by the water balance, the 110-foot Management Level is also supported by a number of other considerations, as follows:

- **Historical considerations.** Historical drawdown has been below the Management Level before, yet supplies were managed to produce water level rise.
- **Aquifer levels rising**. Current aquifer levels have been rising since 2008 and are expected to continue to rise into the 2020s.
- **Future storage.** The selected Management Level leaves ample storage in the Working Reserve untapped for the 100-year planning period and beyond.

4.4.3.2 ALTERNATIVE MANAGEMENT LEVELS

This section examines alternative Management Levels to further support the 110-foot selection. Two hypothetical alternative levels are considered, 50 feet and 200 feet, to summarize the potential effects of managing to a higher and lower Management Level.

Assuming that water levels and groundwater pumping are in equilibrium, the 50-foot Management Level corresponds to long-term average groundwater pumping of about 20,000 afy, and the 200-foot Management Level corresponds to long-term average groundwater pumping of about 167,000 afy (Figure 4.8).

These two alternative Management Levels are compared with the selected Management Level in Figure 4.9, which shows supplies needed to meet demand of 165,000 afy, which is consistent with the Water Authority's current consumptive water rights (see Section 4.4.2.2).

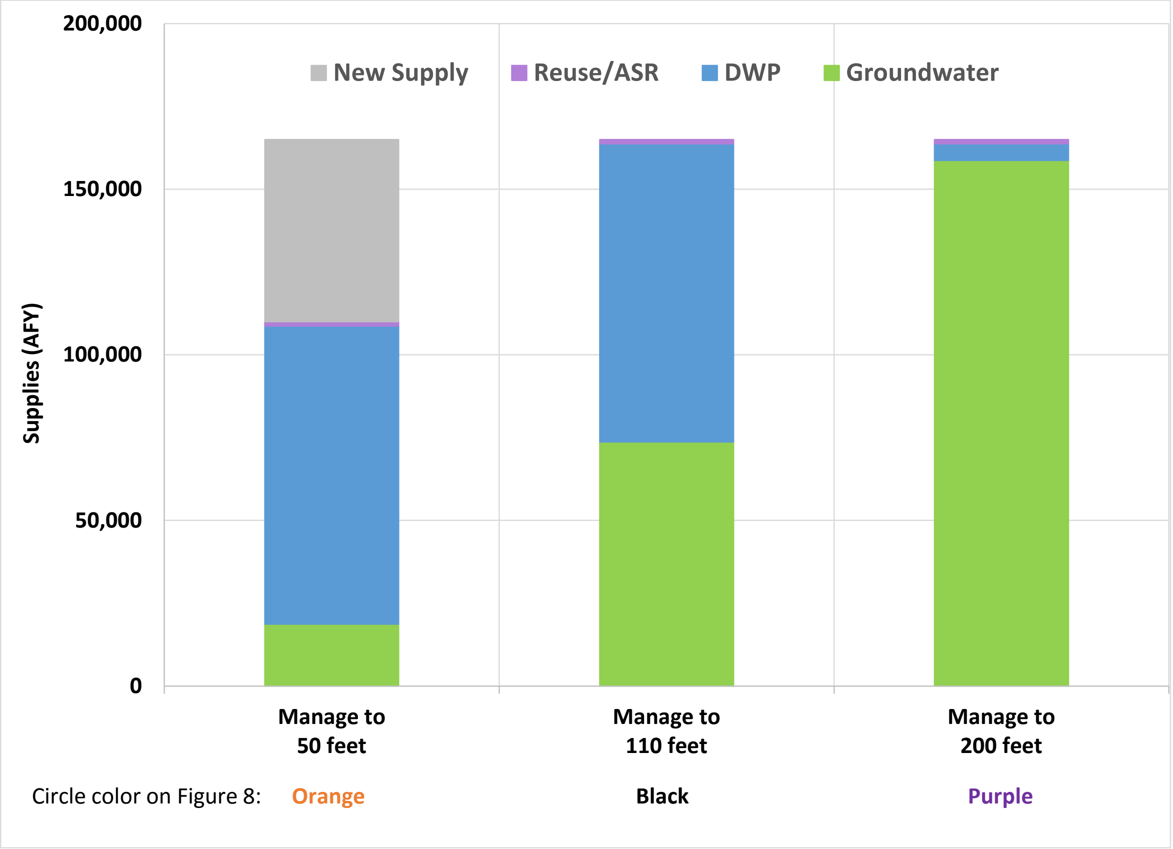
At a hypothetical 50-foot Management Level, a significant investment would need to be made in a new supply. Historical groundwater pumping significantly exceeds the 20,000 afy of pumping associated with the 50-foot Management Level, and this historical supply would need to be replaced. However, new NMOSE permits require a demonstration of need: the Water Authority would be challenged to obtain new permits when sufficient rights and supplies are in hand.

Additionally, pumping only 20,000 afy would forgo the significant groundwater infrastructure investment made to date and would not allow for fully utilizing the Water Authority's existing Rio Grande native water rights.

Finally this approach would violate Policy B, which states "The Authority shall protect its right to fully use its San Juan-Chama and Rio Grande surface water as a direct water supply…" These same considerations would apply to Management Levels between 50 feet and 110 feet.

At a hypothetical 200-foot Management Level, due to greater groundwater use, a significant amount of San Juan-Chama water would need to be used to offset river effects. San Juan-Chama water would be needed to offset river effects and therefore would be unavailable to the DWP and for aquifer storage and ASR. In addition, it would also violate Policy B.

Figure 4.9. Supplies Used, Alternative Management Levels



Supplies used to meet 165,000 afy demand, consistent with consumptive water rights

An additional consideration for selecting the Management Level is the volume and time at which new water supplies will be needed[6]. Because there is an operational floor (bottom of Working Reserve), system water use will eventually need to equal water availability. Neither water availability nor water use change with different aquifer levels.

Therefore, the need for new supplies will be the same in the distant future, once a Management Level is reached, regardless of what that level is. Different Management Levels would, however, result in different timing of the need for new supplies and/or water use reduction, and a different amount of water removed from storage.

4.4.4 Management Approach

In a dynamic system with multiple users and changing supply, it is not feasible to maintain constant aquifer levels, or a balance between water availability and water use over a short-term period (on the order of 5 to 10 years).

In addition, new projects may result in "block" additions of supply (instantaneous increase in supply when the project comes online) that would result in imbalances between water

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[6] See Chapter 6 for an analysis of future supply needs under a range of scenarios. Future supply needs under a given scenario are illustrated using "triangles." The triangles represent both the timing and volume of supply needed.

availability and water use. For example, the DWP resulted in imbalances that could last 20 years or more.

Therefore, a management strategy for the Groundwater Reserve should allow for periods of both declining aquifer levels and rising aquifer levels. One benefit to having a Groundwater Reserve is that it provides a buffer for periods when water availability and water use are in imbalance, whether it's due to hydrologic fluctuations or "block" additions of supply.

Operationally, a prescriptive approach was developed for managing the reserve, with aquifer status updates and implementation level defined as follows:

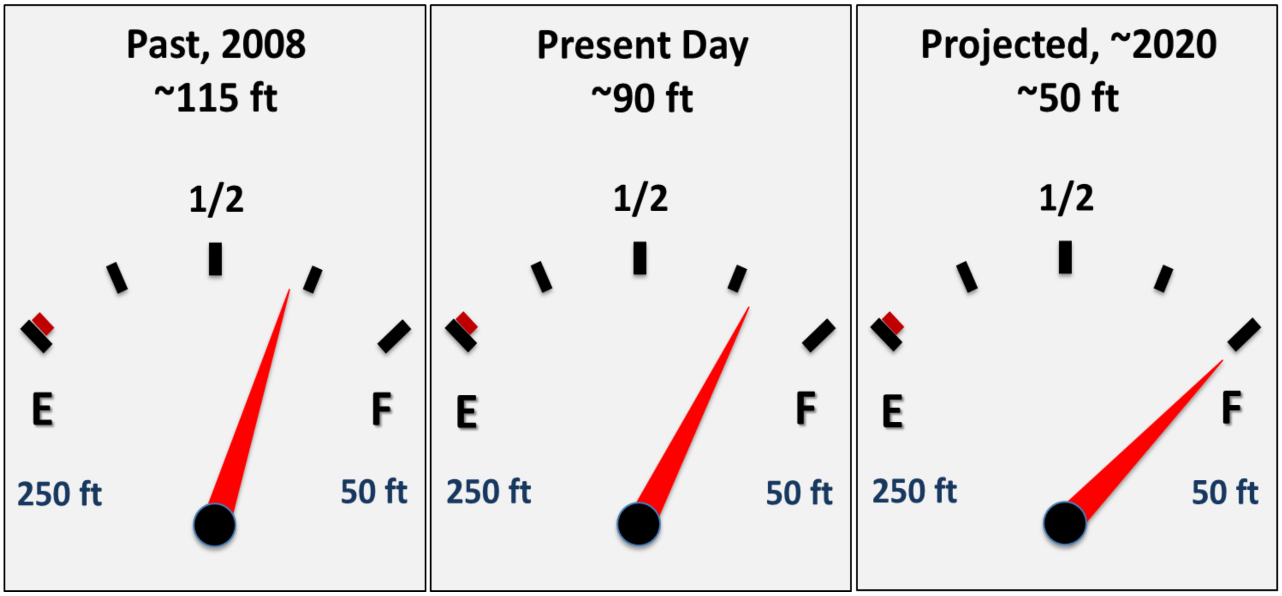
- **Monitoring and aquifer status update.** It will be necessary to regularly monitor the status of the aquifer and the system-wide water balance to estimate when a new project will be needed. Accordingly, it is proposed that status updates be generated on a regular basis. The updates will include a summary of the recent groundwater balance, current groundwater levels, and an assessment of projected future groundwater levels (Appendix 4.D).
- **Implementation level**. If the aquifer status updates project long-term groundwater levels below the Management Level, water supply projects will need to be planned or implemented. The projected groundwater level at which action needs to be taken is termed the "implementation level," and could be below the Management Level.

4.4.4.1 SIMPLIFIED WORKING RESERVE GRAPHICS

In order to simplify depiction of the proposed Working Reserve management plan, a simple gauge (comparable to a car's fuel gauge) is used for reporting the status of the Working Reserve at any time.

Figure 4.10 describes drawdown levels in the Working Reserve on the basis of Full (50 feet of drawdown relative to pre-development) and Empty (250 feet of drawdown).

Figure 4.10. Working Reserve Gauge



To be clear, each quarter of a tank corresponds to 50 feet of drawdown rather than a fixed quantity of water. On this scale, then, the selected Management Level of 110 feet of drawdown from pre-development levels corresponds to 70 percent.

4.4.4.2 MANAGEMENT SUMMARY

Because the management approach is based on a water balance with the current water rights and supply portfolio, the Management Level may change in the future as the water supply portfolio changes. For example, if additional wastewater were used for reuse and/or ASR, the amount of wastewater available for offsets would decrease, and therefore the amount of pumping might need to be reduced. Accordingly, the management approach presented here is flexible and can easily be adapted to changing conditions.

4.4.5 Economic Implications of Management Level Selection

The proposed GRMP is inherently hydrogeological in design. Nevertheless, it is important to highlight its economic implications—both internally for the Water Authority and its ratepayers, and externally for the capital markets and potential new customers.

Internal to the service area, the threshold of irreversible subsidence defines the overall Groundwater Reserve preventing major damage to surface infrastructure. While the value of this service is not easily quantified, the experience of other localities indicates that the damage can be sizable both by structural and economic measures, even extending into the billions of dollars. The Safety Reserve provides long-term insurance against curtailment, even outright rationing, of water use during periods when surface flows are partially or even completely unavailable.

While the number of different ways that surface supply can be interrupted makes the probability of that occurrence somewhat speculative, the consequences of that curtailment could be major, and the Safety Reserve is the last resort for providing supply in times of emergency. The economic injury and disruption to ratepayers can be estimated by what economists' term a "willingness-to-pay" analysis.

A 2002 report (Brown, 2002) estimated the value of the "drought reserve" component of the Safety Reserve and Working Reserve enabled by direct use of San Juan-Chama water to be in the range of $349 million to $1,117 million dollars ($425 million to $1,460 million in current dollars). More tangibly, the simple loss of revenue from curtailment is a minimum measure of its damage.

The Working Reserve functions like an active reservoir with some key differences. In particular, the absence of evaporative and transit losses from groundwater reservoirs is an attractive feature, though gravity imposes pumping costs on 'releases' from groundwater reservoirs that are absent from surface reservoirs. As with any reservoir, the services it provides include insurance, strategic flexibility (i.e. the temporal capacity to change supply strategies), immediate access and stability.

The Management Level of the Working Reserve is similar to the storage level at which a surface reservoir is operated but differs in an important aspect. Namely, because the major portion of inflows to the Working Reserve comes from the Rio Grande (river effects), the Water Authority must balance its withdrawals from the Working Reserve with rights to deplete the river or offsets to that depletion.

It is this balancing that has been heavily relied upon to set the initial Management Level at 110 feet of drawdown from pre-development conditions, because at that level of drawdown the Water Authority's rights and offsets can be effectively in balance with long-term river recharge.

This choice of Management Level warrants some additional discussion because it could have been set at a higher or lower level of drawdown (see 4.4.3.2 above), as long as it remains at or above the Safety Reserve. However, there are economic tradeoffs, unquantified in this report, in moving in either direction.

Setting the Management Level lower allows greater withdrawals from aquifer storage and therefore a longer lead time until new supplies are required. However, the Water Authority's long-term offset obligation increases in line with the graph in Figure 4.8 above. The illustration in Figure 4.9, for example, of a 200-foot Management Level (below pre-development conditions) would require more than 165,000 afy of offset obligations, imposing a major cost burden upon the Authority and ratepayers.

Moving in the other direction, choosing a higher Management Level implies that many of the Water Authority's water rights are not needed and would not be used. Moreover, the higher Management Level would accelerate the future date at which the Water Authority would have to bring new supplies online and would strand the economic investment in the current groundwater system.

Lastly, but perhaps the most important economic implication of setting a Management Level at 110 feet—or any other level of drawdown for that matter—is the necessity of replacing the water lost from storage if and when the Management Level is reached. A major reason the common problem of chronic aquifer drawdown occurs in the first place is the frequent practice of treating the water withdrawn from storage as if it were free when it is not.

In an urban setting like the Middle Rio Grande in which the aquifer provides services including the prevention of irreversible subsidence, protection against catastrophic drought or infrastructure damage from earthquakes, etc., the use of stored water with its consequential drawdown of the aquifer imposes opportunity costs (i.e. the lost opportunity to retain those aquifer services). Even though nature cannot require payment of these opportunity costs as they occur, thereby permitting the illusion that the water is free, the loss of services is nevertheless real.

One way, accordingly, of preventing a reoccurrence of chronic aquifer drawdown is to charge water users, i.e. ratepayers, the cost of replacing all water withdrawn from storage that lowers drawdown below the Management Level. Or, alternatively, advance actions can be taken to prevent a breach of the Management Level in the first place. If the latter alternative is available, it may well be less costly than replacing the water once it has been pumped. The balance of this report seeks to answer that question.

4.5 Summary

The Groundwater Reserve Management Plan was developed to balance the use of the aquifer as a resource and the ability to protect against potential irreversible land surface subsidence.

The selection of the 110-foot Management Level allows for the Water Authority to utilize all of their existing water rights and allows for setting aside a large portion of the Working Reserve for future use. The Safety Reserve provides a significant buffer to protect against subsidence and provide water for unanticipated conditions.

4.5.1 Summary of the GRMP

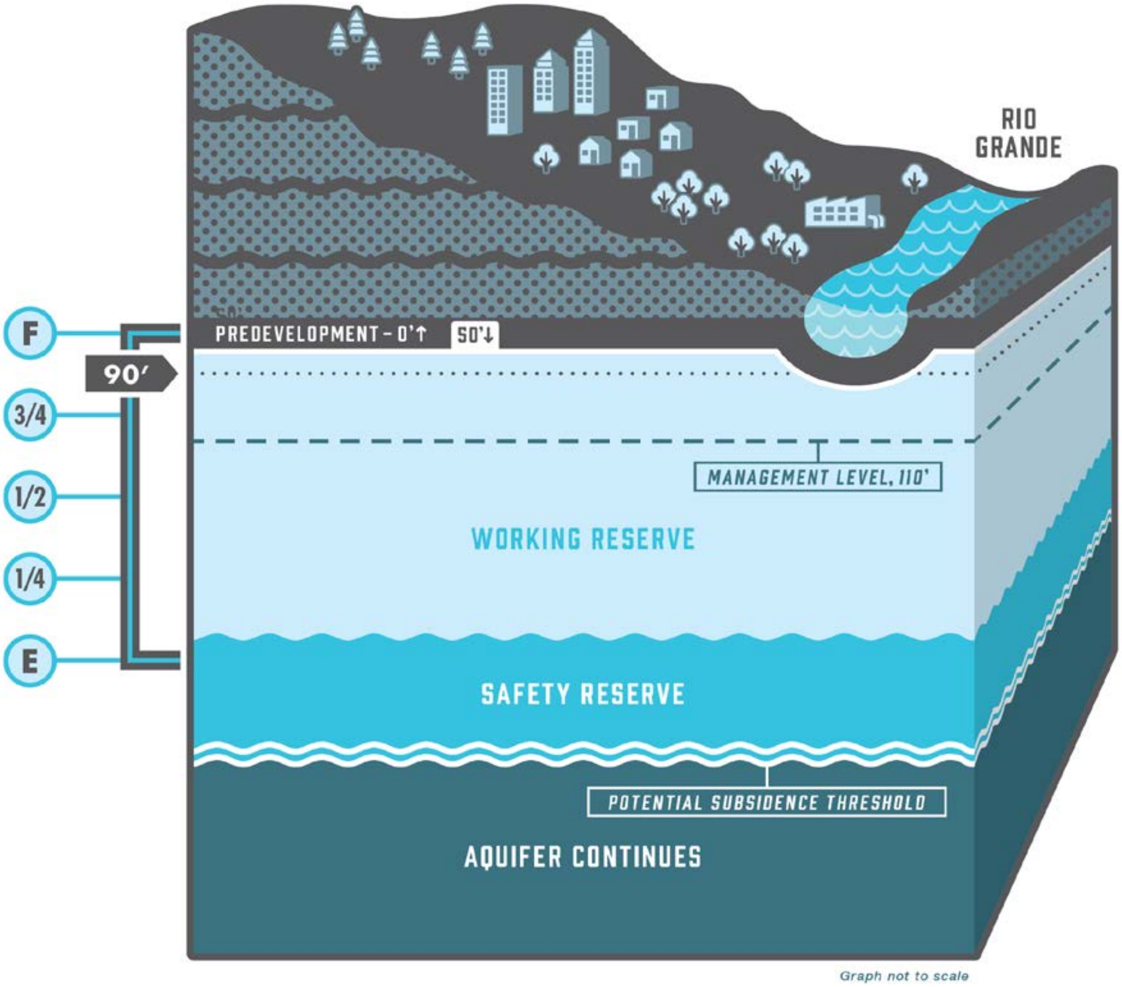
The GRMP can be summarized as follows:

- consistent with 2007 WRMS Policies B (utilizes the existing water rights owned by the Water Authority) and C (establish a ground-water drought reserve that maintains sufficient water in storage in the aquifer to provide water supply during a prolonged drought);
- establishes a Groundwater Reserve above a threshold of irreversible subsidence at

300 feet of drawdown from pre-development levels;

- broadens the concept of “drought reserve” to a Safety Reserve (250 to 300 feet of drawdown from pre-development conditions) as protection against all emergency, largely unquantifiable, supply-related events;
- defines a Working Reserve (Figure 4.11), from 50 to 250 feet of drawdown (above the Safety Reserve), which can be utilized and replenished depending on hydrologic conditions;
- sets a Management Level at 110 feet of drawdown within the Working Reserve as a goal measured by average well drawdown;
- results in no net long-term impact to the aquifer, barring emergency, once the Management Level is reached;
- utilizes a renewable groundwater supply.

Figure 4.11. Working Reserve Management Level



Graph not to scale

4.5.2 General Characteristics of the GRMP

General characteristics of the GRMP include:

- is founded on the best available science, supplemented by professional judgment
- conforms to the Rio Grande water balance as administered by the NMOSE
- can be applied in perpetuity.
- consistent with recent aquifer management experience, which has shown that aquifer management can result in rising water levels (aquifer replenishment)
- enables action decision points regarding new supply that are clearly defined and objective
- protects a large portion of the aquifer to provide options for future rate payers
- can serve as a model to other groundwater users in the Middle Rio Grande Basin and elsewhere

The Water Authority’s successful conservation program and implementation of the DWP have had significant positive effects on the aquifer and the sustainability of the Basin's water resources.

By designing and implementing a GRMP which turns a previously diminishing groundwater supply into a perpetually managed resource, the Water Authority will ensure a viable water supply for the 100-year planning horizon and beyond. Developing such a management instrument further enhances its innovative reputation externally, another important asset in itself.

4.6 References

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Appendix 4.A

Additional Discussion on the Middle Rio Grande Basin Aquifer

Appendix 4.A

Additional Discussion on the Middle Rio Grande Basin Aquifer

Additional Discussion on the Middle Rio Grande Basin Aquifer

This appendix summarizes the dynamic nature of the groundwater system. First, a description of historical conditions and the corresponding groundwater balance are presented. Historical conditions are used to describe the dynamic aquifer response to groundwater pumping. That response can then be applied to potential future conditions and help inform definitions of the Groundwater Reserve and its components, as well as form the basis for managing the aquifer. Because flow between the groundwater system and the Rio Grande cannot be directly measured, the NMOSE developed a numerical groundwater model of the Basin (NMOSE, 2001). The NMOSE model is the basis for quantitative calculations in this section.

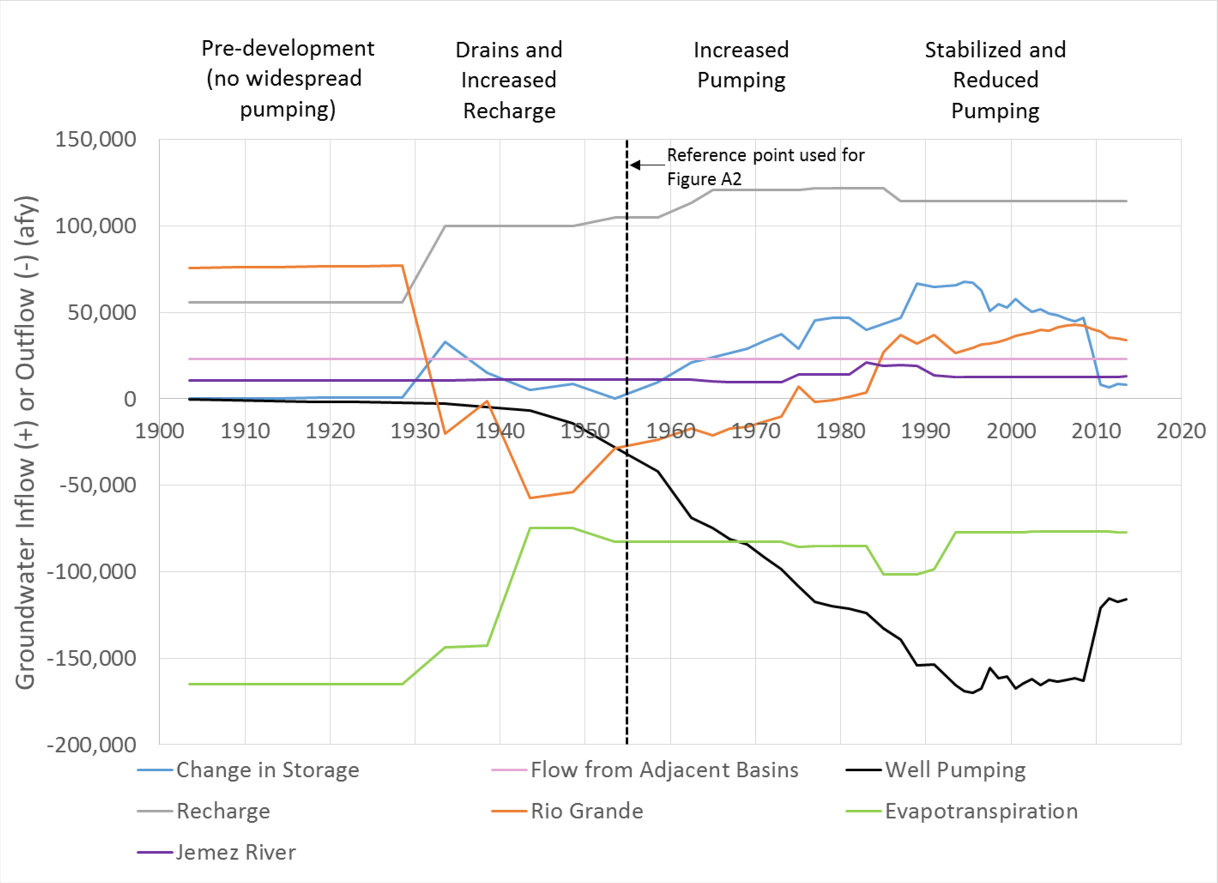
Source of Water to Wells

The NMOSE model begins simulation of irrigation components in the inner valley in the 1930s and includes canals and drains, as well as recharge from deep percolation of applied irrigation water (obtained through river diversions). Taken together, this entire system (referred to herein as the River System) is in direct connection with the aquifer. The flow rate of groundwater to the River System (or River System to groundwater) is dependent on both the elevation of the surface water (river, drains, and canals) and water levels in the aquifer.

Groundwater pumping by the Water Authority and others began to increase in the 1950s, and continued to increase until the early 1990s. In response to groundwater pumping, water was removed from aquifer storage so that water levels in the aquifer were drawn down. However, because the River System is in direct connection with the aquifer, this drawdown also resulted in increased recharge from the River System and/or decreased discharge to the River System (intercepted recharge) (Figure 4.A1).

Taken together, the increased recharge and/or decreased discharge are referred to as the “river effect.” The NMOSE generally requires that the river effect be offset in full. That is, the entity inducing the effect on the river must have enough surface water rights or other water sources, such as wastewater treated and discharged, to equal the pumping effect upon the Rio Grande.

Figure 4.A1. Simulated Historical Groundwater Balance



Simulated groundwater balance, NMOSE model

While groundwater pumping induces a river effect, there is not an immediate one-to-one relationship, and some portion of pumping comes from water previously stored in the aquifer. To compare the relative quantity of historical sources of water drawn from wells (all wells, not just Water Authority wells), NMOSE model groundwater balance terms were compared to those in the quasi-equilibrium period of the late 1940s (after drains were in place and increased recharge, but before large-scale increases in pumping). Results suggest that recently, the river effect has supplied more than 70 percent of water to wells, with previously stored aquifer water providing the remaining 30 percent (Figure 4.A2). The river effect has provided as much as about 100,000 afy to wells. To put this supply in context it is important to note the following:

a) Natural recharge, as noted, is about 100,000 afy (i.e. much of the effect is due to intercepting recharge water that otherwise would have discharged to the Rio Grande)

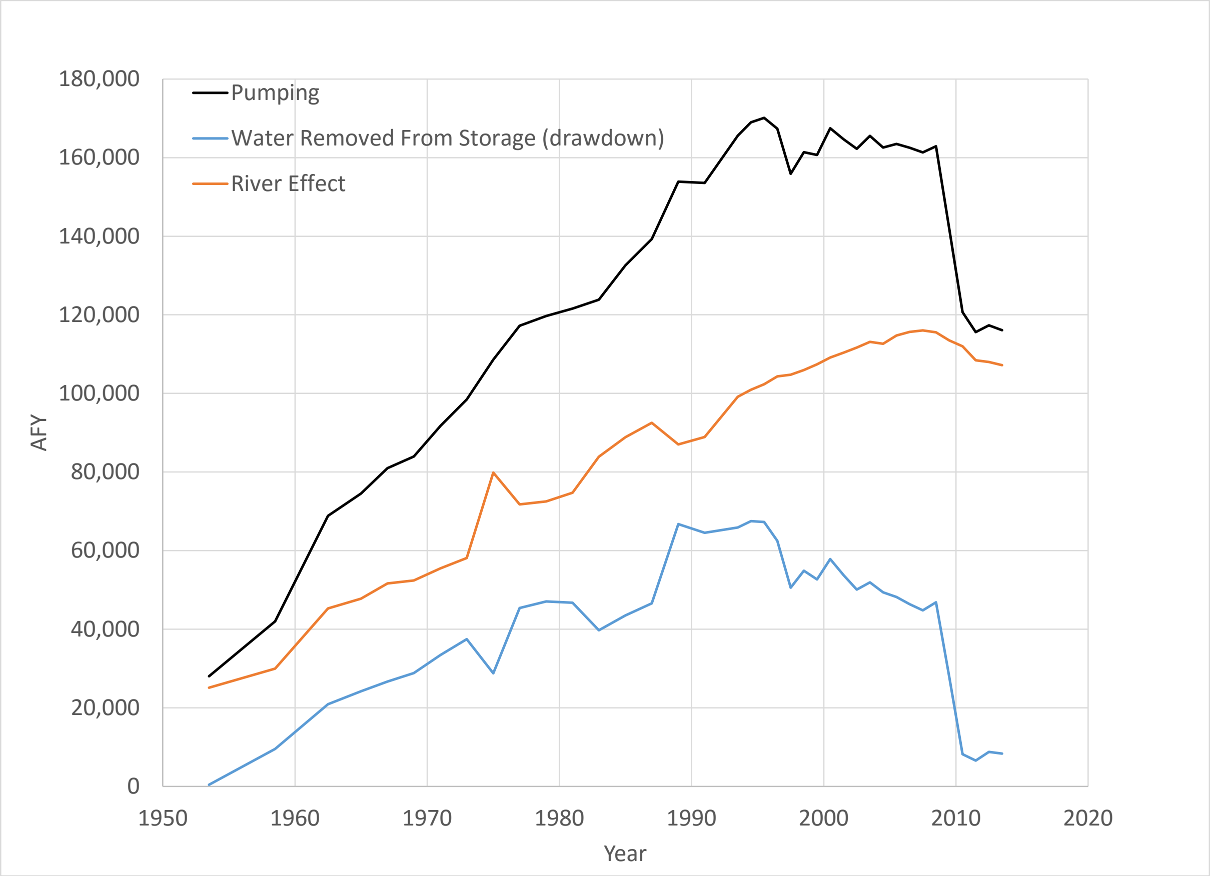
b) Average annual river flows are on the order of 1,000,000 afy, so the effect on the river is not large relative to total flow rates.

c) The NMOSE requires that effects of groundwater pumping on the river be offset.

Three important concepts are apparent from Figure 4.A2:

1. When aquifer pumping was increasing (e.g. 1950-1990; see black line in Figure 4.A2), the river effect also was increasing (see orange line in Figure 4.A2), but there was a time lag – pumping in a given year impacts the river system most in later years. During this time lag, aquifer drawdown continues as withdrawals from aquifer storage (blue line in Figure 4.A2) makes up the difference between pumping and river effects.
2. When groundwater pumping becomes relatively stable (e.g. 1990 to early 2000s; see black line in Figure 4.A2), the river effects (orange line in Figure 4.A2) tend to "catch up" and water withdrawal from storage (blue line in Figure 4.A2) becomes an increasingly smaller source of water to the wells.
3. If groundwater pumping is reduced, it is possible for the river effect to exceed the pumping rates. While this last impact has not occurred on a Basin-wide basis, it has happened in the Albuquerque area in recent years, where groundwater production was greatly reduced by the advent of the San Juan-Chama Drinking Water Project. The Water Authority's river effects, which are offset with treated wastewater and additional San Juan-Chama water, exceed the Water Authority's groundwater pumping, resulting in a net addition of water to the aquifer.

Figure 4.A2. Estimated Sources of Historical Water Pumped from all Wells in the Middle Rio Grande Basin



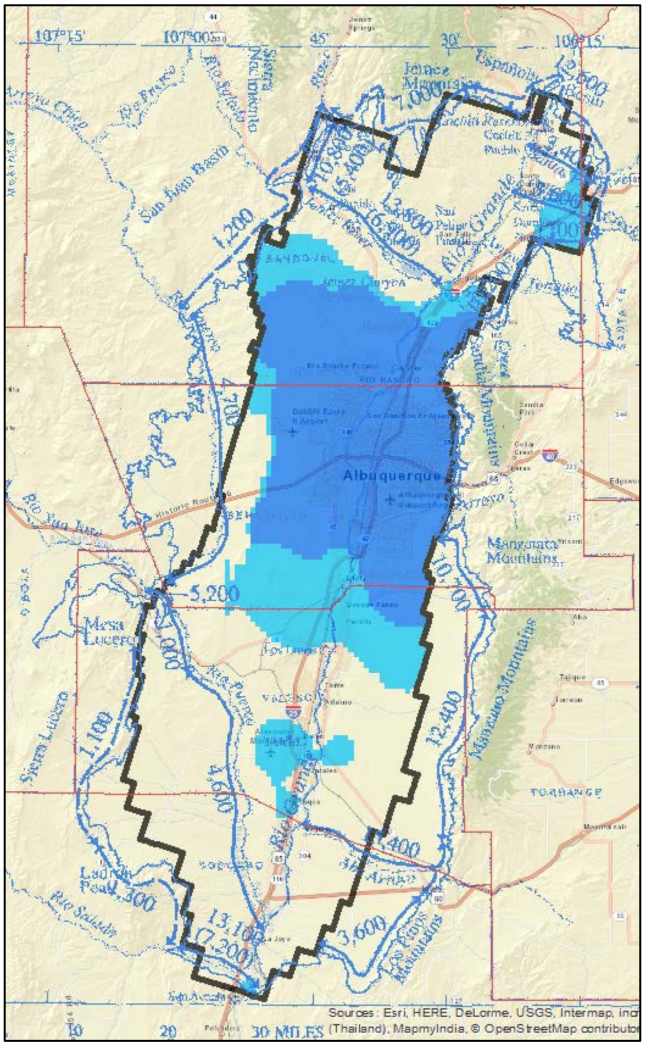
Based on result of the NMOSE model

While there is a lag time associated with pumping, drawdown, and river effect, the NMOSE model suggests that, if pumping were relatively stable over a long period, the river effect would approach an equilibrium state in which the river effect equals pumping from the aquifer. Timing to reach the equilibrium state depends on how far from equilibrium the system is, and could be on the order of 20 to 75 years. Once this equilibrium state is attained, groundwater elevations stabilize (e.g. no additional drawdown). The deeper the equilibrium state drawdown, the greater the river effect and the more pumping could be sustained in perpetuity without continued drawdown (as long as river water is available in sufficient quantity). This equilibrium concept is central to the GRMP.

Equilibrium Pumping Rates

While the drawdown due to historical pumping is large near pumping wells, it is relatively small in distant parts of the Basin. Given that only about 40 percent of the Basin has drawdown of more than three feet, there is room for the cone of depression to grow and additional river effects to ensue (Figure 4.A3).

Figure 4.A3. Simulated Drawdown, pre-development to 2012

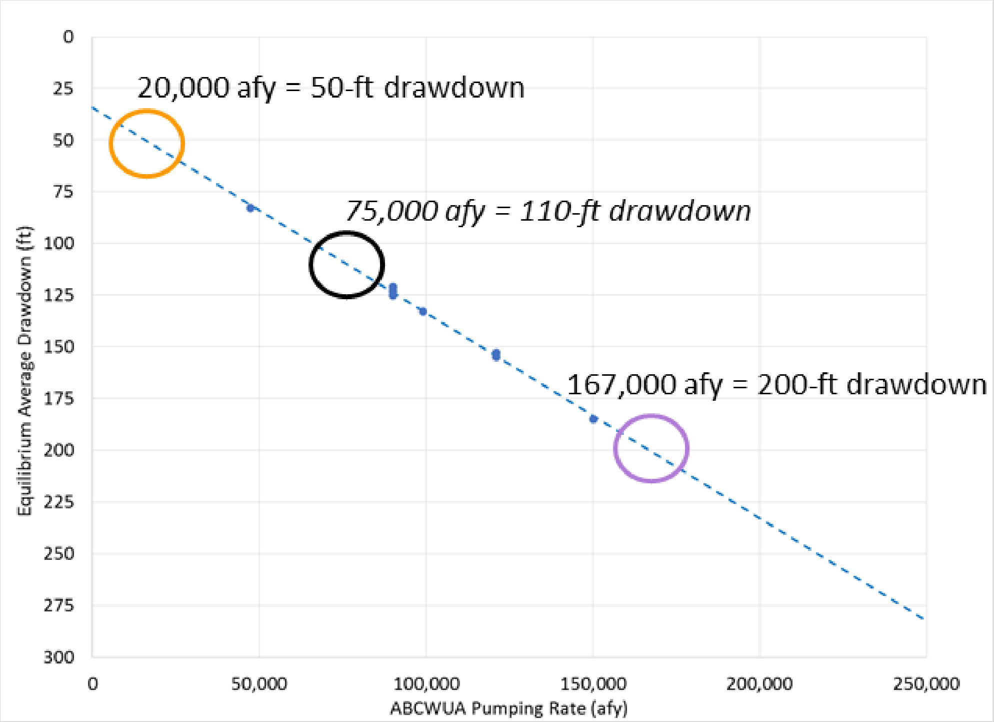


Light blue fill represents area of > 3 feet of drawdown, pre-development to 2012; Dark blue > 10 feet

The aquifer dynamics described in the preceding subsection demonstrate that that the deeper the equilibrium state drawdown, the greater the river effect and the more pumping could be sustained in perpetuity without continued drawdown (as long as river water is available in sufficient quantity). Accordingly, the NMOSE model was used to develop a relationship between equilibrium Water Authority pumping and drawdown levels (Figure 4.A4)[7]. The results indicate that if water levels were drawn down to, say, 200 feet, but not below, the aquifer system would produce more than 165,000 afy for the Water Authority[8] in perpetuity without further aquifer drawdown. This is a hypothetical illustration, without consideration of either the groundwater pumping permits or surface water rights required (the river effect would also approach the pumping rate of 165,000 afy). But, this relationship is an essential element of the GRMP.

In conclusion, due to the dynamic and interrelated nature of aquifer storage and pumping, aquifer zones are defined in terms of drawdown level from pre-development conditions, not volumes of water.

Figure 4.A4. Equilibrium Pumping Rates



Water Authority pumping rates that can be sustained in perpetuity at a particular average drawdown level, based on simulations using the NMOSE model

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[7] The model was run using a particular groundwater management threshold, in which wells automatically get turned off when the threshold is reached. A reasonable number of new wells, about 100, are allowed to then turn on to replace lost production. In each of these cases, pumping stabilized at a certain level, as water levels stabilized at or above the management threshold.

[8] Assuming 140,000 afy of pumping by others, in addition to the 165,000 afy of Water Authority pumping.

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Appendix 4.B

Subsidence Considerations

Appendix 4.B

Subsidence Considerations

For purposes of the present study, the Groundwater Reserve is defined at any given time as the groundwater that can be withdrawn from the aquifer, under the currently existing Water Authority NMOSE permits, from the then-remaining saturated thickness between the pre-development water table and the estimated drawdown elevation at which pre-consolidation stress would be exceeded and inelastic deformation would begin, resulting in irreversible subsidence and loss of storage capacity. Reversible subsidence attributed to groundwater withdrawal, as distinguished from irreversible subsidence, is predicted (Haneberg, 1999; Hohweiler, 1996) and has been observed (Heywood et al., 2002).

Heywood et al. (2002) cite evidence that suggests some inelastic (permanent) compaction and land subsidence may have occurred in the Rio Rancho area, but indicate that the evidence is not conclusive because of a lack of historical water level data.

The Water Authority retained a consultant, Gilbert F. Cochran, Ph.D., P.H., to study the available information relating to the potential for land subsidence caused by groundwater withdrawals and its consequences. The summary below is drawn from published sources and a University of New Mexico master's thesis by L.A. Hohweiler, but does not appear to be in conflict with the conclusions of Dr. Cochran.

Santa Fe Group Aquifer

Haneberg (1999) summarized his research relating to pre-consolidation stress in the Albuquerque area as follows: "[P]reliminary calculations…suggest that the Santa Fe Group aquifer beneath Albuquerque should be overconsolidated by about 1 to 1.5 MPa[9] directly beneath the river, suggesting that irrecoverable virgin compaction should not begin until the water level drawdowns exceed 100 to 150 m." This would imply that irreversible subsidence would not occur until water level drawdowns reached 328 feet to 492 feet from pre-development conditions. Haneberg also makes the point that his analysis is based on an estimate of the depth of incision by the river of the inner valley, about 150 feet, determined from geomorphic evidence, and does not take into account the unknown thickness of the Santa Fe and younger beds that have been eroded from the entire width of the valley. For this reason, his estimate of pre-consolidation stress is likely to be conservative. Hohweiler (1996) calculated pre-consolidation stresses equivalent to 665 feet and 847 feet of drawdown from pre-development water level conditions for the Atrisco No. 1 and Duranes No. 3 wells. These conclusions apply only to the Santa Fe Group aquifer, and not to post-Santa Fe sediments in the inner valley, as will be discussed below.

Heywood et al. (2002) report that "[i]nterferometric measurements of land-surface elevation change suggest that aquifer-system compression resulting from ground-water withdrawals in the Albuquerque area has probably remained elastic (recoverable) from July 1993 through September 1999." By late 1999 to 2001, the total drawdown from pre-development conditions had reached 100 feet or more beneath the area of Albuquerque east of San Mateo Boulevard and south of Osuna

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[9] MPa, megapascal. The pascal, Pa, is the SI unit of pressure (1 MPa = 10^6 Pa = 145.03 pounds per square inch).

Road (see, e.g., Bexfield and Anderholm, 2002), and was 120 feet or more for most of the north-south band lying between Eubank Boulevard and the Sandia Mountain front.

Post-Santa Fe Group Sediments

It is important to recognize that the 100-meter to 150-meter (328 feet to 492 feet) estimated threshold for irreversible subsidence does not apply to the post-Santa Fe Holocene deposits in the inner valley. These beds, typically less than 200 feet thick, have been subjected to little compaction and can be expected to undergo irreversible compaction as water is withdrawn from them. This appears to have occurred in places within the inner valley. For example, Love and Connell (2009) report “[a]s the inner valley of the Rio Grande filled with sediment, thin lenses of low-density peat, representing former ponds and marshes, became buried. As pumping of groundwater from parts of the valley progresses, these peat deposits dry and compact, resulting in local damage to buildings in the North Valley.”

Subsidence-Based Criterion for Determining Safety Reserve

The criterion for measuring theWater Authority Safety Reserve is a maximum drawdown of 300 feet from the pre-development position of the water table, as calculated for the cell in the NMOSE model in which a particular production well is completed. The 300-foot value was chosen as a conservative approximation of the 100-meter lower value in the range estimated by Haneberg. Because of the differences between the characteristics of the Santa Fe Group aquifer and the post-Santa Fe deposits, and the much greater susceptibility of the latter to permanent subsidence due to groundwater withdrawal, the estimate of the Safety Reserve is based on pumping from Water Authority production wells that are outside of the inner valley where the post-Santa Fe beds are present.

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Appendix 4.C

Safety Reserve Examples

Appendix 4.C

Safety Reserve Examples

Due to the dynamic and interrelated nature of aquifer storage and pumping, the Safety Reserve is defined in terms of drawdown level from pre-development conditions.

Based on the pumping-drawdown relationship depicted in Figure 4.8 of the main body of this chapter, the Water Authority could physically pump over 200,000 afy in perpetuity and still maintain water levels above the Safety Reserve under normal conditions[10]. However, the central purpose of the Safety Reserve is to supply water under unforeseen events. Accordingly, the NMOSE model was used to simulate water available to the Water Authority under a range of future conditions[11] beyond the planning scenarios, as summarized below:

- Case 1: Minimal surface water available to the Water Authority over a 20-year period at the end of the 100-year planning period. If the Water Authority can only use 10 percent of its San Juan-Chama allotment, and the Rio Grande flows are similar to historical flow, the NMOSE model indicates that the aquifer could sustain groundwater pumping to meet the entire final 20 years of demand under the “medium” demand scenario (year 2100-2120; total demand between 218,000 afy and 243,000 afy). After this 20-year period, the Water Authority would need to reduce pumping. But, the Water Authority could continue to pump at the full currently permitted amount (165,000 afy) in perpetuity even after this acute 20-year event.
- Case 2: Rio Grande average flow reduced to 30 percent of historical flow and equivalent reduction of irrigation and mountain front recharge to 30 percent of historical. The NMOSE model indicates that the aquifer could sustain Water Authority pumping rates at or close to the full, currently permitted amount in perpetuity, even under these extremely low surface water flow conditions.

Based on NMOSE model analysis under a wide array of extreme hypothetical future conditions, the Safety Reserve could continue to meet all essential water demands, even at the end of the planning period (e.g. 2120 population of 1.8 million people), for an unlimited period of time without the risk of irreversible subsidence.

This definition of the Safety Reserve is also consistent with NMOSE guidelines, which recommend that aquifers not be drawn down beyond 250 feet. NMOSE guidelines are conservative and are recommendations for operating limits for new appropriations. Accordingly, it should be noted that the guidelines are not regulatory in nature, and do not apply to the Water Authority’s existing water rights. Based on the literature, it appears that irreversible subsidence occurs at more than 300 feet of drawdown. However, based upon professional judgment a maximum of 250 feet of drawdown appears to provide a reasonable Safety Reserve without reaching the physical irreversible subsidence threshold.

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[10] There is sufficient flow in the Rio Grande to continue recharging the aquifer.

[11] For consistency, in all cases, it is assumed that others in the Basin are pumping 140,000 afy. In addition, it is assumed that the Water Authority has the ability to add a reasonable number of new wells. Finally, these extreme cases do not explicitly consider water rights or compact compliance; rather they solely examine groundwater availability for emergency supply outside of the foreseeable future condition.

Appendix 4.D

Groundwater Monitoring

Appendix 4.D

Groundwater Monitoring

This appendix summarizes the Water Authority's groundwater monitoring program, performed in collaboration with the USGS, and how groundwater level data collected from the monitoring program will be used to facilitate execution of the Groundwater Reserve Management Plan (GRMP). Collection of high quality groundwater level data is important for the following reasons:

- Track the status of the aquifer.
- Evaluate the effect of water supply alternatives on the aquifer.
- Allow for the Water Authority to react to changing supply and demand conditions before supplies become critical.

Key actions recommended in this appendix include the following:

- Continue the collaborative Water Authority / USGS groundwater monitoring program.
- Provide regular aquifer status update reports.
- Every 10 years, in conjunction with Water Resource Management Strategy updates, perform an evaluation of how well the NMOSE groundwater model is simulating observed changing aquifer conditions. Based on this evaluation, recommendations for simulating future aquifer conditions can be made (e.g., use model as is, apply a correction, or recalibrate).

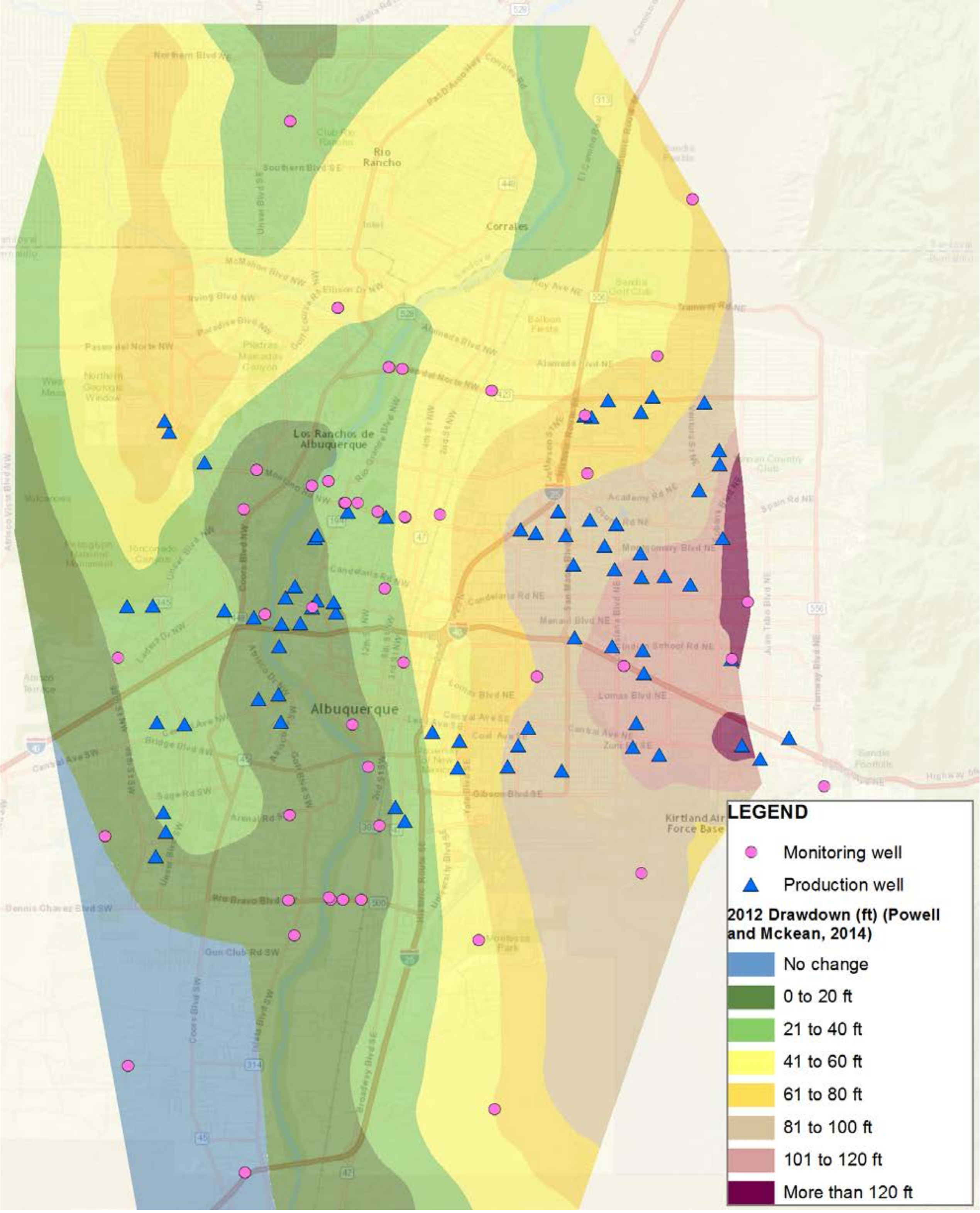
Water Authority / USGS Monitoring Program

The joint Water Authority / USGS groundwater monitoring program was begun in 1996. Wells and piezometers were drilled with the express purpose of monitoring groundwater levels in the Albuquerque area. As of 2014, the monitoring network consists of 125 wells and piezometers, most of which are located between production wells to provide representative aquifer conditions, less influenced by on/off cycles of production wells. Additional information about the monitoring program can be found at http://nm.water.usgs.gov/projects/piezometers/piezometers.city.new.

In addition, the Water Authority measures groundwater levels in production wells. The purpose of monitoring the production wells is to augment the monitoring network discussed above. Production wells are typically shut off for a period of at least two weeks during the winter (when demand is lower), to allow the aquifer to recover and obtain representative static water level measurements. The USGS has used these data, in conjunction with the monitoring network and other regional data, to develop regional drawdown maps (Powell and McKean, 2014; Falk et al., 2011; see Figure 4.D1). Typically the static water levels in production wells match the regional drawdown trends observed in monitoring wells.

It is recommended that these monitoring programs be continued in the future to facilitate evaluation of the aquifer.

Figure 4.D1: Water Authority / USGS Monitoring Well Network and Observed Drawdown[12]



Aquifer Status Updates

As part of the GRMP, it is recommended that regular aquifer status updates be generated. It is anticipated that the updates may include the following information:

- Recent annual groundwater pumping totals
- Recent annual river effect due to Water Authority pumping
- Calculated change in aquifer storage due to Water Authority
- Summary of observed aquifer drawdown or drawup, in the context of the management level and the projected drawdown included in **Water 2120**
- Summary of simulated aquifer drawdown or drawup, compared to observed
- Updated "gage" showing current aquifer level

Evaluation of NMOSE Model for Predictive Capability

The GRMP sets an initial aquifer management level of 110 feet below pre-development conditions. The level was selected based on results from the NMOSE Model. The NMOSE model was also used to estimate future groundwater levels in response to implementation of water supply portfolios in the 2017 WRMS, and these projected groundwater levels were a key consideration in development of the portfolios. Accordingly, it is important to understand how suitable the NMOSE model is for predicting future conditions. This section summarizes how well the model fits to observed data, and sets forth a plan for future assessment of how well the NMOSE model can forecast future conditions.

The NMOSE model was developed prior to implementation of the Drinking Water Project and subsequent aquifer recovery. Accordingly, at the time of development, the model performance/calibration were evaluated with respect to how well it simulated aquifer drawdown. Both the magnitude and historical trend of simulated and observed drawdown match reasonably well (Figure 4.D2), with a slight over-prediction of drawdown in the 2000s. Spatially, historical drawdown is generally more over-predicted near the Rio Grande, compared with areas further from the Rio Grande (Figures 4.D3 and 4.D4).

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[12] The difference between the USGS drawdown map presented here and simulated drawdown presented in Chapter 4 is primarily due to the fact that the pre-development reference point used by the USGS for calculation of drawdown is based on a later time period than the reference point used in the NMOSE model evaluation. The USGS uses water level data from the 1950s, the earliest time when there was reasonable spatial data coverage available, whereas the drawdown based on the NMOSE model (and used in this report), is based on a (higher) simulated condition prior to any significant groundwater pumping. The result is that simulated drawdown presented in the GRMP is typically greater than drawdown reported by the USGS.

The Water Authority uses the NMOSE pre-development condition as the reference point, which is consistent with the administrative model and all modeling performed in support of development of the GRMP.

Figure 4.D2: Time-Series Representation of Observed and Simulated Drawdown

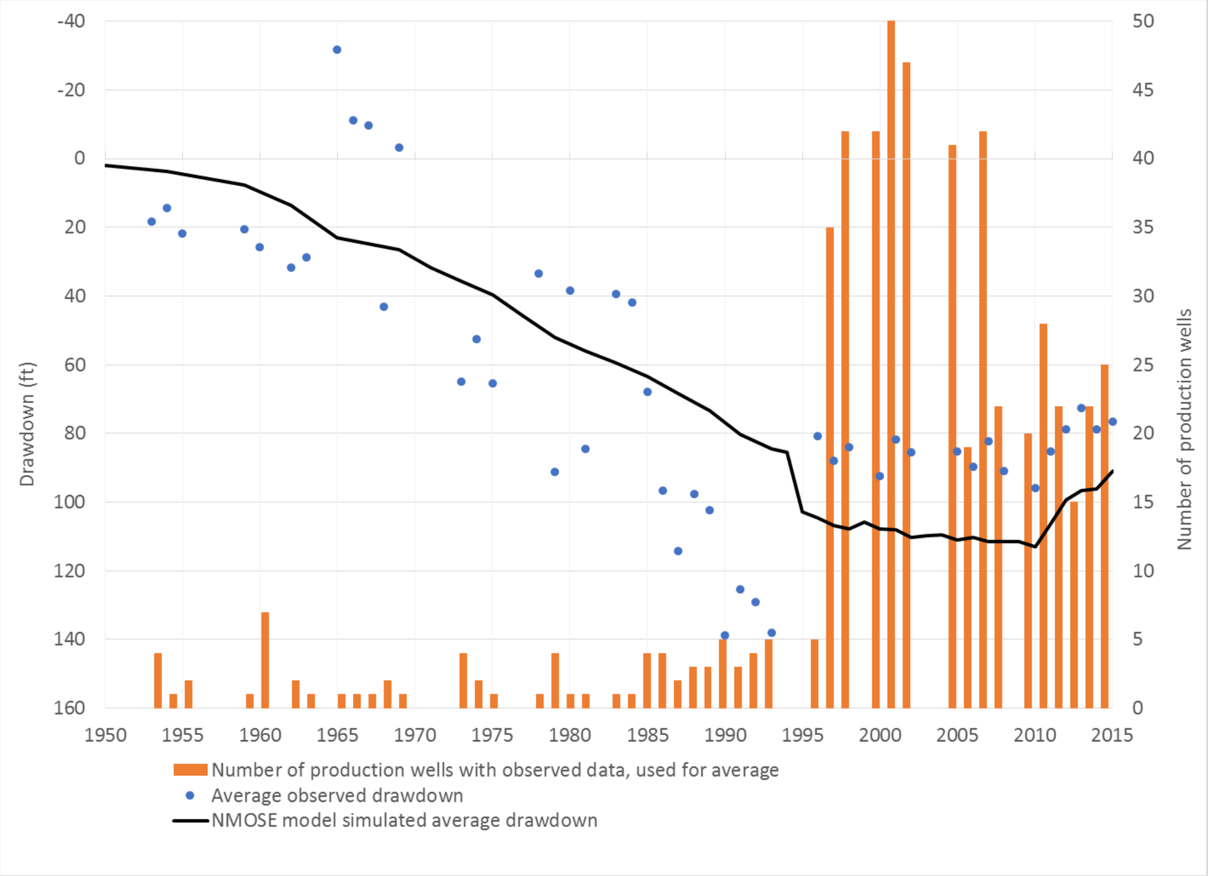


Figure 4.D3: Spatial Representation of Observed and Simulated Drawdown, 2007

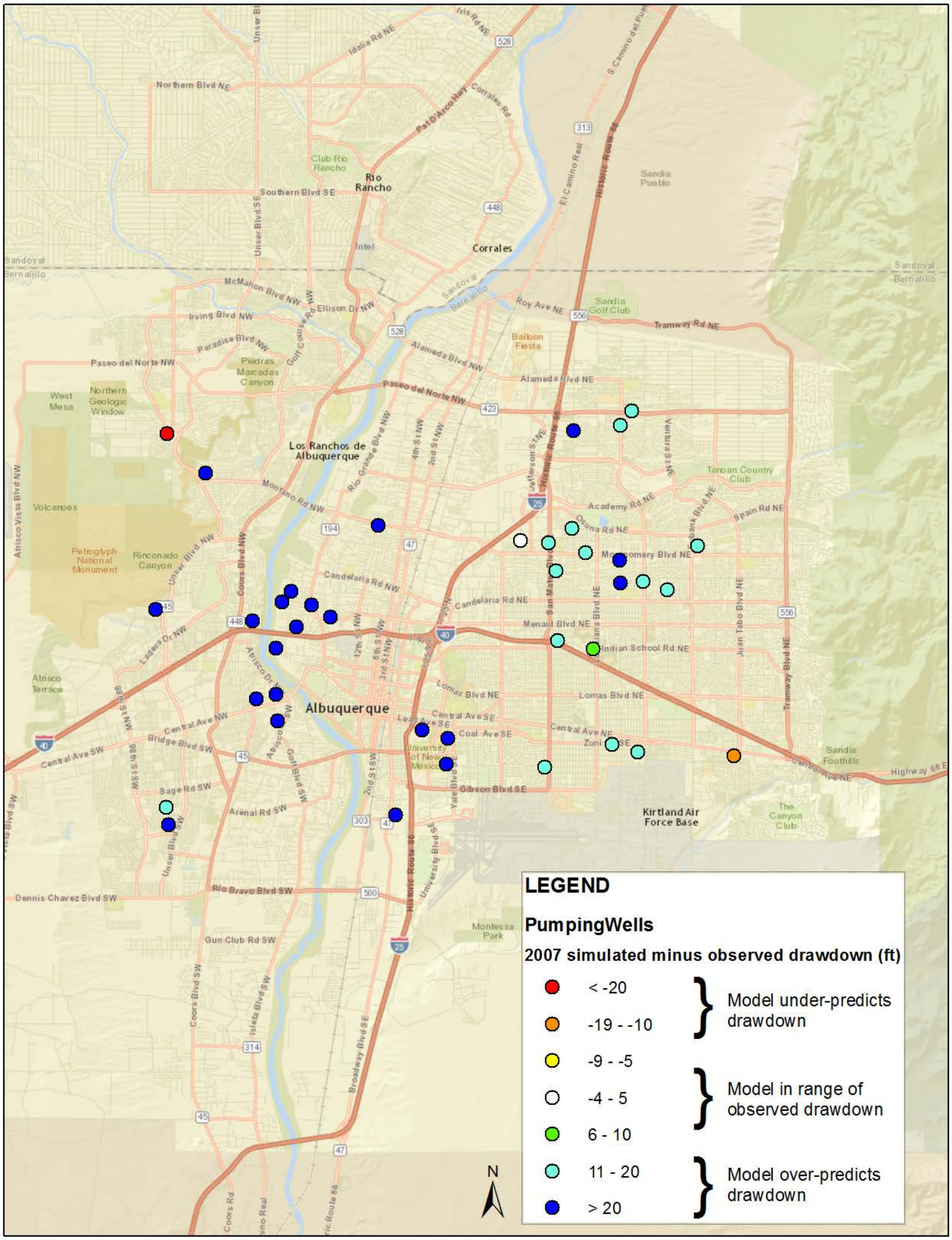
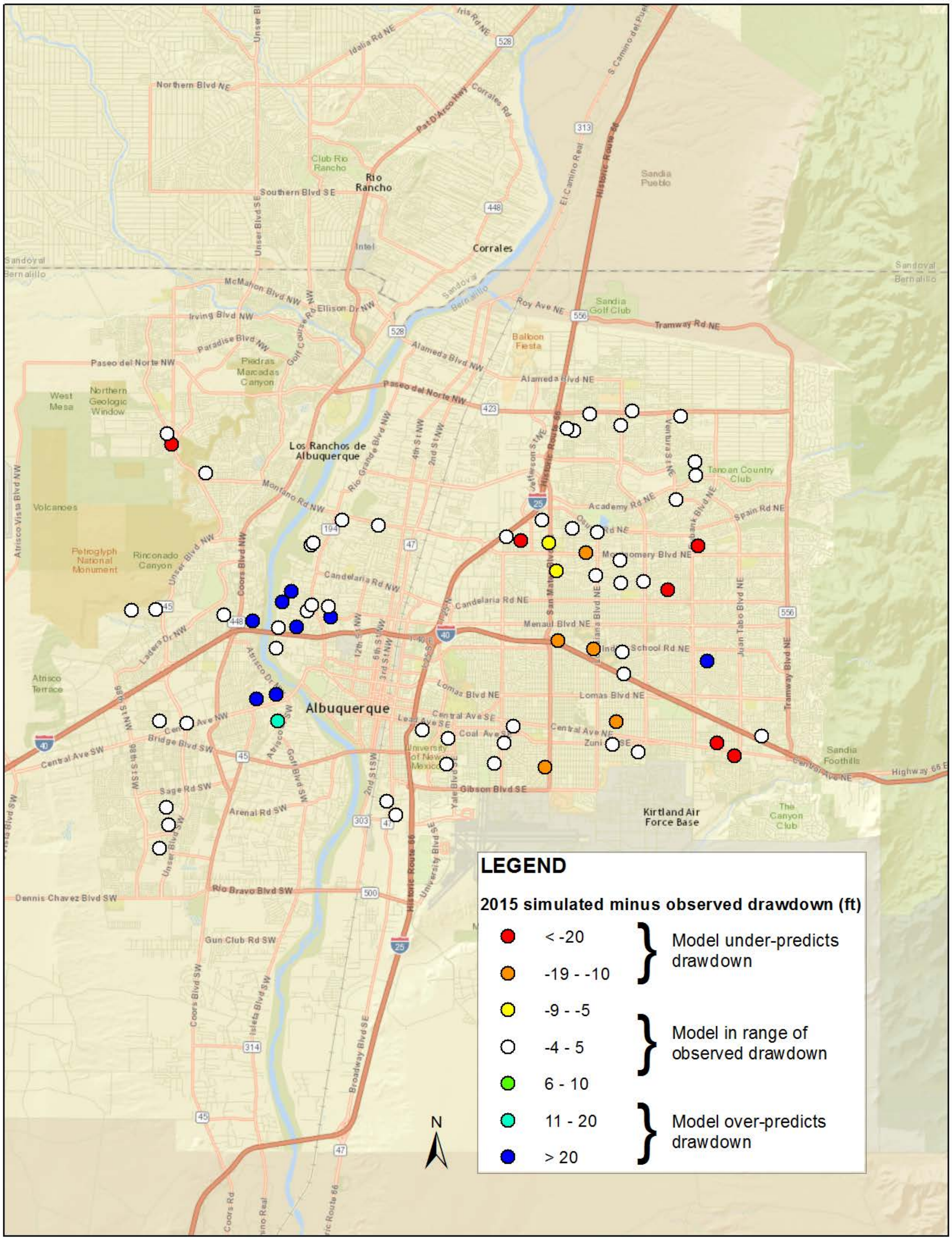


Figure 4.D4: Spatial Representation of Observed and Simulated Drawdown, 2015



It is recommended that model-simulated conditions be compared to observed conditions about every 10 years, in conjunction with Water Resources Management Strategy updates. The evaluation would be similar to the preceding evaluation. If it becomes apparent that there is significant deviation between observed and simulated, it is recommended that an evaluation be performed to estimate how model inaccuracies could affect model predictions, in the context of the management approach outlined in the GRMP. Should significant issues arise, a first-step approach could be to apply a correction to translate model results to real-world results; a potential next step could be to coordinate model re-calibration with NMOSE.

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Water 2120:
Securing
Our Water
Future

CHAPTER 5

Alternatives

5

CHAPTER 5

5.1 Introduction and Purpose

To meet projected water demand over the next 100 years, it is anticipated that new supplies or utilization of existing excess supplies may be required, depending on the availability of surface water.

This chapter presents a brief description of supplies currently in development and information on new supply alternatives that may be used in subsequent WRMS development.

The 1997 WRMS identified and proposed a number of water supply and reuse/recycling projects for evaluation and potential implementation. These projects included the SJC DWP (San Juan-Chama Drinking Water Project), Southside Reuse, the NPP (North I-25 Non-Potable Project), and others.

At the time of the development of the 2007 WRMS, a number of these projects had been fully implemented or were underway. Currently, projects developed as part of previous strategies have also been implemented or are in the permitting process, including:

- Expanded use of Abiquiu storage
- ASR
- Reuse expansion

Projects underway from the 1997 or 2007 WRMS are included in projections of future supply for planning purposes.

Potential ongoing and new supply alternatives considered in the 2017 WRMS include:

- Enhanced water conservation
- Additional surface water use
- Stormwater capture and use
- Watershed management
- Fee, credit, or banked water
- Non-potable reuse of treated wastewater
- Indirect or direct potable wastewater reuse
- Additional large-scale ASR
- Surface storage
- Interbasin water transfer and use
- Produced water
- Additional water rights acquisition
- Brackish groundwater

The alternatives listed above represent broad categories, many of which may include sub-alternatives. For example, surface water use could include utilization of excess SJC water, lease of SJC water, or a new diversion. Any of these could connect to existing facilities or could require new facilities.

The alternatives range from sources that allow for the efficient use of existing resources (e.g. surface storage, reuse, etc.) and enhance supply and our ability to use supplies (e.g. watershed management), to alternatives that add new water to the basin in relatively large quantities that can be beneficially and consumptively used (e.g. interbasin transfer).

Likewise, some of these options use the same supplies and could be mutually exclusive, like non-potable reuse and indirect or direct potable reuse. Others may depend on existing or new infrastructure for utilization, like interbasin transfer or water rights, and may need to be combined with other options.

These options provide yields estimated to range from 500 to 33,000 afy over the planning period and differ significantly in complexity and implementability.

This document summarizes ongoing and new water supply alternatives potentially available for the WRMS related to supply and demand projections through 2120.

5.2 Projects Underway from 1997 and 2007 WRMSs

A number of projects have been planned or are currently in progress resulting from the 1997 and 2007 Strategies. They are included in the baseline along with other current supplies and are as follows:

5.2.1 Abiquiu Storage

- **4831 Application.**
  This permit allows for native storage in Abiquiu Reservoir and direct diversion of native water. The application for permit has been submitted. This permit would allow for storage and direct appropriation of flows in excess of Rio Grande Compact maximum delivery credit, flows in excess of senior water rights holder's needs, or flood flows.
- **Water fees for use of storage.**
  The Water Authority is currently requiring users of its storage space in Abiquiu Reservoir to pay for said use by providing water to the Water Authority. At present a fee of 10 percent of the stored amount is required.
- **Payback of borrowed water.**
  Water has been borrowed from the Water Authority by the Middle Rio Grande Conservancy District (MRGCD), Reclamation and others. About 45,000 ac-ft is currently owed to the Water Authority. This water is scheduled to be paid back to the Water Authority in the future.

5.2.2 ASR

- **Large-scale ASR.**
  Borings, initial testing, and system design have been completed. A dedicated ASR well will be completed at the Water Treatment Plant (WTP) site to test the concept, as well as vadose zone infiltration wells.
- **Bear Canyon Recharge.**
  The Bear Canyon Recharge project is permitted for up to 3,000 ac-ft. It is currently operated at about 1,000 ac-ft over a winter season. This current amount can be increased with the construction of a bridge at Arroyo del Oso Golf Course. This bridge would allow for golf carts to cross the infiltration area.
- **New groundwater wells.**
  Replacement wells are planned and some of these will be completed as dual use wells for ASR. These new wells will allow for SJC water to be stored in the aquifer in the winter, when WTP capacity is greater than demand. This water could then be extracted in summer months, resulting in no net reduction in groundwater level.

5.2.3 Reuse

- **Southside Reuse build-out**.
  The Southside Reuse project is operational, but has remaining capacity of about 700 ac-ft that can be utilized. Additional users are being actively sought, and it is anticipated that full capacity will be reached in the near term.

5.3 New Alternatives

This chapter summarizes alternatives considered as possible new supplies to be used to fill potential future gaps between supply and demand. These gaps, further discussed in Chapter 6, may arise due to increases in overall demand due to population change or new industry, reductions in supply due to climate change, or from some combination of changes in supply and demand.

Each alternative is briefly described along with the associated infrastructure needs, considerations of particular interest, and any potential policy considerations. Likewise, criteria of individual alternatives that could be used to help select alternatives for future use were developed and are discussed in Appendix 5.A.

Selected criteria are presented in Table 5.1 and include:

- Yield
- Reliability
- Frequency of availability
- Regional impact
- Technical feasibility
- Permitting
- Time to implement
- Cultural, historical, and aesthetic values
- Socioeconomic impact
- Ecosystem protection
- Carbon footprint

These combined criteria will assist in selecting individual alternatives for future water supply portfolio development and ultimate implementation.

For example, a portfolio considering the most reliable alternatives with the smallest carbon footprint, or a portfolio with alternatives that are the most technically feasible with the shortest time to implement could be considered.

Alternatives could then be ranked based on the criteria, and then could be selected for implementation based on expected needs. Portfolio development and alternative costs are presented in Chapter 6 and Appendices B and C. Note that in a few cases yields for some alternatives were modified during the portfolio development process.

Sections 5.3.1 through 5.3.21 present each representative alternative, quantification of associated criteria, and performance information.

Table 5.1. Criteria for Evaluation of Alternatives

		Ranking Guide				
Evaluation Categories	**Criteria**	**1**	**2**	**3**	**4**	**5**
Long-Term Sustainability and Resiliency	**Yield**	Calculated normalized value based on the range of nominal yield (project capacity) of the alternatives under consideration (1 = highest relative yield, 5 = lowest relative yield)	Calculated normalized value based on the range of nominal yield (project capacity) of the alternatives under consideration (1 = highest relative yield, 5 = lowest relative yield)	Calculated normalized value based on the range of nominal yield (project capacity) of the alternatives under consideration (1 = highest relative yield, 5 = lowest relative yield)	Calculated normalized value based on the range of nominal yield (project capacity) of the alternatives under consideration (1 = highest relative yield, 5 = lowest relative yield)	Calculated normalized value based on the range of nominal yield (project capacity) of the alternatives under consideration (1 = highest relative yield, 5 = lowest relative yield)
	Reliability	Calculated normalized value based on yield and the number of years that the supply is available out of 100 (1 = highest reliability, 5 = lowest reliability)	Calculated normalized value based on yield and the number of years that the supply is available out of 100 (1 = highest reliability, 5 = lowest reliability)	Calculated normalized value based on yield and the number of years that the supply is available out of 100 (1 = highest reliability, 5 = lowest reliability)	Calculated normalized value based on yield and the number of years that the supply is available out of 100 (1 = highest reliability, 5 = lowest reliability)	Calculated normalized value based on yield and the number of years that the supply is available out of 100 (1 = highest reliability, 5 = lowest reliability)
	Frequency of Availability	Calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available (1 = highest relative frequency of availability, 5 = lowest frequency of availability)	Calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available (1 = highest relative frequency of availability, 5 = lowest frequency of availability)	Calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available (1 = highest relative frequency of availability, 5 = lowest frequency of availability)	Calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available (1 = highest relative frequency of availability, 5 = lowest frequency of availability)	Calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available (1 = highest relative frequency of availability, 5 = lowest frequency of availability)
Implementability	**Regional Impact**	Expected to have a positive impact on areas outside of the region	Expected to have a small positive impact on areas outside of the region	Expected to have a neutral impact on areas outside of the region	Expected to have a small negative impact on areas outside of the region	Expected to have a negative impact on areas outside of the region
	Technical Feasibility	Existing assets can be used; operation and maintenance (O&M) costs are known and expected to be low; technology is well-established and currently being used by the Water Authority	Existing assets can be used; O&M costs are expected to be moderate; technology is well-established and currently being used by the Water Authority	New assets are required; O&M costs are expected to be moderate; technology is well-established but not currently being used by the Water Authority	Requires new assets; O&M costs are expected to be moderate to high; technology is new or emerging and not currently being used by the Water Authority	Requires new assets; O&M costs are expected to be high or are unknown; technology is new and not yet proven beyond the pilot scale; technology is not currently being used by the Water Authority
	Permitting	Can be implemented under the Water Authority's current permits	Requires modification or amendment to current Water Authority permits	Requires that new or revised permits be issued, which would include a public comment process	Requires changes to current permitting practices, and would likely entail public comment and/or litigation	Requires new legislation or significant changes to current permitting practices to be implemented, and would likely entail extensive public comment and/or litigation
Timing	**Time to Implement**	Expected to be able to be permitted and implemented within one year	Expected to be able to be permitted and implemented within 2 to 4 years	Expected to be able to be permitted and implemented within 5 years	Expected to be able to be permitted and implemented within 10 years	May require decades to permit and implement
Quality of Life	**Cultural, Historical and Aesthetic Values**	It is expected that no cultural, political, ethnic, regional or tribal group will perceive inequalities in costs and benefits of the project and some are expected to support it	It is expected that no cultural, political, ethnic, regional or tribal group perceives inequalities in costs and benefits of the project	It is expected that few cultural, political, ethnic, regional or tribal groups may perceive inequalities in costs and benefits of the project but it is expected that supporters outnumber opponents	It is expected that some cultural, political, ethnic, regional or tribal groups perceive inequalities in costs and benefits of the project and may identify the alleged inequalities in cost bearing or distribution of benefits	It is expected that some cultural, political, ethnic, regional or tribal groups perceive inequalities in costs and benefits of the project and strongly oppose the project and/or opponents outnumber supporters
	Socioeconomic Impact	Adequate supply to support socioeconomic benefits including industrial and residential growth, support for recreational opportunities, and amenities such as parks and landscaping are fully supported throughout the service area	Adequate supply to support some growth and development while also supporting recreational opportunities and public amenities such as parks and landscaping	Adequate supply for recreational opportunities and public amenities such as parks and landscaping, but inadequate supply to support growth and development	Inadequate supply for full recreational opportunities and some public amenities such as parks and landscaping	Inadequate supply for recreational opportunities and amenities such as parks and landscaping
Environmental Protection	**Ecosystem Protection**	Expected to increase habitat and bosque area, and/or improve the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley	May slightly increase habitat and bosque area, and/or improve the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley	Expected to have no impacts to the habitat and bosque area, nor the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley	May slightly decrease the habitat and bosque area, and/or impact the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley	May decrease the habitat and bosque area, and/or impact the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley
	Carbon Footprint	Expected to have minimal energy requirements, and result in a minimal carbon footprint	Expected to have low energy requirements, and result in a low carbon footprint	Expected to have moderate energy requirements, and result in a moderate carbon footprint	Expected to have high energy requirements, and result in a high carbon footprint	Expected to have significant energy requirements, and result in a significant carbon footprint

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5.3.1 Conservation

Overview

Historical water conservation goals have resulted in a decrease in water usage rate from about 250 gpcd in the early 1990s to around 135 gpcd recently. This 46 percent reduction in water usage rate has resulted in a reduction of about 30 percent in annual demand, while the population served has nearly doubled. New conservation goals will play a role in reducing future gaps in supply and demand. Based on current operations and Water Authority policies, the effects of conservation will primarily be seen in the reduction of groundwater use.

Description

This alternative has three sub-alternatives with varying goals as follows:

- C1 – Goal of 120 gpcd by 2027
- C2 – Goal of 110 gpcd by 2037
- C3 – Goal of reducing outdoor use by 10 gpcd over 30 years

Savings will increase gradually over time as the program is implemented and will continue to accrue after the goal is reached. On average the reduced demand (yield equivalent) is approximately 18,800 afy under C1, 30,300 afy under C2, and 12,600 afy under C3.

Infrastructure Needs

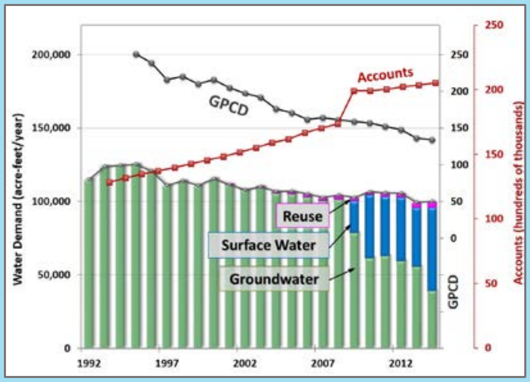
No new infrastructure is required to implement conservation goals.

Other Considerations

Reduced water use also results in reduced revenue which can impact overall Water Authority finances. Loss of revenue and impacts on rates should be considered when evaluating these alternatives, particularly when compared to projects that require capital outlay.

While water conservation has resulted in significant reductions in demand, there are limitations on the Water Authority's ability to conserve without impacting overall quality of life. Community goals regarding minimum technically feasible indoor and outdoor water usage levels should be considered, as well as the need to reduce public green space to meet goals.

Criteria (rank)	C1	C2	C3
Yield	2.5	1.0	3.3
Reliability	2.5	1.0	3.3
Frequency of Availability	1.0	1.0	1.0
Regional Impact	3	3	3
Technical Feasibility	1	1	2
Permitting	1	1	1
Time to Implement	3	4	5
Cultural, Historical and Aesthetic Values	1	1	3
Socioeconomic Impact	2	2	3
Ecosystem Protection	3	3	5
Carbon Footprint	1	1	1



Historical Conservation

Policy Considerations

New conservation goals would require adoption of a new Water Authority policy. Continued use of conservation to reduce demand was contemplated in the 2007 WRMS under Policy D.

Sources

Water Authority historical data, model results

5.3.2 SJC Lease

Overview

San Juan-Chama Project contractors have fixed annual allotments of SJC water, subject to water availability. Not all contractors currently fully utilize their allotments, and the unused portion could be available for lease on a short- or long-term basis. SJC water leases have been negotiated by others in the last 10 years.

Description

Congress has authorized an annual average diversion up to 110,000 ac-ft, with current contracts totaling a little over 86,000 ac-ft. Some contract holders have provided for short-term leases of their water. For example, the Jicarilla Tribe entered into a lease agreement with the City of Santa Fe, and then subsequently auctioned leases of their SJC water. The Water Authority could take advantage of short or long-term leases of its contracted amounts (S1).

To utilize leased water, storage space and/or direct diversion capacity is required. This supply would help extend the availability of non-potable project water supply if SJC storage declines, it could also offset transport and storage losses and extend the ability of the Water Authority to utilize SJC surface water during drought.

It is anticipated that an amount on the order of 1,000 ac-ft to 6,000 ac-ft could be available on a short-term basis. For the purpose of ranking, the low end of this range was used (1,000 ac-ft), based on amounts historically available for lease from SJC contractors.

Infrastructure Needs

Under anticipated future operations, no additional infrastructure or water rights permits would be required to implement this alternative. Additional storage in the form of a new off-channel reservoir could be required, if current storage space is fully utilized.

Other Considerations

Additional SJC lease water could be stored or used with existing infrastructure and permits, and the alternative does not conflict with other supply sources.

Criteria (rank)	S1
Yield	4.9
Reliability	4.9
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	1
Permitting	1
Time to Implement	1
Cultural, Historical and Aesthetic Values	2
Socioeconomic Impact	1
Ecosystem Protection	2
Carbon Footprint	2

San Juan-Chama Project

Policy Considerations

Maintaining current storage and/or sharing agreements to ensure storage availability for this alternative should be considered. This alternative is consistent with the 2007 WRMS Policy G, which recommends short-term leasing.

Sources

Reclamation, 2005

5.3.3 Excess San Juan-Chama Water

Overview

Historically, excess flows on the San Juan River have been marketed to SJC contractors. In 1983 and 1984, in an attempt to mitigate flooding at downstream reservoirs on the Colorado River System, flows in excess of permitted SJC diversions were offered. Based on historical precedent and Colorado River Basin Study results that suggest the potential for future flood flows at downstream gages on the San Juan River and reservoirs, potential future excess SJC water availability is anticipated.

Description

To utilize this water, storage space and/or direct diversion capacity would be required. This supply would help extend the viability of the NPP as SJC storage declines, offset transport and storage losses, and extend the ability of the Water Authority to utilize SJC surface water during drought.

It is anticipated that an amount on the order of 30,000 ac-ft could be made available on a one-time basis over the planning period (S2).

Infrastructure Needs

Under anticipated future operations, no additional infrastructure or water rights permits would be required to implement this alternative. Additional storage could be required, if current storage space (including at Abiquiu and Elephant Butte Reservoirs) is fully utilized.

Other Considerations

This water could be stored or used immediately with existing infrastructure and water rights permits and does not conflict with other supply sources.

Policy Considerations

Maintaining current storage to ensure storage availability for this alternative should be a consideration.

Criteria (rank)	S2
Yield	1.0
Reliability	4.9
Frequency of Availability	4.5
Regional Impact	2
Technical Feasibility	1
Permitting	1
Time to Implement	1
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	2
Carbon Footprint	2

Azotea Tunnel Outlet
Source: http://www.sanjuanchama.org/wp-content/uploads/2014/03/azotea.jpg

Sources

Rio Grande Compact Commission, 1983
Reclamation, 2012. Colorado River Basin Study, Tech Report G, Appendix 4, Supplemental Results

5.3.4 Regional Diversion

Criteria (rank)	S3
Yield	4.3
Reliability	4.3
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	3
Permitting	4
Time to Implement	4
Cultural, Historical and Aesthetic Values	5
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	4

Sub-Surface Diversion, North I-25 Non-Potable Project, Ranney Caisson

Overview

A new regional surface water diversion could be developed cooperatively with other Middle Rio Grande water users for direct use of native pre-1907 rights or imported water, like SJC water. This option would improve regional resiliency.

Description

This project envisions working jointly with other regional water suppliers (municipalities like Rio Rancho and/or others, industries, and commercial users) to develop a new regional surface water diversion. The source of water for this diversion could be pre-1907 native Rio Grande rights either brought to the diversion by the parties or purchased and transferred, SJC water, or another imported surface water source (S3). It is difficult to estimate the yield of this alternative as it depends on the source water developed, but a conservative estimate of 5,000 afy is used for the ranking process.

Infrastructure Needs

A new regional diversion would require at a minimum, surface or sub-surface diversion from the Rio Grande, raw water piping and pump stations to new or existing water treatment facilities, and finished water storage, piping and pump stations for distribution.

Other Considerations

This project would likely require a new surface water diversion permit from the NMOSE and may require transfer or lease of water rights. An Environmental Assessment or Environmental Impact Statement and Section 7 consultation would also likely be required.

Policy Considerations

This option would require extensive coordination with other regional water users and State and Federal agencies. This option meets 2007 WRMS Policy E (support regional water resources planning and management) and 2007 WRMS Policy C (establish and maintain a groundwater drought reserve).

Sources

Not applicable

5.3.5 Stormwater

Overview

Stormwater runoff in the Albuquerque area could be captured and infiltrated or diverted directly during large runoff events rather than allowed to pass.

Description

Intense rainfall events result in the need to detain and convey stormwater to the Rio Grande. Stormwater is currently detained in large quantities within the Water Authority Service Area. NMOSE regulations require that all stormwater detained be discharged within 96 hours (for public health reasons). These large runoff events often result in high flows that cannot be fully diverted by downstream water rights holders. As such, reducing these flows is not likely to affect other water users.

Two alternatives are considered: 1) work with the City, Albuquerque Metropolitan Arroyo Flood Control Authority, or County to modify existing facilities to allow for increased infiltration (SW1) and 2) direct diversion and use. Amounts that could be developed include 1,400 afy (SW1), 500 to 1,000 afy (SW2), and 1,000 to 2,000 (SW3) afy. Values of 1,400 afy, 750 afy, and 1,500 afy were used, respectively, for ranking SW1, SW2, and SW3, based on observed data (SW1) and engineering judgement (SW2 and SW3). Areas where modifications could occur include Bear Canyon Arroyo, Tijeras Arroyo, Calabacillas Arroyo, and other areas where water would infiltrate to the regional aquifer. Direct use could occur from any of the current detention ponds or from the North Diversion Channel. Stormwater is considered a native water source.

Infrastructure Needs

Additional infrastructure may be needed, including conveyance, pump stations, check dams, and/or diversion collection. If check dams are used for infiltration and aquifer storage, existing wells may be used for later diversion and use. If stormwater is directly diverted, diversion, pump station, conveyance and treatment facilities may be required.

Criteria (rank)	SW1	SW2	SW3
Yield	4.8	4.9	4.8
Reliability	4.8	4.9	4.8
Frequency of Availability	1.0	1.0	1.0
Regional Impact	4	4	4
Technical Feasibility	2	3	3
Permitting	5	5	5
Time to Implement	4	4	4
Cultural, Historical and Aesthetic Values	4	4	4
Socioeconomic Impact	1	1	1
Ecosystem Protection	3	4	4
Carbon Footprint	1	2	2

Stormwater Runoff in Albuquerque
Source: USGS (http://nm.water.usgs.gov/projects/urbanstorm/)

Other Considerations

Currently, the NMOSE views all stormwater as “public waters of the State” and utilizes this water to meet Rio Grande Compact compliance. In some years, New Mexico delivers more water than the maximum credit allowed under the Rio Grande Compact. Capture of this water in the aquifer could allow for greater utilization of New Mexico’s apportionment.

Policy Considerations

Utilization of stormwater for aquifer recharge was contemplated as a recommendation under WRMS 2007, Policy B.

Sources

Rio Grande Compact Commission, 1972
Rio Grande Compact Commission, 2006

5.3.6 Watershed Management

Overview

Engage in watershed management in the headwaters of the San Juan and Rio Grande watersheds to 1) increase reliability of watershed yield 2) improve runoff water quality, and 3) reduce the likelihood of catastrophic wildfire.

Description

This alternative entails working jointly with other regional water suppliers, entities, and agencies to manage the watersheds of the upper San Juan River, the Chama River, and the Rio Grande below Otowi gage. Watershed management in the headwaters of the San Juan will help maintain or improve yields of the San Juan-Chama project and reduce the risk of catastrophic wildfire that could impact diversions. Likewise, maintenance of streamflows on the Chama and Rio Grande would allow for utilization of these resources and protects water quality and flow for environmental and cultural uses.

Two options are considered for this alternative: WM1, management of the upper San Juan and Chama watersheds; and WM2, management of the Rio Grande watershed below Otowi gage. Watershed management potentially results in increases in SJC and native water supply.

Infrastructure Needs

This option does not result in the need for new infrastructure for diversion, but improves the reliability and resiliency of existing supplies. Watershed treatments are labor intensive and will require ongoing maintenance to realize benefits. Treatments may include forest thinning, controlled burning, brush clearing, and selective harvesting.

Other Considerations

Direct supply benefits can be estimated, but will be challenging to quantify and are uncertain. Risk reduction will be the primary benefit.

Criteria (rank)	WM1	WM2
Yield	5.0	5.0
Reliability	5.0	5.0
Frequency of Availability	5.0	5.0
Regional Impact	2	3
Technical Feasibility	1	1
Permitting	1	1
Time to Implement	1	1
Cultural, Historical and Aesthetic Values	1	1
Socioeconomic Impact	1	1
Ecosystem Protection	2	1
Carbon Footprint	4	4

Treated Watershed
Source: http://chamapeak.org/wp-content/uploads/2015/04/grass_FLN_lores.jpg

Policy Considerations

This alternative supports the 2007 WRMS Policy E (support regional water resources planning and management), 2007 WRMS Policy B (using SJC water as primary source), 2007 WRMS Policy H (implement the water quality protection plans), and 2007 WRMS Policy J (protect environmental and cultural resources).

Sources

Reclamation, 2012. Colorado River Basin Study. Tech Report F, Appendix 8

Rio Grande Water Fund, 2014

5.3.7 SP-4830 Permit Modification

Overview

Modify the SP-4830 permit (surface water diversion) to increase the quantity that can be diverted or to allow for more flexible operations.

Description

Conditions of approval for SP-4830 permit limit the timing, availability and quantity of San Juan-Chama water that can be diverted. These constraints include an instantaneous limit of 130 cubic feet per second (cfs) diversion (84 million gallons per day), and a requirement that native water diverted must be simultaneously returned through the Southside Water Reclamation Plant. Diversions are prohibited when the flows at the Central Avenue Bridge (Albuquerque gage) are below 122 cfs, or have to be curtailed when the flows above the diversion are below 195 cfs (see Figure 2.1 in Chapter 2 for street locations, or alternatively http://www.abcwua.org for full map of diversion, gages, and water and wastewater treatment plant locations). There is little to no flexibility in operating the diversion, including no ability to “catch-up” after low-flow events or reduced diversions to meet return flow requirements or maintenance needs, resulting in reduced utilization.

Permit modifications (P1) could be sought that would allow for more diversion quantity (up to 10,000 afy) or additional flexibility in the operations of the existing facility (500 afy or less – a value of 442 afy was calculated and used for the ranking).

Infrastructure Needs

No new infrastructure would be needed to implement this alternative.

Other Considerations

Modification of the SP-4830 permit would be a public process through the NMOSE. Given the protracted and contested nature of the original permitting process, there is risk of significant cost and effort, as well as the potential for new permit provisions that could further restrict operations.

Criteria (rank)	P1
Yield	4.7
Reliability	4.7
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	2
Permitting	5
Time to Implement	4
Cultural, Historical and Aesthetic Values	5
Socioeconomic Impact	1
Ecosystem Protection	2
Carbon Footprint	2

SJC DWP Diversion

Policy Considerations

This alternative aligns with 2007 WRMS Policy B, recommendation 5, which directs the Water Authority to protect its water rights.

Sources

Water Authority, 2016

5.3.8 Water Banking

Overview

Water banking involves intentionally reserving supplies through conservation or fallowing. Supplies are "banked" and made available for other users. The Water Authority could participate in regional water banking.

Description

Water banking involves voluntarily contributing unused or unneeded supplies to a water bank, typically in exchange for payment. The banked water is then made available to other users for purchase. This technique is particularly effective in drought years when some regional users may forgo use of water, allowing others to potentially have a larger supply than otherwise would be available.

This option (FCB1) could produce between 2,000 and 8,000 afy of native water supply[1]. For the ranking, a value of 5,000 afy was selected based on engineering judgement.

Infrastructure Needs

Under anticipated future operations, no additional infrastructure or permits would be required to implement this alternative. If water is banked in surface reservoirs for future use, storage space could be required if current storage space is fully utilized.

Other Considerations

This water could be stored or used immediately with existing infrastructure and water rights permits and does not conflict with other supply sources.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy E (support regional water resource planning and management). To fully implement this alternative, policies related to management of storage should be considered.

Sources

Not applicable

Criteria (rank)	FCB1
Yield	4.3
Reliability	4.7
Frequency of Availability	2.9
Regional Impact	3
Technical Feasibility	1
Permitting	2
Time to Implement	3
Cultural, Historical and Aesthetic Values	3
Socioeconomic Impact	1
Ecosystem Protection	4
Carbon Footprint	2

Alfalfa Field
Source: CH2M

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[1] Quantities are approximate and are based on fallowing relatively small portions of irrigated farmland.

5.3.9 Storage Fee Water

Overview

Water users such as the City of Santa Fe, Santa Fe County, or the Reclamation have water storage needs. These needs could be met by the Water Authority storage in Abiquiu Reservoir when storage space is available.

Description

Water users who store their water in Abiquiu Reservoir pay a small 'fee' equal to a percentage (historically 10 percent) of the total amount of water stored. This supply would help extend the viability of the NPP as SJC storage declines, offset transport and storage losses, and extend the ability of the Water Authority to utilize SJC surface water during drought.

This alternative (FCB2) is a formal recognition of current ad hoc practices and could produce between 100 and 1,000 afy of SJC or native water supply.

Infrastructure Needs

No new infrastructure is required for this alternative. Existing or expanded storage in Abiquiu Reservoir would be utilized along with existing diversion facilities.

Other Considerations

This water could be stored or used immediately with existing infrastructure and permits and does not conflict with other supply sources. This supply is being incorporated into new storage agreements.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy E (support regional water resource planning and management). To fully implement this alternative, policies related to management of storage should be considered.

Sources

Current agreement with the City of Santa Fe

Criteria (rank)	FCB2
Yield	4.9
Reliability	5.0
Frequency of Availability	2.8
Regional Impact	2
Technical Feasibility	1
Permitting	1
Time to Implement	1
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	2
Carbon Footprint	2

Abiquiu Reservoir
Source: USACE
(https://www.youtube.com/watch?v=WiQ94jL6Qx4)

5.3.10 Relinquishment Credit Water

Overview

The Water Authority could utilize water relinquished by the State of New Mexico under the Rio Grande Compact.

Description

Relinquishment is the process by which the State of New Mexico utilizes credit water stored in Elephant Butte Reservoir under the Rio Grande Compact. Credit water is released to Texas, and an equal quantity can then be captured upstream. Historically, the State of New Mexico has relinquished more than 400,000 ac-ft of water to Texas and allocated the credit water to the Interstate Stream Commission, City of Santa Fe, MRGCD, and Reclamation.

Allocated water could be captured and stored in Abiquiu Reservoir.

This alternative (FCB3) could produce between 2,000 and 5,000 afy of native water supply.

Infrastructure Needs

Under anticipated future operations, additional infrastructure may be required. Additional permits to store or divert the native water would be required to implement this alternative.

Other Considerations

Permitting to allow storage of native water in Abiquiu Reservoir would be needed for this alternative. This water could be stored or used immediately with existing infrastructure, and does not conflict with other supply sources.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy E (support regional water resource planning and management). To fully implement this alternative, policies related to management of storage should be considered.

Sources

Not applicable

Criteria (rank)	FCB3
Yield	4.3
Reliability	5.0
Frequency of Availability	4.4
Regional Impact	2
Technical Feasibility	1
Permitting	4
Time to Implement	3
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	2

Elephant Butte Reservoir
Source: http://www.sierracountynewmexico.info/wp-content/uploads/2012/05/Elephant-Butte-panoramic.png

5.3.11 Westside Reuse - Bosque

Overview

The Bosque Reuse Project involves construction of a wastewater scalping plant to provide for local reuse, surface storage, or ASR.

Description

The Bosque Reuse Project would provide non-potable water to users in western and southern Albuquerque for irrigation of large turf areas and limited industrial use (R1a). The project would divert wastewater from the Riverside Drain Interceptor and convey it to a new treatment plant. Treated non-potable water would then be conveyed to users west of the Rio Grande, including water during the non-irrigation season for ASR in the Calabacillas Arroyo (R1b). Treated water could also be conveyed to a new reservoir. Total yield expected ranges from 1,000 to 7,500 afy. For the purpose of ranking, yield values of 1,000 afy for R1a and 3,000 afy for R1b were used, respectively, based on an existing engineering feasibility study report.

Infrastructure Needs

This project includes new sewer collection piping to a new wastewater treatment plant, potential outfall piping to the Rio Grande, two lift stations (6.9 million gallons per day capacity each), treated wastewater distribution, and two storage tanks (totaling over 2.8 million gallons). In addition, booster pumps and pressure reducing valves would be required in the distribution system.

For ASR, water could be conveyed to the Calabacillas Arroyo near the non-potable reuse distribution system.

Other Considerations

This alternative would require significant new infrastructure, NMOSE permitting for ASR, groundwater discharge permit for reuse application, and possible additional NPDES permit or modification of Rio Grande outfall.

Criteria (rank)	R1a	R1b
Yield	4.9	4.6
Reliability	4.9	4.6
Frequency of Availability	1.1	1.1
Regional Impact	3	3
Technical Feasibility	3	3
Permitting	3	3
Time to Implement	3	3
Cultural, Historical and Aesthetic Values	2	2
Socioeconomic Impact	1	1
Ecosystem Protection	2	2
Carbon Footprint	3	3

Bosque Water Reclamation Plant
Source: Feasibility Study for Bosque and Tijeras Reuse Projects, 2012

Policy Considerations

This alternative is consistent with 2007 WRMS Policy B, recommendations 2-5 (balance demand with renewable supply, use a combination of supplies, match supply sources with water quality needs, recycle and reuse as much as possible, and protect water rights).

Sources

CH2M, 2012

5.3.12 Eastside Reuse - Tijeras

Criteria (rank)	R2a	R2b
Yield	4.2	4.1
Reliability	4.2	4.1
Frequency of Availability	1.1	1.1
Regional Impact	3	3
Technical Feasibility	3	3
Permitting	3	3
Time to Implement	3	3
Cultural, Historical and Aesthetic Values	2	2
Socioeconomic Impact	1	1
Ecosystem Protection	2	2
Carbon Footprint	3	3

Tijeras Arroyo Water Reclamation Plant

Source: Feasibility Study for Tijeras and Tijeras Reuse Projects, 2012

Overview

The Tijeras Reuse Project involves construction of a wastewater scalping plant to provide for local reuse, surface storage, or ASR.

Description

The Tijeras Reuse Project would provide non-potable water to users in eastern and southern Albuquerque for irrigation of large turf areas and limited industrial use (R2a, modeled based on 6,000 afy yield to non-potable reuse). The project would divert wastewater from the Tijeras interceptor and convey it to a new treatment plant. Treated water would then be conveyed to users east of the Rio Grande, including water during the non-irrigation season for ASR in the Tijeras Arroyo (R2b, modeled based on 1,000 afy yield to storage). Treated water could also be conveyed to a new reservoir. Total yield expected ranges from 6,000 to 7,000 afy.

Infrastructure Needs

This project includes new sewer collection piping to a new wastewater treatment plant, two lift stations (about 6 million gallons per day capacity each), treated wastewater distribution, and one storage tank (about 1 million gallons). In addition, booster pumps and pressure reducing valves would be required in the distribution system.

For ASR, water will be conveyed to the Tijeras Arroyo near the non-potable reuse distribution system.

Other Considerations

This alternative will require significant new infrastructure, NMOSE permitting for ASR, and groundwater discharge permit for reuse application.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy B, recommendations 2-5 (balance demand with renewable supply, use a combination of supplies, match supply sources with water quality needs, recycle and reuse as much as possible, protect water rights).

Sources

CH2M, 2012

5.3.13 Eastside Reuse – Connect Southside to North I-25 Non-potable Project

Overview

The NPP (North I-25 Non-potable Project) is currently permitted for up to 3,000 afy. This project could be expanded by about 50 percent to deliver non-potable water to other large turf areas in the vicinity of the current system. This project could also be connected to the Southside Reuse project to provide supply for this project and the intervening areas (R3-Exand NPP).

Description

It is estimated that up to an additional 1,500 afy of demand could be met by the NPP. This expansion would involve extending the existing pipelines to serve new users. To meet these demands and convert from SJC water, the Southside Reuse project could be connected via pipeline to the NPP.

Infrastructure Needs

This alternative would require additional distribution piping to serve new users. A pipeline and pump station would be required to deliver water from the Southside Reuse project to the NPP and intervening areas.

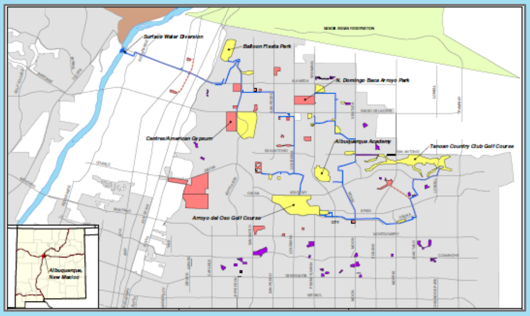
Other Considerations

Expansion of the NPP under the current SP-4819 permit would require additional use of SJC water or an alternative non-potable source of water. This could result in less water available for the DWP if SJC water is allocated for this purpose. Alternatively, if the permit is modified to allow for direct diversion of native Rio Grande rights or if this system were connected to the Southside Reuse project, additional SJC water would be available for the DWP, and this expansion will help optimize utilization of existing rights and resources.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy B.

Criteria (rank)	R3a
Yield	4.8
Reliability	4.9
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	2
Permitting	2
Time to Implement	2
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	3



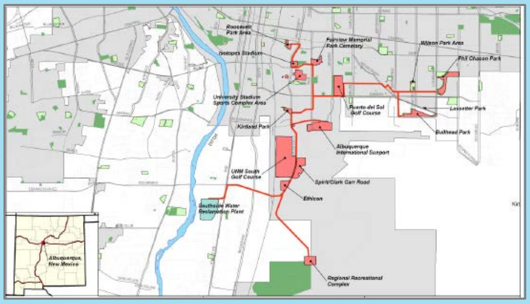
North I-25 Non-potable Project

Sources

Not applicable

5.3.14 Eastside Reuse – Expand Southside Reuse Project

Criteria (rank)	R3b
Yield	4.7
Reliability	4.9
Frequency of Availability	1.1
Regional Impact	3
Technical Feasibility	2
Permitting	2
Time to Implement	2
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	3



Southside Reuse

Overview
The Southside Reuse Project (SRP) is currently permitted for up to 2,500 afy. This project could be expanded to almost double to deliver non-potable water to other large turf areas in the vicinity of the current system (Chapter 2, Figure 2.1).

Description
It is estimated that an additional 3,000 afy of demand could be met by the SRP through use of wastewater (a more conservative value of 2,000 afy was used for ranking based on an existing feasibility study). This expansion would involve extending the existing pipelines to serve new users. Additionally, this added capacity can be used to deliver water for ASR.

Infrastructure Needs
This alternative would require additional distribution piping and storage to serve new users and/or connect to existing systems. Current capacity and pump stations, may be sufficient for the expanded demand.

Other Considerations
This project would require a change to the existing groundwater discharge permit (reflecting new users), and it would reduce the amount of return flow to the Rio Grande. In the short-term (about 10 years), return flow is needed to offset historical groundwater pumping effects. In the long-term, return flow will be available for use and this expansion will help optimize utilization of existing rights and resources.

Policy Considerations
This alternative is consistent with 2007 WRMS Policy B, recommendations 2-5 (balance demand with renewable supply, use a combination of supplies, match supply sources with water quality needs, recycle and reuse as much as possible, and protect water rights).

Sources

Not applicable

5.3.15 Indirect/Direct Potable Reuse

Overview
Indirect (IPR) and direct potable reuse (DPR) utilize available treated wastewater return flows. Return flows are diverted and treated to drinking water standards and conveyed to the potable distribution system directly (DPR), often with an environmental barrier such as blending or re-injection to be consumed indirectly (IPR).

Description
This alternative entails further treatment of wastewater and conveyance of this water through the non-potable system. The non-potable system would be extended north via either discharge to the AMAFCA north diversion channel or via a new pipeline to the WTP. This water would then be blended into the raw water storage ponds, treated, and distributed.

There are numerous possible yields associated with this alternative. Each requires similar infrastructure and investment (Appendix 5.C). Three representative sub-alternatives were selected: 7,500 (I/DPR1), 12,000 (I/DPR2), and 15,000 afy (I/DPR3) from existing treated wastewater sources.

Infrastructure Needs
This alternative will require additional treatment at the wastewater treatment plant beyond tertiary and/or unrestricted urban reuse standards. Additional conveyance would be required to extend piping from the Southside reuse system, north to the WTP or if the Connect Southside to Northside were complete that pipeline could be used).

Other Considerations
DPR and IPR are relatively new technologies in New Mexico and the regulatory framework has not been fully developed. Likewise, public acceptance will be a critical element in implementing this alternative.

This alternative also optimizes utilization of current resources and water rights and potentially extends the Water Authority's ability to meet demand for decades.

Policy Considerations
This alternative is consistent with 2007 WRMS Policy C (maintain a groundwater reserve), and 2007 WRMS Policy F (conjunctively manage resources, favor reclaimed water use).

Criteria (rank)	I/DPR 1	I/DPR 2	I/DPR 3
Yield	4.0	3.4	3.0
Reliability	4.3	3.9	3.7
Frequency of Availability	2.4	2.4	2.4
Regional Impact	3	3	3
Technical Feasibility	3	3	3
Permitting	3	3	3
Time to Implement	3	3	3
Cultural, Historical and Aesthetic Values	3	3	3
Socioeconomic Impact	1	1	1
Ecosystem Protection	3	3	3
Carbon Footprint	3	3	3

RO Facility, Perth
Source: CH2M

Sources
Not applicable

INDIRECT
POTABLE REUSE

5.3.16 Additional Large-Scale Aquifer Storage and Recovery

Criteria (rank)	ASR1
Yield	4.3
Reliability	4.3
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	2
Permitting	3
Time to Implement	2
Cultural, Historical and Aesthetic Values	1
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	3

Bear Canyon ASR

Overview

Additional ASR capacity could be developed within the Water Authority system to fully utilize annual SJC allocation and WTP capacity.

Description

At present, winter demand is significantly less than SJC WTP capacity. This capacity could be utilized to divert and treat SJC water for underground injection. New wells along the SJC DWP transmission pipeline could be completed as dual-use wells such that water can be either injected for storage or pumped for recovery.

Based on current demand, this alternative (ASR1) could supply between 2,000 and 5,000 afy. For ranking, a yield of 5,000 afy was used, based on existing engineering plans.

Infrastructure Needs

Large-scale ASR would require retrofitting existing or additional Water Authority production wells for dual-use.

Other Considerations

NMOSE underground storage and recovery permits would be required to implement this alternative. This alternative optimizes the use of existing resources.

Policy Considerations

This project can be implemented with current Water Authority policies and is consistent with 2007 WRMS Policy B (using SJC water as the primary source), and 2007 WRMS Policy C (establish a groundwater drought reserve, implement an ASR program).

Sources

Not applicable

5.3.17 New Local Storage

Overview

New local off-stream storage could be constructed to facilitate storage and use of available wastewater, stormwater, SJC water, and native Rio Grande water.

Description

A new surface water reservoir could be constructed on the eastside or westside of Albuquerque. A potential reservoir could be excavated to store on the order of 5,000 (ST1), or 10,000 (ST2) ac-ft of water that could be used to 1) store available wastewater, and 2) augment supply during drought or when supplies are compromised due to heavy sediment or ash load. A potential reservoir could be filled using wastewater treated beyond tertiary and/or unrestricted urban reuse standards, directly diverted native Rio Grande or SJC water, or stormwater. For ranking, a nominal yield of 3,750 and 7,500 afy was assumed for ST1 and ST2, respectively, assuming that for aesthetic purposes, these reservoirs would remain 75% full.

There are numerous sub-alternatives to this alternative that vary in water supply sources as well as in location and volume. Storage facilities could be located in the Mesa del Sol area in existing playas, in northeast Albuquerque, or on the westside.

Infrastructure Needs

Additional treatment of wastewater may be required. Conveyance of wastewater would require new pipelines and pump stations. Conveyance of raw native Rio Grande water or SJC water would require new pipelines and pump stations. Utilization of this water would require a new pipeline to the WTP where water could be delivered to the raw water storage ponds, and possibly pump stations. Stormwater use and storage may require new pump stations, pipelines and additional local storage.

Other Considerations

See Alternatives 5.3.5 and 5.3.16.

Policy Considerations

This alternative is consistent with 2007 WRMS Policy B, recommendations 2-5; and 2007 WRMS Policy C (maintain a groundwater reserve), and 2007 WRMS Policy F. (conjunctively manage resources, favor reclaimed water use).

Sources

Not applicable

Criteria (rank)	ST1	ST2
Yield	4.5	4.0
Reliability	4.9	4.8
Frequency of Availability	1.0	1.0
Regional Impact	3	3
Technical Feasibility	3	3
Permitting	2	2
Time to Implement	3	3
Cultural, Historical and Aesthetic Values	3	3
Socioeconomic Impact	1	1
Ecosystem Protection	2	2
Carbon Footprint	2	2

The Rio Grande. Source: Joseph Nicolette

5.3.18 Interbasin Transfer

Overview
This alternative supply involves the importation of water from other surface or groundwater basins, similar to the SJC project.

Description
Two types of options are envisioned for this alternative:

1) Water that is delivered to the Water Authority system ready for distribution (I1 and I3), and
2) Water that would be conveyed to the Water Authority system via the Rio Grande, requiring diversion and treatment (I2 and 4).

The first option is similar to that proposed by the developers of the San Augustin Plains, or the previously proposed Estancia Valley or Fort Sumner projects. The second option is similar to the SJC DWP where water from an adjacent basin is conveyed to Albuquerque via the Rio Grande. Quantities of delivery anticipated range from 5,000 (I1 and I3) to 10,000 (I2 and I4) afy.

There are numerous sub-alternatives for this alternative that involve various different supply sources and types. One alternative of each type in varying quantities is considered to be representative for these alternatives.

Infrastructure Needs
For the first option, no new infrastructure would be needed. Water would be delivered ready for consumption for a fee. To fully consume this resource, additional infrastructure such as non-potable or potable reuse facilities, storage, or aquifer storage and recovery facilities may be needed.

For the second option, in the quantities envisioned, new or expanded surface water treatment facilities would likely also be required.

Other Considerations
Depending on the water source additional permitting may be required, including an Environmental Assessment or Environmental Impact Statement and Section 7 Consultation. In addition, a NMOSE permit may be required for a new or expanded diversion on the Rio Grande.

Criteria (rank)	I1	I2	I3	I4
Max Yield	4.3	3.7	4.3	3.7
Reliability	4.3	3.7	4.3	3.7
Frequency	1.0	1.0	1.0	1.0
Regional Impact	4	4	4	4
Technical Feasibility	1	1	2	2
Permitting	2	2	3	3
Time to Implement	5	5	5	5
Cultural, Historical and Aesthetic Values	4	4	5	5
Socioeconomic Impact	1	1	1	1
Ecosystem Protection	3	3	2	2
Carbon Footprint	4	4	4	4


Central Arizona Project Canal

These projects would add significant new supply to the Middle Valley and could potentially reduce competition for resources.

Policy Considerations
These alternatives would potentially support regional water resource planning (2007 WRMS Policy E) and would help to maintain a drought reserve (2007 WRMS Policy C).

Sources
Not applicable

5.3.19 Produced Water

Overview

Produced water is derived from oil and gas operations in Sandoval County, New Mexico. This water could be treated and transported for potable or non-potable use.

Description

Water produced as part of oil and gas drilling could be collected, transported, and treated for potable or non-potable use. Availability of produced water will vary by production quantity, formation, and oil and gas prices. Likewise, production locations will change over time. Given these factors a low estimate of 1,000 afy yield is applied to this alternative (I5).

Infrastructure Needs

This option would likely require tanker trucks for transport, local storage, and water treatment systems with the capability to treat for a wide variety of constituents including hydrocarbons, radionuclides, metals, and salinity. Brine disposal may also be needed depending on the initial water quality and required treatment methods.

Other Considerations

Availability of this source is likely to change over time and utilization will require coordination with multiple different agencies and organizations. Because this water is imported, it could be used to extinction and would add to the regional water supply. Utilization to extinction may require additional infrastructure for non-potable or potable reuse, or aquifer storage and recovery. Permitting requirements for use of this water is uncertain at this time.

Policy Considerations

Transporting and treating this water will likely be relatively energy intensive, resulting in a large carbon footprint and energy cost.

Sources

Reclamation, 2012. Colorado River Basin Study, Tech Report F

EMNRD, 2015

Criteria (rank)	I5
Yield	4.9
Reliability	4.9
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	5
Permitting	4
Time to Implement	5
Cultural, Historical and Aesthetic Values	3
Socioeconomic Impact	1
Ecosystem Protection	3
Carbon Footprint	5

Pump Jack in New Mexico
Source: EMNRD Annual Report 2015

5.3.20 Pre-1907 Water Rights Acquisition

Criteria (rank)	WR1
Yield	4.9
Reliability	4.9
Frequency of Availability	1.0
Regional Impact	3
Technical Feasibility	1
Permitting	3
Time to Implement	4
Cultural, Historical and Aesthetic Values	4
Socioeconomic Impact	1
Ecosystem Protection	4
Carbon Footprint	2

Rio Grande at Albuquerque

Source: "Sandia Mountains, Central New Mexico," Photo by G. Thomas. Encyclopedia Britannica Online. https://www.britannica.com/place/Sandia-Mountains. 20 Mar. 2016.

Overview

The Water Authority has acquired about 4,500 ac-ft of pre-1907 water rights (consumptive), and additional pre-1907 rights could be purchased to augment existing water rights and supplies. These water rights can be used for offsets to groundwater production or potentially be directly diverted for either potable or non-potable use.

Description

The Water Authority could pursue purchase of additional pre-1907 water rights for utilization in augmenting surface supplies or groundwater offsets (WR1). Water rights purchase and transfer would require a willing seller and permitting through the NMOSE.

Infrastructure Needs

Depending on the quantity purchased, new infrastructure may be required to fully utilize this water. If this alternative increased the volume of directly diverted supplies, expansion of the water treatment plant and a new diversion permit could be required. Full utilization in this case, or if used for offsets to groundwater production, could require additional non-potable or potable reuse, native water storage, or aquifer storage and recovery.

Other Considerations

Pre-1907 water rights are largely tied to historical agriculture. This alternative is consistent with 2007 WRMS Policy G (implement long-term water acquisition plan).

Policy Considerations

While this alternative is consistent with 2007 WRMS Policy G (implement long-term water acquisition plan), it may be inconsistent with policies J (protect environmental and cultural resources) and K (preserve quality of life).

Sources

Not applicable

5.3.21 Brackish Water

Overview

New Mexico has vast brackish groundwater resources. Within the Water Authority service area, deep brackish groundwater could be utilized for drought supply or short-term peaking capacity.

Description

Conceptually, brackish water projects could be realized within the Water Authority service area, utilizing deep wells. The brackish water is likely to range in total dissolved solids from 17,000 to 50,000 milligrams per liter. This water would be treated to appropriate quality for utilization within the existing system. Treatment of brackish water results in a concentrated reject brine solution. This reject brine solution could be disposed of either through blending in the sanitary sewer system or through evaporation ponds or other means. Conceptually, 2,000 (B1) to 5,000 (B2) afy of brackish water could be developed.

Infrastructure Needs

To develop brackish water, deep production wells, pumps, conveyance, and new water treatment facilities would be required. To fully consume water produced, non-potable reuse, direct or indirect potable reuse, or aquifer storage and recovery may be required.

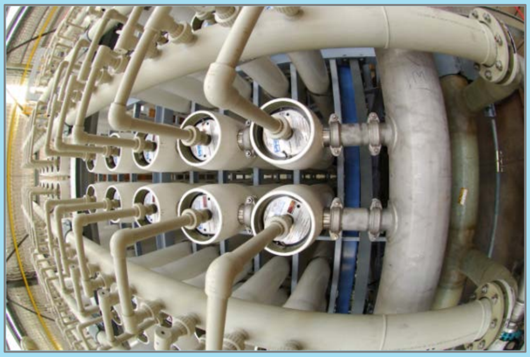
Other Considerations

Brackish water development is regulated by the NMOSE. However, specific procedures and permits have not been fully developed. In addition, brackish resources in the Middle Rio Grande are somewhat connected to freshwater sources. The potential need for offsets/mitigation would be considered. In addition, this process typically requires significant energy, and brine reject water may be expensive to dispose.

Policy Considerations

Brackish water is not renewable, but is very reliable/resilient. It has a relatively high cost and may be inconsistent with 2007 WRMS Policy J (protect environmental and cultural resources). It supports Policy G (develop and implement long-term water resources acquisition plan).

Criteria (rank)	B1	B2
Yield	4.7	4.3
Reliability	4.9	4.9
Frequency of Availability	3.9	3.9
Regional Impact	3	3
Technical Feasibility	4	4
Permitting	3	3
Time to Implement	4	4
Cultural, Historical and Aesthetic Values	2	2
Socioeconomic Impact	1	1
Ecosystem Protection	3	3
Carbon Footprint	5	5



Desalination Facility
Source: CH2M

Sources

Shomaker, 2013

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Appendix 5.A

Criteria Development

Appendix 5.A

Criteria Development

Introduction

A wide variety of alternatives were developed for potential future implementation. These alternatives may be implemented based on their ability to help fill potential future supply gaps, their ability to meet stakeholder preferences, and their costs. Because no single alternative will fill future gaps, tradeoffs in supply philosophies can be examined through the development of portfolios. In order to facilitate selection of alternatives into portfolios, non-monetary screening criteria were developed. These criteria represent stakeholder values and allow for selecting alternatives into portfolios based on their overall performance.

Criteria were developed to rank the supply alternatives based on a wide range of issues. The purpose of the ranking exercise was to perform a structured and unbiased analysis of the alternatives, to guide in selecting the supply alternatives that could be most readily implemented, particularly in light of current Water Authority infrastructure and permits. Since the criteria were designed based on a wide array of topics from environmental and public acceptance to engineering and legal constraints, the intent was to be able to clearly identify those alternatives that could meet potential supply gaps as well be readily implemented based on engineering, permitting, stakeholder acceptance and other key issues. Put simply, the alternatives ranking process was designed to clearly identify those supply alternatives that could be implemented in the near term.

Methods

An initial list of criteria was developed based on the 1997 Water Resources Management Strategy (City of Albuquerque Public Works Department [COA], 1997). Criteria presented in COA (1997) included environmental protection, implementability, sustainability and reliability of supply, support of quality of life in New Mexico, and financial performance. Note that in the current process, financial performance (cost) was not considered during the initial alternative ranking (estimated unit costs per ac-ft were added only after supply amounts had been defined for each sub-alternative through modeling). Rather, the analysis of relative cost was deferred until sets of selected supply alternatives were grouped into supply portfolios, and then the relative costs of those portfolios were evaluated to allow for ranking on a cost basis (Chapter 6).

Criteria development included soliciting feedback from the Technical Customer Advisory Committee (TCAC) on several occasions, including a meeting facilitated by a professional facilitator to get input from the TCAC.

Once the criteria were selected, the criteria were quantified in a phased process by the project technical team. In the first step, a subset of the technical team performed individual rankings of each alternative (for those criteria that were not calculated). Those rankings were then summarized and statistics were generated to highlight differences in the rankings, if any. For those criteria ranking values where all parties were in agreement, the values were accepted. For criteria where rankings differed, these were discussed until all parties agreed on a value. The initial ranking was then taken to the full technical team, where each ranking value was discussed until full agreement was reached.

Subsequent to the ranking performed by the technical team, a series of rankings were presented to the TCAC several times for discussion and feedback before being finalized in an iterative fashion.

Results

For this alternatives analysis process, criteria were developed and grouped into the following categories shown in Table 5.A1. A brief description of each criterion follows.

Table 5.A1. Category and evaluation type for each criterion.

Category	Criterion	Evaluation Type
Quality of Life	Cultural, Historical and Aesthetic Values	Qualitative
	Socioeconomic Impact	Qualitative
Environmental Protection	Ecosystem Protection	Qualitative
	Carbon Footprint	Engineering Judgement
Long-Term Sustainability and Resiliency	Yield	Quantitative
	Reliability	Quantitative
	Frequency of Availability	Quantitative
Implementability	Regional Impact	Qualitative
	Technical Feasibility	Engineering Judgement
	Permitting	Engineering Judgement
Timing	Timing	Engineering Judgement

Cultural, Historical, and Aesthetic Values

This criterion is meant to address potential or perceived inequalities due to the implementation of a particular alternative relative to cultural, political, ethnic, regional or tribal groups either within or outside of the Region (Heron Lake to Elephant Butte Dam). In general, it is qualitatively evaluated on the basis of whether there are no perceived inequalities, or the degree to which there will be perceived inequalities. Specific cultural, political, ethnic, regional or tribal groups are not identified as part of this criterion.

Socioeconomic Impact

This criterion was developed to measure the ability of a particular alternative to provide supply that is adequate to meet the needs of industrial and residential growth, support for recreational opportunities, and amenities such as parks and landscaping are fully supported throughout the service area. Since all alternatives are designed to meet the basic metric of providing adequate supply, most will rank in this category in a similar fashion. However, some alternatives, such as higher levels of conservation, may result in, for example, less turf irrigation and green space in the service area, and thus rank slightly lower.

Ecosystem Protection

This criterion addresses the ability of a particular alternative to maintain a balanced ecosystem. In particular, each alternative is ranked based on its relative ability to increase habitat and bosque area, and/or improve the local ecosystem, the Rio Grande, and/or the aquifer in the Middle Valley (Cochiti

Dam to Elephant Butte Dam). Consideration is given to potential effects such as contributing to rising aquifer levels, contributing to an increase in surface water flows, etc. As an example, activities such as watershed restoration typically scored well in this category.

Carbon Footprint

Carbon footprint is evaluated in a relative sense based on engineering judgement. Energy usage is considered to be a proxy for carbon footprint. That is, low energy usage is assumed to equate to a small carbon footprint, while high energy usage is considered to result in a large carbon footprint. Alternatives such as conservation, which have low or no energy requirements, rank highly in the category. Likewise, alternatives such as brackish groundwater desalination, which has a high energy requirement for the desalination process, rank low in this category. Note that green energy alternatives are not considered in this analysis, such as brackish groundwater desalination powered by solar energy. These types of hybrid alternatives may be considered in the future.

Yield

Yield is expressed as either the actual nominal yield of the alternative based on a conceptual engineering design or a calculated yield (e.g. for a storage option) and has been normalized to a 1 to 5 scale for evaluation.

Normalized yield for alternative *n* is calculated using the following equation:

$$\text{normalized yield} = 5 - (\text{yield}_n/\text{maximum yield of all alternatives}) * 4$$

where

yield_n is the nominal yield of alternative *n*.

Values used for yield_n are tabulated in Table 5.A1 below.

Reliability

Reliability is defined as a given alternative's ability to meet a particular demand on a constant basis. Supply alternatives that are available on a consistent basis (for example conservation) rank highly, while alternatives that are available more sporadically (for example, stormwater capture) rank low. Reliability is calculated based on yield and the number of years that the supply is expected to be available out of 100 and normalized from a 1 to 5 scale for evaluation.

Normalized reliability for alternative *n* is calculated using the following equation:

$$\text{normalized reliability} = 5 - (\text{yield}_{rn}/\text{maximum yield}_{rn} \text{ for all alternatives}) * 4$$

where

$\text{yield}_{rn} = \text{yield}_n * \text{years}_n/100$ (reliability yield in Table 5.A1), and

years_n is the number of years out of 100 that alternative *n* is expected to be available.

Values used for yield_n and years_n are tabulated in Table 5.A1 below.

Frequency of Availability

The frequency of availability can be quantified using either engineering judgement (i.e. groundwater is generally always available, and Heron spills are expected to be quite rare) or model runs (e.g. a full supply of San Juan-Chama water may only be available six out of ten years under Hot-Dry conditions). The frequency of availability is a calculated normalized value based on the number of years out of 100 and the number of months in any given year that the supply is expected to be available.

Normalized frequency of availability for alternative *n* is calculated using the following equation:

$$F = 5 - (((\text{years}_n/100) * 100/112 + \text{months}_n/12 * 12/112)) * 4$$

where

years_n is the number of years out of 100 that alternative *n* is expected to be available, and

months_n is the number of months out of the year that alternative *n* is expected to be available.

Values used for years_n and months_n are tabulated in Table 5.A1 below.

Regional Impact

This broad category was originally suggested by the TCAC. In general, it is meant to capture potential regional-scale impacts (outside of the Middle Valley) that may result from a given alternative. For example, a watershed restoration project would be expected to provide positive regional impacts and would score well in this category. Conversely, an importation project where water is brought in from outside of the Middle Rio Grande Valley, while potentially advantageous to the Middle Valley community may have some negative effects on the source area for the water supply and hence may score lower in terms of regional impact.

Technical Feasibility

Technical feasibility is based on engineering judgement and is generally based on whether (1) existing assets can be used, (2) operation and maintenance costs are known and are expected to be low, and (3) the proposed alternative or technology is well-established and currently being used by the Water Authority. Alternatives with a high ranking for this criterion use existing infrastructure and current technology (for example, ASR). Alternatives that are untested and potentially expensive (for example, brackish groundwater desalination) generally rank low under this criterion.

Permitting

The permitting criterion is meant to evaluate how easily a given alternative can be permitted, or implemented under current Water Authority permits. Alternatives that require no permitting (for example, conservation) or can be implemented under current Water Authority permits rank highly in this category. Converse, alternatives which require new permits or for which there is no current permitting scheme under New Mexico law (for example, stormwater capture) rank low.

Time to Implement

This criterion is based on engineering and legal judgement, and is intended to generally represent, in a relative sense, the time required to bring a particular alternative on-line. Alternatives like conservation can be brought on-line very quickly since they require no permitting or infrastructure, while alternatives such as brackish groundwater take longer because they require designing, testing, and building new infrastructure, as well as meeting new permitting requirements outside of the current Water Authority permits.

Application of the Criteria Evaluation Process

The criteria were applied based on a combination of expert judgement and calculated values. For the more qualitative criteria, development of the criterion values was done collaboratively. First, each member of the project team individually performed selected criteria values. This was followed by a statistical comparison of the criteria to determine both areas of agreement and areas of disagreement. For many criteria, all project team members agreed on the value initially, and those were selected outright. For criteria where there was disagreement, the project team discussed those values until all members converged upon and agreed on a single value. For criterion values based on calculation or engineering judgement (for example yield), those values are presented in Table 5.A1.

Once a value was selected for each criterion for each alternative, they were arranged in a table and summed to get a total score, then ranked by increasing score (low scores indicate the best alternatives). These results are presented in Table 5.A2.

Table 5.A1. Criterion Values Based on Calculation or Engineering Judgement

	Alternative	Source	Nominal Yield for Ranking	Normalized Nominal Yield for Ranking	Reliability Yield for Ranking	Normalized Reliability	Yield Basis	Years Available out of 100	Est Months per Year Available	Normalized Frequency of Availability
Conservation										
C1	120 gpcd in 10 years	Reduces groundwater use	18,812	2.5	18,812	2.5	Calculated from demand scenarios, average over the period of implementation	100	12	1.0
C2	110 gpcd in 20 years	Reduces groundwater use	30,317	1.0	30,317	1.0	Calculated from demand scenarios, average over the period of implementation	100	12	1.0
C3	Outdoor-only conservation (10 gpcd reduction over 30 years)	Reduces groundwater use	12,641	3.3	12,641	3.3	Calculated from demand scenarios, average over the period of implementation	100	12	1.0
Surface Water										
S1	Lease or short-term purchase of additional San Juan-Chama water	San Juan-Chama	1,000	4.9	1,000	4.9	Amount historically available from the Jicarilla	100	12	1.0
S2	Excess San Juan-Chama water	San Juan-Chama	30,000	1.0	750	4.9	Historical quantities	2.5	12	4.5
S3	New regional surface water diversion	Pre-1907 water rights	5,000	4.3	5,000	4.3	Engineering judgement	100	11	1.0
Nonpotable reuse										
R1a	Westside Reuse	Wastewater	1,000	4.9	1,000	4.9	Existing feasibility study report	100	8	1.1
R1b	Westside Reuse with storage	Wastewater	3,000	4.6	3,000	4.6	Existing feasibility study report	100	8	1.1
R2a	Eastside Reuse	Wastewater	6,000	4.2	6,000	4.2	Engineering judgement	100	8	1.1
R2b	Eastside Reuse with storage	Wastewater	7,000	4.1	7,000	4.1	Engineering judgement	100	8	1.1
R3a	Connect Southside Reuse System to North I-25 Non-Potable Project	Wastewater/San Jaun Chama	1,500	4.8	1,000	4.9	Existing feasibility study report	100	12	1.0
R3b	Expand Southside Reuse System	Wastewater	2,000	4.7	1,000	4.9	Existing feasibility study report	100	8	1.1

Table 5.A1. Criterion Values Based on Calculation or Engineering Judgement

	Alternative	Source	Nominal Yield for Ranking	Normalized Nominal Yield for Ranking	Reliability Yield for Ranking	Normalized Reliability	Yield Basis	Years Available out of 100	Est Months per Year Available	Normalized Frequency of Availability
ASR										
ASR1	Large-scale ASR	San Juan-Chama/ Wastewater	5,000	4.3	5,000	4.3	Engineering judgement	100	12	1.0
Stormwater										
SW1	Stormwater capture from existing facilities with spreading basins for infiltration	Stormwater/native water	1,400	4.8	1,400	4.8	Based on observed data	100	12	1.0
SW2	Stormwater capture in Calabacillas Arroyo/Tijeras Arroyo/N Diversion Channel. 500-1,000 ac-ft/yr	Stormwater/native water	750	4.9	750	4.9	Engineering judgement	100	12	1.0
SW3	Stormwater capture in Calabacillas Arroyo/Tijeras Arroyo/N Diversion Channel. 1,000-2,000 ac-ft/yr	Stormwater/native water	1,500	4.8	1,500	4.8	Engineering judgement	100	12	1.0
Interbasin Transfer										
I1	Interbasin Transfer 5,000 afy, delivered to Water Authority system	Surface water and/or groundwater	5,000	4.3	5,000	4.3	Range of known potential projects (Navajo project, Plains of San Augustin)	100	12	1.0
I2	Interbasin Transfer 10,000 afy, delivered to Water Authority system	Surface water and/or groundwater	10,000	3.7	10,000	3.7	Range of known potential projects (Navajo project, Plains of San Augustin)	100	12	1.0
I3	Interbasin Transfer 5,000 afy, transferred to Water Authority system	Surface water and/or groundwater	5,000	4.3	5,000	4.3	Range of known potential projects (Navajo project, Plains of San Augustin)	100	12	1.0
I4	Interbasin Transfer 10,000 afy, transferred to Water Authority system	Surface water and/or groundwater	10,000	3.7	10,000	3.7	Range of known potential projects (Navajo project, Plains of San Augustin)	100	12	1.0
I5	Produced water	Groundwater	1,000	4.9	1,000	4.9	Engineering judgement	100	12	1.0
Indirect/direct potable reuse										
I/DPR1	7,500 afy. Extend reuse from Yale to Lomas, flow via North Diversion channel to Singer, divert to surface-water treatment plan	Wastewater	7,500	4.0	680	4.3	Estimated excess return flows	68	4	2.4
I/DPR2	12,000 afy	Wastewater	12,000	3.4	2,040	3.9	Estimated excess return flows	68	4	2.4
I/DPR3	15,000 afy	Wastewater	15,000	3.0	3,400	3.7	Estimated excess return flows	68	4	2.4

Table 5.A1. Criterion Values Based on Calculation or Engineering Judgement

	Alternative	Source	Nominal Yield for Ranking	Normalized Nominal Yield for Ranking	Reliability Yield for Ranking	Normalized Reliability	Yield Basis	Years Available out of 100	Est Months per Year Available	Normalized Frequency of Availability
Fee, Credit, or Banked Water										
FCB1	Water banking/leasing/forbearance	Pre-1907 water rights/San-Juan Chama	5,000	4.3	2,500	4.7	Engineering judgement	50	8	2.9
FCB2	Future storage fee water	San-Juan Chama/Native water	500	4.9	250	5.0	Known existing fee water	50	12	2.8
FCB3	Rio Grande Compact relinquishment credit water	Native water	5,000	4.3	200	5.0	Known historical relinquishments	4	12	4.4
Surface Storage										
ST1	Storage Small. 5,000 ac-ft/yr	Wastewater, stormwater, San-Juan Chama, and/or native water	3,750	4.5	624	4.9	Nominal yield: assume 75% full for aesthetics; Reliability yield: calculated from the model	100	12	1.0
ST2	Storage Large. 10,000 ac-ft/yr	Wastewater, stormwater, San-Juan Chama, and/or native water	7,500	4.0	1,200	4.8	Nominal yield: assume 75% full for aesthetics; Reliability yield: calculated from the model	100	12	1.0
Water Rights										
WR1	Purchase of pre-1907 water rights	Native water	1,000	4.9	1,000	4.9	Engineering judgement	100	11	1.0
Watershed Management										
WM1	Watershed management. San Juan River tributaries	NA	0	5.0	0	5.0	NA	0	0	5.0
WM2	Watershed management. Rio Grande main stem and/or tributaries below Otowi	NA	0	5.0	0	5.0	NA	0	0	5.0
Brackish Groundwater										
B1	Brackish groundwater. 2,000 ac-ft/yr	Groundwater	2,000	4.7	400	4.9	Shomaker (2015) work	20	12	3.9
B2	Brackish groundwater. 5,000 ac-ft/yr	Groundwater	5,000	4.3	1,000	4.9	Shomaker (2015) work	20	12	3.9
Permit modification										
P1	Operational flexibility under existing 4830 permit	San-Juan Chama	442	4.9	442	4.9	Current operating practice	100	11	1.0

Table 5.A2. Results of Ranking

Alternative		Rank	Score	Yield	Reliability	Frequency of Availability	Regional Impact	Technical Feasibility	Permitting	Time to Implement	Cultural, Historical, and Aesthetic Values	Socioeconomic Impact	Ecosystem Protection	Carbon Footprint
C2	110 gpcd in 20 years	🟢 1	19.0	1.0	1.0	1.0	3	1	1	4	1	2	3	1
C1	120 gpcd in 10 years	🟢 2	21.0	2.5	2.5	1.0	3	1	1	3	1	2	3	1
S2	Excess San Juan-Chama water	🟢 3	21.4	1.0	4.9	4.5	2	1	1	1	1	1	2	2
FCB2	Future storage fee water	🟢 4	23.7	4.9	5.0	2.8	2	1	1	1	1	1	2	2
S1	Lease or short-term purchase of additional San Juan-Chama water	🟢 5	23.7	4.9	4.9	1.0	3	1	1	1	2	1	2	2
R3a	Connect southside reuse system to North I-25 Non-Potable Project	🟢 6	27.7	4.8	4.9	1.0	3	2	2	2	1	1	3	3
ASR1	Large-scale ASR projects	🟢 7	27.7	4.3	4.3	1.0	3	2	3	2	1	1	3	3
R3b	Expand southside reuse system	🟢 8	27.7	4.7	4.9	1.1	3	2	2	2	1	1	3	3
WM1	Watershed management -San Juan tributaries	🟢 9	28.0	5.0	5.0	5.0	2	1	1	1	1	1	2	4
WM2	Watershed management - Rio Grande and tributaries below Otowi	🟢 9	28.0	5.0	5.0	5.0	3	1	1	1	1	1	1	4
ST2	New reservoir 10,000 ac-ft	🟢 11	28.9	4.0	4.8	1.0	3	3	2	3	3	1	2	2
R2b	Eastside Reuse with storage	🟢 12	29.3	4.1	4.1	1.1	3	3	3	3	2	1	2	3
ST1	New reservoir 5,000 ac-ft	🟡 13	29.4	4.5	4.9	1.0	3	3	2	3	3	1	2	2
R2a	Eastside Reuse	🟡 14	29.6	4.2	4.2	1.1	3	3	3	3	2	1	2	3
R1b	Westside Reuse with storage	🟡 15	30.4	4.6	4.6	1.1	3	3	3	3	2	1	2	3
C3	Outdoor-only, 10 gpcd reduction over 30 years	🟡 16	30.7	3.3	3.3	1.0	3	2	1	5	3	3	5	1
FCB3	Relinquishment Credit Water	🟡 17	30.7	4.3	5.0	4.4	2	1	4	3	1	1	3	2
R1a	Westside Reuse	🟡 18	30.9	4.9	4.9	1.1	3	3	3	3	2	1	2	3
FCB1	Water banking	🟡 19	30.9	4.3	4.7	2.9	3	1	2	3	3	1	4	2
I/DPR3	I/DPR3	🟡 20	31.1	3.0	3.7	2.4	3	3	3	3	3	1	3	3
I/DPR2	I/DPR2	🟡 21	31.8	3.4	3.9	2.4	3	3	3	3	3	1	3	3
I2	Interbasin Transfer 10,000 afy, delivered to Water Authority system	🟡 22	32.4	3.7	3.7	1.0	4	1	2	5	4	1	3	4
I/DPR1	I/DPR1	🟡 23	32.8	4.0	4.3	2.4	3	3	3	3	3	1	3	3
WR1	Pre-1907 Water Rights Acquisition	🟡 24	32.8	4.9	4.9	1.0	3	1	3	4	4	1	4	2
I1	Interbasin Transfer 5,000 afy, delivered to Water Authority system	🔴 25	33.7	4.3	4.3	1.0	4	1	2	5	4	1	3	4
I4	Interbasin Transfer 10,000 afy, transferred to Water Authority system	🔴 26	34.4	3.7	3.7	1.0	4	2	3	5	5	1	2	4
P1	Operational flexibility under existing SP-4830 permit	🔴 27	34.4	4.7	4.7	1.0	3	2	5	4	5	1	2	2
SW1	Stormwater capture from existing facilities	🔴 28	34.6	4.8	4.8	1.0	4	2	5	4	4	1	3	1
I3	Interbasin Transfer 5,000 afy, transferred to Water Authority system	🔴 29	35.7	4.3	4.3	1.0	4	2	3	5	5	1	2	4
S3	Regional Diversion	🔴 30	36.7	4.3	4.3	1.0	3	3	4	4	5	1	3	4
SW3	Stormwater capture 1,000 – 2,000 afy	🔴 31	37.6	4.8	4.8	1.0	4	3	5	4	4	1	4	2
SW2	Stormwater capture 500 – 1,000 afy	🔴 32	37.8	4.9	4.9	1.0	4	3	5	4	4	1	4	2
B2	Brackish groundwater 5,000 afy	🔴 33	38.1	4.3	4.9	3.9	3	4	3	4	2	1	3	5
B1	Brackish groundwater 2,000 afy	🔴 34	38.5	4.7	4.9	3.9	3	4	3	4	2	1	3	5
I5	Produced water	🔴 35	39.7	4.9	4.9	1.0	3	5	4	5	3	1	3	5

References

City of Albuquerque Public Works Department. 1997. Evaluation of Alternatives Strategy Formulation. March.

Appendix 5.B

Cost Basis of Current Water Authority Operations and Associated Supply Alternatives

Water Authority WRMS Current and Associated Supply Alternative Cost Development

PREPARED FOR:	Water Authority
PREPARED BY:	INTERA
DATE:	August 2016

Water supply alternatives described in this appendix have either been previously developed (e.g. Bosque Reuse Project) or they are similar to, or expansions of, current operations. Costs for these water supply alternatives were developed based on available Water Authority historical data and conceptual design studies. Capital and annual O&M costs are presented for the following supply alternatives:

- Conservation
- San Juan-Chama Lease
- Excess San Juan-Chama Water
- SP-4830 Permit Modification
- Water Banking
- Storage Fee Water
- Payback of Borrowed Water
- Relinquishment Credit Water
- Westside Reuse – Bosque
- Eastside Reuse – Tijeras
- Large-scale ASR
- Pre-1907 Water Rights Acquisition

Data provided by the Water Authority include historical costs from pilot studies or existing production, as well as costs from conceptual designs provided to the Water Authority for new ASR and reuse projects. The cost estimates provided below are intended to provide relative comparisons of the alternatives, not accurate projections of the cost of a particular project or new supply.

Table 5.B1 presents a summary of the cost estimates.

Table 5.B1. Water Supply Alternative Summary Cost Estimates[1]

Water Supply Alternative	Yield, afy	Capital Cost Estimate	Annual O&M Cost Estimate	Present Worth Unit Cost, $/ac-ft
Conservation (120 gpcd in 10 years)	18,547	$ 0	$ 13,483,994	$ 730
Conservation (110 gpcd in 20 years)	29,745	$ 0	$ 21,730,166	$ 730
Conservation (reducing outdoor use by 10 gpcd over 30 years)	12,403	$ 0	$ 9,060,881	$730
San Juan-Chama Lease	1,000	$ 0	$ 337,000	$ 337
Excess San Juan-Chama Water	10,000	$ 0	$ 2,370,000	$ 237
SP-4830 Permit Modification	10,000	$ 2,000,000	$ 2,370,000	$250
Water Banking	8,000	$ 0	$ 3,496,000	$ 437
Storage Fee Water	1,000	$ 0	$ 237,000	$ 237
Payback of Borrowed Water	1,000	$ 0	$ 237,000	$ 237
Relinquishment Credit Water	5,000	$ 0	$ 1,685,000	$ 337
Westside Reuse (Bosque)	7,500	$ 137,396,439	$ 3,593,125	$ 1,643
Eastside Reuse (Tijeras)	7,000	$ 99,435,015	$ 3,935,752	$ 1,465
ASR, Re-drill Existing Well to Dual-Purpose Well	5,000	$4,666,250	$ 2,085,000	$ 476
Pre-1907 Water Rights Acquisition	4,500	$ 75,000,000	$1,066,500	$ 1,296

Note: Yields in Table 5.B1 may be slightly different than Table 5.A1 due to adjustments made to some yields during the course of the analysis. The present worth unit costs are not significantly impacted by this.

Cost Estimates for Supply Alternatives

Conservation

The conservation supply alternative includes three sub-alternatives, each of which includes varying water conservation goals as discussed in the main body of this chapter. The three conservation goals are:

- 120 gpcd by 2027,
- 110 gpcd by 2037, and
- Reducing outdoor use by 10 gpcd over 30 years.

While conservation increases the amount of water available for future uses it also decreases revenue by decreasing the amount of water billed to customers. For each of the three conservation sub-alternatives, a cost was estimated by calculating the “loss of revenue” resulting from a decrease in demand. The change in demand for each sub-alternative was calculated by subtracting the sub-alternative demand from the baseline demand. This difference in volume of demand was then multiplied by a unit cost.

The loss of revenue unit cost was calculated using the commodity price of \$1.68 for 1 unit of water charged by the Water Authority. The commodity price is what the Water Authority charges to pump, treat, and deliver water to customers. One unit of water is equal to 748 gallons. The equation to calculate the unit cost of loss of revenue per ac-ft reduction is the following:

$$UC = (C * V_U)$$

Where: UC = Unit cost for loss of revenue

C = Commodity price of \$1.68 per unit

V_u = Volume of 1 unit is 748 gallons

The unit cost for conservation loss of revenue is \$730/ac-ft. The equation to calculate the cost of the conservation sub-alternatives is the following:

$$C = UC * (D_b - D_a)$$

Where: C = Cost of alternative

UC = Unit cost for loss of revenue

D_b = Baseline demand

D_a = Conservation sub-alternative demand

San Juan-Chama Lease

This alternative does not include any capital costs because the water will be pumped, piped and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of \$237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority. In addition, the O&M cost for lease or short-term purchase of San Juan-Chama water includes a price agreement for the lease. The Water Authority has held discussions with San Juan-Chama contract holders that do not use their full permitted amount. Based on these discussions an estimated cost for the lease of San Juan-Chama water is \$100/ac-ft (Lieuwen, 2016, pers. comm.).

Excess San Juan-Chama Water

This alternative does not include any capital costs because the water will be pumped, piped and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of \$237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority.

SP-4830 Permit Modification

Modifying the SP-4830 permit for surface water diversion could increase the quantity of water that can be diverted, piped, and treated through existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of \$237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority. To modify the SP-4830 permit the Water Authority will have to go through a, potentially lengthy, legal and public process. Based on the costs of previous permitting efforts, an estimated capital cost for the legal and public process to modify SP-4830 is \$2 to \$5 million (Stomp, 2016, pers. comm.). The capital cost to modify SP-4830 could vary significantly.

Water Banking

This alternative does not include any capital costs. Water Banking will use existing infrastructure to divert, pipe, and treat water. The O&M cost includes additional diversion and water treatment at the existing plant of $237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority. In addition, water banking O&M includes a lease cost for the water. An estimate of $200/ac-ft for leased agricultural water for water banking was determined based on a water banking analysis completed for the Middle Rio Grande Valley (Oat and Paskus, 2013).

Storage Fee Water

This alternative does not include any capital costs because the water will be pumped, piped, and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of $237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority.

Payback of Borrowed water

This alternative does not include any capital costs because the water will be pumped, piped and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of $237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority.

Relinquishment Credit Water

This alternative does not include any capital costs since the water will be pumped, piped and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of $237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority.

Westside Reuse – Bosque

The westside reuse (Bosque Reuse Project) alternative was evaluated by CH2M and was provided to the Water Authority in May 2012 (CH2M, 2012). It was evaluated as a 7,500 ac-ft project. The cost opinions developed in 2011were approximately $124 million in capital costs and $430/ac-ft in O&M costs (CH2M, 2012). These past cost opinions were escalated to present value (in 2016 dollars) using the Engineering News Record Construction Cost Index (ENR CCI), May 2016 value of 10,315. The present value is approximately $137 million and the present value of the O&M cost is $479/ac-ft.

Eastside reuse – Tijeras

The eastside reuse (Tijeras Reuse Project) alternative was evaluated by CH2M and was provided to the Water Authority in May 2012 (CH2M, 2012). It was evaluated as a 7,000 ac-ft project. The cost opinions developed in 2011 were approximately $89 million in capital costs and $505/ac-ft in O&M costs (CH2M, 2012). These past cost opinions were escalated to present value (2016 dollars) using the Engineering News Record Construction Cost Index (ENR CCI), May 2016 value of 10,315. The present value is approximately $99 million, and the present value of the O&M cost is $562/ac-ft.

Aquifer Storage and Recovery (ASR)

Additional ASR capacity could provide the Water Authority with the ability to store excess water for later use. The capital cost estimate of approximately $4.7 million to install and connect one well to the water treatment plant was developed as a preliminary cost estimate in 2012 and updated in 2016 (DBSA and CH2M, 2012, 2016). The O&M cost for ASR was estimated by using historical O&M costs for water treatment before injection ($237/ac-ft) and for groundwater pumping ($125/ac-ft) plus the estimated injection well O&M and replacement costs from the Water Authority ($62/ac-ft) (Yuhas, 2016, pers. comm.). The total O&M cost for ASR is estimated to be $424/ac-ft.

Pre-1907 Water Rights Acquisition

Purchasing additional pre-1907 water rights would include purchase and permitting of water rights (capital costs) as well as associated O&M. The price of pre-1907 water rights is approximately $15,000/ac-ft in the Middle Rio Grande Valley, and the permitting cost may be approximately $500/ac-ft (Lieuwen, 2016, pers. comm.). Water would be pumped, piped and treated with existing infrastructure. The O&M cost includes additional diversion and water treatment at the existing plant of $237/ac-ft. This unit cost for water treatment is based on existing diversion and treatment cost data provided by the Water Authority.

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Appendix 5.C

Cost Basis for New Supply Alternatives

Water Authority WRMS New Supply Alternative Cost Opinions

PREPARED FOR: Water Authority

PREPARED BY: CH2M

DATE: May 2016

Executive Summary

The cost opinions presented herein are in support of ABCWUA new water supply scenario planning. Capital and annual O&M cost opinions are presented for the following new water supply alternatives:

- New 3.6-mgd regional surface water diversion including a source water Ranney collector, raw water pump station and pipeline, new water treatment plant, and finished water pump station and pipeline to existing finished water storage tank.
- Stormwater capture from the existing AMAFCA channel including a new 15-mgd pump station to lift stormwater to an existing water treatment plant.
- Interbasin transfer of surface water via Rio Grande including expansion of the San Juan-Chama water treatment plant to 120-mgd capacity.
- Delivery of 0.9-mgd produced water from Sandoval County including a pump station, pipeline and reverse osmosis water treatment plant and solar evaporation pond concentrate disposal.
- New indirect or direct potable reuse supply ranging from 3- to 9- to 14-mgd nominal capacity and peak capacity factor of 2, including winter use of wastewater effluent, advanced treatment, pump station and pipeline from southside reuse to the raw water pipeline to the San Juan-Chama water treatment plant raw water ponds (or shared infrastructure with the "Connect Southside Reuse Project…" below).
- Connect Southside Reuse Project to North I-25 Non-Potable Project including pump station and pipelines to support 5-mgd south to north transfer.
- New 5,000- or 10,000-ac-ft, silt-lined, earthen reservoir storage for various surplus water supplies including reservoir itself as well as influent pump station and pipeline.
- New brackish groundwater desalters including either 1.8- or 4.5-mgd influent capacity, deep wells, reverse osmosis treatment, finished water delivery, and reverse osmosis concentrate solar evaporation disposal ponds.

The cost opinions presented herein are classified as Association for the Advancement of Cost Engineering (AACE International) Class 5 cost estimate as defined below:

Class 5. This estimate is prepared based on information, where the preliminary engineering is from 0 to 2 percent complete. Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long- range capital planning, etc. Examples of estimating methods used would include stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.

Given the water supply schemes will only include sufficient major process design criteria inputs to advance the concept to 0 to 2 percent complete, the cost estimates presented herein, and any resulting conclusions on project financial or economic feasibility or funding requirements, are prepared for guidance in relative project evaluation and implementation and use the information available at the time of the estimate. The final costs of a project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimates provided in this document.

Table 5.C1 below presents a summary of the cost opinions developed.

Table 5.C1. New Water Supply Alternative Summary Cost Opinions

New Water Supply Alternative	Yield, afy	Capital Cost Estimate	Annual O&M Cost Estimate	Present Worth Unit Cost, $/AF
New Regional Surface Water Diversion	4,000	$34,204,281	$1,328,000	$875
Stormwater Capture	1,400	$1,447,578	$95,000	$134
Connect expanded southside reuse system to NI-25 Non-Potable Project	3,000	$23,443,875	$699,000	$730
Indirect/Direct Potable Reuse 3	15,700	$116,859,600	$4,296,000	$747
Indirect/Direct Potable Reuse 2	10,100	$86,360,625	$3,100,000	$850
Indirect/Direct Potable Reuse 1	3,400	$49,188,263	$1,688,000	$1,416
New Reservoir	5,000	$56,014,300	$1,040,000	$920
New Reservoir	10,000	$69,615,550	$1,185,000	$561
Produced Water	1,000	$112,071,375	$2,900,000	$10,021
Interbasin Transfer	10,000	$58,140,858	$2,912,000	$661
Brackish Groundwater	5,000	$75,503,318	$6,934,000	$2,346
Brackish Groundwater	2,000	$54,051,075	$3,844,000	$3,639

The remainder of this technical memorandum presents further detail supporting the Table 5.C1 cost opinion summary. Cost Opinion Detail tables at the end of this appendix present more detailed cost opinion breakdown for each new water supply alternative.

Capital Cost Estimate Preparation

Project Component Construction Costs

Water infrastructure, unit process, component construction costs were generated using CH2M Parametric Design and Cost Estimating System (CPES). CPES is a proprietary conceptual cost estimating tool composed of a group of Excel spreadsheets each representing a specific water infrastructure, unit process, component model. The CPES water infrastructure models are based on actual CH2M designed and constructed facilities with flexibility to receive project-specific conceptual process design criteria inputs. The conceptual design criteria inputs allow for sizing the unit process facility as well as conceptual quantity take-off calculations for earthwork, reinforced steel concrete, masonry, metals, woods & plastics, doors & windows, equipment, instrumentation & controls, mechanical, and electrical model components. RSMeans unit costs serve as the unit cost basis for construction materials and installation labor. Actual historical budgetary equipment costs serve as the unit cost basis for equipment.

Table 5.C2 presents the site wide allowances included within the water infrastructure component construction costs developed from CPES for water treatment plants and pump stations, as these components include additional supporting infrastructure to enable the group of unit processes to perform in a secure environment. These allowances are based on actual constructed projects and experience for the cost of site grading, roadways, site secondary power distribution, site instrumentation and control signal transmission, and yard piping to interconnect the unit processes as a percentage of the total facility unit process component construction cost.

Table 5.C2. Site Wide Allowances for WTPs and Pump Stations

Project Component	Allowance
Site Grading, Roadways, Stormwater Management	3%
Site Electrical Distribution (less primary & standby power provisions)	4.5%
Site Yard Piping	5.5%
Site I&C/SCADA Network	1.5%
TOTAL SITE WIDE ALLOWANCE	**14.5%**

The following subsections provide fundamental, conceptual design criteria assumptions regarding the development of each of the new water supply alternatives to support cost opinion development.

New Regional Surface Water Diversion

- Capacity: 4,000 afy source water, 3.6-mgd infrastructure capacity.
- Source Water: Rio Grande via Ranney collector south of Highway 550.
- Raw Water Conveyance: 1-mile pipeline and 60-foot static lift from Ranney to new water treatment plant.
- Water Treatment: ozone – biologically active carbon filtration – free chlorine disinfection – treated water pumping.
- Treated Water Conveyance: 2-mile pipeline and 150-foot static lift to existing tankage.

Stormwater Capture from the Existing AMAFCA Channel

- Capacity: 1,400 afy source water, 15-mgd infrastructure capacity.

- Source Water: stormwater.
- Raw Water Conveyance: pump station with 20-foot static lift from channel to San Juan-Chama WTP raw water pipeline.
- Water Treatment: existing San Juan-Chama WTP.

Connect Expanded Southside Reuse System to NI-25 Non-Potable Project

- Capacity: 3,000 afy source water, 5-mgd infrastructure capacity.
- Source Water: non-potable water from Southside Reuse Project.
- Treated Water Conveyance: 8.3-mile pipeline main with 240-foot static lift and 65 psi connection back pressure to existing north reuse system; and 2.75 miles of service laterals.

Indirect or Direct Potable Reuse

- Capacity: 3,400, 10,100, and 15,700 afy source water; 3-, 9-, and 14-mgd average capacity; 6-, 18-, and 28-mgd maximum infrastructure capacity.
- Source Water: WWTP secondary effluent.
- Water Treatment: ozone – biologically activated carbon filtration - membrane filtration - GAC adsorption - UV disinfection – treated water pumping.
- Treated Water Conveyance: 6-mile pipeline with 70-foot static lift at pipeline high point and delivery to the existing San Juan-Chama WTP raw water pipeline (ASR options do not require additional pipelines).

New Reservoir Storage

- Capacity: 5,000 or 10,000 ac-ft storage, 5-mgd infrastructure capacity.
- Source Water: Varies.
- Raw Water Conveyance: 3-mile pipeline with 700-foot static lift.

Produced Water from Sandoval County

- Capacity: 1,000 afy source water, 0.9-mgd infrastructure capacity.
- Source Water: produced water from shale fracturing with assumed TDS of 30,000 mg/L.
- Raw Water Conveyance: 40-mile pipeline with 250-foot static lift at pipeline high point and 800-foot fall to new WTP.
- Water Treatment: dissolved air flotation - lime softening – evaporator – free chlorine disinfection – treated water pumping - evaporator brine to solar evaporation pond.
- Treated Water Conveyance: via existing San Juan-Chama WTP delivery system.

Interbasin Transfer of Surface Water

- Capacity: 10,000 afy source water, 9-mgd infrastructure capacity.
- Source Water: Rio Grande via existing San Juan-Chama WTP intake.
- Raw Water Conveyance: via existing San Juan-Chama WTP system.
- Water Treatment: expand San Juan-Chama WTP to 120-mgd.
- Treated Water Conveyance: via existing San Juan-Chama WTP delivery system.

Brackish Groundwater Desalting

- Capacity: 2,000 or 5,000 afy source water, 1.8- or 4.5-mgd infrastructure capacity.
- Source Water: brackish groundwater with 10,000 mg/L TDS.
- Raw Water Conveyance: 1,000-gpm capacity wells, 6,500 feet deep with 2,500-foot spacing and collector well piping to WTP.
- Water Treatment: sand filtration – full-stream reverse osmosis – stabilization – free chlorine – treated water pumping - disinfection with concentrate disposal to solar evaporation ponds.
- Treated Water Conveyance: 1.7-mile pipeline with 65 psi interconnection back pressure to existing infrastructure.

Project Contingency

Project contingency is defined as unknown or unforeseen costs. Depending upon the project phase when the cost estimates are developed, the contingency varies as presented in Table 5.C4. The contingency is applied to the Construction Cost subtotal including project component construction costs. Following application of the contingency, a Project Construction Cost is generated.

Table 5.C4. Contingency Allowance by Project Definition Phase

Project Phase	Project Cost Contingency (%)
5%/10% Planning/Conceptual	**30**
30% Schematic Level	20
50%/60% Plans/Specifications	15
90% Plans/Specifications	10
Final Plans/Specifications	10
Construction Contract	5

For the estimates presented herein, a 30 percent contingency is applied to the sum of the project component costs to account for incomplete definition and design.

Construction Cost Index

The project component cost estimates for this effort are based on a 20-Cities Engineering News Record Construction Cost Index (ENR CCI), January 2016 value of 10,133.

Non-Construction Costs

Non-construction costs are project costs, which are not included in the construction and land cost categories. Non-construction costs, estimated as a percentage of the project construction cost including contingency are described in Table 5.C5. The non-construction costs are based on ASCE guidance for procurement of engineering services and on CH2M experience with delivery of projects of similar scope and magnitude as the ABCWUA new, alternative water supply concepts. Likewise, ABCWUA guidance was utilized where applicable.

For example, where additional information is known for a given alternative, costs are estimated directly (e.g. Land Acquisition). The value of 12.5 percent will be used for the cost opinions presented herein.

Table 5.C5. Non-Construction Costs

Description	Percent of Construction Cost
Program Management	
Includes management and procurement assistance for permitting, design, construction, and public relations.	1.0
Design Services	
Includes preparation of plans and specifications to construct the work and obtain bids, as necessary	5.0
Design Services During Construction	
Includes shop drawing review, engineering assistance, meeting attendance, and record drawings	1.0
Construction Management Services	
Includes management, document control, inspection, and environmental compliance monitoring during construction	5.0
Startup and Training	
Includes training of owners, staff, and operation and maintenance manuals	0.5
Total	**12.5%**

Land Costs

A number of the facilities are planned for property already owned by the Water Authority. In general, other facilities would be collocated with City/County or Water Authority facilities or on lands provided by others as part of supply agreements. Rights of way and easements would be similarly shared with existing facilities, are already owned, or would be provided by others as part of supply agreements.

Annual O&M Cost Estimate Preparation

Annual O&M cost includes the following elements:

- Labor
- Chemicals
- Power
- Ultimate Residuals Disposal
- Repair and Maintenance Materials

Chemicals, power and ultimate residuals disposal are based on average annual day flow capacity. Labor, as well as repair and maintenance materials are considered fixed costs unrelated to flow rate.

Labor

Table 5.C6 presents the assumed base staffing requirements and hourly rates for water treatment plants and pump stations based on CH2M experience which includes a wide range of staffing philosophies across water utilities world-wide.

Table 5.C6. Project Component Staffing Requirements & Rates

Project Component Staffing	**Staffing Rates**	**Annual Cost**
Pump Station		
1 – Maintenance/Operator @ 8 hrs per day – 5 days per week	$30/hr	$62,400
Pump Station Annual Labor Cost		$62,400
Water Treatment Plant		
1 – Superintendent @ 8 hrs per day – 5 days per week	$50/hr	$104,000
3 – Operators onsite to cover 16 hrs per day – 7 days per week – no night shift	$30/hr	$187,200
2 – Maintenance Workers to cover 8 hrs per day – 7 days per week	$30/hr	$124,800
1 – Clerical/Lab Worker @ 8 hrs per day – 5 days per week	$20/hr	$41,600
Water Treatment Plant Annual Labor Cost		$457,600

Chemicals

Table 5.C7 presents the chemicals, average annual dose assumptions, and chemical unit costs associated with each WTP type, resulting in a total chemical cost per million gallons by WTP type.

Table 5.C7. Chemical Costs

Chemical	**Unit Cost ($/dry ton)**	**Brackish Groundwater WTP Dose, mg/L**	**Surface WTP with Ranney Collector Dose, mg/L**	**San Juan-Chama WTP Expansion Dose, mg/L**	**Potable Reuse WTP Dose, mg/L**	**Produced Water WTP Dose, mg/L**
Sodium Hypochlorite	$1,500	3	3	3	3	3
Sodium Hydroxide	$600	25	12.5	12.5	12.5	2
Calcium Hydroxide	$300	0	0	0	0	200
Carbon Dioxide	$150	20	0	0	0	0
Sulfuric Acid	$200	20	12.5	12.5	12.5	50
Ferric Chloride	$450	0	0	60	0	0
Polymer	$2,500	0	0	1.5	0	3
Scale Inhibitor	$3,500	2.5	0	0	0	0
Liquid Oxygen	$150	0	33.3	33.3	33.3	0
GAC	$2,000	0	2 (8-yr replace rate)	2 (8-yr replace rate)	6 (3-yr replace rate)	0
Total WTP Chemical Unit Cost, $/MG		**$147**	**$98**	**$226**	**$131**	**$350**

Power

Power cost is based on a unit power rate of $0.07 per kilowatt-hour. Table 5.C8 presents the annual power cost assumptions and calculation method for each major power consuming project component.

Table 5.C8. Average Annual Power Costs

Project Component	Annual Power Cost Assumptions & Calculation Method
Groundwater Production Wells	Use total connected HP and adjust by average annual day to maximum day flow capacity ratio.
Brackish Groundwater WTP	Use 300 psi RO feed pump TDH, average annual day permeate capacity divided by 80% product water recovery, 80% RO feed pump power efficiency, and assume this represents 90% of total WTP power usage.
Surface WTP	Assume 100 HP per 1 mgd of WTP capacity and adjust by average annual day to maximum day flow capacity ratio.
Produced Water WTP	Assume 2,000 HP per 1 mgd of WTP capacity and adjust by average annual day to maximum day flow capacity ratio.
Potable Reuse WTP	Assume 150 HP per 1 mgd of WTP capacity and adjust by average annual day to maximum day flow capacity ratio.
Pump Station	Use maximum duty HP and adjust by average annual day to maximum day flow capacity ratio.

Ultimate Residuals Disposal

Table 5.C9 presents assumptions regarding ultimate solids disposal associated with the water treatment plants.

Table 5.C9. Average Solid Residuals Disposal Costs

Project Component	Annual Power Cost Assumptions & Calculation Method
Brackish Groundwater WTP & New Surface WTP with Ranney Collector	1 mg/L each of TSS, particulate iron, and particulate manganese resulting in 25 dry lb/MG, 20% dried solids resulting in 125 lb sludge/MG, 70.42 lb sludge/cf resulting in 1.8 cf sludge/MG or 0.067 cy sludge/MG, and haul and disposal cost of $50/cy sludge.
San Juan-Chama WTP Expansion	100 mg/L of TSS and 60 mg/L of ferric sludge resulting in 1300 dry lb/MG, 20% dried solids resulting in 6,500 lb sludge/MG, 70.42 lb sludge/cf resulting in 93 cf sludge/MG or 3.44 cy sludge/MG, and haul and disposal cost of $50/cy sludge.
Produced Water WTP	200 mg/L lime resulting in 400 mg/L of hardness sludge translating to 3336 dry lb/MG, 20% dried solids resulting in 16,680 lb sludge/MG, 70.42 lb sludge/cf resulting in 237 cf sludge/MG or 9 cy sludge/MG, and haul and disposal cost of $50/cy sludge.
Indirect/Direct Potable Reuse WTP	20 mg/L of TSS resulting in 167 dry lb/MG, 20% dried solids resulting in 835 lb sludge/MG, 70.42 lb sludge/cf resulting in 12 cf sludge/MG or 0.44 cy sludge/MG, and haul and disposal cost of $50/cy sludge.

Repair and Maintenance Materials

Annual repair and maintenance materials allowance as a percentage of project component construction cost with no allowances added are presented in Table 5.C10. Table 5.C10 also presents the number of years at the given repair and maintenance allowance until the project component cost is replaced.

Table 5.C10. Annual Repair and Maintenance Allowances

Project Component	Annual O&M Cost as % of Project Component Construction Cost	Years to Reach Project Component Construction Cost
Groundwater Production Wells	3%	25
Wellfield Collector Piping	1%	70
Water Treatment Plants	3%	25
RO Concentrate Solar Evaporation Ponds & Earthen Storage Reservoirs	1%	70
Raw & Treated Water Pipelines	1%	70
Pump Station	3%	25
Sleeve Valve Pressure Reducing Vault	3%	25

Present Worth Cost Estimate Preparation

A present worth cost evaluation is important for allowing side by side comparison of overall alternative project costs to evaluate project sensitivity to combined capital and annual O&M costs. For the purposes of this guide, a rate of 2.4 percent and 20 years are used for application to the total capital cost estimate to create an annual capital debt payment. This annual capital debt payment is then added to the total annual O&M cost to create a total present worth cost estimate that can be divided by either average annual or maximum annual water production to yield a total present worth unit cost estimate in terms of dollars per ac-ft.

Cost Opinion Detail

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
New Surface Water Diversion Project Component	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Ranney Collector System	$2,720,000	$3,536,000	$3,978,000	$3,978,000					$27,200	$27,200
Raw Water Pump Station	$1,550,000	$2,015,000	$2,266,875	$2,266,875	$62,400		$29,210		$46,500	$138,110
Raw Water Pipeline	$1,150,000	$1,794,000	$2,018,250	$2,049,150					$11,500	$11,500
Water Treatment Plant	$12,430,000	$19,390,800	$21,814,650	$21,825,450	$457,600	$128,772	$164,615	$4,400	$372,900	$1,128,287
Treated Water Pipeline	$2,292,311	$3,576,005	$4,023,006	$4,084,806					$22,923	$22,923
TOTAL	**$20,142,311**	**$30,311,805**	**$34,100,781**	**$34,204,281**	**$520,000**	**$128,772**	**$193,825**	**$4,400**	**$481,023**	**$1,328,020**
Annualized Capital Cost	**$2,173,434**									
Total Annual Cost	**$3,501,454**									
Annual Yield, AFY	**4,000**									
Total Unit Cost, $/AF	**$875**									

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
InterBasin Transfer Project Component	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Water Treatment Plant	$39,754,433	$51,680,763	$58,140,858	$58,140,858	$0	$742,410	$411,537	$565,020	$1,192,633	$2,911,600
TOTAL	**$39,754,433**	$51,680,763	**$58,140,858**	$58,140,858	**$0**	**$742,410**	**$411,537**	**$565,020**	**$1,192,633**	**$2,911,600**
Annualized Capital Cost	**$3,694,430**									
Total Annual Cost	**$6,606,030**									
Annual Yield, AFY	**10,000**									
Total Unit Cost, $/AF	**$661**									

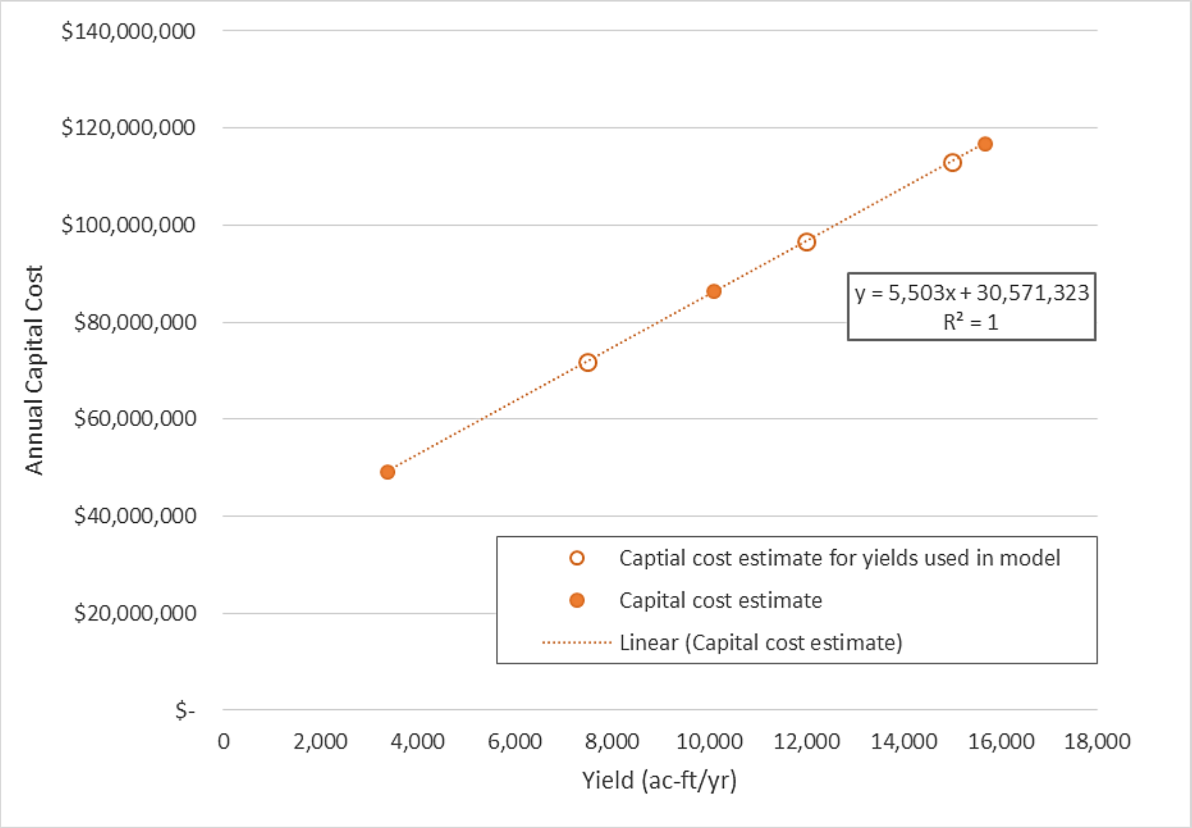
	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
Produced Water from Sandoval Company	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Raw Water Pump Station	$1,800,000	$2,340,000	$2,632,500	$2,632,500	$62,400	$0	$22,800	$0	$54,000	$139,200
Raw Water Pipeline	$45,550,000	$59,215,000	$66,616,875	$66,616,875	$0	$0	$0	$0	$455,500	$455,500
Water Treatment Plant	$24,400,000	$38,064,000	$42,822,000	$42,822,000	$457,600	$115,000	$850,000	$148,000	$732,000	$2,302,600
TOTAL	**$71,750,000**	**$99,619,000**	**$112,071,375**	**$112,071,375**	**$520,000**	**$115,000**	**$872,800**	**$148,000**	**$1,241,500**	**$2,897,300**
Annualized Capital Cost	**$7,121,323**									
Total Annual Cost	**$10,018,623**									
Annual Yield, AFY	**1,000**									
Total Unit Cost, $/AF	**$10,019**									

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
Potable Reuse (3 mgd Average, 6 mgd Peak)	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Water Treatment Plant	$26,020,000	$33,826,000	$38,054,250	$38,054,250	$457,600	$144,000	$206,000	$24,000	$780,600	$1,612,200
Treated Water Pipeline	$7,613,000	$9,896,900	$11,134,013	$11,134,013	$0	$0	$0	$0	$76,130	$76,130
TOTAL	**$33,633,000**	**$43,722,900**	**$49,188,263**	**$49,188,263**	**$457,600**	**$144,000**	**$206,000**	**$24,000**	**$856,730**	**$1,688,330**
Annualized Capital Cost	**$3,125,558**									
Total Annual Cost	**$4,813,888**									
Annual Yield, AFY	**3,400**									
Total Unit Cost, $/AF	**$1,416**									

	CAPITAL COST ESTIMATE				**ANNUAL O&M COST ESTIMATE**					
Potable Reuse (9 mgd Average, 18 mgd Peak)	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Water Treatment Plant	$46,550,000	$60,515,000	$68,079,375	$68,079,375	$457,600	$432,000	$618,000	$72,000	$1,396,500	$2,976,100
Treated Water Pipeline	$12,500,000	$16,250,000	$18,281,250	$18,281,250	$0	$0	$0	$0	$125,000	$125,000
TOTAL	**$59,050,000**	**$76,765,000**	**$86,360,625**	**$86,360,625**	**$457,600**	**$432,000**	**$618,000**	**$72,000**	**$1,521,500**	**$3,101,100**
Annualized Capital Cost	**$5,487,592**									
Total Annual Cost	**$8,588,692**									
Annual Yield, AFY	**10,100**									
Total Unit Cost, $/AF	**$850**									

	CAPITAL COST ESTIMATE				**ANNUAL O&M COST ESTIMATE**					
Potable Reuse (14 mgd Average, 28 mgd Peak)	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Water Treatment Plant	$64,740,000	$84,162,000	$94,682,250	$94,682,250	$457,600	$672,000	$961,000	$112,000	$1,942,200	$4,144,800
Treated Water Pipeline	$15,164,000	$19,713,200	$22,177,350	$22,177,350	$0	$0	$0	$0	$151,640	$151,640
TOTAL	**$79,904,000**	**$103,875,200**	**$116,859,600**	**$116,859,600**	**$457,600**	**$672,000**	**$961,000**	**$112,000**	**$2,093,840**	**$4,296,440**
Annualized Capital Cost	**$7,425,580**									
Total Annual Cost	**$11,722,020**									
Annual Yield, AFY	**15,700**									
Total Unit Cost, $/AF	**$747**									

Peak flow	**Annual Yield (afy)**	**Capital cost estimate**	**Annual Yield Used in Model (afy)**	**Capital cost estimate for yields used in model**
6 mgd	3,400	$49,188,263	7,500	$71,845,600
18 mgd	10,100	$86,360,625	12,000	$96,610,166
28 mgd	15,700	$116,859,600	15,000	$113,119,877



	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
Connect Expanded Southside Reuse System to NI-25 Non-Potable Project	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Treated Water Pump Station	$3,420,000	$4,446,000	$5,001,750	$5,001,750	$62,400	$0	$408,000	$0	$102,600	$573,000
Treated Water Pipeline	$12,610,000	$16,393,000	$18,442,125	$18,442,125	$0	$0	$0	$0	$126,100	$126,100
TOTAL	**$16,030,000**	**$20,839,000**	**$23,443,875**	**$23,443,875**	**$62,400**	**$0**	**$408,000**	**$0**	**$228,700**	**$699,100**
Annualized Capital Cost	**$1,489,688**									
Total Annual Cost	**$2,188,788**									
Annual Yield, AFY	**3,000**									
Total Unit Cost, $/AF	**$730**									

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
5000 AF New Storage	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Raw Water Pump Station	$3,661,000	$4,759,300	$5,354,213	$5,354,213	$62,400	$0	$512,000	$0	$109,830	$684,230
Raw Water Pipeline	$3,439,376	$4,471,188	$5,030,087	$5,030,087	$0	$0	$0	$0	$34,394	$34,394
Earthen Storage Reservoir	$26,000,000	$40,560,000	$45,630,000	$45,630,000	$0	$0	$0	$0	$260,000	$260,000
TOTAL	**$33,100,376**	**$49,790,488**	**$56,014,300**	**$56,014,300**	**$62,400**	**$0**	**$512,000**	**$0**	**$404,224**	**$978,624**
Annualized Capital Cost	**$3,559,303**									
Total Annual Cost	**$4,537,926**									
Annual Yield, AFY	**5,000**									
Total Unit Cost, $/AF	**$908**									

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
10000 AF New Storage	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Raw Water Pump Station	$3,661,000	$4,759,300	$5,354,213	$5,354,213	$62,400	$0	$512,000	$0	$109,830	$684,230
Raw Water Pipeline	$3,439,376	$4,471,188	$5,030,087	$5,030,087	$0	$0	$0	$0	$34,394	$34,394
Earthen Storage Reservoir	$40,500,000	$52,650,000	$59,231,250	$59,231,250	$0	$0	$0	$0	$405,000	$405,000
TOTAL	**$47,600,376**	**$61,880,488**	**$69,615,550**	**$69,615,550**	**$62,400**	**$0**	**$512,000**	**$0**	**$549,224**	**$1,123,624**
Annualized Capital Cost	**$4,423,564**									
Total Annual Cost	**$5,547,187**									
Annual Yield, AFY	**10,000**									
Total Unit Cost, $/AF	**$555**									

	CAPITAL COST ESTIMATE				ANNUAL O&M COST ESTIMATE					
2000 AFY Brackish Groundwater Desalter	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Well Field & Collector Piping	$19,370,000	$25,181,000	$28,328,625	$28,328,625	$62,400	$0	$2,176,000	$0	$581,100	$2,819,500
Water Treatment Plant	$8,360,000	$10,868,000	$12,226,500	$12,226,500	$457,600	$97,000	$140,000	$2,200	$250,800	$947,600
Brine Solar Evaporation Pond	$5,740,000	$8,954,400	$10,073,700	$10,073,700	$0	$0	$0	$0	$57,400	$57,400
Treated Water Pipeline	$1,950,000	$3,042,000	$3,422,250	$3,422,250	$0	$0	$0	$0	$19,500	$19,500
TOTAL	**$35,420,000**	**$48,045,400**	**$54,051,075**	**$54,051,075**	**$520,000**	**$97,000**	**$2,316,000**	**$2,200**	**$908,800**	**$3,844,000**
Annualized Capital Cost	**$3,434,554**									
Total Annual Cost	**$7,278,554**									
Annual Yield, AFY	**2,000**									
Total Unit Cost, $/AF	**$3,639**									

	CAPITAL COST ESTIMATE				**ANNUAL O&M COST ESTIMATE**					
5000 AFY Brackish Groundwater Desalter	**Project Component Direct Construction Cost Estimate**	**Project Component Construction with Contingency Cost Estimate**	**Project Component Construction with Contingency & Non-Construction Cost Estimate**	**Capital Cost Estimate**	**Labor**	**Chemicals**	**Power**	**Ultimate Residuals Disposal**	**Repair & Maintenance**	**Annual O&M Cost**
Well Field & Collector Piping	$33,740,000	$43,862,000	$49,344,750	$49,344,750	$62,400	$0	$4,350,000	$0	$1,012,200	$5,424,600
Water Treatment Plant	$14,033,000	$18,242,900	$20,523,263	$20,523,263	$457,600	$243,000	$350,000	$5,500	$420,990	$1,477,090
Brine Solar Evaporation Pond	$1,261,000	$1,967,160	$2,213,055	$2,213,055	$0	$0	$0	$0	$12,610	$12,610
Treated Water Pipeline	$1,950,000	$3,042,000	$3,422,250	$3,422,250	$0	$0	$0	$0	$19,500	$19,500
TOTAL	**$50,984,000**	**$67,114,060**	**$75,503,318**	**$75,503,318**	**$520,000**	**$243,000**	**$4,700,000**	**$5,500**	**$1,465,300**	**$6,933,800**
Annualized Capital Cost	**$4,797,689**									
Total Annual Cost	**$11,731,489**									
Annual Yield, AFY	**5,000**									
Total Unit Cost, $/AF	**$2,346**									

Water 2120:
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CHAPTER 6

Filling Future Gaps in Supply

CHAPTER 6

6.1 Introduction and Purpose

Fundamental to developing a strategy for meeting future gaps in supply and demand is an understanding of the potential timing and magnitude of said gaps, as well as a means to fill them. Methods to fill gaps developed in this chapter will inform decision makers about the need for and efficacy of potential options and strategies for future supply.

As part of the 2007 WRMS, the Water Authority utilized a single water demand projection which was based on historical system growth using the current water conservation goal (150 gpcd at that time), and one water supply projection which was based on historical water availability.

As noted in the Chapter 2, Water Demand, and Chapter 3, Water Supply, the Water Authority recognizes the inherent uncertainty in projecting future water demand and supply and the associated need to plan for a range of possible futures.

As such, the Water Authority is combining the demand and supply projections from previous chapters into discrete scenarios of alternative futures. These scenarios allow for consideration of a range of future conditions and development of portfolios of alternatives that are flexible and adaptable over a range of possibilities.

This chapter presents the following information:

- Scenarios of future demand and supply
- Metrics for analysis of supply options
- Gaps in future supply
- Criteria for selecting portfolios
- Evaluations and implementation options for chosen portfolios

6.2 Historical Gap Analysis and Portfolio

As part of the work leading up to the 1997 and 2007 Strategies, a number of alternatives and combinations of alternatives were evaluated for their ability to meet future water demand while considering a number of other factors like hydrologic effects on the aquifer and river system. Alternatives were analyzed to see how they impacted consumptive use of existing resources, aquifer mining, and the preservation and protection of groundwater as a drought reserve. The combination of alternatives that best met the performance metrics and satisfied decision and financial criteria was selected to be carried forward in the 1997 and 2007 Strategies and have been implemented. This portfolio included:

- Groundwater
- Surface water - SJC DWP
- Conservation
- Reuse
- ASR

Figures 6.1 and 6.2 show a timeline of the strategy results and a geographic representation of broad concepts and specific projects, respectively. As part of the 1997 WRMS, it was noted that there was a fundamental disconnect in historical operations and the ability to use the Water Authority's SJC supply. Direct diversion allowed for the full consumptive use of SJC water as opposed to using it in the future solely for groundwater offsets. As such, a key component of the 1997 WRMS was the conversion to direct diversion of SJC water through the DWP. The DWP and other implemented alternatives largely filled projected gaps in supply and utilized the resources that the Water Authority owned through 2060. Figure 6.1 shows a graphical representation of the adopted 1997 WRMS (Figure 6.2). This strategy didn't attempt to fill distant future supply gaps as represented by the triangle circled in red and labeled "Gap." This water supply gap has continued to diminish, largely due to the successful efforts in water conservation and implementation of other water supply projects (i.e. reuse).

Water 2120 builds on the groundbreaking work of the 1997 and 2007 Strategies, updates demand and supply projections utilizing the best available science to provide a flexible and adaptable plan that satisfies customer needs through 2120.

Figure 6.1. Historical WRMS Timeline, 1997

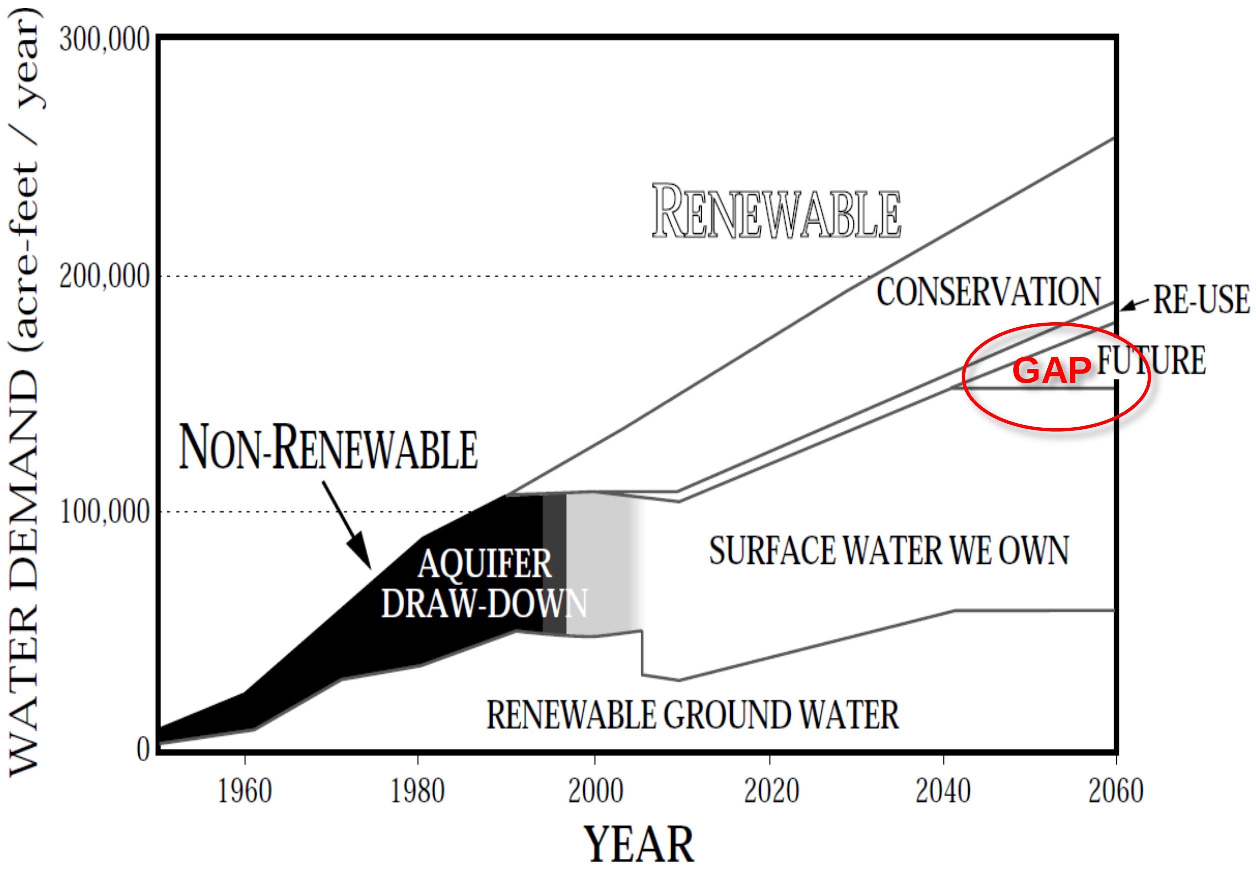
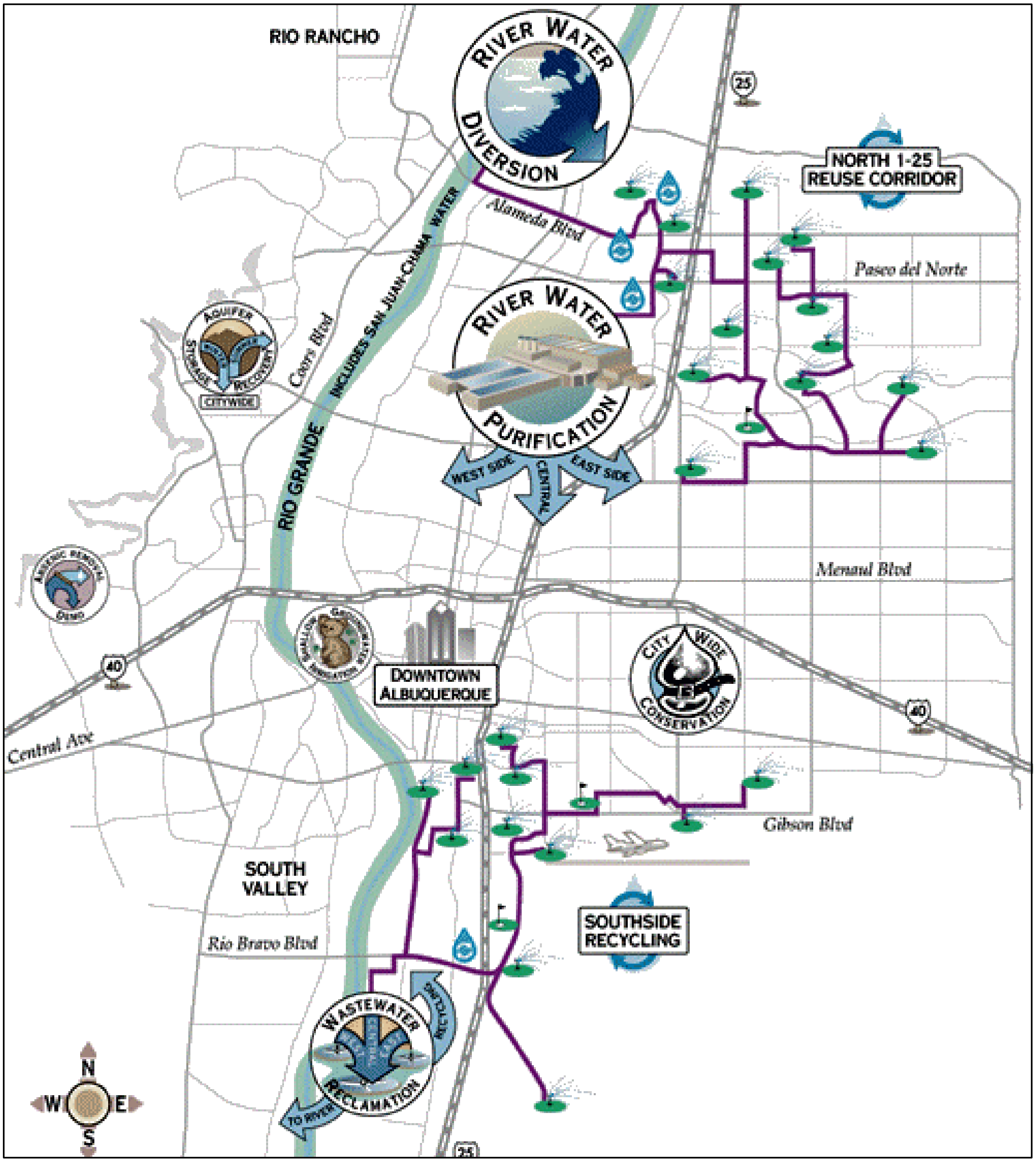


Figure 6.2. Historical WRMS Schematic Portfolio, 1997

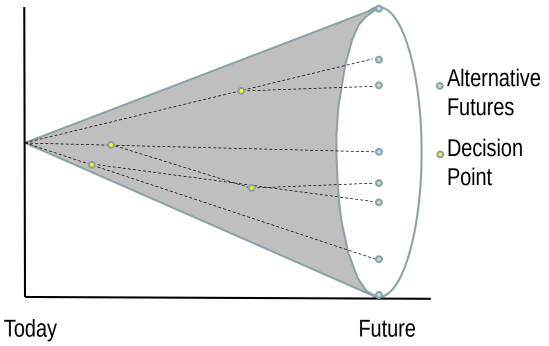


6.3 Projections of Supply and Demand – Scenarios

Future conditions are driven by forces such as hydrologic or climatic variability, demographics, economics, regulations, and technology. Variability in these driving forces results in different future paths; and, since a path cannot be known in advance, uncertainty in future conditions.

The range of uncertainty can be described as a cone, where near events are relatively well known and uncertainty grows as predictions are made further out in time (Figure 6.3).

Figure 6.3. The Cone of Uncertainty



Source: adapted from Timpe and Scheepers, 2003

If we only consider one path, we risk either being ill-prepared for possible conditions or alternatively over-investing. Uncertainty can be mitigated through consideration of a range of future paths or scenarios.

Scenarios are not predictions of the future but rather describe a range of plausible future outcomes that can be considered by planners when evaluating options and making decisions.

In previous chapters of **Water 2120**, three future water supply alternatives and three future water demand alternatives are developed, which describe a wide range of future conditions. The combination of these alternatives results in nine potential scenarios of future conditions. These scenarios span the range of uncertainty and allow for consideration of multiple future paths.

Consideration of multiple paths allows for a flexible and adaptable plan. Figure 6.4 shows how water supply and demand projections are combined to develop scenarios. The scenarios range from Low Demand–High Supply (LH) to High Demand–Low Supply (HL).

Figure 6.4. Combining Projections

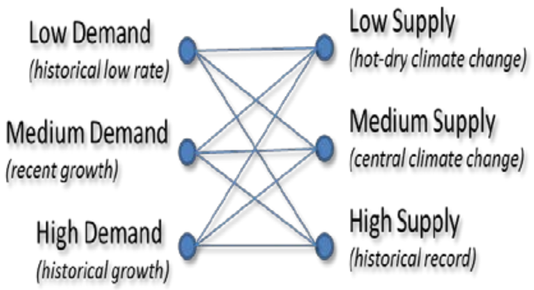
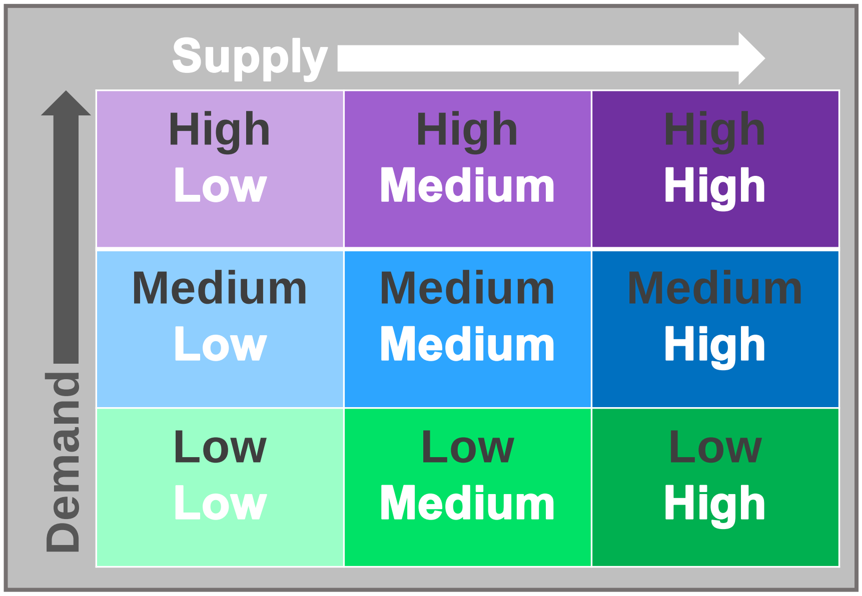


Figure 6.5 provides a representation of the resulting nine scenarios with supply increasing as you move across the block from left to right and demand increasing as you move from bottom to top. Note that the Medium Demand–Medium Supply (MM) scenario falls in the middle of the conceptual range.

The remaining portions of this section develop key metrics for evaluation of scenarios and present an analysis of associated future supply needs or gaps.

Figure 6.5. Scenario Matrix[1]



High Low	High Medium	High High
Medium Low	Medium Medium	Medium High
Low Low	Low Medium	Low High

6.3.1 Supply Performance Metrics

By definition, the scenarios above result in differing future conditions. In order to evaluate important Water Authority goals, a number of key metrics were established.

These metrics allow for evaluation of system performance under future conditions as well as the ability of portfolios to improve these conditions. These metrics include:

- **Change in aquifer drawdown from baseline.** This metric allows for evaluation of system performance when compared to the GRMP. The GRMP established an aquifer management level within the Working Reserve of 110-feet of drawdown below pre-development conditions. This level is used to help understand when new supplies are needed.
- **Supply gap.** The supply gap is an estimate of the new supply needed under future conditions as well as the timing of initial need of new supply. This metric represents the amount of water needed to meet full demand for a given scenario when aquifer drawdown is managed under the GRMP.
- **Excess return flows.** Available return flow is a good surrogate for utilization of existing water resources, which is key to meeting the goal of utilizing existing resources first.
- **Portfolio costs.** The discounted present value of future water supply costs, including expected capital and operation and maintenance costs, for the portfolio considered is developed.

The methods used to develop the discounted present value of portfolios is presented in Appendix 6.D.

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[1] The scenarios include Low Demand–High Supply (LH), Medium Demand–High Supply (MH), High Demand–High Supply (HH), Low Demand–Medium Supply (LM), Medium Demand–Medium Supply (MM), High Demand–Medium Supply (HM), Low Demand–Low Supply (LL), Medium Demand–Low Supply (ML), and High Demand–Low Supply (HL).

6.3.2 Scenario Simulations Results

In order to evaluate future alternative supply options and strategies, supply performance metrics are first estimated with current supplies across the scenarios.

This future condition under current supplies is referred to as the “Baseline” and is used for comparison to potential actions to evaluate the performance of these actions. This section summarizes key results of the Baseline simulations. Detailed results are presented in Appendix 6.A.

6.3.2.1 SUPPLIES USED TO MEET DEMAND

For the Baseline simulation, a detailed look at supplies used to meet demand for the three bounding scenarios Low Demand–High Supply (LH), Medium Demand–Medium Supply (MM), and High Demand–Low Supply (HL) are presented in Figures 6.6A-6.6C.

These figures show the various supplies utilized to meet demands under the differing amounts of surface supply. In each scenario, demand increases over time and variability in surface supply can be clearly seen in the blue “DWP” category.

Note that drought years can be recognized in these figures as a reduction in surface water availability (reduced DWP source, blue). As demand increases, these reductions result in a steady increase in groundwater pumping, up to the maximum of the permitted amount of 165,000 afy.

Groundwater used as a source to fill supply gaps is limited by permit restrictions and ultimately available water rights and cannot be solely relied upon to meet future supply gaps. In addition, groundwater management goals described in Chapter 4, Groundwater Management, suggest that new supplies are needed (gaps) to limit aquifer drawdown and balance overall water rights.

Maximizing use of current water rights and resources is a first priority. However, additional supplies will be needed to make up for the years when demand is increased and surface water availability is low. NMOSE permit conditions often limit the ability to utilize the Drinking Water Project in a given year, but the portion not used during the summer months can then be stored and used the following year(s) or that winter for aquifer storage and recovery operations. Full utilization of existing resources is critical in minimizing the need for future supplies.

Figure 6.6A. Simulated Result of Supplies Meeting Demand under the Low Demand–High Supply Scenario

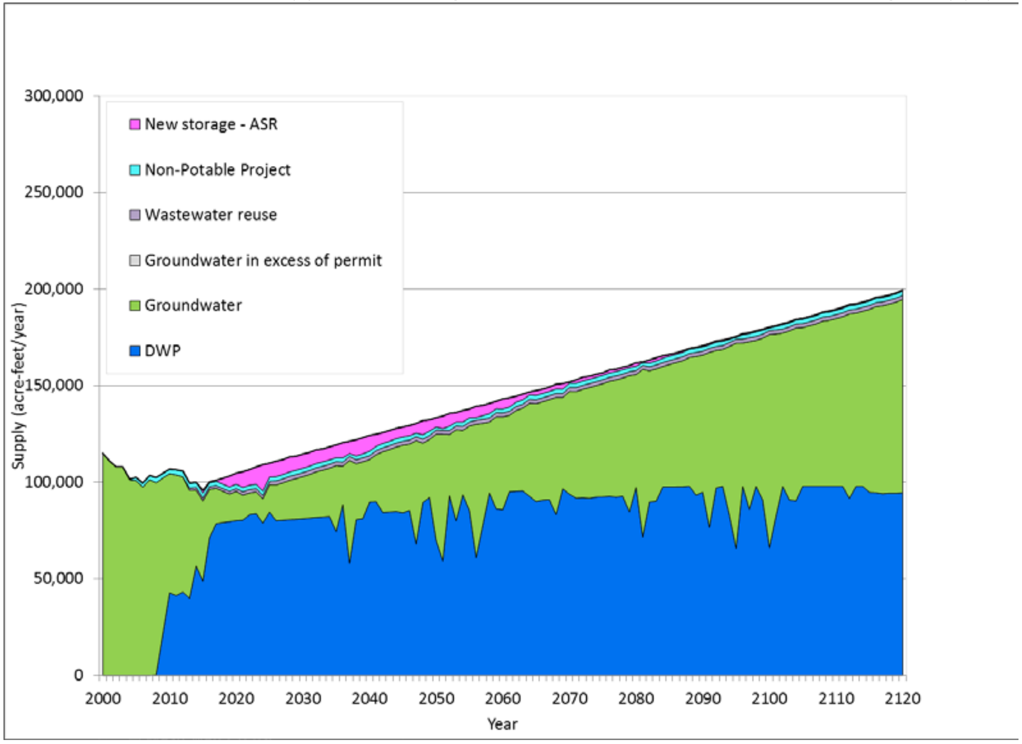


Figure 6.6B. Simulated Result of Supplies Meeting Demand under the Medium Demand–Medium Supply Scenario

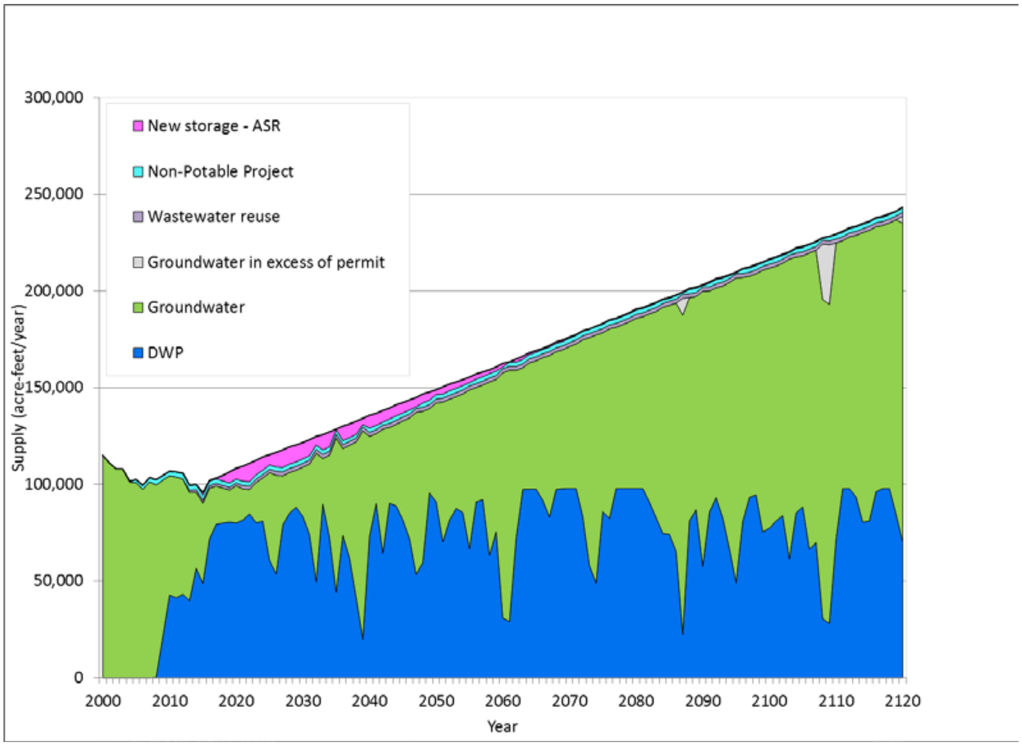
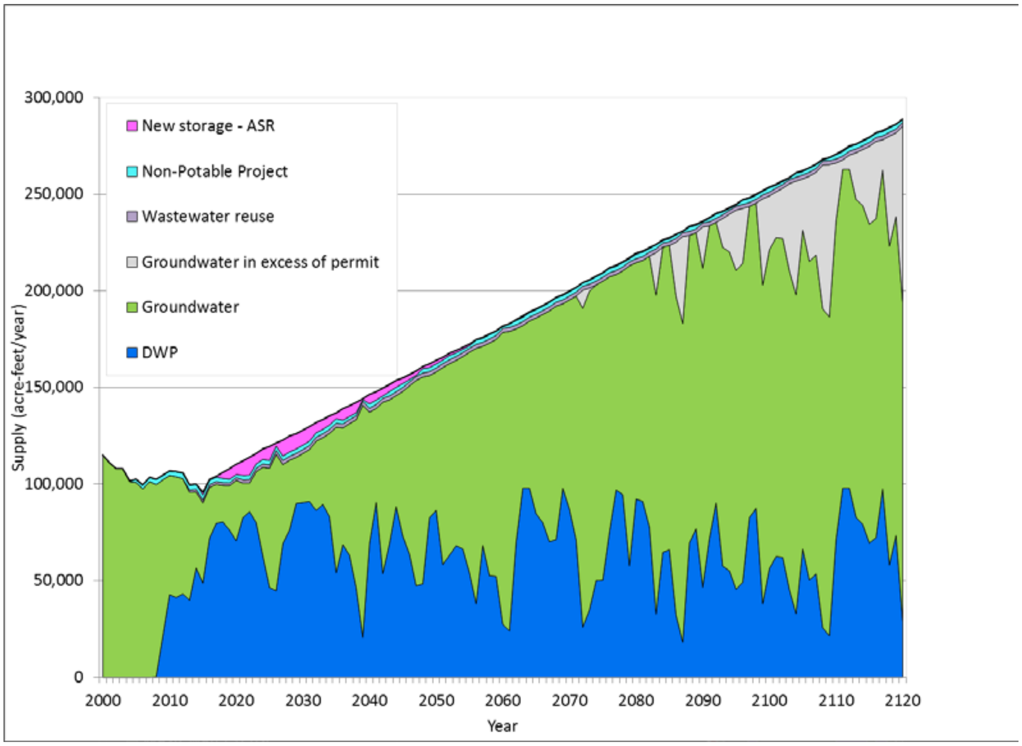


Figure 6.6C. Simulated Result of Supplies Meeting Demand under the High Demand–Low Supply Scenario



Additionally, as discussed in Chapter 3, the Medium and Low water supply projections reflect the impacts of climate change. This impact affects surface supplies through reduced availability and subsequent reliability when compared to historical surface water availability. Additionally, the projected rise in temperatures affects the rate of evaporation from reservoirs and increases outdoor demand. These effects are accounted for in the volume of supplies available in the Baseline results under the climate change scenarios, the associated demands, and ultimately the supplies needed.

6.3.2.2 BASELINE SUPPLY GAPS

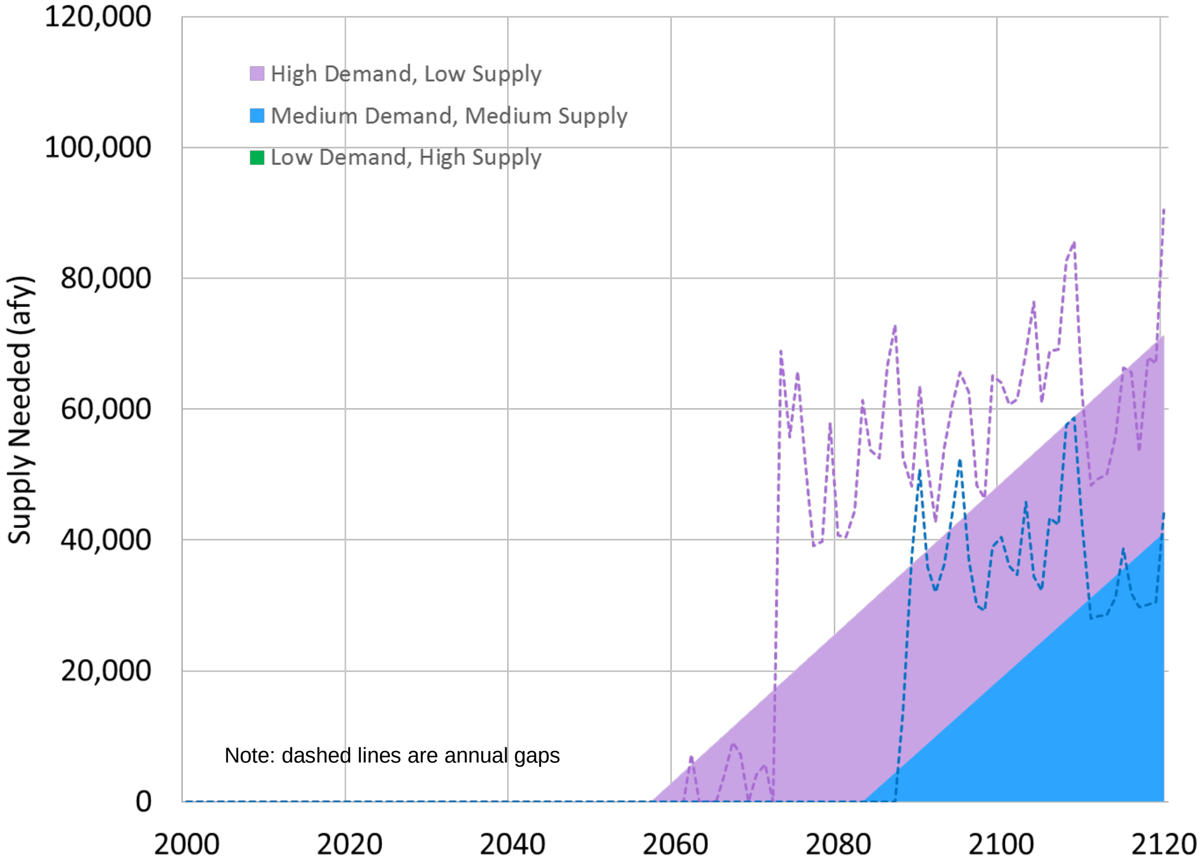
As with previous strategies, supply gaps can be roughly represented with "triangle" plots. These plots show the general timeframe and magnitude of need for new supplies. Figure 6.7 presents the supply gap triangles for the range of future scenarios (LH, MM, HL) for the baseline.

The purple triangle represents supply gaps under the HL scenario. The blue triangle represents supply gaps under the MM scenario. Note that no gaps are anticipated under the LH scenario through the planning period. These triangle plots are a simplified representation of actual supply gaps. The annual supply gaps are overlain on this plot as a dashed line in the same color.

From these plots, it can be seen that new supplies are needed as early as about 2060 in the worst case (HL), 2080 in the middle case (MM), and not at all in the best case (LH). The magnitude of new supplies required ranges from a worst-case average of about 40,000 afy, a middle case of about 25,000 afy, and none in the best case at the end of the planning period.

For each scenario, the groundwater reserve management level of 110 feet below pre-development conditions (see Chapter 4) is maintained. New supply needs or gaps are estimated as the amount of water required to maintain this management level.

Figure 6.7. Simulated Baseline Supply Gap Triangle Plot Showing Three Scenarios with Actual Annual Gap Superimposed (Low Demand–High Supply is absent, no supply gap)



6.3.2.3 BASELINE AVAILABLE WASTEWATER

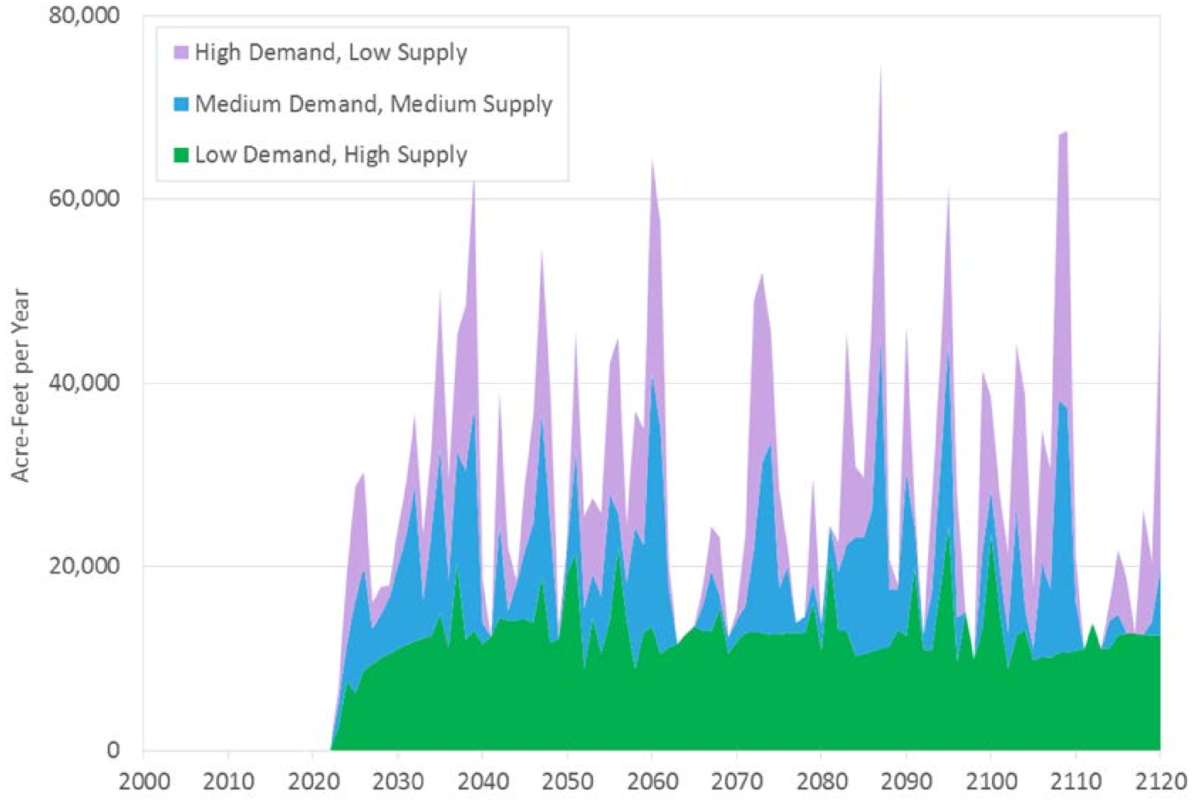
Available return flows (treated wastewater) are used to offset river effects due to groundwater production, return diverted native water to the Rio Grande, or potentially be utilized for supply. Likewise, understanding how much wastewater is available for supply provides insight into further options for maximizing use of existing resources.

Available wastewater can be stored through ASR, a new reservoir, or through exchange in existing reservoirs; used in non-potable projects, or used for indirect or direct potable reuse (IDPR/DPR).

Available return flows (Figure 6.8) should be used when possible in order to minimize the need for new supplies.

Available return flows are directly impacted by the need to offset groundwater production impacts on the Rio Grande. Therefore, as groundwater production is reduced, the need for offsets is reduced and available return flows increases. Because these return flows can be utilized as a supply source, potentially further reducing groundwater use, fully utilizing available wastewater is highly effective and necessary for meeting future demands.

Figure 6.8. Available Return Flow (in excess of water rights obligations)



6.3.2.4 BASELINE AQUIFER DRAWDOWN

If current practices continued under the Medium Demand–Medium Supply scenario, with no new supplies added, by 2120 the average aquifer drawdown from pre-development will be 203 feet, or 93 feet below the selected groundwater management level outlined in Chapter 4 of this report (Figure 6.9). At that time, the drawdown will be well below the management level and trending toward undesirable further declines.

Managing near the groundwater reserve management level of 110 feet is an important component of meeting demands over the next 100 years. This metric defines the need for new supplies and provides a useful measure of the ability of the Water Authority to respond to extreme drought – drawdowns near the management level provide a large factor of safety for meeting future drought, surface supply interruption, and/or unforeseeable events. Ultimately and most importantly, setting the groundwater management level is a more conservative approach than just establishing and maintaining a drought reserve.

6.3.2.5 SUMMARY METRICS

The metrics for baseline conditions across the scenarios show that under the continuation of current practices (baseline), new supplies will generally be needed, the aquifer drawdown could approach the safety reserve limit, and there will be available resources (wastewater). Table 6.1 presents the summary metrics for the baseline condition across the three bounding scenarios.

Figure 6.9. Simulated Drawdown, Baseline Scenario

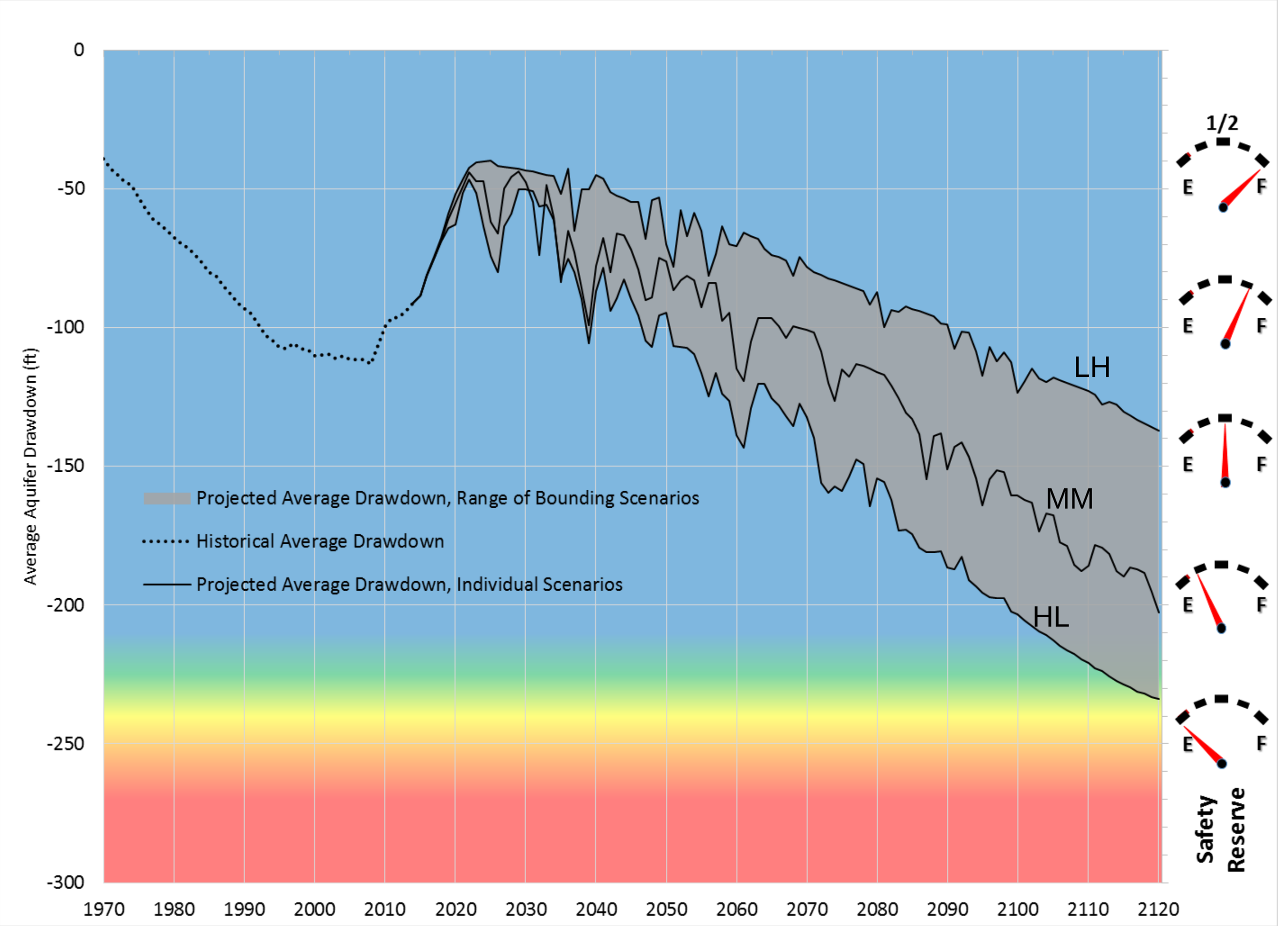


Table 6.1. Summary of Metrics for Evaluating Current Practices under the Baseline Scenarios

Metric	Measure	LH	MM	HL	Unit
Aquifer Drawdown	Average production well drawdown, year 2120	137	203	234	ft
Supply Gap	First year new supply needed, while maintaining the management level	--	2088	2062	yr
Supply Gap	Average annual new supply needed, 2100-2120	0	38,000	65,000	ac-ft
Available Return Flow	Average annual available return flow, 2040-2120	13,195	7,323	9,358	ac-ft

6.4 Options and Strategies for Meeting Future Demand

Filling all gaps under the worst case, or High Demand–Low Supply (HL) scenario runs the risk of over-investment in infrastructure, potentially resulting in high costs to ratepayers and stranded capacity. Relying on the best-case scenario or Low Demand–High Supply (LH), could result in under-investment and an inability to meet future demand if conditions are worse than expected.

To be equally conservative a balanced approach is taken, whereby portfolios are developed to fill gaps associated with the Medium Demand–Medium Supply (MM) scenario. In this way, the Water Authority has met potential future conditions that are less extreme, but is poised to react if conditions are worse.

Baseline conditions suggest the need for options and strategies to meet future demands and close gaps in supply and demand under the MM scenario. Chapter 5, Water Supply Alternatives, presented a number of alternatives that could be utilized to fill gaps and increase resiliency.

Performance criteria for individual alternatives were also presented in Chapter 5. These criteria were used to rank individual alternatives and facilitate selection of alternatives for inclusion in portfolios. Alternative rankings are shown in Appendix 6.B.

This section presents selected portfolios and compares their performance to the baseline performance presented in the previous section.

6.4.1 Portfolios

Because conservation has been, and will continue to be, a critical component of future supply, portfolios were envisioned that revolve around different levels and broad types of conservation. Conservation is used to fill initial gaps with the balance filled by the highest ranked alternatives that meet the needs of a given portfolio.

Initial portfolios were selected using a balanced approach considering “no regrets” options, or options that will be implemented under any circumstance, “low regrets” options, or options that would be implemented under most scenarios, options to meet medium term supply gaps, and options preserved for far-term supply gaps or special circumstances. In general, the first priority options are those that rank the highest, whereas the lowest ranking alternatives are the most likely to be preserved for future consideration.

“No regrets” options include lease or short-term purchase of additional San Juan-Chama water, utilization of excess San Juan-Chama water, and collection of future storage water fees. All of these items have been available or utilized in the past to increase supply and require little effort to implement. In general, these options will be used opportunistically, as available, but will not be explicitly relied on in determining portfolio performance.

“Low regrets” options are those that are likely to be implemented in most future scenarios. These include items like additional conservation and aquifer storage and recovery.

Medium term supply alternatives include options that require new infrastructure but help to utilize existing resources like new reuse or storage options.

Preserved options include new water supply sources that require more extensive infrastructure and permitting such as brackish groundwater, stormwater, or interbasin transfer. These are options that may be required in the future, but the need is sufficiently uncertain that these options are preserved for later consideration.

This approach builds on the success of previous efforts in building a diverse portfolio of supplies. Three example portfolios based on different levels of conservation are presented in Table 6.2.

Table 6.2. Alternatives Selected in Portfolios 1, 2, and 3

Alternative	**Portfolio 1**	**Portfolio 2**	**Portfolio 3**
Conservation			
120 gpcd in 10 years		✓	
110 gpcd in 20 years	✓		
Outdoor-only conservation, 10 gpcd reduction over 30 years			✓
Surface Water			
Lease or short-term purchase of additional San Juan-Chama water	NR✓	NR✓	NR✓
Utilization of excess San Juan-Chama water	NR✓	NR✓	NR✓
New regional surface water diversion			
Non-potable and reuse			
Westside reuse with ASR in Calabacillas Arroyo	2,000✓	6,000✓	10,000✓
Eastside reuse with ASR in Tijeras Arroyo	6,000✓	10,000✓	10,000✓
Connect expanded southside reuse system to NI-25 Non-Potable Project	✓	✓	✓
ASR			
Additional large-scale ASR projects	✓	✓	✓
Stormwater			
Stormwater capture from existing facilities			
Stormwater capture - 500 – 1,000 afy			
Stormwater capture - 1,000 – 2,000 afy	✓	✓	✓
Interbasin Transfer			
Interbasin transfer - 5,000 afy yield - delivered to Authority system		✓	
Interbasin transfer - 10,000 afy yield - delivered to Authority system			
Interbasin transfer - 5,000 afy yield - transfer to Authority			
Interbasin transfer - 10,000 afy yield - transfer to Authority			
Produced water			
Indirect/Direct Potable Reuse			
I/DPR1			
I/DPR2	12,000✓	12,000✓	
I/DPR3			15,000✓
Fee, Credit, or Banked Water			
Water banking			
Future storage fee water	NR✓	NR✓	NR✓
Rio Grande Compact relinquishment credit water - Abiquiu	✓	✓	✓
Surface Storage			
New reservoir 5,000 ac-ft	✓	✓	
New reservoir 10,000 ac-ft			✓
Water Rights			
Pre-1907 Water Rights Acquisition			
Watershed Management			
Watershed management - San Juan tributaries	✓	✓	✓
Watershed management - Rio Grande and tributaries below Otowi	✓	✓	✓
Brackish Groundwater			
Brackish groundwater - 2,000 afy			
Brackish groundwater - 5,000 afy		✓	✓
Permit Modification			
Operational flexibility under existing 4830 permit			

Key: “NR” refers to “no regrets”; Relative Ranking: High, Medium, Low (see Appendix 6.B, Alternative Ranking).

6.4.2 Portfolio Evaluation

Three portfolios were explored to fill or prevent future supply gaps. As combinations of supply alternatives that can be mixed and matched, they are crafted to be flexible as planning needs change.

While portfolios are intended to be modified with time, they can be used as tools to help explore available options in preventing supply gaps, minimizing available return flow, and maintaining the groundwater management level. The capacity of a portfolio to affect future supplies used to meet demand is measured against the baseline metrics.

Appendix 6.C presents the detailed results of the portfolios. Table 6.3 presents the summary metrics for the baseline and portfolios 1, 2, and 3. Each of the portfolios was designed to fill the bounding scenario gaps (LH, MM, HL). Therefore, aquifer drawdown results are relatively similar. However, while generally balanced, they each utilize different magnitudes and combinations of options resulting in varying overall performance and costs.

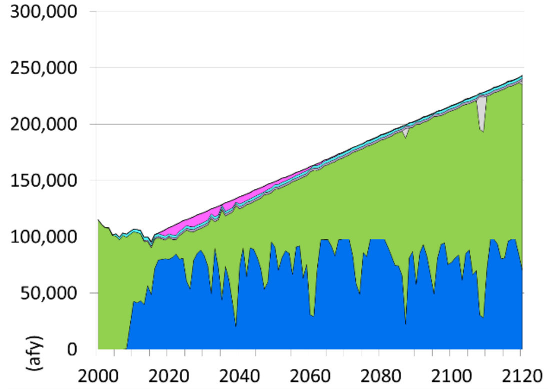
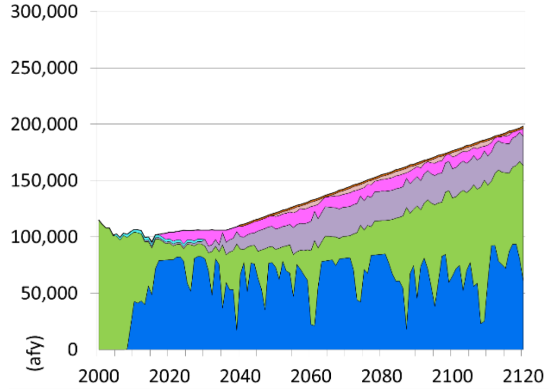
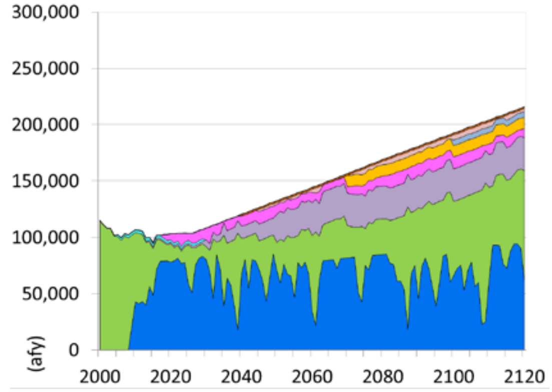
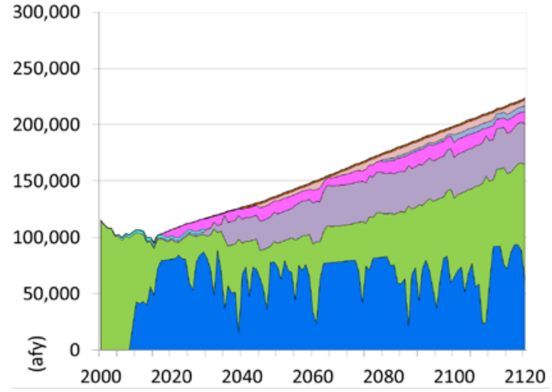
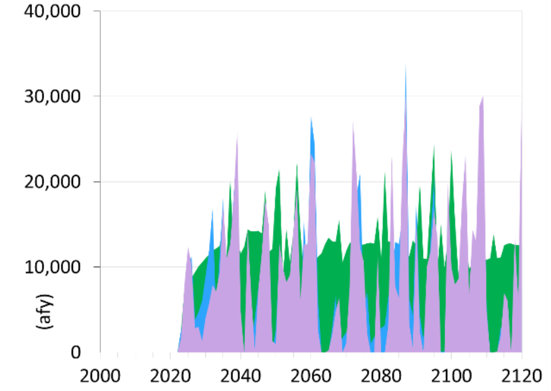
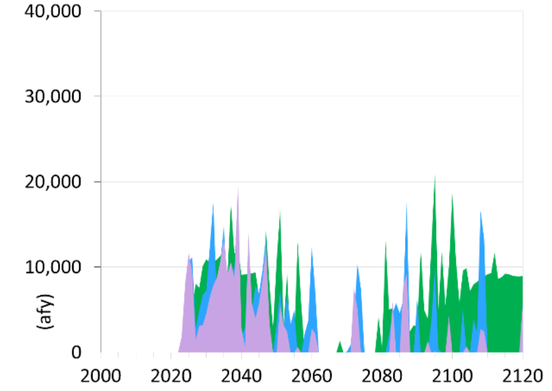
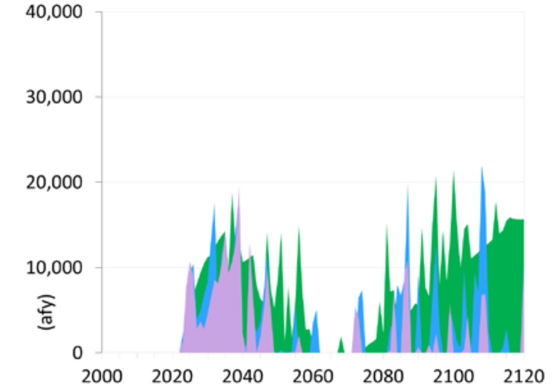
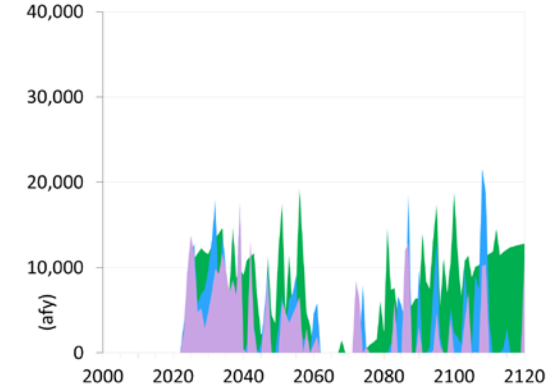
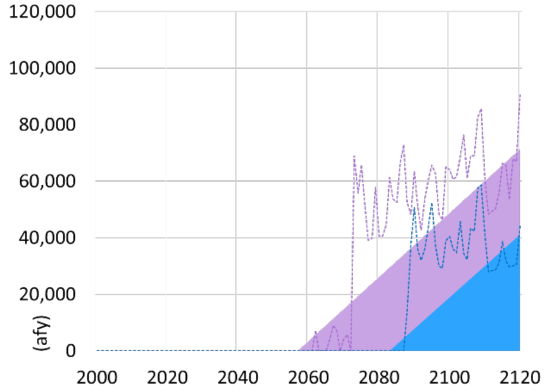
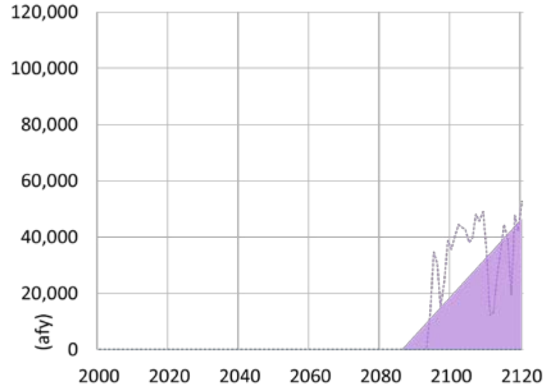
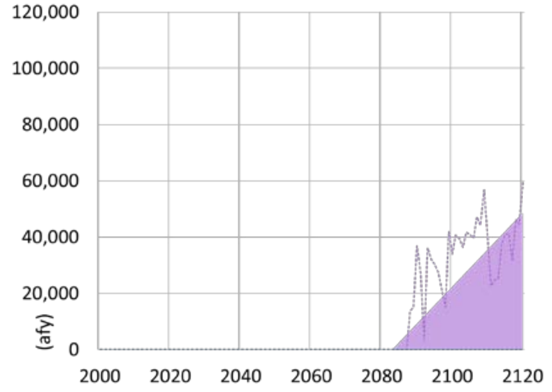
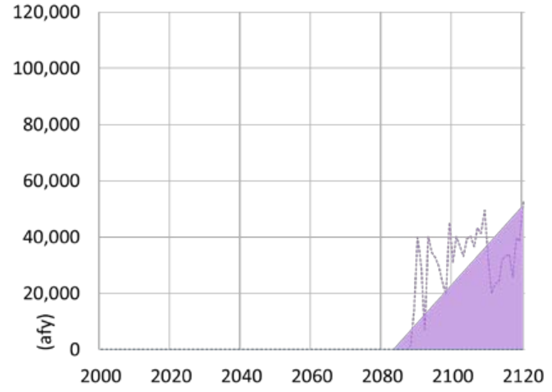
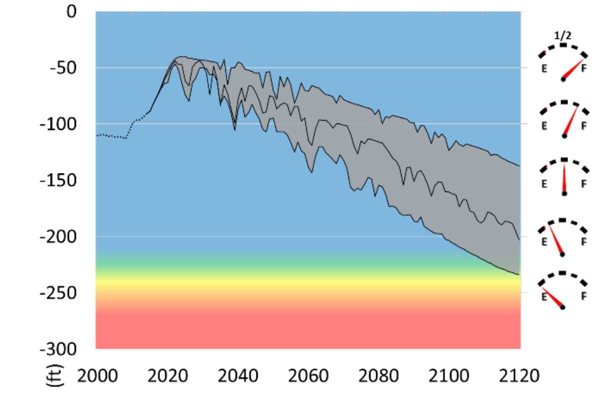
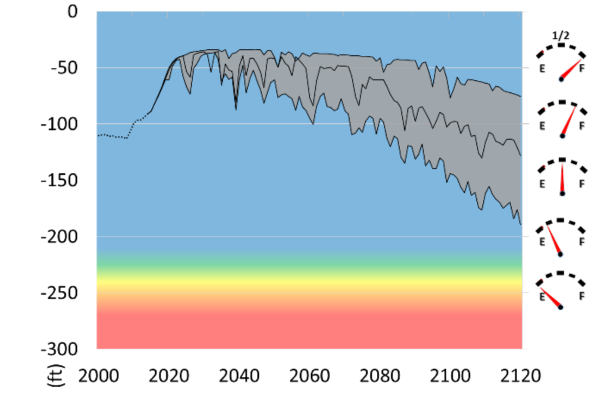
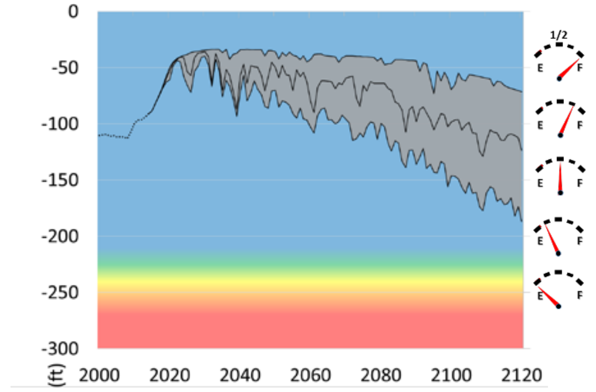
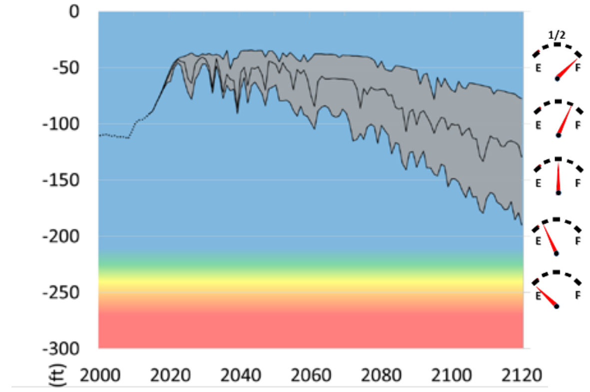
The costs presented in Table 6.3 are provided for relative comparison of the discounted present value (DPV) of the portfolios. These should not be considered accurate forecasts for budgeting of future costs. Appendix 6.D provides additional information about the methods used to calculate portfolio costs (individual alternative costs are developed in Chapter 5).

Table 6.4 presents figures similar to those described in Section 6.3 in development of the baseline gaps. These figures allow for broad comparison of the performance of the baseline and the three portfolios.

Table 6.3. Simulated Portfolio Results

Metric	**Baseline**	**Portfolio 1**	**Portfolio 2**	**Portfolio 3**	**Unit**
a. Low Demand–High Supply					
Aquifer drawdown, 2120	137	75	72	78	ft
First year new supply needed	-	-	-	-	
Average new supply, 2100-2120	0	0	0	0	afy
Available return flow	13,195	9,511	11,152	9,320	afy
Total cost (DPV)	38.0	37.1	38.6	39.6	$ Billions
b. Medium Demand–Medium Supply					
Aquifer drawdown, 2120	203	128	123	129	ft
First year new supply needed	2088	-	-	-	
Average new supply, 2100-2120	38,000	0	0	0	afy
Available return flow	7,323	3,028	3,108	3,156	afy
Total cost (DPV)	46.8	40.2	41.9	42.9	$ Billions
c. High Demand–Low Supply					
Aquifer drawdown, 2120	234	189	187	190	ft
First year new supply needed	2062	2091	2088	2088	
Average new supply, 2100-2120	65,000	38,000	39,800	35,600	afy
Available return flow	9,358	1,154	1,504	2,086	afy
Total cost (DPV)	55.2	43.5	45.0	46.2	$ Billions

Table 6.4: Summary Results of Baseline and Portfolios

	Baseline	Portfolio 1	Portfolio 2	Portfolio 3
Supplies Meeting Demand ■ Stormwater ■ New storage ■ Brackish groundwater ■ Interbasin transfer ■ ASR ■ Non-Potable Project ■ Wastewater reuse ■ Groundwater in excess of permit ■ Groundwater ■ DWP				
Available return flow ■ High demand, low supply ■ Medium demand, medium supply ■ Low demand, high supply				
Supply gaps ■ High demand, low supply ■ Medium demand, medium supply ■ Low demand, high supply				
Groundwater Reserve Drawdown ■ Range of bounding scenarios ...... Historical average drawdown — Projected drawdown, individual scenarios				

6.4.2.1 PORTFOLIO 1 RESULTS

Portfolio 1 results in lower demand than baseline due to the implementation of conservation (110 gpcd goal). Most of the remaining demand is met with a combination of ASR and wastewater reuse (Table 6.4, Supplies Meeting Demand, Baseline and Portfolio 1). These changes result in less available wastewater (Table 6.4, Available return flow, Baseline and Portfolio 1) than baseline. On average, there is between about 2,000 afy and 8,000 afy less available wastewater than in the Baseline condition, depending on the scenario (Table 6.3).

Portfolio 1 results in no need for new supply in the 100-year planning period for the Low Demand–High Supply and Medium Demand–Medium Supply scenarios (Table 6.4, Supply Gaps, Portfolio 1), with average drawdown near or above the management level for the entire planning period (Table 6.4, Historical Average Drawdown, Portfolio 1). In the High Demand–Low Supply scenario, the need for new supplies is pushed back to year 2091 (from 2062 in baseline; see (Table 6.4, Supply Gaps, Portfolio 1), total new supply needed is reduced to about 38,000 afy at the end of the planning period (from about 65,000 afy in baseline; see Table 6.4, Supply Gaps, Baseline), and aquifer drawdown is reduced to about 190 feet at the end of the planning period (from 234 feet in baseline; see Table 6.4, Historical Average Drawdown, Baseline and Portfolio 1).

6.4.2.2 PORTFOLIO 2 RESULTS

Portfolio 2 results in lower demand than baseline, due to the implementation of conservation (120 gpcd goal), but greater demand than Portfolio 1. Most of the remaining demand is met with a combination of ASR and wastewater reuse, but additional supplies are needed, including stormwater, brackish groundwater, and interbasin transfer (Table 6.4, Supplies Meeting Demands, Baseline and Portfolio 2). These changes result in less available wastewater (Table 6.4, Available Return flow, Baseline and Portfolio 2) than baseline. On average, there is between about 2,000 afy and 8,000 afy less available wastewater than in the Baseline condition, depending on the scenario (Table 6.3).

Portfolio 2 results in no need for new supply in the 100-year planning period for the Low Demand–High Supply and Medium Demand–Medium Supply scenarios (Table 6.4, Supply Gaps, Portfolio 2), with average drawdown near or above the management level for the entire planning period (Table 6.4, Historical Average Drawdown, Portfolio 2). In High Demand–Low Supply scenario, the need for new supplies is pushed back to year 2088 (from 2062 in baseline; see Table 6.4, Supply Gaps, Portfolio 1), total new supply needed is reduced to about 40,000 afy at the end of the planning period (from about 65,000 afy in baseline; see Table 6.4, Supply Gaps, Baseline), and aquifer drawdown is reduced to about 187 feet at the end of the planning period (from 234 feet in baseline; see Table 6.4, Average Drawdown, Baseline and Portfolio 2).

6.4.2.3 PORTFOLIO 3 RESULTS

Portfolio 3 results in lower consumptive demand than baseline, due to the implementation of conservation (outdoor only). Most of the remaining demand is met with a combination of ASR and wastewater reuse, with some brackish groundwater and stormwater capture needed in late time (Table 6.4, Supplies Meeting Demands, and Portfolio 3). More wastewater reuse and ASR is utilized than in Portfolios 1 and 2. These changes result in less available wastewater (Table 6.4, Available return flow, and Portfolio 3) than baseline. On average, there is between about 4,000 afy and 7,000 afy less available wastewater than in the Baseline condition, depending on the scenario (Table 6.3).

Portfolio 3 results in no need for new supply in the 100-year planning period for the Low Demand–High Supply and Medium Demand–Medium Supply scenarios (Table 6.4, Supply Gaps, Portfolio 3), with average drawdown near or above the management level for the entire planning period (Table 6.4, Historical Average

Drawdown, Portfolio 3). In the High Demand–Low Supply scenario, the need for new supplies is pushed back to year 2088 (from 2062 in baseline; see Table 6.4, Supply Gaps, Portfolio 3), total new supply needed is reduced to about 36,000 afy at the end of the planning period (from about 65,000 afy in baseline; see Table 6.4, Supply Gaps, Baseline), and aquifer drawdown is reduced to about 190 feet at the end of the planning period (from 234 feet in baseline; see Table 6.4, Historical Average Drawdown, Baseline and Portfolio 3).

6.5 References

Brown, F., S. Lee, Chris Nunn, John W. Shomaker and Gary Woodard. 1996. The Value of Water. January 15.

Timpe, C. and M.J.J. Scheepers. 2003. SUSTELNET: A Look into the Future: Scenarios for Distributed Generation in Europe.

Appendix 6.A

Detailed Baseline Results Tables

This appendix summarizes the hydrologic water balance by type for the Baseline (current practice) supplies under the following scenarios: Low Demand–High Supply, Medium Demand–Medium Supply, and High Demand–Low Supply.

Table 6.A1. Low Demand–High Supply – Page 1 of 2

Summary of Hydrologic Water Balance
Water balance summaries by type.
All units are in acre-feet (AF) unless otherwise noted.

BASELINE

Model Settings*
Low Demand, High Supply

No alternatives selected in baseline model run.

	Supplies Used to Meet Demand												River Effects Accounting Summary			Wastewater Accounting Summary				
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	**(11)**		(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2016	24,899	71,373	1,366	2,066	375	0	0	0	0	0	**100,078**	2016	61,033	26,444	16,209	18,504	55,557	0	35,686	**0**
2017	18,256	78,567	1,362	2,300	458	0	0	0	0	0	**100,944**	2017	57,508	26,372	15,705	15,391	56,037	0	39,284	**0**
2018	16,185	79,096	1,362	2,300	3,141	0	0	0	0	0	**102,083**	2018	54,105	26,372	11,936	15,760	56,670	0	39,548	**0**
2019	14,269	79,597	1,362	2,300	5,694	0	0	0	0	0	**103,223**	2019	50,197	26,372	7,649	16,142	57,302	0	39,799	**0**
2020	15,156	80,102	1,366	2,300	5,724	0	0	0	0	0	**104,648**	2020	46,087	26,444	3,061	16,677	58,094	0	40,051	**0**
2021	12,896	80,382	1,679	2,300	8,245	0	0	0	0	0	**105,502**	2021	41,774	24,072	975	16,698	58,567	0	40,191	**0**
2022	11,201	83,231	1,679	2,300	8,229	0	0	0	0	0	**106,641**	2022	38,015	22,084	0	15,905	59,200	0	41,616	**0**
2023	11,201	83,760	1,679	2,300	8,841	0	0	0	0	0	**107,780**	2023	35,297	21,574	0	13,700	59,832	0	41,880	**2,574**
2024	12,558	78,830	1,683	2,300	13,847	0	0	0	0	0	**109,218**	2024	33,541	21,639	0	11,971	60,631	0	39,415	**7,561**
2025	14,125	84,562	1,679	2,300	7,192	0	0	0	0	0	**109,857**	2025	32,381	21,574	0	10,785	60,985	0	42,281	**6,240**
2026	18,535	80,058	1,999	2,300	7,904	0	0	0	0	0	**110,795**	2026	32,325	21,574	0	10,729	61,506	0	40,029	**8,749**
2027	19,351	80,314	1,999	2,300	7,768	0	0	0	0	0	**111,733**	2027	32,058	21,574	0	10,463	62,026	0	40,157	**9,408**
2028	20,337	80,632	2,004	2,300	7,706	0	0	0	0	0	**112,979**	2028	31,880	21,639	0	10,306	62,718	0	40,316	**10,092**
2029	21,114	80,782	1,999	2,300	7,413	0	0	0	0	0	**113,608**	2029	31,718	21,574	0	10,122	63,067	0	40,391	**10,555**
2030	21,822	81,083	1,999	2,300	7,342	0	0	0	0	0	**114,545**	2030	31,596	21,574	0	10,001	63,588	0	40,542	**11,047**
2031	22,615	81,384	1,999	2,300	7,185	0	0	0	0	0	**115,483**	2031	31,533	21,574	0	9,938	64,108	0	40,692	**11,480**
2032	23,608	81,756	2,004	2,300	7,071	0	0	0	0	0	**116,739**	2032	31,553	21,639	0	9,979	64,806	0	40,878	**11,944**
2033	24,263	81,987	1,999	2,300	6,809	0	0	0	0	0	**117,358**	2033	31,571	21,574	0	9,975	65,149	0	40,993	**12,182**
2034	24,971	82,288	1,999	2,300	6,737	0	0	0	0	0	**118,295**	2034	31,621	21,574	0	10,026	65,669	0	41,144	**12,501**
2035	34,151	74,437	1,999	2,066	6,580	0	0	0	0	0	**119,233**	2035	33,814	21,808	0	11,983	66,190	0	37,219	**14,989**
2036	19,860	88,460	2,004	2,300	7,875	0	0	0	0	0	**120,500**	2036	31,131	21,639	0	9,556	66,893	0	44,230	**11,103**
2037	53,394	57,951	1,999	1,478	6,286	0	0	0	0	0	**121,108**	2037	38,231	22,395	0	15,810	67,231	0	28,976	**20,447**
2038	28,991	80,606	1,999	1,997	8,453	0	0	0	0	0	**122,046**	2038	35,304	21,877	0	13,402	67,751	0	40,303	**12,047**
2039	29,433	81,156	1,999	2,066	8,329	0	0	0	0	0	**122,983**	2039	34,431	21,808	0	12,600	68,272	0	40,578	**13,095**
2040	22,060	89,655	2,004	2,300	8,241	0	0	0	0	0	**124,260**	2040	32,125	21,639	0	10,552	68,981	0	44,828	**11,597**
2041	24,441	89,864	1,999	2,300	6,255	0	0	0	0	0	**124,858**	2041	31,562	21,574	0	9,967	69,313	0	44,932	**12,415**
2042	31,437	84,355	1,999	2,300	5,705	0	0	0	0	0	**125,796**	2042	32,837	21,574	0	11,241	69,833	0	42,177	**14,416**
2043	32,329	84,581	1,999	2,300	5,525	0	0	0	0	0	**126,733**	2043	33,490	21,574	0	11,893	70,354	0	42,290	**14,171**
2044	33,377	84,860	2,004	2,300	5,480	0	0	0	0	0	**128,021**	2044	34,007	21,639	0	12,438	71,068	0	42,430	**14,196**
2045	35,060	84,121	1,999	2,300	5,128	0	0	0	0	0	**128,608**	2045	34,686	21,574	0	13,089	71,395	0	42,060	**14,247**
2046	34,271	85,497	1,999	2,300	5,480	0	0	0	0	0	**129,546**	2046	34,804	21,574	0	13,207	71,915	0	42,748	**13,961**
2047	53,579	68,010	1,999	1,890	5,007	0	0	0	0	0	**130,483**	2047	39,438	21,984	0	17,427	72,436	0	34,005	**19,005**
2048	30,866	89,410	2,004	2,300	7,201	0	0	0	0	0	**131,781**	2048	36,252	21,639	0	14,687	73,156	0	44,705	**11,760**
2049	30,053	92,087	1,999	2,300	5,920	0	0	0	0	0	**132,359**	2049	34,882	21,574	0	13,285	73,476	0	46,044	**12,149**
2050	55,077	69,861	1,999	1,683	4,676	0	0	0	0	0	**133,296**	2050	40,016	22,190	0	17,798	73,997	0	34,931	**19,270**
2051	65,631	59,220	1,999	969	6,415	0	0	0	0	0	**134,234**	2051	44,313	22,905	0	21,378	74,517	0	29,610	**21,531**
2052	31,740	92,999	2,004	2,300	6,498	0	0	0	0	0	**135,542**	2052	39,436	21,639	0	17,878	75,243	0	46,500	**8,862**
2053	47,186	79,958	1,999	2,066	4,901	0	0	0	0	0	**136,109**	2053	40,934	21,808	0	19,098	75,558	0	39,979	**14,483**
2054	33,381	93,477	1,999	2,300	5,890	0	0	0	0	0	**137,046**	2054	38,364	21,574	0	16,764	76,079	0	46,739	**10,578**
2055	43,839	85,331	1,999	2,124	4,691	0	0	0	0	0	**137,984**	2055	39,612	21,749	0	17,835	76,599	0	42,666	**14,100**
2056	69,155	60,905	2,004	1,385	5,854	0	0	0	0	0	**139,302**	2056	45,183	22,555	0	22,721	77,331	0	30,452	**22,153**
2057	52,895	77,638	1,999	1,890	5,437	0	0	0	0	0	**139,859**	2057	44,659	21,984	0	22,645	77,640	0	38,819	**14,177**
2058	36,768	94,427	1,999	2,300	5,303	0	0	0	0	0	**140,797**	2058	41,579	21,574	0	19,977	78,161	0	47,214	**8,971**
2059	47,631	86,216	1,999	2,124	3,763	0	0	0	0	0	**141,734**	2059	42,482	21,749	0	20,703	78,681	0	43,108	**12,871**
2060	48,012	85,780	2,004	2,066	5,200	0	0	0	0	0	**143,062**	2060	42,812	21,873	0	21,026	79,419	0	42,890	**13,498**
2061	39,563	95,066	1,999	2,300	4,681	0	0	0	0	0	**143,609**	2061	41,229	21,574	0	19,627	79,722	0	47,533	**10,563**
2062	41,837	95,279	1,999	2,300	3,132	0	0	0	0	0	**144,547**	2062	40,998	21,574	0	19,396	80,242	0	47,640	**11,208**
2063	42,841	95,492	1,999	2,300	2,853	0	0	0	0	0	**145,484**	2063	41,005	21,574	0	19,403	80,763	0	47,746	**11,615**
2064	48,172	92,698	2,004	2,300	1,649	0	0	0	0	0	**146,823**	2064	42,024	21,639	0	20,471	81,506	0	46,349	**12,682**
2065	50,720	89,916	1,999	2,300	2,424	0	0	0	0	0	**147,359**	2065	42,995	21,574	0	21,392	81,804	0	44,958	**13,456**

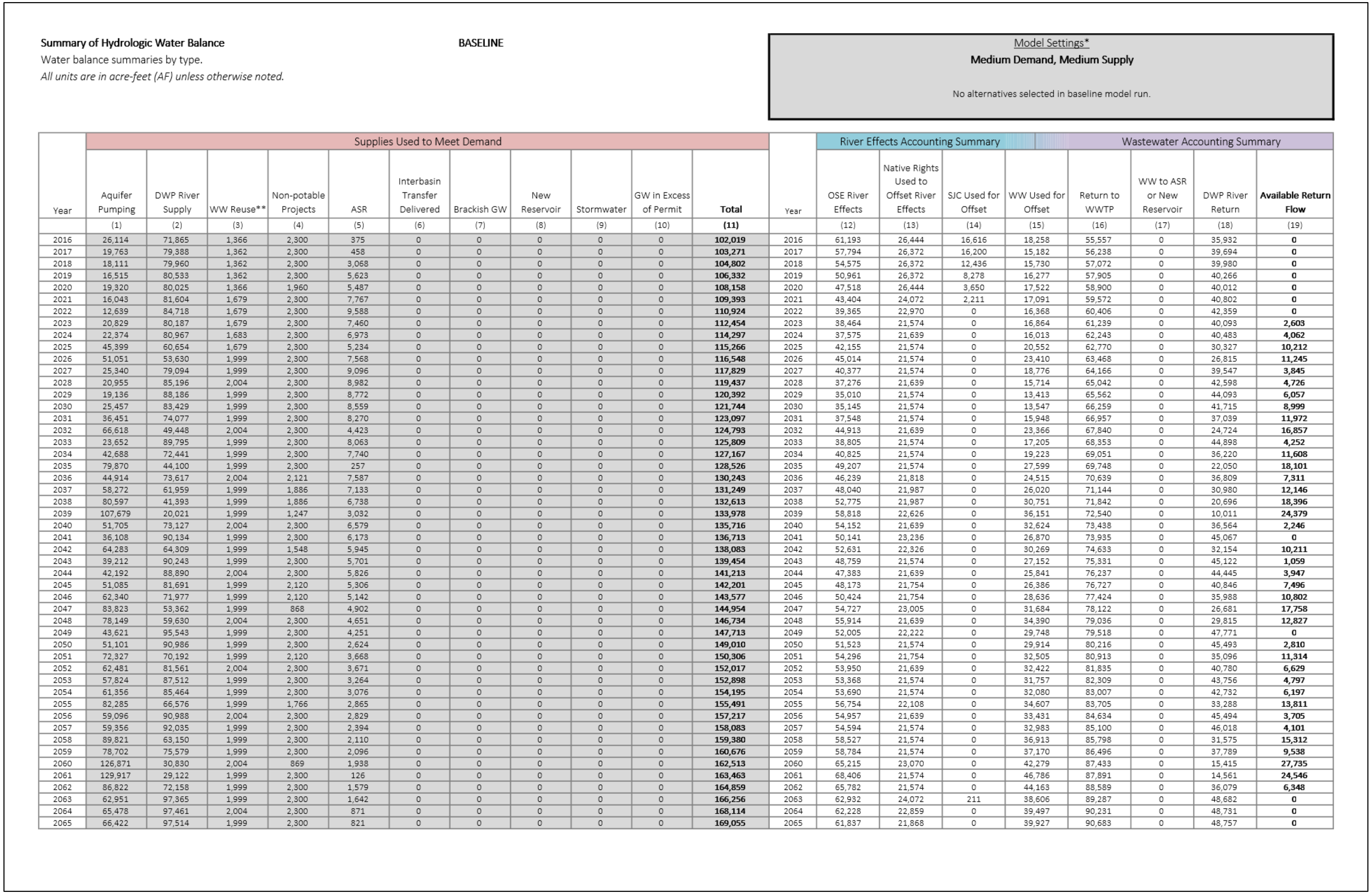
Table 6.A1. Low Demand–High Supply – Page 2 of 2

	Supplies Used to Meet Demand												River Effects Accounting Summary			Wastewater Accounting Summary				
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	50,997	90,672	1,999	2,300	2,329	0	0	0	0	0	**148,297**	2066	43,546	21,574	0	21,942	82,324	0	45,336	**13,047**
2067	51,846	90,899	1,999	2,300	2,191	0	0	0	0	0	**149,234**	2067	44,043	21,574	0	22,439	82,845	0	45,449	**12,957**
2068	60,688	83,245	2,004	2,300	2,346	0	0	0	0	0	**150,583**	2068	45,999	21,639	0	24,454	83,594	0	41,623	**15,513**
2069	47,303	96,575	1,999	2,300	2,932	0	0	0	0	0	**151,110**	2069	44,632	21,574	0	23,027	83,886	0	48,288	**10,572**
2070	53,186	93,820	1,999	2,300	743	0	0	0	0	0	**152,047**	2070	45,236	21,574	0	23,632	84,406	0	46,910	**11,866**
2071	55,235	91,695	1,999	2,300	1,756	0	0	0	0	0	**152,985**	2071	45,853	21,574	0	24,248	84,927	0	45,848	**12,832**
2072	56,197	91,909	2,004	2,300	1,934	0	0	0	0	0	**154,344**	2072	46,363	21,639	0	24,819	85,681	0	45,954	**12,903**
2073	57,415	91,618	1,999	2,300	1,527	0	0	0	0	0	**154,860**	2073	46,918	21,574	0	25,312	85,968	0	45,809	**12,848**
2074	57,756	92,272	1,999	2,300	1,471	0	0	0	0	0	**155,797**	2074	47,338	21,574	0	25,732	86,488	0	46,136	**12,622**
2075	58,631	92,385	1,999	2,300	1,420	0	0	0	0	0	**156,735**	2075	47,783	21,574	0	26,176	87,008	0	46,193	**12,641**
2076	59,648	92,631	2,004	2,300	1,522	0	0	0	0	0	**158,104**	2076	48,200	21,639	0	26,660	87,769	0	46,315	**12,789**
2077	60,781	92,236	1,999	2,300	1,294	0	0	0	0	0	**158,610**	2077	48,694	21,574	0	27,087	88,049	0	46,118	**12,846**
2078	61,280	92,702	1,999	2,300	1,266	0	0	0	0	0	**159,547**	2078	49,080	21,574	0	27,472	88,570	0	46,351	**12,748**
2079	70,564	84,642	1,999	2,066	1,215	0	0	0	0	0	**160,485**	2079	50,651	21,808	0	28,808	89,090	0	42,321	**15,963**
2080	58,483	97,265	2,004	2,300	1,812	0	0	0	0	0	**161,865**	2080	49,841	21,639	0	28,305	89,856	0	48,633	**10,915**
2081	86,865	71,602	1,999	1,478	416	0	0	0	0	0	**162,360**	2081	53,466	22,395	0	31,034	90,131	0	35,801	**21,298**
2082	67,992	89,722	1,999	1,997	1,589	0	0	0	0	0	**163,298**	2082	52,709	21,877	0	30,796	90,652	0	44,861	**12,997**
2083	68,589	90,096	1,999	2,066	1,486	0	0	0	0	0	**164,235**	2083	52,970	21,808	0	31,126	91,172	0	45,048	**13,000**
2084	62,445	97,475	2,004	2,300	1,401	0	0	0	0	0	**165,625**	2084	52,467	21,639	0	30,936	91,944	0	48,738	**10,266**
2085	63,477	97,505	1,999	2,300	829	0	0	0	0	0	**166,110**	2085	52,543	21,574	0	30,934	92,213	0	48,753	**10,528**
2086	64,414	97,558	1,999	2,300	777	0	0	0	0	0	**167,048**	2086	52,725	21,574	0	31,115	92,734	0	48,779	**10,841**
2087	65,351	97,610	1,999	2,300	726	0	0	0	0	0	**167,985**	2087	52,971	21,574	0	31,361	93,254	0	48,805	**11,089**
2088	66,701	97,922	2,004	2,300	458	0	0	0	0	0	**169,386**	2088	53,272	21,639	0	31,743	94,031	0	48,961	**11,324**
2089	71,883	93,263	1,999	2,300	416	0	0	0	0	0	**169,861**	2089	54,133	21,574	0	32,522	94,295	0	46,631	**13,143**
2090	70,996	94,851	1,999	2,300	653	0	0	0	0	0	**170,798**	2090	54,496	21,574	0	32,885	94,815	0	47,425	**12,507**
2091	90,704	76,541	1,999	1,890	602	0	0	0	0	0	**171,736**	2091	57,126	21,984	0	35,103	95,336	0	38,271	**19,964**
2092	71,283	96,964	2,004	2,300	594	0	0	0	0	0	**173,146**	2092	56,137	21,639	0	34,613	96,119	0	48,482	**11,019**
2093	70,915	97,840	1,999	2,300	557	0	0	0	0	0	**173,611**	2093	56,131	21,574	0	34,519	96,377	0	48,920	**10,939**
2094	87,488	82,879	1,999	1,683	500	0	0	0	0	0	**174,548**	2094	58,146	22,190	0	35,915	96,897	0	41,440	**17,544**
2095	106,259	65,760	1,999	969	500	0	0	0	0	0	**175,486**	2095	61,089	22,905	0	38,143	97,418	0	32,880	**24,396**
2096	74,265	97,837	2,004	2,300	501	0	0	0	0	0	**176,907**	2096	59,143	21,639	0	37,626	98,207	0	48,919	**9,658**
2097	86,855	85,942	1,999	2,066	500	0	0	0	0	0	**177,361**	2097	60,323	21,808	0	38,473	98,459	0	42,971	**15,016**
2098	75,661	97,840	1,999	2,300	500	0	0	0	0	0	**178,299**	2098	59,719	21,574	0	38,104	98,979	0	48,920	**9,956**
2099	83,854	90,760	1,999	2,124	500	0	0	0	0	0	**179,236**	2099	60,584	21,749	0	38,793	99,500	0	45,380	**13,328**
2100	110,407	66,032	2,002	1,383	500	0	0	0	0	0	**180,323**	2100	63,701	22,491	0	41,341	100,018	0	33,016	**23,659**
2101	94,116	82,608	1,999	1,890	500	0	0	0	0	0	**181,111**	2101	63,833	21,984	0	41,806	100,541	0	41,304	**15,432**
2102	79,411	97,840	1,999	2,300	500	0	0	0	0	0	**182,049**	2102	62,851	21,574	0	41,234	101,061	0	48,920	**8,908**
2103	87,604	90,760	1,999	2,124	500	0	0	0	0	0	**182,986**	2103	63,431	21,749	0	41,638	101,582	0	45,380	**12,565**
2104	89,533	90,324	2,004	2,066	501	0	0	0	0	0	**184,428**	2104	63,792	21,873	0	42,050	102,382	0	45,162	**13,166**
2105	82,223	97,840	1,999	2,300	500	0	0	0	0	0	**184,861**	2105	63,488	21,574	0	41,871	102,622	0	48,920	**9,833**
2106	83,161	97,840	1,999	2,300	500	0	0	0	0	0	**185,799**	2106	63,634	21,574	0	42,017	103,143	0	48,920	**10,208**
2107	84,099	97,840	1,999	2,300	500	0	0	0	0	0	**186,736**	2107	64,280	21,574	0	42,662	103,663	0	48,920	**10,082**
2108	85,546	97,837	2,004	2,300	501	0	0	0	0	0	**188,188**	2108	64,394	21,639	0	42,887	104,469	0	48,919	**10,660**
2109	85,974	97,840	1,999	2,300	500	0	0	0	0	0	**188,612**	2109	64,709	21,574	0	43,091	104,704	0	48,920	**10,694**
2110	86,911	97,840	1,999	2,300	500	0	0	0	0	0	**189,549**	2110	65,056	21,574	0	43,438	105,225	0	48,920	**10,868**
2111	87,849	97,840	1,999	2,300	500	0	0	0	0	0	**190,487**	2111	65,420	21,574	0	43,801	105,745	0	48,920	**11,025**
2112	95,556	91,588	2,004	2,300	501	0	0	0	0	0	**191,949**	2112	66,404	21,639	0	44,901	106,557	0	45,794	**13,858**
2113	89,724	97,840	1,999	2,300	500	0	0	0	0	0	**192,362**	2113	66,448	21,574	0	44,829	106,786	0	48,920	**11,039**
2114	90,619	97,925	1,999	2,300	457	0	0	0	0	0	**193,299**	2114	66,811	21,574	0	45,192	107,307	0	48,962	**11,154**
2115	94,747	94,734	1,999	2,300	457	0	0	0	0	0	**194,237**	2115	67,513	21,574	0	45,893	107,827	0	47,367	**12,568**
2116	96,419	94,528	2,004	2,300	458	0	0	0	0	0	**195,709**	2116	68,130	21,639	0	46,631	108,644	0	47,264	**12,746**
2117	97,348	94,008	1,999	2,300	457	0	0	0	0	0	**196,112**	2117	68,731	21,574	0	47,110	108,868	0	47,004	**12,755**
2118	98,027	94,266	1,999	2,300	457	0	0	0	0	0	**197,050**	2118	69,267	21,574	0	47,646	109,388	0	47,133	**12,611**
2119	98,975	94,256	1,999	2,300	457	0	0	0	0	0	**197,987**	2119	69,834	21,574	0	48,212	109,909	0	47,128	**12,570**
2120	100,179	94,528	2,004	2,300	458	0	0	0	0	0	**199,470**	2120	70,407	21,639	0	48,912	110,732	0	47,264	**12,552**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Table 6.A2. Medium Demand–Medium Supply – Page 1 of 2



Summary of Hydrologic Water Balance
Water balance summaries by type.
All units are in acre-feet (AF) unless otherwise noted.

BASELINE

Model Settings*
Medium Demand, Medium Supply

No alternatives selected in baseline model run.

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	**(11)**		(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2016	26,114	71,865	1,366	2,300	375	0	0	0	0	0	**102,019**	2016	61,193	26,444	16,616	18,258	55,557	0	35,932	**0**
2017	19,763	79,388	1,362	2,300	458	0	0	0	0	0	**103,271**	2017	57,794	26,372	16,200	15,182	56,238	0	39,694	**0**
2018	18,111	79,960	1,362	2,300	3,068	0	0	0	0	0	**104,802**	2018	54,575	26,372	12,436	15,730	57,072	0	39,980	**0**
2019	16,515	80,533	1,362	2,300	5,623	0	0	0	0	0	**106,332**	2019	50,961	26,372	8,278	16,277	57,905	0	40,266	**0**
2020	19,320	80,025	1,366	1,960	5,487	0	0	0	0	0	**108,158**	2020	47,518	26,444	3,650	17,522	58,900	0	40,012	**0**
2021	16,043	81,604	1,679	2,300	7,767	0	0	0	0	0	**109,393**	2021	43,404	24,072	2,211	17,091	59,572	0	40,802	**0**
2022	12,639	84,718	1,679	2,300	9,588	0	0	0	0	0	**110,924**	2022	39,365	22,970	0	16,368	60,406	0	42,359	**0**
2023	20,829	80,187	1,679	2,300	7,460	0	0	0	0	0	**112,454**	2023	38,464	21,574	0	16,864	61,239	0	40,093	**2,603**
2024	22,374	80,967	1,683	2,300	6,973	0	0	0	0	0	**114,297**	2024	37,575	21,639	0	16,013	62,243	0	40,483	**4,062**
2025	45,399	60,654	1,679	2,300	5,234	0	0	0	0	0	**115,266**	2025	42,155	21,574	0	20,552	62,770	0	30,327	**10,212**
2026	51,051	53,630	1,999	2,300	7,568	0	0	0	0	0	**116,548**	2026	45,014	21,574	0	23,410	63,468	0	26,815	**11,245**
2027	25,340	79,094	1,999	2,300	9,096	0	0	0	0	0	**117,829**	2027	40,377	21,574	0	18,776	64,166	0	39,547	**3,845**
2028	20,955	85,196	2,004	2,300	8,982	0	0	0	0	0	**119,437**	2028	37,276	21,639	0	15,714	65,042	0	42,598	**4,726**
2029	19,136	88,186	1,999	2,300	8,772	0	0	0	0	0	**120,392**	2029	35,010	21,574	0	13,413	65,562	0	44,093	**6,057**
2030	25,457	83,429	1,999	2,300	8,559	0	0	0	0	0	**121,744**	2030	35,145	21,574	0	13,547	66,259	0	41,715	**8,999**
2031	36,451	74,077	1,999	2,300	8,270	0	0	0	0	0	**123,097**	2031	37,548	21,574	0	15,948	66,957	0	37,039	**11,972**
2032	66,618	49,448	2,004	2,300	4,423	0	0	0	0	0	**124,793**	2032	44,913	21,639	0	23,366	67,840	0	24,724	**16,857**
2033	23,652	89,795	1,999	2,300	8,063	0	0	0	0	0	**125,809**	2033	38,805	21,574	0	17,205	68,353	0	44,898	**4,252**
2034	42,688	72,441	1,999	2,300	7,740	0	0	0	0	0	**127,167**	2034	40,825	21,574	0	19,223	69,051	0	36,220	**11,608**
2035	79,870	44,100	1,999	2,300	257	0	0	0	0	0	**128,526**	2035	49,207	21,574	0	27,599	69,748	0	22,050	**18,101**
2036	44,914	73,617	2,004	2,121	7,587	0	0	0	0	0	**130,243**	2036	46,239	21,818	0	24,515	70,639	0	36,809	**7,311**
2037	58,272	61,959	1,999	1,886	7,133	0	0	0	0	0	**131,249**	2037	48,040	21,987	0	26,020	71,144	0	30,980	**12,146**
2038	80,597	41,393	1,999	1,886	6,738	0	0	0	0	0	**132,613**	2038	52,775	21,987	0	30,751	71,842	0	20,696	**18,396**
2039	107,679	20,021	1,999	1,247	3,032	0	0	0	0	0	**133,978**	2039	58,818	22,626	0	36,151	72,540	0	10,011	**24,379**
2040	51,705	73,127	2,004	2,300	6,579	0	0	0	0	0	**135,716**	2040	54,152	21,639	0	32,624	73,438	0	36,564	**2,246**
2041	36,108	90,134	1,999	2,300	6,173	0	0	0	0	0	**136,713**	2041	50,141	23,236	0	26,870	73,935	0	45,067	**0**
2042	64,283	64,309	1,999	1,548	5,945	0	0	0	0	0	**138,083**	2042	52,631	22,326	0	30,269	74,633	0	32,154	**10,211**
2043	39,212	90,243	1,999	2,300	5,701	0	0	0	0	0	**139,454**	2043	48,759	21,574	0	27,152	75,331	0	45,122	**1,059**
2044	42,192	88,890	2,004	2,300	5,826	0	0	0	0	0	**141,213**	2044	47,383	21,639	0	25,841	76,237	0	44,445	**3,947**
2045	51,085	81,691	1,999	2,120	5,306	0	0	0	0	0	**142,201**	2045	48,173	21,754	0	26,386	76,727	0	40,846	**7,496**
2046	62,340	71,977	1,999	2,120	5,142	0	0	0	0	0	**143,577**	2046	50,424	21,754	0	28,636	77,424	0	35,988	**10,802**
2047	83,823	53,362	1,999	868	4,902	0	0	0	0	0	**144,954**	2047	54,727	23,005	0	31,684	78,122	0	26,681	**17,758**
2048	78,149	59,630	2,004	2,300	4,651	0	0	0	0	0	**146,734**	2048	55,914	21,639	0	34,390	79,036	0	29,815	**12,827**
2049	43,621	95,543	1,999	2,300	4,251	0	0	0	0	0	**147,713**	2049	52,005	22,222	0	29,748	79,518	0	47,771	**0**
2050	51,101	90,986	1,999	2,300	2,624	0	0	0	0	0	**149,010**	2050	51,523	21,574	0	29,914	80,216	0	45,493	**2,810**
2051	72,327	70,192	1,999	2,120	3,668	0	0	0	0	0	**150,306**	2051	54,296	21,754	0	32,505	80,913	0	35,096	**11,314**
2052	62,481	81,561	2,004	2,300	3,671	0	0	0	0	0	**152,017**	2052	53,950	21,639	0	32,422	81,835	0	40,780	**6,629**
2053	57,824	87,512	1,999	2,300	3,264	0	0	0	0	0	**152,898**	2053	53,368	21,574	0	31,757	82,309	0	43,756	**4,797**
2054	61,356	85,464	1,999	2,300	3,076	0	0	0	0	0	**154,195**	2054	53,690	21,574	0	32,080	83,007	0	42,732	**6,197**
2055	82,285	66,576	1,999	1,766	2,865	0	0	0	0	0	**155,491**	2055	56,754	22,108	0	34,607	83,705	0	33,288	**13,811**
2056	59,096	90,988	2,004	2,300	2,829	0	0	0	0	0	**157,217**	2056	54,957	21,639	0	33,431	84,634	0	45,494	**3,705**
2057	59,356	92,035	1,999	2,300	2,394	0	0	0	0	0	**158,083**	2057	54,594	21,574	0	32,983	85,100	0	46,018	**4,101**
2058	89,821	63,150	1,999	2,300	2,110	0	0	0	0	0	**159,380**	2058	58,527	21,574	0	36,913	85,798	0	31,575	**15,312**
2059	78,702	75,579	1,999	2,300	2,096	0	0	0	0	0	**160,676**	2059	58,784	21,574	0	37,170	86,496	0	37,789	**9,538**
2060	126,871	30,830	2,004	869	1,938	0	0	0	0	0	**162,513**	2060	65,215	23,070	0	42,279	87,433	0	15,415	**27,735**
2061	129,917	29,122	1,999	2,300	126	0	0	0	0	0	**163,463**	2061	68,406	21,574	0	46,786	87,891	0	14,561	**24,546**
2062	86,822	72,158	1,999	2,300	1,579	0	0	0	0	0	**164,859**	2062	65,782	21,574	0	44,163	88,589	0	36,079	**6,348**
2063	62,951	97,365	1,999	2,300	1,642	0	0	0	0	0	**166,256**	2063	62,932	24,072	211	38,606	89,287	0	48,682	**0**
2064	65,478	97,461	2,004	2,300	871	0	0	0	0	0	**168,114**	2064	62,228	22,859	0	39,497	90,231	0	48,731	**0**
2065	66,422	97,514	1,999	2,300	821	0	0	0	0	0	**169,055**	2065	61,837	21,868	0	39,927	90,683	0	48,757	**0**

Table 6.A2. Medium Demand–Medium Supply – Page 2 of 2

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	73,820	91,758	1,999	2,300	580	0	0	0	0	0	**170,457**	2066	62,359	21,574	0	40,743	91,380	0	45,879	**2,760**
2067	83,574	83,096	1,999	2,300	892	0	0	0	0	0	**171,861**	2067	63,505	21,574	0	41,888	92,078	0	41,548	**6,643**
2068	71,279	97,353	2,004	2,300	805	0	0	0	0	0	**173,740**	2068	62,627	21,639	0	41,117	93,030	0	48,676	**1,233**
2069	71,820	97,813	1,999	2,300	741	0	0	0	0	0	**174,672**	2069	62,480	21,574	0	40,863	93,474	0	48,906	**1,706**
2070	73,442	97,840	1,999	2,300	500	0	0	0	0	0	**176,080**	2070	62,530	21,574	0	40,914	94,172	0	48,920	**2,340**
2071	74,852	97,840	1,999	2,300	500	0	0	0	0	0	**177,490**	2071	62,666	21,574	0	41,049	94,870	0	48,920	**2,902**
2072	91,349	83,447	2,004	2,300	292	0	0	0	0	0	**179,391**	2072	64,601	21,639	0	43,095	95,829	0	41,724	**9,007**
2073	117,822	58,070	1,999	2,300	123	0	0	0	0	0	**180,314**	2073	68,340	21,574	0	46,720	96,265	0	29,035	**18,512**
2074	128,374	48,888	1,999	2,300	167	0	0	0	0	0	**181,728**	2074	71,234	21,574	0	49,611	96,963	0	24,444	**20,909**
2075	92,471	85,959	1,999	2,300	416	0	0	0	0	0	**183,144**	2075	69,248	21,574	0	47,627	97,661	0	42,979	**5,056**
2076	97,982	82,406	2,004	2,300	375	0	0	0	0	0	**185,067**	2076	69,776	21,639	0	48,281	98,628	0	41,203	**7,140**
2077	83,342	97,840	1,999	2,300	500	0	0	0	0	0	**185,980**	2077	68,701	21,574	0	47,081	99,056	0	48,920	**1,057**
2078	84,763	97,840	1,999	2,300	500	0	0	0	0	0	**187,401**	2078	68,661	21,574	0	47,040	99,754	0	48,920	**1,795**
2079	86,185	97,840	1,999	2,300	500	0	0	0	0	0	**188,823**	2079	68,840	21,574	0	47,219	100,452	0	48,920	**2,314**
2080	88,013	97,837	2,004	2,300	501	0	0	0	0	0	**190,655**	2080	69,126	21,639	0	47,628	101,427	0	48,919	**2,876**
2081	88,808	97,840	1,999	2,300	500	0	0	0	0	0	**191,446**	2081	69,405	21,574	0	47,784	101,848	0	48,920	**3,145**
2082	97,381	90,760	1,999	2,119	500	0	0	0	0	0	**192,758**	2082	70,478	21,754	0	48,675	102,545	0	45,380	**6,492**
2083	106,495	82,903	1,999	2,300	374	0	0	0	0	0	**194,070**	2083	71,962	21,574	0	50,339	103,243	0	41,451	**9,454**
2084	116,903	74,624	2,004	1,885	501	0	0	0	0	0	**195,917**	2084	73,855	22,054	0	51,952	104,226	0	37,312	**12,957**
2085	118,425	74,184	1,999	1,586	500	0	0	0	0	0	**196,693**	2085	75,175	22,287	0	52,836	104,639	0	37,092	**12,712**
2086	128,392	65,356	1,999	1,885	374	0	0	0	0	0	**198,005**	2086	77,118	21,989	0	55,076	105,337	0	32,678	**15,584**
2087	165,000	22,502	1,999	874	250	0	0	0	0	8,691	**199,316**	2087	81,993	22,999	0	58,938	106,034	0	11,251	**33,847**
2088	115,276	81,222	2,004	2,300	375	0	0	0	0	0	**201,178**	2088	79,619	21,639	0	58,143	107,025	0	40,611	**6,266**
2089	110,257	86,885	1,999	2,300	500	0	0	0	0	0	**201,940**	2089	79,271	21,574	0	57,643	107,430	0	43,442	**4,346**
2090	142,271	57,608	1,999	874	500	0	0	0	0	0	**203,251**	2090	82,619	22,999	0	59,563	108,128	0	28,804	**17,762**
2091	114,359	85,640	1,999	2,066	500	0	0	0	0	0	**204,563**	2091	81,549	21,808	0	59,685	108,826	0	42,820	**4,321**
2092	108,477	93,157	2,004	2,300	501	0	0	0	0	0	**206,439**	2092	81,166	21,639	0	59,694	109,823	0	46,578	**1,547**
2093	119,735	82,834	1,999	2,119	500	0	0	0	0	0	**207,187**	2093	82,461	21,754	0	60,650	110,221	0	41,417	**6,156**
2094	137,656	66,758	1,999	1,586	500	0	0	0	0	0	**208,498**	2094	84,887	22,287	0	62,542	110,919	0	33,379	**13,000**
2095	157,559	49,184	1,999	568	500	0	0	0	0	0	**209,810**	2095	88,005	23,305	0	64,640	111,617	0	24,592	**20,387**
2096	126,156	80,865	2,004	2,300	375	0	0	0	0	0	**211,700**	2096	86,791	21,639	0	65,330	112,622	0	40,432	**4,856**
2097	114,452	93,183	1,999	2,300	500	0	0	0	0	0	**212,433**	2097	85,971	21,574	0	64,339	113,012	0	46,592	**84**
2098	114,364	94,583	1,999	2,300	500	0	0	0	0	0	**213,745**	2098	85,986	21,574	0	64,354	113,710	0	47,291	**66**
2099	135,371	75,386	1,999	1,885	416	0	0	0	0	0	**215,057**	2099	88,412	21,989	0	66,363	114,408	0	37,693	**8,353**
2100	134,496	77,366	2,002	2,298	394	0	0	0	0	0	**216,556**	2100	89,093	21,576	0	67,701	115,104	0	38,683	**4,812**
2101	131,717	81,165	1,999	2,300	500	0	0	0	0	0	**217,680**	2101	90,018	21,574	0	68,383	115,804	0	40,582	**4,840**
2102	130,576	83,852	1,999	2,066	500	0	0	0	0	0	**218,992**	2102	90,611	21,808	0	68,742	116,501	0	41,926	**3,835**
2103	155,193	61,323	1,999	1,289	500	0	0	0	0	0	**220,303**	2103	93,202	22,585	0	70,554	117,199	0	30,661	**13,985**
2104	132,251	85,292	2,004	2,300	375	0	0	0	0	0	**222,222**	2104	92,623	21,639	0	71,174	118,220	0	42,646	**2,396**
2105	129,778	88,393	1,999	2,300	457	0	0	0	0	0	**222,927**	2105	92,827	21,574	0	71,190	118,595	0	44,196	**1,210**
2106	153,260	66,389	1,999	2,300	290	0	0	0	0	0	**224,239**	2106	95,493	21,574	0	73,854	119,293	0	33,195	**10,245**
2107	150,973	69,947	1,999	2,300	331	0	0	0	0	0	**225,550**	2107	97,132	21,574	0	75,492	119,990	0	34,974	**7,526**
2108	165,000	30,535	2,004	874	334	0	0	0	0	28,736	**227,483**	2108	99,135	23,065	0	76,274	121,019	0	15,267	**27,473**
2109	165,000	28,082	1,999	2,119	167	0	0	0	0	30,806	**228,174**	2109	100,543	21,754	0	78,720	121,386	0	14,041	**26,626**
2110	153,244	71,610	1,999	2,300	333	0	0	0	0	0	**229,485**	2110	100,659	21,574	0	79,017	122,084	0	35,805	**5,264**
2111	128,159	97,840	1,999	2,300	500	0	0	0	0	0	**230,797**	2111	99,011	24,072	3,008	71,863	122,782	0	48,920	**0**
2112	130,102	97,837	2,004	2,300	501	0	0	0	0	0	**232,745**	2112	98,960	24,144	2,124	72,895	123,818	0	48,919	**0**
2113	135,248	93,500	1,999	2,300	374	0	0	0	0	0	**233,420**	2113	99,621	24,072	52	75,429	124,177	0	46,750	**0**
2114	149,656	80,487	1,999	2,300	290	0	0	0	0	0	**234,732**	2114	101,293	21,574	0	79,650	124,875	0	40,244	**2,983**
2115	150,231	81,141	1,999	2,300	374	0	0	0	0	0	**236,044**	2115	102,375	21,574	0	80,731	125,573	0	40,570	**2,273**
2116	137,027	96,216	2,004	2,300	458	0	0	0	0	0	**238,006**	2116	101,944	24,144	1,505	76,505	126,617	0	48,108	**0**
2117	136,029	97,840	1,999	2,300	500	0	0	0	0	0	**238,667**	2117	102,092	24,072	1,900	76,050	126,969	0	48,920	**0**
2118	137,341	97,840	1,999	2,300	500	0	0	0	0	0	**239,979**	2118	102,463	24,072	1,573	76,748	127,666	0	48,920	**0**
2119	152,073	84,710	1,999	2,300	209	0	0	0	0	0	**241,290**	2119	104,311	21,574	0	82,666	128,364	0	42,355	**1,510**
2120	165,000	70,066	2,004	2,300	292	0	0	0	0	3,605	**243,267**	2120	106,405	21,639	0	84,985	129,416	0	35,033	**7,393**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Table 6.A3. High Demand–Low Supply – Page 1 of 2

Summary of Hydrologic Water Balance
Water balance summaries by type.
All units are in acre-feet (AF) unless otherwise noted.

BASELINE

Model Settings*
High Demand, Low Supply

No alternatives selected in baseline model run.

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	**(11)**		(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2016	26,296	71,966	1,366	2,300	375	0	0	0	0	0	**102,303**	2016	61,216	26,444	16,690	18,208	55,557	0	35,983	**0**
2017	20,240	79,635	1,362	2,300	458	0	0	0	0	0	**103,996**	2017	57,875	26,372	16,167	15,296	56,476	0	39,817	**0**
2018	18,865	80,372	1,362	2,300	3,068	0	0	0	0	0	**105,968**	2018	54,734	26,372	12,326	15,998	57,547	0	40,186	**0**
2019	22,921	76,189	1,362	1,960	5,507	0	0	0	0	0	**107,940**	2019	52,196	26,372	6,627	19,161	58,618	0	38,095	**0**
2020	31,336	70,595	1,366	1,578	5,338	0	0	0	0	0	**110,213**	2020	50,680	26,444	1,151	23,189	59,852	0	35,297	**0**
2021	17,955	82,511	1,679	2,300	7,439	0	0	0	0	0	**111,884**	2021	45,699	24,072	3,770	17,825	60,759	0	41,255	**0**
2022	14,723	85,789	1,679	2,300	9,365	0	0	0	0	0	**113,856**	2022	41,440	24,072	83	17,257	61,830	0	42,894	**0**
2023	26,407	80,029	1,679	2,300	5,413	0	0	0	0	0	**115,828**	2023	41,089	21,574	0	19,487	62,901	0	40,014	**1,655**
2024	45,937	62,781	1,683	2,300	5,422	0	0	0	0	0	**118,123**	2024	44,651	21,639	0	23,104	64,148	0	31,390	**7,970**
2025	61,647	46,529	1,679	2,300	7,319	0	0	0	0	0	**119,474**	2025	49,193	21,574	0	27,586	64,881	0	23,264	**12,352**
2026	70,632	44,739	1,999	2,300	1,478	0	0	0	0	0	**121,147**	2026	52,724	21,574	0	31,114	65,790	0	22,369	**10,308**
2027	41,050	69,081	1,999	2,300	8,391	0	0	0	0	0	**122,821**	2027	48,917	21,574	0	27,310	66,699	0	34,540	**2,850**
2028	35,994	76,311	2,004	2,300	8,227	0	0	0	0	0	**124,836**	2028	46,178	21,639	0	24,634	67,793	0	38,155	**3,000**
2029	23,914	89,920	1,999	2,300	8,035	0	0	0	0	0	**126,168**	2029	41,793	21,574	0	20,190	68,517	0	44,960	**1,368**
2030	25,388	90,433	1,999	2,300	7,829	0	0	0	0	0	**127,948**	2030	39,748	21,574	0	18,148	69,426	0	45,217	**4,063**
2031	26,983	90,947	1,999	2,300	7,503	0	0	0	0	0	**129,731**	2031	38,695	21,574	0	17,095	70,334	0	45,474	**5,767**
2032	35,896	86,333	2,004	2,300	5,344	0	0	0	0	0	**131,878**	2032	39,925	21,639	0	18,368	71,438	0	43,167	**7,900**
2033	34,488	89,504	1,999	2,300	5,016	0	0	0	0	0	**133,306**	2033	39,844	21,574	0	18,243	72,152	0	44,752	**7,158**
2034	43,117	83,140	1,999	2,300	4,542	0	0	0	0	0	**135,097**	2034	41,707	21,574	0	20,105	73,061	0	41,570	**9,388**
2035	75,438	54,013	1,999	2,300	3,142	0	0	0	0	0	**136,892**	2035	49,202	21,574	0	27,595	73,970	0	27,006	**17,370**
2036	60,382	68,671	2,004	1,888	6,124	0	0	0	0	0	**139,069**	2036	49,696	22,051	0	27,747	75,084	0	34,335	**10,998**
2037	68,146	63,157	1,999	1,587	5,599	0	0	0	0	0	**140,488**	2037	51,834	22,286	0	29,512	75,788	0	31,579	**12,698**
2038	86,949	46,340	1,999	1,549	5,454	0	0	0	0	0	**142,291**	2038	55,893	22,324	0	33,531	76,697	0	23,170	**17,997**
2039	120,235	20,546	1,999	868	449	0	0	0	0	0	**144,096**	2039	62,436	23,005	0	39,388	77,605	0	10,273	**25,946**
2040	68,189	68,974	2,004	2,300	4,837	0	0	0	0	0	**146,304**	2040	58,937	21,639	0	37,419	78,729	0	34,487	**4,819**
2041	48,549	90,567	1,999	2,300	4,302	0	0	0	0	0	**147,716**	2041	55,667	23,488	0	32,141	79,423	0	45,283	**0**
2042	88,693	53,622	1,999	1,250	3,966	0	0	0	0	0	**149,529**	2042	59,824	22,624	0	37,159	80,332	0	26,811	**14,363**
2043	74,411	69,123	1,999	2,300	3,513	0	0	0	0	0	**151,346**	2043	59,433	21,574	0	37,819	81,241	0	34,561	**6,862**
2044	57,344	88,395	2,004	2,300	3,542	0	0	0	0	0	**153,585**	2044	57,317	21,639	0	35,796	82,375	0	44,198	**377**
2045	74,842	73,093	1,999	2,121	2,933	0	0	0	0	0	**154,988**	2045	58,945	21,753	0	37,152	83,059	0	36,547	**7,361**
2046	87,210	63,642	1,999	1,250	2,711	0	0	0	0	0	**156,812**	2046	61,134	22,623	0	38,469	83,967	0	31,821	**11,679**
2047	106,297	47,327	1,999	566	2,450	0	0	0	0	0	**158,640**	2047	64,623	23,307	0	41,272	84,876	0	23,664	**17,942**
2048	107,065	48,356	2,004	2,300	1,185	0	0	0	0	0	**160,910**	2048	66,479	21,639	0	44,976	86,020	0	24,178	**14,862**
2049	73,627	82,512	1,999	2,121	2,046	0	0	0	0	0	**162,304**	2049	63,912	21,753	0	42,115	86,694	0	41,256	**1,324**
2050	71,543	86,461	1,999	2,121	1,883	0	0	0	0	0	**164,006**	2050	63,178	21,753	0	41,382	87,603	0	43,230	**992**
2051	101,993	58,296	1,999	1,888	1,532	0	0	0	0	0	**165,707**	2051	66,575	21,986	0	44,544	88,512	0	29,148	**12,821**
2052	99,080	63,199	2,004	2,300	1,284	0	0	0	0	0	**167,867**	2052	67,562	21,639	0	46,061	89,666	0	31,599	**10,001**
2053	95,904	68,083	1,999	1,888	1,236	0	0	0	0	0	**169,110**	2053	68,080	21,986	0	46,047	90,330	0	34,042	**8,242**
2054	99,653	66,368	1,999	1,767	1,025	0	0	0	0	0	**170,812**	2054	69,128	22,107	0	46,974	91,238	0	33,184	**9,082**
2055	114,266	53,997	1,999	1,284	968	0	0	0	0	0	**172,513**	2055	71,476	22,590	0	48,837	92,147	0	26,998	**14,314**
2056	132,263	37,999	2,004	2,300	126	0	0	0	0	0	**174,692**	2056	74,676	21,639	0	53,191	93,311	0	19,000	**19,117**
2057	103,121	68,232	1,999	2,067	498	0	0	0	0	0	**175,916**	2057	73,413	21,807	0	51,556	93,965	0	34,116	**6,295**
2058	120,429	52,590	1,999	2,300	300	0	0	0	0	0	**177,618**	2058	75,526	21,574	0	53,901	94,874	0	26,295	**12,679**
2059	122,643	52,215	1,999	2,121	342	0	0	0	0	0	**179,320**	2059	76,847	21,753	0	55,041	95,783	0	26,108	**12,636**
2060	151,098	27,367	2,004	871	334	0	0	0	0	0	**181,675**	2060	80,852	23,068	0	57,951	96,957	0	13,684	**23,318**
2061	155,048	23,940	1,999	1,887	167	0	0	0	0	0	**183,041**	2061	83,372	21,986	0	61,329	97,601	0	11,970	**22,303**
2062	110,570	69,705	1,999	2,300	333	0	0	0	0	0	**184,906**	2062	80,719	21,574	0	59,090	98,510	0	34,852	**2,568**
2063	84,136	97,840	1,999	2,300	500	0	0	0	0	0	**186,774**	2063	77,858	24,072	5,233	48,500	99,418	0	48,920	**0**
2064	86,520	97,837	2,004	2,300	501	0	0	0	0	0	**189,162**	2064	77,174	24,144	3,509	49,680	100,602	0	48,919	**0**
2065	101,243	84,687	1,999	2,300	290	0	0	0	0	0	**190,519**	2065	78,286	21,574	0	56,659	101,236	0	42,344	**235**

Table 6.A3. High Demand–Low Supply – Page 2 of 2

	Supplies Used to Meet Demand												River Effects Accounting Summary			Wastewater Accounting Summary				
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	107,755	80,000	1,999	2,300	342	0	0	0	0	0	**192,396**	2066	79,127	21,574	0	57,499	102,145	0	40,000	**2,030**
2067	119,510	70,109	1,999	2,300	358	0	0	0	0	0	**194,276**	2067	80,396	21,574	0	58,768	103,054	0	35,054	**4,776**
2068	120,803	71,255	2,004	2,300	334	0	0	0	0	0	**196,696**	2068	81,694	21,639	0	60,223	104,248	0	35,627	**6,393**
2069	95,406	97,840	1,999	2,300	500	0	0	0	0	0	**198,044**	2069	79,928	24,072	1,848	53,953	104,872	0	48,920	**0**
2070	108,272	86,989	1,999	2,300	374	0	0	0	0	0	**199,933**	2070	80,853	21,574	0	59,224	105,781	0	43,495	**1,064**
2071	126,088	71,189	1,999	2,300	249	0	0	0	0	0	**201,825**	2071	83,009	21,574	0	61,378	106,689	0	35,594	**7,718**
2072	165,000	25,957	2,004	1,767	167	0	0	0	0	9,383	**204,278**	2072	87,909	22,172	0	65,918	107,893	0	12,978	**26,993**
2073	165,000	34,781	1,999	2,001	252	0	0	0	0	1,585	**205,617**	2073	90,335	21,873	0	68,401	108,507	0	17,390	**20,717**
2074	153,028	49,972	1,999	2,300	219	0	0	0	0	0	**207,518**	2074	90,961	21,574	0	69,325	109,416	0	24,986	**12,225**
2075	154,897	50,090	1,999	2,120	316	0	0	0	0	0	**209,421**	2075	91,939	21,753	0	70,123	110,325	0	25,045	**10,711**
2076	132,162	75,107	2,004	2,300	334	0	0	0	0	0	**211,907**	2076	91,221	21,639	0	69,769	111,539	0	37,553	**2,212**
2077	111,539	96,900	1,999	2,300	500	0	0	0	0	0	**213,237**	2077	89,594	24,072	3,766	61,694	112,143	0	48,450	**0**
2078	115,813	94,538	1,999	2,300	500	0	0	0	0	0	**215,150**	2078	89,955	24,072	2,038	63,784	113,052	0	47,269	**0**
2079	155,272	57,707	1,999	1,587	500	0	0	0	0	0	**217,065**	2079	93,975	22,287	0	71,624	113,960	0	28,854	**11,484**
2080	122,419	92,172	2,004	2,300	501	0	0	0	0	0	**219,396**	2080	92,432	24,144	1,384	67,094	115,184	0	46,086	**0**
2081	124,691	91,038	1,999	2,300	500	0	0	0	0	0	**220,527**	2081	92,684	24,072	289	68,260	115,778	0	45,519	**0**
2082	140,207	77,752	1,999	1,886	415	0	0	0	0	0	**222,259**	2082	94,700	21,988	0	72,648	116,687	0	38,876	**3,165**
2083	165,000	32,680	1,999	2,120	209	0	0	0	0	21,981	**223,990**	2083	98,052	21,753	0	76,232	117,596	0	16,340	**23,025**
2084	157,967	64,615	2,004	1,253	501	0	0	0	0	0	**226,339**	2084	99,272	22,686	0	76,790	118,829	0	32,307	**7,728**
2085	157,374	65,993	1,999	1,587	500	0	0	0	0	0	**227,452**	2085	100,359	22,287	0	78,003	119,414	0	32,997	**6,415**
2086	165,000	32,106	1,999	1,886	207	0	0	0	0	27,986	**229,183**	2086	102,097	21,988	0	80,039	120,322	0	16,053	**22,231**
2087	165,000	18,063	1,999	571	293	0	0	0	0	44,990	**230,914**	2087	103,350	23,303	0	79,977	121,231	0	9,031	**30,225**
2088	159,172	69,473	2,004	2,300	334	0	0	0	0	0	**233,283**	2088	103,871	21,639	0	82,445	122,475	0	34,736	**3,289**
2089	153,100	76,892	1,999	1,886	500	0	0	0	0	0	**234,377**	2089	104,130	21,988	0	82,072	123,049	0	38,446	**533**
2090	165,000	46,687	1,999	571	500	0	0	0	0	21,352	**236,108**	2090	106,011	23,303	0	82,635	123,958	0	23,343	**15,981**
2091	161,990	71,667	1,999	1,767	416	0	0	0	0	0	**237,839**	2091	106,831	22,107	0	84,651	124,867	0	35,834	**2,383**
2092	145,194	90,228	2,004	2,300	501	0	0	0	0	0	**240,227**	2092	106,137	24,144	3,209	79,002	126,120	0	45,114	**0**
2093	165,000	57,487	1,999	1,587	374	0	0	0	0	14,855	**241,301**	2093	108,201	22,287	0	85,840	126,685	0	28,744	**10,102**
2094	165,000	55,068	1,999	875	500	0	0	0	0	19,591	**243,033**	2094	109,376	22,998	0	86,303	127,593	0	27,534	**11,758**
2095	165,000	45,560	1,999	571	500	0	0	0	0	31,135	**244,764**	2095	110,330	23,303	0	86,951	128,502	0	22,780	**16,773**
2096	165,000	49,215	2,004	2,300	209	0	0	0	0	28,442	**247,170**	2096	111,171	21,639	0	89,760	129,766	0	24,607	**13,394**
2097	161,052	82,598	1,999	2,120	457	0	0	0	0	0	**248,226**	2097	111,631	24,252	281	87,022	130,320	0	41,299	**0**
2098	157,832	87,507	1,999	2,120	500	0	0	0	0	0	**249,957**	2098	112,120	24,252	2,314	85,477	131,229	0	43,753	**0**
2099	165,000	37,999	1,999	1,886	209	0	0	0	0	44,596	**251,689**	2099	113,465	21,988	0	91,399	132,138	0	18,999	**19,741**
2100	164,969	56,258	2,002	2,298	290	0	0	0	0	27,824	**253,642**	2100	114,306	21,576	0	92,965	133,045	0	28,129	**9,949**
2101	165,000	62,475	1,999	1,587	416	0	0	0	0	23,675	**255,151**	2101	115,113	22,287	0	92,747	133,956	0	31,237	**7,973**
2102	165,000	62,038	1,999	1,390	415	0	0	0	0	26,041	**256,882**	2102	115,748	22,484	0	93,185	134,865	0	31,019	**8,662**
2103	165,000	45,408	1,999	751	417	0	0	0	0	45,039	**258,613**	2103	116,454	23,123	0	93,251	135,773	0	22,704	**17,820**
2104	165,000	32,875	2,004	2,120	167	0	0	0	0	58,891	**261,058**	2104	117,072	21,819	0	95,494	137,057	0	16,438	**23,121**
2105	165,000	66,364	1,999	1,767	416	0	0	0	0	26,530	**262,076**	2105	117,886	22,107	0	95,699	137,591	0	33,182	**6,711**
2106	165,000	50,206	1,999	2,300	209	0	0	0	0	44,093	**263,807**	2106	118,673	21,574	0	97,018	138,500	0	25,103	**14,380**
2107	165,000	53,507	1,999	1,886	374	0	0	0	0	42,773	**265,538**	2107	119,691	21,988	0	97,621	139,409	0	26,753	**13,035**
2108	165,000	25,655	2,004	571	376	0	0	0	0	74,395	**268,001**	2108	120,068	23,368	0	96,946	140,702	0	12,828	**28,924**
2109	165,000	21,469	1,999	1,587	167	0	0	0	0	78,779	**269,000**	2109	120,750	22,287	0	98,381	141,227	0	10,734	**30,113**
2110	165,000	71,110	1,999	2,300	333	0	0	0	0	29,990	**270,732**	2110	121,367	21,574	0	99,710	142,136	0	35,555	**4,872**
2111	165,000	97,840	1,999	2,300	500	0	0	0	0	4,825	**272,463**	2111	122,001	24,072	5,720	92,126	143,044	0	48,920	**0**
2112	165,000	97,837	2,004	2,300	501	0	0	0	0	7,303	**274,945**	2112	122,580	24,144	5,263	93,425	144,348	0	48,919	**0**
2113	164,473	82,812	1,999	2,300	209	0	0	0	0	24,133	**275,925**	2113	123,266	21,574	0	101,608	144,862	0	41,406	**130**
2114	165,000	79,149	1,999	2,300	333	0	0	0	0	28,876	**277,656**	2114	123,900	21,574	0	102,241	145,771	0	39,575	**1,957**
2115	165,000	69,418	1,999	2,300	333	0	0	0	0	40,338	**279,387**	2115	124,648	21,574	0	102,989	146,680	0	34,709	**6,983**
2116	165,000	72,294	2,004	2,300	334	0	0	0	0	39,957	**281,889**	2116	125,198	21,639	0	103,816	147,993	0	36,147	**6,026**
2117	165,000	97,463	1,999	2,300	457	0	0	0	0	15,631	**282,850**	2117	125,799	24,072	3,874	97,767	148,498	0	48,732	**0**
2118	165,000	58,022	1,999	2,300	290	0	0	0	0	56,970	**284,581**	2118	126,435	21,574	0	104,775	149,407	0	29,011	**13,622**
2119	165,000	73,391	1,999	2,300	333	0	0	0	0	43,290	**286,312**	2119	126,967	21,574	0	105,307	150,315	0	36,696	**6,315**
2120	165,000	28,561	2,004	1,433	252	0	0	0	0	91,583	**288,832**	2120	127,425	22,507	0	105,180	151,639	0	14,281	**30,174**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Appendix 6.B

Alternative Ranking

Alternative		Rank	Score	Yield	Reliability	Frequency of Availability	Regional Impact	Technical Feasibility	Permitting	Time to Implement	Cultural, Historical, and Aesthetic Values	Socioeconomic Impact	Ecosystem Protection	Carbon Footprint
C2	**110 gpcd in 20 years**	🟢 **1**	19.0	1.0	1.0	1.0	3	1	1	4	1	2	3	1
C1	**120 gpcd in 10 years**	🟢 **2**	21.0	2.5	2.5	1.0	3	1	1	3	1	2	3	1
S2	**Excess San Juan-Chama water**	🟢 **3**	21.4	1.0	4.9	4.5	2	1	1	1	1	1	2	2
FCB2	**Future storage fee water**	🟢 **4**	23.7	4.9	5.0	2.8	2	1	1	1	1	1	2	2
S1	**Lease or short-term purchase of additional San Juan-Chama water**	🟢 **5**	23.7	4.9	4.9	1.0	3	1	1	1	2	1	2	2
R3a	**Connect southside reuse system to North I-25 Non-Potable Project**	🟢 **6**	27.7	4.8	4.9	1.0	3	2	2	2	1	1	3	3
ASR1	**Large-scale ASR projects**	🟢 **7**	27.7	4.3	4.3	1.0	3	2	3	2	1	1	3	3
R3b	**Expand southside reuse system**	🟢 **8**	27.7	4.7	4.9	1.1	3	2	2	2	1	1	3	3
WM1	**Watershed management -San Juan tributaries**	🟢 **9**	28.0	5.0	5.0	5.0	2	1	1	1	1	1	2	4
WM2	**Watershed management - Rio Grande and tributaries below Otowi**	🟢 **9**	28.0	5.0	5.0	5.0	3	1	1	1	1	1	1	4
ST2	**New reservoir 10,000 af**	🟢 **11**	28.9	4.0	4.8	1.0	3	3	2	3	3	1	2	2
R2b	**Eastside Reuse with storage**	🟢 **12**	29.3	4.1	4.1	1.1	3	3	3	3	2	1	2	3
ST1	**New reservoir 5,000 af**	🟡 **13**	29.4	4.5	4.9	1.0	3	3	2	3	3	1	2	2
R2a	**Eastside Reuse**	🟡 **14**	29.6	4.2	4.2	1.1	3	3	3	3	2	1	2	3
R1b	**Westside Reuse with storage**	🟡 **15**	30.4	4.6	4.6	1.1	3	3	3	3	2	1	2	3
C3	**Outdoor-only, 10 gpcd reduction over 30 years**	🟡 **16**	30.7	3.3	3.3	1.0	3	2	1	5	3	3	5	1
FCB3	**Relinquishment Credit Water**	🟡 **17**	30.7	4.3	5.0	4.4	2	1	4	3	1	1	3	2
R1a	**Westside Reuse**	🟡 **18**	30.9	4.9	4.9	1.1	3	3	3	3	2	1	2	3
FCB1	**Water banking**	🟡 **19**	30.9	4.3	4.7	2.9	3	1	2	3	3	1	4	2
I/DPR3	**I/DPR3**	🟡 **20**	31.1	3.0	3.7	2.4	3	3	3	3	3	1	3	3
I/DPR2	**I/DPR2**	🟡 **21**	31.8	3.4	3.9	2.4	3	3	3	3	3	1	3	3
I2	**Interbasin Transfer 10,000 afy, delivered to Water Authority system**	🟡 **22**	32.4	3.7	3.7	1.0	4	1	2	5	4	1	3	4
I/DPR1	**I/DPR1**	🟡 **23**	32.8	4.0	4.3	2.4	3	3	3	3	3	1	3	3
WR1	**Pre-1907 Water Rights Acquisition**	🟡 **24**	32.8	4.9	4.9	1.0	3	1	3	4	4	1	4	2
I1	**Interbasin Transfer 5,000 afy, delivered to Water Authority system**	🔴 **25**	33.7	4.3	4.3	1.0	4	1	2	5	4	1	3	4
I4	**Interbasin Transfer 10,000 afy, transferred to Water Authority system**	🔴 **26**	34.4	3.7	3.7	1.0	4	2	3	5	5	1	2	4
P1	**Operational flexibility under existing SP-4830 permit**	🔴 **27**	34.4	4.7	4.7	1.0	3	2	5	4	5	1	2	2
SW1	**Stormwater capture from existing facilities**	🔴 **28**	34.6	4.8	4.8	1.0	4	2	5	4	4	1	3	1
I3	**Interbasin Transfer 5,000 afy, transferred to Water Authority system**	🔴 **29**	35.7	4.3	4.3	1.0	4	2	3	5	5	1	2	4
S3	**Regional Diversion**	🔴 **30**	36.7	4.3	4.3	1.0	3	3	4	4	5	1	3	4
SW3	**Stormwater capture 1,000 – 2,000 afy**	🔴 **31**	37.6	4.8	4.8	1.0	4	3	5	4	4	1	4	2
SW2	**Stormwater capture 500 – 1,000 afy**	🔴 **32**	37.8	4.9	4.9	1.0	4	3	5	4	4	1	4	2
B2	**Brackish groundwater 5,000 afy**	🔴 **33**	38.1	4.3	4.9	3.9	3	4	3	4	2	1	3	5
B1	**Brackish groundwater 2,000 afy**	🔴 **34**	38.5	4.7	4.9	3.9	3	4	3	4	2	1	3	5
I5	**Produced water**	🔴 **35**	39.7	4.9	4.9	1.0	3	5	4	5	3	1	3	5

Appendix 6.C

Detailed Portfolio Results Table

This appendix summarizes the hydrologic water balance by type for the medium demand, medium supply scenario for Portfolio 1, 2, and 3.

Table 6.C1 Portfolio 1 Page 1 of 2

Summary of Hydrologic Water Balance **PORTFOLIO 1**
Water balance summaries by type.
All units are in acre-feet (AF) unless otherwise noted.

Model Settings*
Medium Demand, Medium Supply

Conservation (110 gpcd in 20 yrs)	Westside reuse	Rio Grande Compact relinquishment credit
Additional storage	Eastside reuse	Connect southside to NI-25
Additional large-scale ASR	Indirect potable reuse	Stormwater

	Supplies Used to Meet Demand												River Effects Accounting Summary			Wastewater Accounting Summary				
Year	Aquifer Pumping (1)	DWP River Supply (2)	WW Reuse** (3)	Non-potable Projects (4)	ASR (5)	Interbasin Transfer Delivered (6)	Brackish GW (7)	New Reservoir (8)	Stormwater (9)	GW in Excess of Permit (10)	**Total (11)**	Year	OSE River Effects (12)	Native Rights Used to Offset River Effects (13)	SJC Used for Offset (14)	WW Used for Offset (15)	Return to WWTP (16)	WW to ASR or New Reservoir (17)	DWP River Return (18)	**Available Return Flow (19)**
2016	26,114	71,865	1,366	2,300	375	0	0	0	0	0	**102,019**	2016	61,193	26,444	16,616	18,258	55,557	0	35,932	**0**
2017	19,205	78,989	1,362	2,300	458	0	0	0	0	0	**102,315**	2017	57,716	26,372	16,444	14,861	55,718	0	39,495	**0**
2018	16,897	79,234	1,362	2,300	3,068	0	0	0	0	0	**102,861**	2018	54,349	26,372	12,904	15,036	56,015	0	39,617	**0**
2019	14,595	79,428	1,362	2,300	5,694	0	0	0	0	0	**103,379**	2019	50,468	26,372	8,841	15,221	56,297	0	39,714	**0**
2020	15,077	79,686	1,366	2,300	5,724	0	0	0	0	0	**104,153**	2020	46,306	26,444	4,448	15,509	56,718	0	39,843	**0**
2021	12,397	79,710	1,679	2,300	8,244	0	0	0	0	0	**104,329**	2021	41,845	24,072	2,464	15,281	56,814	0	39,855	**0**
2022	11,201	82,141	1,679	2,300	7,440	0	0	0	0	0	**104,762**	2022	38,104	23,777	0	14,301	57,050	0	41,070	**0**
2023	11,201	82,327	1,679	2,300	7,658	0	0	0	0	0	**105,166**	2023	35,373	21,574	0	13,775	57,270	0	41,164	**653**
2024	11,232	78,473	1,683	2,300	12,142	0	0	0	0	0	**105,831**	2024	33,275	21,639	0	11,704	57,632	0	39,237	**5,008**
2025	34,453	58,971	1,679	2,300	8,259	0	0	0	0	0	**105,661**	2025	37,304	21,574	0	15,705	57,540	0	29,485	**10,671**
2026	41,291	51,828	1,999	2,300	8,339	0	0	0	0	0	**105,756**	2026	40,137	21,574	0	18,536	57,592	0	25,914	**11,143**
2027	11,201	80,914	1,999	2,300	9,414	0	0	0	0	0	**105,828**	2027	33,981	21,574	0	12,384	57,631	0	40,457	**2,791**
2028	11,232	82,654	2,004	2,300	7,976	0	0	0	0	0	**106,166**	2028	31,128	21,639	0	9,553	57,815	0	41,327	**4,931**
2029	11,201	82,564	1,999	2,300	7,837	0	0	0	0	0	**105,900**	2029	29,258	21,574	0	7,665	57,670	0	41,282	**6,725**
2030	11,201	80,613	5,996	0	8,152	0	0	0	0	0	**105,962**	2030	27,983	23,874	0	4,091	57,670	0	40,306	**7,277**
2031	16,061	69,880	5,996	0	14,064	0	0	0	0	0	**106,001**	2031	28,298	23,874	0	4,405	57,658	0	34,940	**12,316**
2032	38,804	48,309	6,012	0	13,180	0	0	0	0	0	**106,305**	2032	33,873	23,939	0	10,004	57,790	0	24,154	**17,619**
2033	11,201	80,578	5,996	0	8,230	0	0	0	0	0	**106,005**	2033	29,132	23,874	0	5,238	57,594	0	40,289	**6,070**
2034	11,201	75,649	5,996	0	13,125	0	0	0	0	0	**105,972**	2034	26,980	23,874	0	3,087	57,542	0	37,825	**10,634**
2035	55,868	37,050	10,965	0	2,032	0	0	0	0	0	**105,915**	2035	37,095	23,874	0	13,196	57,478	0	18,525	**14,792**
2036	24,659	59,572	11,023	0	10,869	0	0	0	0	0	**106,124**	2036	33,534	23,939	0	9,664	57,558	0	29,786	**7,086**
2037	33,295	53,312	10,965	0	9,371	0	0	0	0	0	**106,944**	2037	34,458	23,874	0	10,561	57,969	0	26,656	**9,787**
2038	34,600	53,259	10,965	0	9,231	0	0	0	0	0	**108,055**	2038	35,101	23,874	0	11,204	58,538	0	26,629	**9,740**
2039	76,592	17,173	10,965	0	4,438	0	0	0	0	0	**109,168**	2039	44,918	23,874	0	21,013	59,106	0	8,586	**18,542**
2040	22,912	66,349	11,023	0	9,053	0	0	0	1,247	0	**110,583**	2040	37,558	23,939	0	13,696	59,839	0	33,175	**1,946**
2041	11,510	77,320	10,965	0	10,101	0	0	0	1,500	0	**111,396**	2041	31,633	23,874	0	7,738	60,244	0	38,660	**2,880**
2042	39,411	51,517	10,965	0	9,119	0	0	0	1,500	0	**112,512**	2042	35,473	23,874	0	11,575	60,812	0	25,759	**12,514**
2043	15,450	76,755	10,965	0	9,078	0	0	0	1,382	0	**113,630**	2043	30,881	23,874	0	6,987	61,381	0	38,377	**5,052**
2044	16,560	76,073	11,023	0	9,907	0	0	0	1,500	0	**115,062**	2044	29,104	23,939	0	5,224	62,119	0	38,037	**7,835**
2045	23,962	63,354	17,933	0	9,119	0	0	0	1,500	0	**115,868**	2045	29,842	23,874	0	5,948	62,518	0	31,677	**6,960**
2046	34,818	53,619	17,933	0	9,119	0	0	0	1,500	0	**116,989**	2046	32,589	23,874	0	8,693	63,086	0	26,809	**9,651**
2047	54,196	35,364	17,933	0	9,119	0	0	0	1,500	0	**118,111**	2047	38,310	23,874	0	14,410	63,655	0	17,682	**13,630**
2048	14,179	76,757	18,037	0	9,136	0	0	0	1,452	0	**119,561**	2048	31,410	23,939	0	7,535	64,400	0	38,378	**449**
2049	14,255	77,242	17,933	0	9,477	0	0	0	1,452	0	**120,359**	2049	28,547	23,874	0	4,654	64,792	3,585	38,621	**0**
2050	15,916	73,049	17,933	0	11,243	0	0	1,775	1,500	0	**121,415**	2050	27,337	23,874	0	3,444	65,361	4,000	36,524	**3,459**
2051	27,608	62,331	17,933	0	11,119	0	0	1,980	1,500	0	**122,471**	2051	29,387	23,874	0	5,494	65,929	4,000	31,166	**7,337**
2052	12,832	78,471	18,037	0	11,094	0	0	1,980	1,452	0	**123,866**	2052	26,395	23,939	0	2,510	66,680	4,000	39,235	**2,898**
2053	22,136	69,869	17,933	0	11,165	0	0	1,981	1,500	0	**124,584**	2053	27,347	23,874	0	3,455	67,067	4,000	34,934	**6,745**
2054	25,236	67,920	17,933	0	11,070	0	0	1,981	1,500	0	**125,640**	2054	28,310	23,874	0	4,417	67,635	8,000	33,960	**3,326**
2055	37,068	47,328	23,929	0	12,963	0	0	3,956	1,452	0	**126,696**	2055	31,570	23,874	0	7,675	68,204	8,000	23,664	**4,936**
2056	11,232	75,648	24,049	0	11,765	0	0	3,956	1,452	0	**128,102**	2056	26,637	23,939	0	2,752	68,961	4,335	37,824	**0**
2057	16,794	71,431	23,929	0	13,057	0	0	2,146	1,452	0	**128,809**	2057	25,910	23,874	0	2,018	69,341	7,679	35,715	**0**
2058	21,458	66,343	23,929	0	12,882	0	0	3,798	1,455	0	**129,865**	2058	26,486	23,874	0	2,594	69,910	8,000	33,172	**2,215**
2059	27,038	61,524	23,929	0	12,974	0	0	3,957	1,500	0	**130,921**	2059	27,957	23,874	0	4,064	70,478	8,000	30,762	**3,724**
2060	65,494	22,328	26,053	0	13,074	0	0	3,968	1,500	0	**132,418**	2060	37,505	23,939	0	13,643	71,241	8,000	11,164	**12,381**
2061	75,678	21,173	25,916	0	4,949	0	0	3,976	1,500	0	**133,192**	2061	43,125	23,874	0	19,222	71,615	8,000	10,586	**7,030**
2062	34,261	56,041	25,916	0	12,649	0	0	3,962	1,500	0	**134,329**	2062	38,418	23,874	0	14,519	72,184	3,728	28,020	**0**
2063	17,496	78,138	25,916	0	10,569	0	0	1,848	1,500	0	**135,468**	2063	32,751	24,962	0	7,767	72,752	0	39,069	**0**
2064	22,059	78,675	26,053	0	8,694	0	0	0	1,500	0	**136,982**	2064	30,894	23,939	0	7,018	73,522	1,113	39,338	**0**
2065	21,502	79,177	25,916	0	9,101	0	0	552	1,500	0	**137,749**	2065	29,501	23,874	0	5,607	73,890	2,777	39,589	**0**

Table 6.C1 Portfolio 1 Page 2 of 2

	Supplies Used to Meet Demand											River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	20,603	79,609	25,916	0	9,885	0	0	1,377	1,500	0	**138,891**	2066	28,374	23,874	0	4,481	74,458	4,256	39,805	**0**
2067	25,419	74,577	25,916	0	10,513	0	0	2,109	1,500	0	**140,035**	2067	28,792	23,874	0	4,899	75,027	6,923	37,289	**0**
2068	18,254	80,453	26,053	0	11,877	0	0	3,428	1,500	0	**141,566**	2068	27,061	23,939	0	3,178	75,802	6,345	40,226	**0**
2069	19,453	80,876	25,916	0	11,438	0	0	3,143	1,500	0	**142,326**	2069	26,501	23,874	0	2,609	76,164	7,200	40,438	**0**
2070	19,374	81,298	25,916	0	11,818	0	0	3,566	1,500	0	**143,473**	2070	25,986	23,874	0	2,095	76,733	8,000	40,649	**72**
2071	19,422	81,674	25,916	0	12,148	0	0	3,961	1,500	0	**144,622**	2071	25,589	23,874	0	1,698	77,301	8,000	40,837	**850**
2072	31,660	70,984	26,053	0	12,011	0	0	3,963	1,500	0	**146,171**	2072	28,269	23,939	0	4,388	78,083	8,000	35,492	**4,150**
2073	59,831	43,969	25,916	0	11,735	0	0	3,971	1,500	0	**146,922**	2073	35,437	23,874	0	11,539	78,438	8,000	21,985	**10,331**
2074	68,031	42,417	25,916	0	6,234	0	0	3,977	1,500	0	**148,075**	2074	40,378	23,874	0	16,477	79,007	8,000	21,208	**7,405**
2075	34,882	71,183	25,916	0	11,785	0	0	3,963	1,500	0	**149,229**	2075	36,672	23,874	0	12,774	79,575	5,294	35,591	**0**
2076	42,512	67,729	26,053	0	10,377	0	0	2,624	1,500	0	**150,795**	2076	36,914	23,939	0	13,051	80,364	7,395	33,865	**0**
2077	25,409	83,648	25,916	0	11,401	0	0	3,665	1,500	0	**151,540**	2077	33,287	23,874	0	9,391	80,713	3,581	41,824	**0**
2078	30,077	83,978	25,916	0	9,448	0	0	1,777	1,500	0	**152,697**	2078	32,599	23,874	0	8,703	81,281	4,672	41,989	**0**
2079	29,891	84,309	25,916	0	9,923	0	0	2,317	1,500	0	**153,856**	2079	32,021	23,874	0	8,125	81,850	5,654	42,154	**0**
2080	29,981	84,610	26,053	0	10,402	0	0	2,803	1,500	0	**155,349**	2080	31,614	23,939	0	7,740	82,644	6,546	42,305	**0**
2081	29,700	84,911	25,916	0	10,721	0	0	3,245	1,500	0	**155,993**	2081	31,285	23,874	0	7,390	82,987	7,225	42,456	**0**
2082	38,292	76,733	25,916	0	11,039	0	0	3,581	1,500	0	**157,062**	2082	32,996	23,874	0	9,099	83,555	8,000	38,367	**2,173**
2083	48,236	67,274	25,916	0	11,239	0	0	3,965	1,500	0	**158,131**	2083	35,792	23,874	0	11,894	84,124	8,000	33,637	**4,676**
2084	55,868	60,784	26,053	0	11,465	0	0	3,965	1,500	0	**159,636**	2084	38,571	23,939	0	14,711	84,925	8,000	30,392	**5,768**
2085	56,585	60,895	25,916	0	11,406	0	0	3,965	1,500	0	**160,268**	2085	40,187	23,874	0	16,286	85,261	8,000	30,448	**4,611**
2086	64,242	54,433	25,916	0	11,280	0	0	3,965	1,500	0	**161,337**	2086	42,505	23,874	0	18,602	85,830	8,000	27,217	**6,094**
2087	108,042	18,136	25,916	0	4,833	0	0	3,978	1,500	0	**162,406**	2087	49,674	23,874	0	25,766	86,398	8,000	9,068	**17,648**
2088	53,615	67,450	26,053	0	11,339	0	0	3,965	1,500	0	**163,923**	2088	46,106	23,939	0	22,261	87,205	5,165	33,725	**0**
2089	49,996	74,580	25,916	0	9,989	0	0	2,562	1,500	0	**164,544**	2089	45,046	23,874	0	21,142	87,536	3,187	37,290	**0**
2090	82,090	45,549	25,916	0	8,975	0	0	1,582	1,500	0	**165,612**	2090	48,849	23,874	0	24,942	88,104	8,000	22,775	**6,471**
2091	50,163	73,828	25,916	0	11,308	0	0	3,966	1,500	0	**166,681**	2091	46,308	23,874	0	22,403	88,673	3,439	36,914	**0**
2092	48,676	81,291	26,053	0	8,982	0	0	1,707	1,500	0	**168,209**	2092	45,425	23,939	0	21,580	89,486	1,208	40,645	**0**
2093	61,525	71,513	25,916	0	7,764	0	0	599	1,500	0	**168,819**	2093	46,645	23,874	0	22,740	89,810	5,397	35,757	**0**
2094	74,324	55,683	25,916	0	9,785	0	0	2,678	1,500	0	**169,887**	2094	48,781	23,874	0	24,874	90,378	8,000	27,842	**3,746**
2095	90,204	38,356	25,916	0	11,013	0	0	3,966	1,500	0	**170,956**	2095	51,766	23,874	0	27,857	90,947	8,000	19,178	**9,995**
2096	69,616	60,555	26,053	0	10,801	0	0	3,971	1,500	0	**172,496**	2096	50,876	23,939	0	27,041	91,766	8,000	30,278	**394**
2097	47,998	82,847	25,916	0	10,866	0	0	3,967	1,500	0	**173,094**	2097	48,442	23,874	0	24,535	92,084	209	41,423	**0**
2098	55,253	84,492	25,916	0	6,897	0	0	104	1,500	0	**174,163**	2098	48,480	23,957	0	24,490	92,653	0	42,246	**0**
2099	81,566	59,614	25,916	0	6,635	0	0	0	1,500	0	**175,231**	2099	51,496	23,874	0	27,587	93,221	8,000	29,807	**1,911**
2100	69,097	65,500	25,943	0	10,447	0	0	3,967	1,500	0	**176,453**	2100	51,205	23,874	0	27,437	93,788	7,659	32,750	**0**
2101	63,940	71,812	25,916	0	10,401	0	0	3,798	1,500	0	**177,369**	2101	51,039	23,874	0	27,130	94,359	5,406	35,906	**0**
2102	64,392	74,745	25,916	0	9,201	0	0	2,683	1,500	0	**178,438**	2102	51,260	23,874	0	27,351	94,927	4,287	37,373	**0**
2103	88,932	52,462	25,916	0	8,568	0	0	2,128	1,500	0	**179,507**	2103	54,051	23,874	0	30,140	95,496	8,000	26,231	**5,208**
2104	69,140	70,197	26,053	0	10,210	0	0	3,969	1,500	0	**181,070**	2104	52,920	23,939	0	29,090	96,327	6,085	35,099	**0**
2105	64,576	77,354	25,916	0	9,278	0	0	3,020	1,500	0	**181,644**	2105	52,248	23,874	0	28,339	96,633	3,700	38,677	**0**
2106	89,982	56,198	25,916	0	7,278	0	0	1,839	1,500	0	**182,713**	2106	55,134	23,874	0	31,223	97,201	8,000	28,099	**3,963**
2107	83,403	58,990	25,916	0	10,004	0	0	3,968	1,500	0	**183,782**	2107	55,952	23,874	0	32,040	97,770	8,000	29,495	**2,319**
2108	121,238	23,020	26,053	0	9,569	0	0	3,976	1,500	0	**185,357**	2108	60,302	23,939	0	36,487	98,608	8,000	11,510	**16,558**
2109	125,115	25,280	25,916	0	4,126	0	0	3,982	1,500	0	**185,919**	2109	62,881	23,874	0	38,964	98,907	8,000	12,640	**13,387**
2110	84,724	61,261	25,916	0	9,615	0	0	3,971	1,500	0	**186,988**	2110	60,338	23,874	0	36,423	99,476	5,609	30,631	**0**
2111	57,119	92,291	25,916	0	8,446	0	0	2,784	1,500	0	**188,057**	2111	57,446	26,372	3,053	27,982	100,044	0	46,145	**0**
2112	63,781	92,522	26,053	0	5,787	0	0	0	1,500	0	**189,644**	2112	57,166	26,444	2,265	28,574	100,889	0	46,261	**0**
2113	81,061	78,400	25,916	0	3,327	0	0	0	1,490	0	**190,194**	2113	58,674	23,874	0	34,760	101,182	1,315	39,200	**0**
2114	82,080	75,395	25,916	0	5,717	0	0	653	1,500	0	**191,263**	2114	59,247	23,874	0	35,333	101,750	2,803	37,698	**0**
2115	84,979	72,100	25,916	0	6,446	0	0	1,391	1,500	0	**192,332**	2115	59,885	23,874	0	35,971	102,319	4,382	36,050	**0**
2116	69,625	86,942	26,053	0	7,636	0	0	2,175	1,500	0	**193,931**	2116	58,725	25,200	0	33,645	103,169	0	43,471	**0**
2117	68,433	93,524	25,916	0	5,096	0	0	0	1,500	0	**194,470**	2117	58,354	26,372	1,165	30,777	103,456	0	46,762	**0**
2118	69,711	93,697	25,916	0	4,714	0	0	0	1,500	0	**195,538**	2118	58,307	26,372	636	31,259	104,024	0	46,848	**0**
2119	86,779	80,299	25,916	0	2,131	0	0	0	1,482	0	**196,607**	2119	59,988	23,874	0	36,073	104,593	2,472	40,149	**0**
2120	102,397	60,854	26,053	0	6,183	0	0	1,230	1,500	0	**198,217**	2120	62,179	23,939	0	38,367	105,450	8,000	30,427	**2,602**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Table 6.C2 Portfolio 2 Page 1 of 2

Summary of Hydrologic Water Balance

Water balance summaries by type.

All units are in acre-feet (AF) unless otherwise noted.

PORTFOLIO 2

Model Settings*

Medium Demand, Medium Supply

Conservation (120 gpcd in 10 yrs)	Westside reuse	Rio Grande Compact relinquishment credit
Additional storage	Eastside reuse	Connect southside to NI-25
Additional large-scale ASR	Indirect potable reuse	Stormwater, Brackish water, Interbasin transfer

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	**(11)**		(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2016	26,114	71,865	1,366	2,300	375	0	0	0	0	0	**102,019**	2016	61,193	26,444	16,616	18,258	55,557	0	35,932	**0**
2017	19,102	78,901	1,362	2,300	458	0	0	0	0	0	**102,124**	2017	57,702	26,372	16,490	14,801	55,613	0	39,450	**0**
2018	16,654	79,062	1,362	2,300	3,095	0	0	0	0	0	**102,473**	2018	54,305	26,372	12,985	14,910	55,803	0	39,531	**0**
2019	14,225	79,207	1,362	2,300	5,694	0	0	0	0	0	**102,788**	2019	50,369	26,372	8,953	15,010	55,975	0	39,603	**0**
2020	16,213	78,131	1,366	1,960	5,681	0	0	0	0	0	**103,351**	2020	46,477	26,444	4,278	15,851	56,282	0	39,065	**0**
2021	11,744	79,331	1,679	2,300	8,263	0	0	0	0	0	**103,316**	2021	41,770	24,072	2,751	14,918	56,263	0	39,665	**0**
2022	11,201	81,572	1,679	2,300	6,777	0	0	0	0	0	**103,529**	2022	38,076	24,072	64	13,914	56,379	0	40,786	**0**
2023	11,201	76,782	1,679	2,300	11,746	0	0	0	0	0	**103,708**	2023	35,357	21,574	0	13,759	56,476	0	38,391	**2,280**
2024	14,192	77,715	1,683	2,300	8,248	0	0	0	0	0	**104,138**	2024	33,992	21,639	0	12,423	56,710	0	38,857	**3,747**
2025	34,685	58,703	1,679	2,300	6,373	0	0	0	0	0	**103,740**	2025	37,677	21,574	0	16,078	56,493	0	29,351	**9,385**
2026	39,472	51,262	1,999	2,300	8,565	0	0	0	0	0	**103,598**	2026	39,911	21,574	0	18,310	56,416	0	25,631	**10,476**
2027	15,335	75,450	1,999	2,300	9,654	0	0	0	0	0	**104,737**	2027	34,939	21,574	0	13,342	57,036	0	37,725	**3,971**
2028	11,232	81,671	2,004	2,300	8,959	0	0	0	0	0	**106,166**	2028	31,598	21,639	0	10,024	57,815	0	40,836	**4,951**
2029	11,201	83,078	1,999	2,300	8,437	0	0	0	0	0	**107,015**	2029	29,547	21,574	0	7,953	58,277	0	41,539	**6,786**
2030	11,201	80,698	5,996	0	10,321	0	0	0	0	0	**108,217**	2030	28,180	23,874	0	4,287	58,897	0	40,349	**8,265**
2031	18,120	70,416	5,996	0	14,888	0	0	0	0	0	**109,420**	2031	28,993	23,874	0	5,100	59,518	0	35,208	**13,214**
2032	52,820	45,829	6,012	0	6,266	0	0	0	0	0	**110,927**	2032	37,652	23,939	0	13,790	60,303	0	22,914	**17,586**
2033	11,286	84,501	5,996	0	10,047	0	0	0	0	0	**111,830**	2033	31,018	23,874	0	7,124	60,758	0	42,250	**5,388**
2034	24,918	72,277	5,996	0	9,846	0	0	0	0	0	**113,037**	2034	31,725	23,874	0	7,830	61,378	0	36,139	**11,414**
2035	62,710	39,303	10,965	0	1,267	0	0	0	0	0	**114,245**	2035	40,491	23,874	0	16,589	61,999	0	19,652	**13,903**
2036	30,783	64,093	11,023	0	9,873	0	0	0	0	0	**115,771**	2036	37,081	23,939	0	13,218	62,790	0	32,047	**6,503**
2037	39,025	57,557	10,965	0	9,119	0	0	0	0	0	**116,666**	2037	37,932	23,874	0	14,032	63,239	0	28,778	**9,463**
2038	58,833	39,130	10,965	0	8,950	0	0	0	0	0	**117,878**	2038	42,846	23,874	0	18,943	63,859	0	19,565	**14,386**
2039	86,232	17,727	10,965	0	4,168	0	0	0	0	0	**119,092**	2039	50,107	23,874	0	26,199	64,480	0	8,863	**18,452**
2040	31,598	67,511	11,023	0	9,053	0	0	0	1,452	0	**120,636**	2040	43,536	23,939	0	19,687	65,278	0	33,756	**814**
2041	19,323	80,444	10,965	0	9,291	0	0	0	1,500	0	**121,523**	2041	37,604	23,874	0	13,705	65,720	0	40,222	**829**
2042	46,581	54,575	10,965	0	9,119	0	0	0	1,500	0	**122,741**	2042	40,841	23,874	0	16,939	66,341	0	27,288	**11,149**
2043	21,922	80,472	10,965	0	9,101	0	0	0	1,500	0	**123,960**	2043	36,100	23,874	0	12,201	66,961	0	40,236	**3,558**
2044	24,776	79,140	11,023	0	9,084	0	0	0	1,500	0	**125,523**	2044	34,565	23,939	0	10,697	67,766	4,000	39,570	**2,476**
2045	25,455	71,573	14,962	0	10,930	0	0	1,981	1,500	0	**126,401**	2045	33,722	23,874	0	9,825	68,201	4,000	35,787	**3,627**
2046	36,465	61,683	14,962	0	11,033	0	0	1,981	1,500	0	**127,624**	2046	35,762	23,874	0	11,864	68,822	4,000	30,841	**7,154**
2047	56,280	43,167	14,962	0	10,958	0	0	1,982	1,500	0	**128,848**	2047	41,072	23,874	0	17,170	69,442	4,000	21,583	**11,726**
2048	36,692	64,402	15,031	0	10,824	0	0	1,982	1,500	0	**130,430**	2048	38,598	23,939	0	14,738	70,254	4,000	32,201	**3,408**
2049	16,622	85,448	14,962	0	10,786	0	0	1,982	1,500	0	**131,301**	2049	33,404	23,874	0	9,507	70,682	3,489	42,724	**0**
2050	25,075	70,541	24,901	0	8,707	0	0	1,730	1,500	0	**132,453**	2050	32,941	23,874	0	9,044	71,303	2,087	35,270	**0**
2051	38,357	59,877	24,901	0	7,935	0	0	1,036	1,500	0	**133,605**	2051	35,580	23,874	0	11,682	71,923	5,000	29,938	**402**
2052	20,649	76,070	25,051	0	9,378	0	0	2,478	1,500	0	**135,127**	2052	32,308	23,939	0	8,436	72,742	1,220	38,035	**0**
2053	34,046	67,521	24,901	0	7,336	0	0	606	1,500	0	**135,910**	2053	34,121	23,874	0	10,224	73,164	4,278	33,761	**0**
2054	34,099	65,626	24,901	0	8,816	0	0	2,121	1,500	0	**137,062**	2054	34,723	23,874	0	10,826	73,784	5,000	32,813	**244**
2055	53,338	46,891	24,901	0	9,105	0	0	2,478	1,500	0	**138,214**	2055	39,441	23,874	0	15,540	74,404	5,000	23,446	**5,518**
2056	24,100	77,526	25,051	0	9,092	0	0	2,478	1,500	0	**139,748**	2056	34,849	23,939	0	10,982	75,230	434	38,763	**0**
2057	34,221	73,024	24,901	0	6,657	0	0	216	1,500	0	**140,518**	2057	35,384	23,874	0	11,486	75,645	2,745	36,512	**0**
2058	27,853	78,291	24,901	0	7,764	0	0	1,362	1,500	0	**141,671**	2058	33,916	23,874	0	10,019	76,265	2,199	39,145	**0**
2059	40,320	67,592	24,901	0	7,419	0	0	1,092	1,500	0	**142,823**	2059	36,156	23,874	0	12,258	76,885	5,931	33,796	**0**
2060	67,282	34,403	29,060	0	9,272	0	0	2,939	1,500	0	**144,456**	2060	42,755	23,939	0	18,904	77,718	9,000	17,201	**3,553**
2061	83,199	21,776	28,898	0	5,456	0	0	4,472	1,500	0	**145,300**	2061	48,186	23,874	0	24,280	78,126	9,000	10,888	**5,060**
2062	38,564	62,493	28,898	0	10,628	0	0	4,457	1,500	0	**146,541**	2062	43,662	25,031	0	18,601	78,746	0	31,247	**0**
2063	31,885	79,321	28,898	0	6,179	0	0	0	1,500	0	**147,783**	2063	40,410	26,372	3,203	10,808	79,366	0	39,661	**0**
2064	33,051	79,663	29,060	0	6,161	0	0	0	1,500	0	**149,435**	2064	38,744	26,444	1,065	11,315	80,206	0	39,831	**0**
2065	33,799	80,071	28,898	0	6,003	0	0	0	1,500	0	**150,271**	2065	37,804	26,104	0	11,673	80,607	0	40,035	**0**

Table 6.C2 Portfolio 2 Page 2 of 2

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	34,722	80,446	28,898	0	5,951	0	0	0	1,500	0	**151,517**	2066	37,327	25,195	0	12,106	81,227	0	40,223	**0**
2067	43,804	72,771	28,898	0	5,792	0	0	0	1,500	0	**152,765**	2067	38,907	23,874	0	15,007	81,847	1,557	36,385	**0**
2068	35,299	81,167	29,060	0	6,636	0	0	773	1,500	0	**154,436**	2068	37,675	24,702	0	13,050	82,694	0	40,584	**0**
2069	37,595	81,572	28,898	0	5,699	0	0	0	1,500	0	**155,264**	2069	37,694	24,264	0	13,404	83,088	0	40,786	**0**
2070	28,546	81,882	28,898	0	5,690	0	0	0	1,500	0	**156,516**	2070	35,542	23,874	0	11,644	83,708	2,225	40,941	**0**
2071	27,335	82,182	28,898	0	6,749	0	0	1,104	1,500	0	**157,769**	2071	34,176	23,874	0	10,279	84,328	4,061	41,091	**0**
2072	26,729	82,431	29,060	0	7,726	0	0	2,013	1,500	0	**159,459**	2072	33,207	23,939	0	9,336	85,181	5,570	41,216	**0**
2073	57,275	51,645	28,898	0	8,170	0	0	2,761	1,500	0	**160,250**	2073	39,233	23,874	0	15,332	85,569	9,000	25,823	**6,516**
2074	66,884	42,859	28,898	0	6,924	0	0	4,471	1,500	0	**161,536**	2074	43,385	23,874	0	19,482	86,189	9,000	21,430	**7,380**
2075	32,755	75,132	28,898	0	10,053	0	0	4,456	1,500	0	**162,795**	2075	39,343	23,874	0	15,442	86,810	4,904	37,566	**0**
2076	42,016	71,434	29,060	0	8,064	0	0	2,431	1,500	0	**164,504**	2076	39,560	23,939	0	15,702	87,669	7,191	35,717	**0**
2077	28,139	83,983	28,898	0	9,232	0	0	3,563	1,500	0	**165,316**	2077	36,620	23,874	0	12,721	88,050	4,439	41,992	**0**
2078	31,839	84,284	28,898	0	7,856	0	0	2,201	1,500	0	**166,579**	2078	35,934	23,874	0	12,036	88,670	5,594	42,142	**0**
2079	31,652	84,585	28,898	0	8,434	0	0	2,773	1,500	0	**167,843**	2079	35,320	23,874	0	11,422	89,291	6,678	42,292	**0**
2080	31,734	84,833	29,060	0	9,035	0	0	3,310	1,500	0	**169,472**	2080	34,860	23,939	0	10,993	90,157	7,688	42,417	**0**
2081	31,315	85,170	28,898	0	9,481	0	0	3,810	1,500	0	**170,174**	2081	34,444	23,874	0	10,547	90,531	8,501	42,585	**0**
2082	38,036	77,038	28,898	0	11,657	0	0	4,211	1,500	0	**171,340**	2082	35,594	23,874	0	11,696	91,151	9,000	38,519	**3,038**
2083	39,704	76,082	28,898	0	11,864	0	0	4,458	1,500	0	**172,506**	2083	36,363	23,874	0	12,465	91,772	9,000	38,041	**3,368**
2084	56,047	61,119	29,060	0	11,965	0	0	4,458	1,500	0	**174,148**	2084	39,891	23,939	0	16,034	92,645	9,000	30,559	**7,993**
2085	56,808	61,267	28,898	0	11,906	0	0	4,459	1,500	0	**174,838**	2085	41,665	23,874	0	17,763	93,012	9,000	30,634	**6,718**
2086	65,323	54,043	28,898	0	11,780	0	0	4,459	1,500	0	**176,004**	2086	44,096	23,874	0	20,192	93,633	9,000	27,022	**8,520**
2087	108,763	18,267	28,898	0	5,270	0	0	4,472	1,500	0	**177,170**	2087	51,154	23,874	0	27,245	94,253	9,000	9,134	**19,976**
2088	54,335	67,801	29,060	0	11,670	0	0	4,460	1,500	0	**178,825**	2088	47,616	23,939	0	23,774	95,133	8,399	33,900	**0**
2089	48,512	75,042	28,898	0	11,388	0	0	4,163	1,500	0	**179,502**	2089	46,296	23,874	0	22,391	95,493	6,683	37,521	**0**
2090	80,473	46,033	28,898	0	10,450	0	0	3,313	1,500	0	**180,668**	2090	49,926	23,874	0	26,018	96,114	9,000	23,017	**9,180**
2091	51,113	74,334	28,898	0	11,528	0	0	4,460	1,500	0	**181,834**	2091	47,637	23,874	0	23,731	96,734	6,938	37,167	**0**
2092	47,255	81,804	29,060	0	10,443	0	0	3,439	1,500	0	**183,501**	2092	46,521	23,939	0	22,678	97,621	4,981	40,902	**0**
2093	59,874	72,064	28,898	0	9,358	0	0	2,471	1,500	0	**184,166**	2093	47,635	23,874	0	23,729	97,974	9,000	36,032	**315**
2094	72,929	56,257	28,898	0	11,287	0	0	4,461	1,500	0	**185,332**	2094	49,674	23,874	0	25,766	98,595	9,000	28,128	**6,802**
2095	91,481	38,951	28,898	0	11,207	0	0	4,461	1,500	0	**186,498**	2095	52,886	23,874	0	28,976	99,215	9,000	19,476	**12,865**
2096	70,805	61,363	29,060	0	10,985	0	0	4,465	1,500	0	**188,178**	2096	52,060	23,939	0	28,227	100,109	9,000	30,682	**3,140**
2097	49,437	83,487	28,898	0	11,047	0	0	4,461	1,500	0	**188,830**	2097	49,736	23,874	0	25,829	100,455	3,985	41,743	**0**
2098	54,005	85,155	28,898	0	8,459	0	0	1,978	1,500	0	**189,996**	2098	49,503	23,874	0	25,596	101,076	4,004	42,577	**0**
2099	80,036	60,435	28,898	0	8,305	0	0	1,988	1,500	0	**191,161**	2099	52,353	23,874	0	28,443	101,696	9,000	30,218	**5,137**
2100	65,811	66,194	28,924	0	10,604	0	5,000	4,460	1,500	0	**192,495**	2100	51,755	23,874	0	27,988	102,315	9,000	33,097	**3,305**
2101	60,367	72,542	28,898	0	10,725	0	5,000	4,460	1,500	0	**193,493**	2101	51,378	23,874	0	27,470	102,937	9,000	36,271	**1,298**
2102	58,658	75,497	28,898	0	10,645	0	5,000	4,460	1,500	0	**194,659**	2102	51,202	23,874	0	27,294	103,557	9,000	37,749	**616**
2103	82,165	53,237	28,898	0	10,565	0	5,000	4,460	1,500	0	**195,825**	2103	53,655	23,874	0	29,745	104,177	9,000	26,618	**9,916**
2104	66,304	70,865	29,060	0	10,341	0	5,000	4,461	1,500	0	**197,531**	2104	52,731	23,939	0	28,900	105,085	9,000	35,433	**2,692**
2105	59,786	78,201	28,898	0	10,311	0	5,000	4,461	1,500	0	**198,157**	2105	51,806	23,874	0	27,897	105,418	9,000	39,101	**522**
2106	83,207	56,436	28,898	0	9,814	0	5,000	4,469	1,500	0	**199,323**	2106	54,407	23,874	0	30,496	106,038	9,000	28,218	**9,426**
2107	80,586	60,103	28,898	0	9,941	0	5,000	4,461	1,500	0	**200,489**	2107	55,457	23,874	0	31,545	106,658	9,000	30,052	**7,163**
2108	119,212	22,896	29,060	0	10,069	0	5,000	4,470	1,500	0	**202,207**	2108	59,933	23,939	0	36,117	107,572	9,000	11,448	**21,947**
2109	122,906	25,416	28,898	0	4,626	0	5,000	4,474	1,500	0	**202,821**	2109	62,502	23,874	0	38,585	107,899	9,000	12,708	**18,707**
2110	82,242	62,267	28,898	0	9,613	0	5,000	4,467	1,500	0	**203,987**	2110	59,962	23,874	0	36,047	108,519	9,000	31,134	**2,544**
2111	52,556	93,030	28,898	0	9,708	0	5,000	4,461	1,500	0	**205,153**	2111	56,822	23,874	0	32,910	109,139	817	46,515	**0**
2112	61,816	93,153	29,060	0	5,950	0	5,000	405	1,500	0	**206,884**	2112	56,730	23,939	0	32,907	110,060	1,517	46,576	**0**
2113	63,139	92,804	28,898	0	5,391	0	5,000	753	1,500	0	**207,485**	2113	56,585	23,874	0	32,672	110,380	2,408	46,402	**0**
2114	79,550	76,494	28,898	0	6,013	0	5,000	1,195	1,500	0	**208,651**	2114	58,126	23,874	0	34,213	111,000	9,000	38,247	**642**
2115	78,044	72,623	28,898	0	9,289	0	5,000	4,463	1,500	0	**209,817**	2115	58,501	23,874	0	34,588	111,620	9,000	36,311	**2,823**
2116	64,396	87,438	29,060	0	9,706	0	5,000	4,462	1,500	0	**211,561**	2116	57,350	23,939	0	33,529	112,548	6,241	43,719	**0**
2117	61,546	94,159	28,898	0	7,950	0	5,000	3,096	1,500	0	**212,149**	2117	56,723	23,874	0	32,811	112,861	4,073	47,079	**0**
2118	65,433	94,347	28,898	0	6,115	0	5,000	2,022	1,500	0	**213,314**	2118	56,813	23,874	0	32,900	113,481	4,510	47,173	**0**
2119	70,289	90,491	28,898	0	6,063	0	5,000	2,239	1,500	0	**214,480**	2119	57,310	23,874	0	33,397	114,101	6,560	45,246	**0**
2120	97,789	61,520	29,060	0	8,107	0	5,000	3,261	1,500	0	**216,237**	2120	60,331	23,939	0	36,516	115,036	9,000	30,760	**9,700**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Table 6.C3 Portfolio 3 Page 1 of 2

Summary of Hydrologic Water Balance

Water balance summaries by type.

All units are in acre-feet (AF) unless otherwise noted.

PORTFOLIO 3

Model Settings*

Medium Demand, Medium Supply

Conservation (outdoor only)
Additional storage
Additional large-scale ASR
Westside reuse
Eastside reuse
Indirect potable reuse
Rio Grande Compact relinquishment credit
Connect southside to NI-25
Stormwater, Brackish water

	Supplies Used to Meet Demand											River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping (1)	DWP River Supply (2)	WW Reuse** (3)	Non-potable Projects (4)	ASR (5)	Interbasin Transfer Delivered (6)	Brackish GW (7)	New Reservoir (8)	Stormwater (9)	GW in Excess of Permit (10)	**Total (11)**	Year	OSE River Effects (12)	Native Rights Used to Offset River Effects (13)	SJC Used for Offset (14)	WW Used for Offset (15)	Return to WWTP (16)	WW to ASR or New Reservoir (17)	DWP River Return (18)	**Available Return Flow (19)**
2016	26,114	71,865	1,366	2,300	375	0	0	0	0	0	**102,019**	2016	61,193	26,444	16,616	18,258	55,557	0	35,932	**0**
2017	19,556	79,325	1,362	2,300	458	0	0	0	0	0	**103,001**	2017	57,765	26,372	16,140	15,214	56,238	0	39,662	**0**
2018	17,691	79,833	1,362	2,300	3,068	0	0	0	0	0	**104,254**	2018	54,495	26,372	12,293	15,793	57,072	0	39,916	**0**
2019	15,832	80,339	1,362	2,300	5,665	0	0	0	0	0	**105,498**	2019	50,788	26,372	8,007	16,374	57,905	0	40,169	**0**
2020	17,371	80,778	1,366	1,960	5,552	0	0	0	0	0	**107,027**	2020	47,000	26,444	3,508	17,145	58,900	0	40,389	**0**
2021	14,786	81,272	1,679	2,300	7,927	0	0	0	0	0	**107,963**	2021	42,812	24,072	1,453	17,258	59,572	0	40,636	**0**
2022	11,201	84,313	1,679	2,300	9,690	0	0	0	0	0	**109,183**	2022	38,668	22,072	0	16,570	60,406	0	42,156	**0**
2023	17,188	81,002	1,679	2,300	8,228	0	0	0	0	0	**110,396**	2023	37,188	21,574	0	15,589	61,239	0	40,501	**3,470**
2024	20,015	80,503	1,683	2,300	7,405	0	0	0	0	0	**111,906**	2024	36,340	21,639	0	14,775	62,243	0	40,251	**5,533**
2025	42,898	60,265	1,679	2,300	5,412	0	0	0	0	0	**112,553**	2025	40,881	21,574	0	19,279	62,770	0	30,132	**11,680**
2026	48,263	53,160	1,999	2,300	7,778	0	0	0	0	0	**113,500**	2026	43,662	21,574	0	22,059	63,468	0	26,580	**12,831**
2027	22,398	78,241	1,999	2,300	9,503	0	0	0	0	0	**114,440**	2027	38,850	21,574	0	17,250	64,166	0	39,120	**5,797**
2028	17,701	84,250	2,004	2,300	9,434	0	0	0	0	0	**115,689**	2028	35,519	21,639	0	13,953	65,042	0	42,125	**6,959**
2029	15,499	87,233	1,999	2,300	9,268	0	0	0	0	0	**116,299**	2029	33,064	21,574	0	11,467	65,562	1,000	43,617	**7,479**
2030	19,248	81,898	5,996	0	9,645	0	0	496	0	0	**117,284**	2030	32,460	23,874	0	8,565	66,259	1,000	40,949	**9,750**
2031	29,629	72,603	5,996	0	9,537	0	0	496	0	0	**118,262**	2031	34,353	23,874	0	10,456	66,957	1,000	36,302	**13,204**
2032	59,078	48,569	6,012	0	5,403	0	0	498	0	0	**119,561**	2032	41,558	23,939	0	17,705	67,840	1,000	24,285	**17,950**
2033	15,845	88,494	5,996	0	9,369	0	0	496	0	0	**120,200**	2033	34,769	23,874	0	10,871	68,353	1,000	44,247	**6,239**
2034	34,532	71,021	5,996	0	9,115	0	0	496	0	0	**121,160**	2034	36,542	23,874	0	12,643	69,051	1,000	35,511	**13,901**
2035	61,518	37,005	20,903	0	2,189	0	0	498	0	0	**122,113**	2035	43,342	23,874	0	19,439	69,748	1,000	18,502	**9,904**
2036	35,011	57,255	21,043	0	9,593	0	0	496	0	0	**123,398**	2036	40,226	23,939	0	16,369	70,639	1,000	28,627	**3,599**
2037	42,432	50,770	20,903	0	9,400	0	0	496	0	0	**124,001**	2037	40,897	23,874	0	16,995	71,144	1,000	25,385	**6,860**
2038	43,048	51,177	20,903	0	9,311	0	0	496	0	0	**124,936**	2038	41,278	23,874	0	17,376	71,842	1,000	25,589	**6,974**
2039	83,351	15,176	20,903	0	5,937	0	0	498	0	0	**125,864**	2039	49,634	23,874	0	25,727	72,540	1,000	7,588	**17,322**
2040	27,250	67,650	21,043	0	9,195	0	0	496	1,500	0	**127,133**	2040	42,558	24,075	0	18,570	73,438	0	33,825	**0**
2041	23,112	73,554	20,903	0	8,632	0	0	0	1,500	0	**127,701**	2041	38,245	23,874	0	14,345	73,935	1,000	36,777	**910**
2042	48,966	47,657	20,903	0	9,087	0	0	496	1,500	0	**128,610**	2042	41,896	23,874	0	17,994	74,633	1,000	23,829	**10,907**
2043	24,068	73,524	20,903	0	9,021	0	0	496	1,500	0	**129,513**	2043	37,401	23,874	0	13,502	75,331	1,000	36,762	**3,164**
2044	26,626	72,087	21,043	0	9,014	0	0	496	1,500	0	**130,766**	2044	35,961	23,939	0	12,096	76,237	7,000	36,043	**54**
2045	24,010	64,557	25,900	0	11,868	0	0	3,463	1,500	0	**131,298**	2045	34,367	23,874	0	10,469	76,727	7,000	32,279	**1,078**
2046	34,768	54,529	25,900	0	12,021	0	0	3,464	1,500	0	**132,181**	2046	36,011	23,874	0	12,113	77,424	7,000	27,265	**5,147**
2047	54,632	35,989	25,900	0	11,956	0	0	3,464	1,500	0	**133,442**	2047	41,127	23,874	0	17,225	78,122	7,000	17,995	**10,002**
2048	14,223	77,896	26,053	0	11,935	0	0	3,464	1,500	0	**135,072**	2048	33,983	23,939	0	10,114	79,036	3,920	38,948	**0**
2049	18,068	78,320	25,900	0	10,234	0	0	1,943	1,500	0	**135,966**	2049	31,784	23,874	0	7,889	79,518	6,569	39,160	**0**
2050	21,169	73,837	25,900	0	11,501	0	0	3,252	1,500	0	**137,159**	2050	31,147	23,874	0	7,252	80,216	7,000	36,918	**3,145**
2051	32,672	63,174	25,900	0	11,640	0	0	3,466	1,500	0	**138,352**	2051	33,358	23,874	0	9,461	80,913	7,000	31,587	**6,965**
2052	17,917	79,369	26,053	0	11,622	0	0	3,466	1,500	0	**139,927**	2052	30,525	23,939	0	6,649	81,835	7,000	39,684	**2,448**
2053	27,588	70,819	25,900	0	11,464	0	0	3,467	1,500	0	**140,738**	2053	31,609	23,874	0	7,713	82,309	7,000	35,410	**6,286**
2054	30,728	68,925	25,900	0	11,411	0	0	3,467	1,500	0	**141,931**	2054	32,632	23,874	0	8,736	83,007	7,000	34,463	**6,908**
2055	53,148	44,573	30,869	0	9,565	0	0	3,469	1,500	0	**143,124**	2055	38,303	23,874	0	14,404	83,705	7,000	22,287	**9,145**
2056	23,921	75,212	31,064	0	9,548	0	0	3,469	1,500	0	**144,713**	2056	34,020	23,939	0	10,151	84,634	5,813	37,606	**0**
2057	30,690	70,775	30,869	0	8,795	0	0	2,882	1,500	0	**145,511**	2057	33,972	23,874	0	10,075	85,100	7,000	35,387	**1,769**
2058	25,453	76,076	30,869	0	9,337	0	0	3,470	1,500	0	**146,704**	2058	32,524	23,874	0	8,628	85,798	7,000	38,038	**1,263**
2059	37,387	65,411	30,869	0	9,260	0	0	3,470	1,500	0	**147,897**	2059	34,661	23,874	0	10,763	86,496	12,158	32,706	**0**
2060	59,967	34,201	36,074	0	11,821	0	0	6,016	1,500	0	**149,579**	2060	40,495	23,939	0	16,639	87,433	13,000	17,100	**4,619**
2061	72,870	23,348	35,866	0	10,406	0	0	6,455	1,500	0	**150,444**	2061	45,438	23,874	0	21,533	87,891	13,000	11,674	**5,819**
2062	32,677	63,106	35,866	0	12,137	0	0	6,433	1,500	0	**151,720**	2062	40,447	23,874	0	16,546	88,589	4,624	31,553	**0**
2063	28,352	76,990	35,866	0	7,995	0	0	2,294	1,500	0	**152,997**	2063	37,384	23,874	0	13,485	89,287	1,441	38,495	**0**
2064	32,763	77,229	36,074	0	6,416	0	0	716	1,500	0	**154,698**	2064	36,643	23,939	0	12,779	90,231	2,764	38,615	**0**
2065	32,152	77,646	35,866	0	7,019	0	0	1,372	1,500	0	**155,554**	2065	35,890	23,874	0	11,992	90,683	4,002	38,823	**0**

Table 6.C3 Portfolio 3 Page 2 of 2

	Supplies Used to Meet Demand												River Effects Accounting Summary				Wastewater Accounting Summary			
Year	Aquifer Pumping	DWP River Supply	WW Reuse**	Non-potable Projects	ASR	Interbasin Transfer Delivered	Brackish GW	New Reservoir	Stormwater	GW in Excess of Permit	**Total**	Year	OSE River Effects	Native Rights Used to Offset River Effects	SJC Used for Offset	WW Used for Offset	Return to WWTP	WW to ASR or New Reservoir	DWP River Return	**Available Return Flow**
2066	31,871	77,974	35,866	0	7,638	0	0	1,986	1,500	0	**156,835**	2066	35,308	23,874	0	11,410	91,380	5,118	38,987	**0**
2067	31,715	78,302	35,866	0	8,196	0	0	2,539	1,500	0	**158,117**	2067	34,835	23,874	0	10,937	92,078	6,124	39,151	**0**
2068	31,924	78,545	36,074	0	8,757	0	0	3,037	1,500	0	**159,837**	2068	34,573	23,939	0	10,705	93,030	6,979	39,272	**0**
2069	31,774	78,958	35,866	0	9,127	0	0	3,460	1,500	0	**160,685**	2069	34,348	23,874	0	10,451	93,474	7,678	39,479	**0**
2070	32,036	79,286	35,866	0	9,476	0	0	3,806	1,500	0	**161,970**	2070	34,168	23,874	0	10,271	94,172	8,392	39,643	**0**
2071	32,284	79,615	35,866	0	9,833	0	0	4,160	1,500	0	**163,257**	2071	34,052	23,874	0	10,155	94,870	9,041	39,807	**0**
2072	32,864	79,862	36,074	0	10,216	0	0	4,481	1,500	0	**164,996**	2072	34,075	23,939	0	10,205	95,829	9,619	39,931	**0**
2073	43,687	69,737	35,866	0	10,278	0	0	4,768	1,500	0	**165,835**	2073	36,463	23,874	0	12,565	96,265	12,966	34,868	**0**
2074	71,887	42,189	35,866	0	9,244	0	0	6,441	1,500	0	**167,126**	2074	42,858	23,874	0	18,955	96,963	13,000	21,094	**8,048**
2075	37,804	74,716	35,866	0	12,094	0	0	6,438	1,500	0	**168,418**	2075	39,689	23,874	0	15,788	97,661	8,649	37,358	**0**
2076	47,187	71,192	36,074	0	9,936	0	0	4,287	1,500	0	**170,177**	2076	40,438	23,939	0	16,582	98,628	10,376	35,596	**0**
2077	36,085	81,589	35,866	0	10,825	0	0	5,143	1,500	0	**171,006**	2077	38,557	23,874	0	14,657	99,056	7,739	40,794	**0**
2078	39,674	81,918	35,866	0	9,507	0	0	3,838	1,500	0	**172,302**	2078	38,418	23,874	0	14,518	99,754	8,412	40,959	**0**
2079	39,973	82,247	35,866	0	9,843	0	0	4,171	1,500	0	**173,600**	2079	38,308	23,874	0	14,408	100,452	9,054	41,124	**0**
2080	38,507	82,495	36,074	0	10,222	0	2,000	4,486	1,500	0	**175,284**	2080	37,881	23,939	0	14,020	101,427	10,086	41,248	**0**
2081	38,077	82,892	35,866	0	10,680	0	2,000	4,997	1,500	0	**176,011**	2081	37,587	23,874	0	13,687	101,848	10,848	41,446	**0**
2082	46,626	74,790	35,866	0	11,061	0	2,000	5,374	1,500	0	**177,217**	2082	39,109	23,874	0	15,208	102,545	13,000	37,395	**1,076**
2083	44,723	75,761	35,866	0	12,137	0	2,000	6,437	1,500	0	**178,423**	2083	39,396	23,874	0	15,495	103,243	13,000	37,880	**1,002**
2084	62,959	58,957	36,074	0	12,195	0	2,000	6,437	1,500	0	**180,121**	2084	42,853	23,939	0	19,002	104,226	13,000	29,478	**6,671**
2085	63,714	59,181	35,866	0	12,137	0	2,000	6,437	1,500	0	**180,835**	2085	44,561	23,874	0	20,657	104,639	13,000	29,591	**5,526**
2086	58,954	63,378	35,866	0	13,906	0	2,000	6,438	1,500	0	**182,041**	2086	44,989	23,874	0	21,085	105,337	13,000	31,689	**3,697**
2087	106,531	21,401	35,866	0	9,493	0	2,000	6,456	1,500	0	**183,247**	2087	51,782	23,874	0	27,873	106,034	13,000	10,701	**18,595**
2088	57,775	67,331	36,074	0	13,839	0	2,000	6,440	1,500	0	**184,958**	2088	48,739	23,939	0	24,900	107,025	12,385	33,665	**0**
2089	53,488	73,072	35,866	0	13,599	0	2,000	6,135	1,500	0	**185,659**	2089	47,776	23,874	0	23,870	107,430	11,158	36,536	**0**
2090	84,900	44,084	35,866	0	12,985	0	2,000	5,529	1,500	0	**186,865**	2090	51,457	23,874	0	27,548	108,128	13,000	22,042	**9,672**
2091	55,953	72,406	35,866	0	13,906	0	2,000	6,440	1,500	0	**188,071**	2091	49,389	23,874	0	25,482	108,826	11,275	36,203	**0**
2092	51,668	79,864	36,074	0	13,102	0	2,000	5,587	1,500	0	**189,795**	2092	48,407	23,939	0	24,567	109,823	9,250	39,932	**0**
2093	64,322	70,178	35,866	0	12,031	0	2,000	4,585	1,500	0	**190,483**	2093	49,587	23,874	0	25,679	110,221	13,000	35,089	**587**
2094	77,584	54,392	35,866	0	13,906	0	2,000	6,441	1,500	0	**191,689**	2094	51,658	23,874	0	27,749	110,919	13,000	27,196	**7,109**
2095	96,136	37,107	35,866	0	13,844	0	2,000	6,442	1,500	0	**192,895**	2095	54,820	23,874	0	30,909	111,617	13,000	18,554	**13,288**
2096	71,054	63,907	36,074	0	13,656	0	2,000	6,441	1,500	0	**194,632**	2096	53,537	23,939	0	29,708	112,622	13,000	31,953	**1,887**
2097	54,140	81,685	35,866	0	13,674	0	2,000	6,442	1,500	0	**195,307**	2097	51,638	23,874	0	27,729	113,012	8,575	40,843	**0**
2098	58,144	83,374	35,866	0	11,377	0	2,000	4,252	1,500	0	**196,512**	2098	51,490	23,874	0	27,581	113,710	8,577	41,687	**0**
2099	82,920	59,971	35,866	0	11,209	0	2,000	4,252	1,500	0	**197,718**	2099	54,173	23,874	0	30,262	114,408	13,000	29,986	**5,294**
2100	70,109	64,855	35,896	0	13,277	0	7,000	6,442	1,500	0	**199,080**	2100	53,274	23,874	0	29,510	115,104	13,000	32,428	**2,365**
2101	67,164	70,824	35,866	0	13,334	0	5,000	6,442	1,500	0	**200,130**	2101	53,605	23,874	0	29,695	115,804	13,000	35,412	**1,830**
2102	65,478	73,801	35,866	0	13,249	0	5,000	6,442	1,500	0	**201,336**	2102	53,609	23,874	0	29,699	116,501	13,000	36,900	**1,036**
2103	89,008	51,561	35,866	0	13,164	0	5,000	6,443	1,500	0	**202,542**	2103	56,146	23,874	0	32,233	117,199	13,000	25,781	**10,319**
2104	74,132	68,221	36,074	0	12,934	0	5,000	6,445	1,500	0	**204,306**	2104	55,461	23,939	0	31,636	118,220	13,000	34,110	**3,400**
2105	66,358	76,835	35,866	0	12,952	0	5,000	6,443	1,500	0	**204,954**	2105	54,452	23,874	0	30,541	118,595	13,000	38,418	**770**
2106	89,217	56,201	35,866	0	11,927	0	5,000	6,449	1,500	0	**206,160**	2106	57,140	23,874	0	33,227	119,293	13,000	28,101	**9,099**
2107	87,273	58,585	35,866	0	12,699	0	5,000	6,443	1,500	0	**207,366**	2107	58,303	23,874	0	34,390	119,990	13,000	29,293	**7,443**
2108	124,828	23,220	36,074	0	12,069	0	5,000	6,453	1,500	0	**209,143**	2108	62,615	23,939	0	38,805	121,019	13,000	11,610	**21,530**
2109	129,238	25,087	35,866	0	6,626	0	5,000	6,461	1,500	0	**209,778**	2109	65,221	23,874	0	41,303	121,386	13,000	12,543	**18,674**
2110	89,035	60,817	35,866	0	12,320	0	5,000	6,447	1,500	0	**210,984**	2110	62,960	23,874	0	39,043	122,084	13,000	30,408	**3,766**
2111	59,309	91,737	35,866	0	12,334	0	5,000	6,444	1,500	0	**212,190**	2111	59,845	23,874	0	35,930	122,782	5,117	45,868	**0**
2112	68,422	91,966	36,074	0	8,478	0	5,000	2,540	1,500	0	**213,980**	2112	59,820	23,939	0	36,004	123,818	5,757	45,983	**0**
2113	68,657	92,316	35,866	0	8,406	0	5,000	2,857	1,500	0	**214,602**	2113	59,651	23,874	0	35,737	124,177	6,417	46,158	**0**
2114	85,701	76,140	35,866	0	8,416	0	5,000	3,185	1,500	0	**215,808**	2114	61,273	23,874	0	37,358	124,875	13,000	38,070	**582**
2115	84,563	72,086	35,866	0	11,554	0	5,000	6,446	1,500	0	**217,013**	2115	61,716	23,874	0	37,800	125,573	13,000	36,043	**2,865**
2116	70,989	86,791	36,074	0	12,020	0	5,000	6,444	1,500	0	**218,817**	2116	60,665	23,939	0	36,850	126,617	10,297	43,395	**0**
2117	68,417	93,312	35,866	0	10,224	0	5,000	5,107	1,500	0	**219,425**	2117	60,168	23,874	0	36,253	126,969	8,194	46,656	**0**
2118	71,670	93,517	35,866	0	9,013	0	5,000	4,066	1,500	0	**220,631**	2118	60,271	23,874	0	36,356	127,666	8,686	46,758	**0**
2119	77,530	88,686	35,866	0	8,946	0	5,000	4,310	1,500	0	**221,837**	2119	60,917	23,874	0	37,001	128,364	11,154	44,343	**0**
2120	103,882	60,984	36,074	0	10,673	0	5,000	5,542	1,500	0	**223,654**	2120	63,819	23,939	0	40,011	129,416	13,000	30,492	**9,838**

*No regrets and watershed management alternatives are assumed to be implemented regardless of portfolio, however they are not included in model results.

*Total includes existing reuse plus any alternatives selected: westside reuse, eastside reuse, connect southside to northside, indirect potable reuse, NI-25 Non-potable Project and southside reuse project; including the expansion of any of these as applicable.

Appendix 6.D

Economic Module Description

Appendix 6.D

Albuquerque Bernalillo County Water Utility Authority - Economic Module Description

An economic module was developed for the purpose of evaluating the selected portfolios with respect to cost. This appendix summarizes the cost analysis component of portfolio development. The module was designed to calculate the discounted present value (DPV) for each portfolio and compare them to the baseline. Baseline reflects a continuation of current practice.

To calculate the cost of current practice, it is assumed that these costs include all current operation and maintenance (O&M) costs for existing supplies and currently planned capital improvements (which includes baseline costs plus the opportunity costs for utilization of groundwater beyond the management level). The opportunity costs are those necessary to maintain groundwater levels at the 110-foot management level or above rather than using the supply to the permitted limit, as defined in Chapter 4.

From an economic perspective both current practice and alternative supply strategies can be represented as distinct series of annual costs extending from the present year to the end of the 100-year planning period. Consequently, comparison of the current practice versus alternative supply cost series, utilizing the same pattern of underlying supply and demand but different selections for new supplies, enables economic analyses of the relative cost of the alternative new supply strategies. The DPV of each series can be calculated using common assumptions about future inflation and discount rates.

Components of the Economic Module

The base economic module was developed using historical supply and demand data along with historical O&M costs received from the Water Authority Finance Division.

The historical data were used to develop simple linear regressions to develop cost coefficients (or unit cost) for each of the water supply sources discussed in Chapter 3, as well as for distribution (pipelines, lift stations, and reservoirs), wastewater treatment, compliance (water quality testing), and administrative costs such as customer services, finance, human resources, engineering and planning, information services, and other general administrative costs.

Each cost coefficient or unit cost was then used to project the annual O&M costs through 2120 for the baseline supply. As the volume of water from each source changes the O&M cost for that source changes.

The costs used to calculate the linear regressions were deflated costs. The following equation was used to develop the deflated costs:

$$C_r = \frac{C_a}{I_u}$$

Where:

C_r = Cost used for the regression calculation
C_a = Actual cost
I_U = Consumer Price Index for utilities (CPI-U)

To calculate the projected annual O&M cost for the supply sources with sufficient historical data to develop a cost coefficient from a regression, the following equation was used:

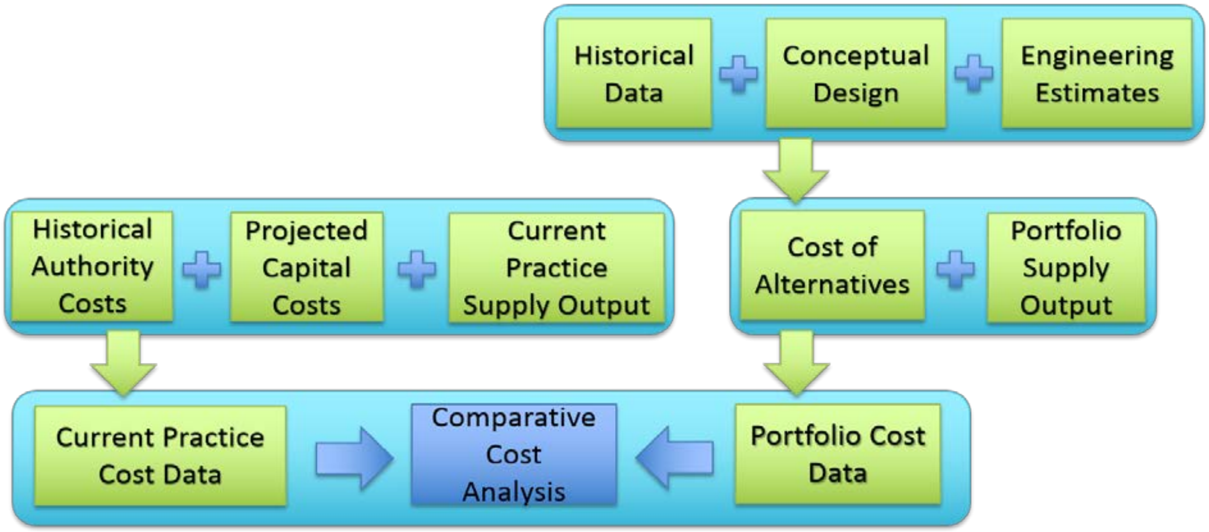
$$O\&M_A = (Cc * V) * (I_u((1 + (i/100))^{t_1 - t_2})$$

Where:

$O\&M_A$ = Annual O&M Cost
Cc = Cost coefficient developed from the regression
V = Annual volume of supply
I_U = 2014 Consumer Price Index for utilities (CPI-U), the final year of the calculated regression
i = Inflation Rate
t_1 = Year of the O&M calculation
t_2 = Final year of the calculated regression

The projected capital costs for existing supplies were compiled from the Water Authority's *Asset Management Plan* (2011) and the projected capital costs for alternative new supplies were developed as described in Appendix 5.C of Chapter 5. The projected capital and projected O&M costs were combined to develop the cost data for the current practice strategy (Figure 6.A1).

Figure 6.A1. Schematic of the Economic Module Components



The alternative supply strategies used to develop portfolios are discussed in Chapters 5 and 6. As described in Appendix 5.C of Chapter 5, historical cost date (when available), conceptual design reports, and engineering estimates were used to develop capital and O&M cost data for each of the alternative supply strategies (Figure 6.A1). An O&M unit cost for each alternative supply was then used to develop the projected annual O&M costs for that supply. The capital costs were then added into the economic module when the alternative supply was projected to be needed to fill supply gaps. The projected capital and O&M cost for each alternative supply were then added to the economic module to develop the cost data for each portfolio.

To calculate the annual O&M cost for new alternative supply sources and existing supply sources without sufficient historical data to develop a cost coefficient from a regression, the following equation was used:

$$O\&M_A = (U * V) * \left(\left(1 + (i/100)\right)^{t_1 - t_2}\right)$$

Where:

$O\&M_A$ = Annual O&M cost
U = Unit cost for the supply source
V = Annual volume of supply
i = Inflation rate
t_1 = Year of the O&M calculation
t_2 = First year of projected costs

An inflation rate of 2.9 percent was used in the economic module to project the costs out into the future to 2120. A discount rate of 2.4 percent was used to calculate the present value of the total projected costs of the current practice and each portfolio. These rates are currently used by the Water Authority (Allred, 2016, pers. comm.).

To calculate the annual capital costs, the following equation was used:

$$C_A = (C) * \left(\left(1 + (i/100)\right)^{t_1 - t_2}\right)$$

Where:

C_A = Annual capital cost
C = 2015 Capital cost
i = Inflation rate
t_1 = Year of the O&M calculation
t_2 = First year of projected costs

Economic Module Analysis of the Portfolios

To calculate the DPV for each portfolio, the economic module takes the various annual quantities of supply in the portfolios or current practice and assigns a series of annual capital and O&M costs to the supply. These capital and O&M costs are projected to estimate the future costs out to 2120 and then the economic module calculates the DPV of continuing current practice and the DPV of switching to an alternative new supply strategy. In fact, multiple alternative supply strategies can be compared simultaneously using the relative cost of each strategy along with current practice. In this manner, an informed judgment can be made as to which alternative supply strategies offer potential cost savings to the Water Authority. Moreover, by use of the spreadsheet, altered future patterns of supply and demand as well as changes to key cost parameters can also be readily calculated to determine the robustness with which an alternative supply strategy may maintain or lose its cost advantage.

To calculate the annual DPV for each portfolio the following equation was used:

$$DPV = FC_1/(1 + (r/100))^t$$

Where:

DPV = Discounted present value
FC_1 = Future cost
t = Time in years from the starting year
r = Discount rate

The economic module was evaluated through a sensitivity analysis of the inflation and discount rates. The costs of the current practice and portfolios were calculated using a variety of inflation rates from zero to 4.6 percent and a variety of discount rates ranging from zero to 4.0 percent. These calculated DPV's were compared to determine whether the relative cost comparisons changed with different combinations of inflation and discount rates.

The economic analysis is limited by the need to accumulate enough substantive change in costs and timing that the DPV results between the current practice and portfolios are noticeable. The timing with which the costs of alternative supplies are incurred can have a significant impact on the DPV of each portfolio. While each component of the Water Authority's costs was analyzed and included in the module there are costs that are not captured in this economic analysis. Additionally, these calculations are not intended to be accurate forecasts of future costs or a rate analysis, but they allow comparison of the relative cost of alternative strategies (time-specific portfolios) when the same assumptions are used for each strategy. The key utility of the economic module arises from a comparison of the discounted present values of strategies that are sufficiently different, and remain so under pertinent parametric changes.

References

Albuquerque Bernalillo County Water Utility Authority (Water Authority). 2011. Asset Management Plan 2011.

Allred, Stan, Chief Financial Officer, ABCWUA. 2016. Personal communication with Annelia Tinklenberg, INTERA. May 10.