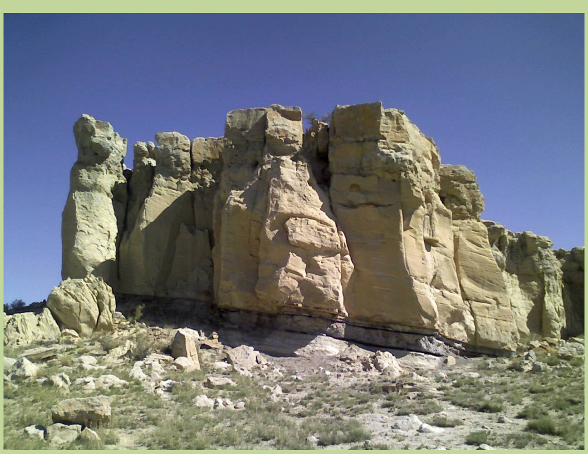

SANDOVAL COUNTY
WHOLESALE WATER SUPPLY UTILITY
DESALINATION TREATMENT FACILITY

PRELIMINARY ENGINEERING REPORT

APRIL 15, 2011

UNIVERSAL ASSET MANAGEMENT
Engineered Reliability

CDM

INTERA

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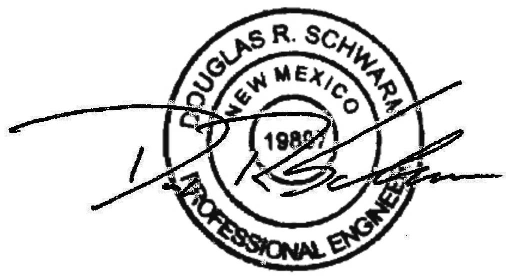
CERTIFICATION

Registered Professional Engineer Certification:



Panoramic view of the Pilot Treatment Plant at Exploration Well EXP-6

SECTION 1
EXECUTIVE SUMMARY (OVERVIEW)

1.1 FINDINGS

Sandoval County proposes to create a wholesale water utility that will supply 5.0 MGD potable water sold wholesale to existing and new to water utilities serving the area between the City of Rio Rancho and the Rio Puerco. The service area is adjacent to the fastest-growing community in New Mexico and is designated by County and State planning entities for dense mixed-use development.

This preliminary engineering report (PER) provides a comprehensive evaluation of the County's proposal to develop this wholesale water utility. It evaluates various issues facing the County and presents a recommended action plan. The report reviews previous groundwater development efforts, describes the selected water treatment process, summarizes pilot testing that confirms these processes, and outlines a financial analysis of the recommended project.

The proposed wholesale water supply utility will extract brackish groundwater and treat it to drinking water standards using a reverse osmosis process preceded by multi-stage pretreatment. All design criteria comply with the U.S. Safe Drinking Water Act administered by the U.S. Environmental Protection Agency (USEPA) together with the regulations and policy of the New Mexico Environmental Department (NMED).

Fostering economic growth is the County's preliminary motivation in initiating this project. By developing a new potable water supply, the County intends to add new industrial and commercial enterprises along with an increase in housing. It should be noted, however, that the overriding focus is to create more employment opportunities within Sandoval County.

This water project is also an economic development catalyst. Where possible, this project seeks to reduce waste plant residuals by converting them into marketable products. In the course of this effort the water treatment process itself creates ancillary enterprises and additional employment opportunities.

1.2 FUTURE WATER DEMAND

As the plant capacity is expanded beyond 5 MGD, the cost of water produced is projected to decrease, although at a much reduced rate. This reduction in cost is primarily associated with a decrease in marginal operating expenses.

1.3 EXISTING WATER DEMAND

The City of Rio Rancho has an immediate need for 5.0 MGD of additional supply. The proposed project would supply this need, offering Rio Rancho an alternative water source to their ongoing buy-and-retire initiative.

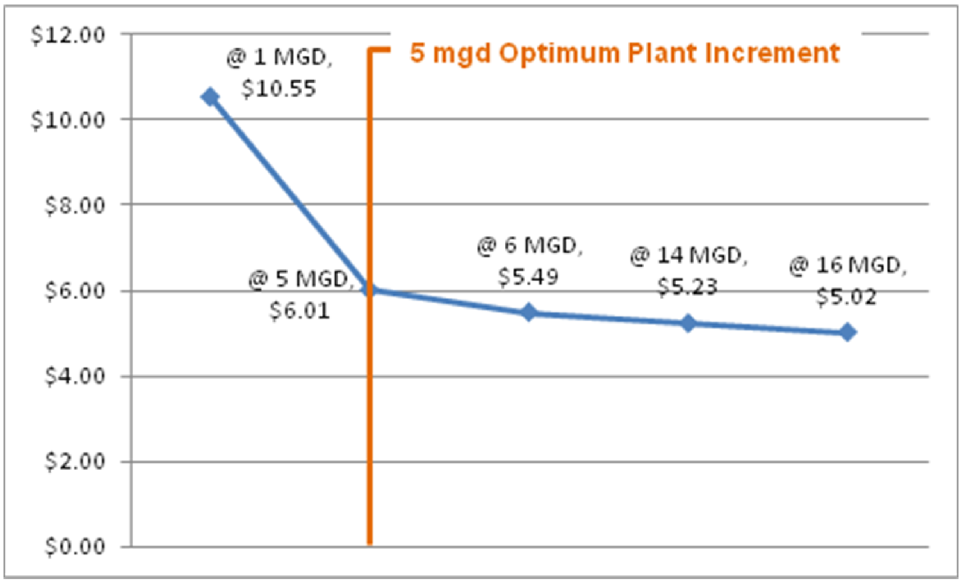
The Rio West master planned community, located within the service area, also requires a 100-year potable water supply before proceeding with development. Depending on Rio Rancho's progress buying-and-retiring existing water rights, the Project water could be made available to facilitate the Rio West project.

A firm purchase commitment from either party, or from one of the other master planned communities proposed in the service area, is necessary to secure financing for the Project. The water supply approvals are necessary concurrently to secure the necessary supply agreement.

1.4 PROJECT CAPACITY

In a previous study completed by the County in 2009 by Universal Asset Management it was determined that 5 MGD treatment trains were optimal for this project. Figure 1-1 illustrates that the 5 MGD plant size represents the most cost effective module. As future demand grows it is proposed that the wholesale water supply utility could expand in 5 MGD increments, although such expansions are not necessary for the proposed Project.

Figure 1-1
Capacity vs Rate Plot



1.5 SOURCE ALTERNATIVES

Three alternatives were evaluated for supplying raw water necessary to supply the 5.0 MGD project.

- Treat brackish groundwater from the aquifer directly beneath the service area,
- Buy and retire water rights in the Middle Rio Grande Basin and transport the water from the point(s) of diversion 21 miles over to a treatment plant and storage tank within the service area, and
- Buy and retire water rights from the Pecos River, similar to the project proposed by Barrendo LLC, and transport raw water 175 miles west to a treatment plant and storage tank within the service area.

Table 1-1 summarizes the three water source alternatives evaluated in this report:

Table 1-1
Water Source Alternatives

Description	Intake Type	Point of Diversion	Transmission
Brackish Groundwater	5 Deep Wells	Below Service Area	½ -mile Collector Pipelines
Buy & Retire Middle Rio Grande Rights	River Intake w/ Pump Station	West Bank Rio Grande	21-mile Pipeline
Buy & Retire Pecos River Rights	River Intake w/ Pump Station	Lake Sumner	175-mile Pipeline

Conservation, wastewater reclamation, and similar alternatives are not feasible because the service area is undeveloped and the County does not have control over significant wastewater being treated and disposed of by the municipalities located within the County boundaries.

1.6 PREFERRED SOURCE

The Rio Puerco brackish water aquifer is the preferred water source on the basis of cost and schedule advantages. The Rio Puerco aquifer is a confined aquifer located at a depth of 3,500 feet. Aquifer testing and analysis reveals at least 576,000 acre-feet of recoverable water and may store up to 2,600,000 acre-feet. At an initial plant capacity of 5 MGD the aquifer will provide a 100-year supply under the lower storage estimate.

The brackish raw water quality is represented in Table 1-2. Constituents in bold type exceed drinking water standards. These constituents dictate the target water treatment processes selected.

Table 1-2
Well EXP-6 Water Chemistry

Parameter	Well EXP-6 Water	Primary Drinking Water Standard	Secondary Drinking Water Standard
Alkalinity (mg/l) as $CaCO_3$	1,800	N/A	N/A
Arsenic (mg/l)	**0.634**	**0.01**	**N/A**
Bicarbonate (mg/l)	1800	N/A	N/A
Boron (mg/l)	9.7	N/A	N/A
Calcium (mg/l)	450	N/A	N/A
Carbon Dioxide (mg CO_2/l)	1900	N/A	N/A
Chloride (mg/l)	**3,100**	**N/A**	**250**
Fluoride (mg/l)	**4.8**	**4.0**	**2.0**
Gross Alpha (pCi/l)	**209**	**15**	**N/A**
Hardness (mg/l as $CaCO_3$)	1,500	N/A	N/A
Iron (mg/l)	**3.3**	**N/A**	**0.3**
Lead (mg/l)	ND	0.015	N/A
Magnesium (mg/l)	97	N/A	N/A
Phosphorus (mg/l)	0.29	N/A	N/A
pH	7.05	N/A	6.5-8.5
Radium 226+228 (pCi/l)	**85**	**5**	**N/A**
Salinity (unitless)	10.4	N/A	N/A
Silica (mg/l)	32	N/A	N/A
Sodium (mg/l)	3,600	N/A	N/A
Strontium (mg/l)	8.8	N/A	N/A
Sulfate (mg/l)	**4,400**	**N/A**	**250**
TDS (mg/l)	**12,000**	**N/A**	**500**
Temperature	150 F	N/A	N/A
Turbidity (NTU)	13	N/A	N/A
Thallium (mg/l)	**0.007**	**0.002**	**N/A**
Uranium (mg/l)	0.002	0.03	N/A

1.7 SELECTED WATER TREATMENT PROCESS

Three alternative water treatment processes were evaluated:

- Alternative 1: Warm Lime Softening with Media Filtration and Reverse Osmosis (RO)

- Alternative 2: Warm Lime Softening with Media Filtration, Weak Acid Cation (WAC) Ion Exchange and Reverse Osmosis
- Alternative 3: Nanofiltration Softening with Reverse Osmosis (RO)

Alternative 2 is the recommended treatment process. This process is illustrated in Figure 1-2. Process flow diagrams showing additional detail are in Appendix A.

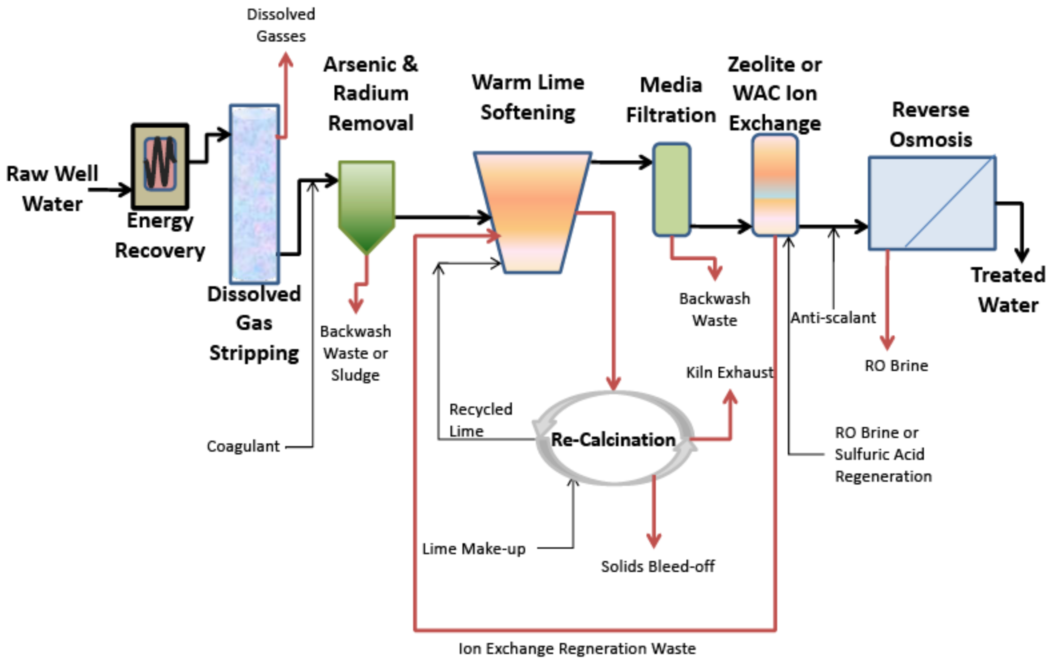


Figure 1-2 Process Alternative 2:
Warm Lime Softening +Media Filtration + WAC Ion Exchange + RO

1.8 RESIDUAL PRODUCTS

Processing residual waste into marketable products, or disposing of wastes with no commercial opportunity, represents a significant cost to constructing and operating this brackish water treatment plant. In an attempt to maximize the sustainability of this facility the following residual management protocol regarding the handling of residuals has been followed:

- First: Reuse residuals internally within the proposed water plant
- Second: Find a commercial market into which processed residuals can be sold; thus creating a revenue stream for the plant
- Third: If no is feasible, find the least costly means of safe disposal

The following table illustrates the residuals produced and their proposed disposition.

Table 1-3
Disposition of Residuals

Residual Description	I Reuse Internally	II Marketable Product	III Dispose
CO_2	X		
Pressure	X		
Heat	X		
Arsenic & Radium			X
Lime	X	X	
Magnesium Carbonate		X	
Salt (Sodium Chloride)	X	X	X
Salt (Sodium Sulfate)			X
WAC Regeneration Waste			X

The three primary marketable residuals are magnesium carbonate, sodium chloride, and lime. All together these products represent potential revenues of approximately $4.5 million per year. This is a significant revenue stream and long-term contracts for the sale of these products should be secured before final project financing is closed. A preliminary market survey was performed and resulted in letters of interest for all marketable products[1].

The primary residuals ultimately requiring disposal include: a) ferric precipitates containing arsenic and radio nuclides which must be handled as hazardous waste, and b) reverse osmosis brine mixed with the regenerative waste of the ion exchange unit that will be disposed using an injection well. Exploratory well EXP-5 will be converted to an injection well for this purpose. The residuals disposed in this manner would be injected into the topmost units of the Madera group formation about 1,500 feet below the San Andreas and Glorieta (SAG) source formation[2].

1.9 ENERGY

After residual handling and processing energy represents the second most significant expense. Energy also represents the least predictable component of operational expense. In analyzing the options for this plant project the following criteria were followed:

- Maximize the use of renewable energy resources
- Reduce the carbon footprint of the facility and its impact on greenhouse gas emissions
- Evaluate the most sustainable and predictable price structure

The proposed desalination treatment facility requires a considerable amount of energy in the form of heat and electricity. The County faces several choices in meeting these energy requirements:

- ***Option 1 – Existing Utility Services:*** The County could buy electricity from Public Services of New Mexico (PNM) and natural gas from New Mexico Gas Company.
- **Option 2 – Combined Heat & Power (CHP):** The County could buy natural gas only from New Mexico Gas Company and the treatment plant could produce its own electrical power.

[1] A supplemental financial analysis was performed (Appendix L) assuming no markets for residual projects, which has financial impact but not preferred

[2] Similarly, the possibility that the New Mexico Ground Water Quality Bureau would disallow brine injection is addressed by assuming solar evaporation ponds in Appendix L's worst-case financial analysis.

- ***Option 3 – Alternative Renewable Energy:*** The County could produce their own gas using an agricultural based energy crop anaerobically digested to create biogas. This biogas would fuel a combined heat and power (CHP) energy plant.
- ***Option 4 – 250 MW Gas Fired Power Plant***: The County has been approached by Native Energy Development, LLC to co-locate a gas-fired power plant with the proposed water plant. The County would purchase power directly from the power plant and benefit from free heat. The water plant would reciprocate by supplying cooling water.

Table 1-4 illustrates the aggregate annual energy cost for each option.

Table 1-4 Annual Energy Cost

Option	Annual Energy Cost
1. Existing Utility	$3,300,000
2. CHP	$2,500,000
3. Biogas Renewable Energy	$3,800,000
4. Gas Fired Power Plant	$1,500,000

The financial analyses indicate that Option No. 4, the Gas Fired Power Plant is preferred.

If this power project failed to materialize in a timely manner the County could fall back to Option No. 2 CHP choosing to negotiate for the purchase of natural gas from PNM or Native Energy Development, LLC. If Option No. 2 is activated as a result of the gas fired power plant not materializing, the County must be aware of the unpredictable nature of gas pricing. As a long-term plan any CHP energy alternative should include future use of renewable biogas produced on-site.

1.10 RECOMMENDATIONS

1. Water Source – Construct five wells each with a capacity of 1,100 gpm.
2. Water Treatment and Residual Processing – Construct a treatment plant based on reverse osmosis salt removal following multi-stage pretreatment to remove heat, pressure, gasses, metals, and hardness. Make best use of the residual products within the plant, like heat and pressure, and build adjacent processing facilities to manufacture commercially valuable commodities from other residual products.
3. Energy
   - Proceed with Native Energy Development, LLC in the co-location of a 250 MW gas fired power plant
   - If this first plan fails to materialize initially construct a gas fueled co-generation plant using a combined heat and power (CHP) process

1.11 FINANCING

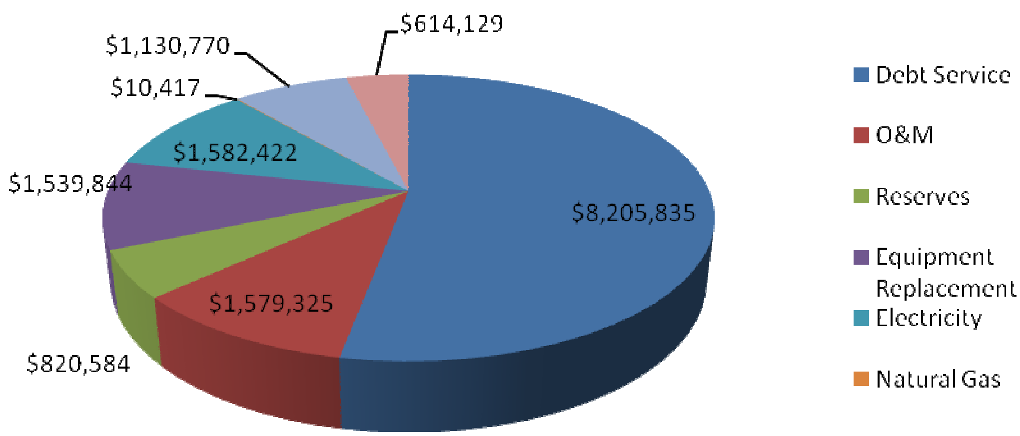
TABLE 1-5
EXPECTED PROJECT COST

ITEM	AMOUNT
Total Estimated Construction Cost	$76,992,200
Total Project Cost	$105,140,250
Long-Term Debt Requirement	$106,740,985
Projected Water Rate	$6.01/1,000 gallons

In order to reduce the initial capital cost of the basic plant, it is recommended that the lime and salt recovery elements be financed as an operating lease with companies specializing in these areas or through grants obtained by the County.

The average annual operation cost required to produce 5 MGD is $15.5 million. This cost can be segregated into the categories displayed in Figure 1–3.

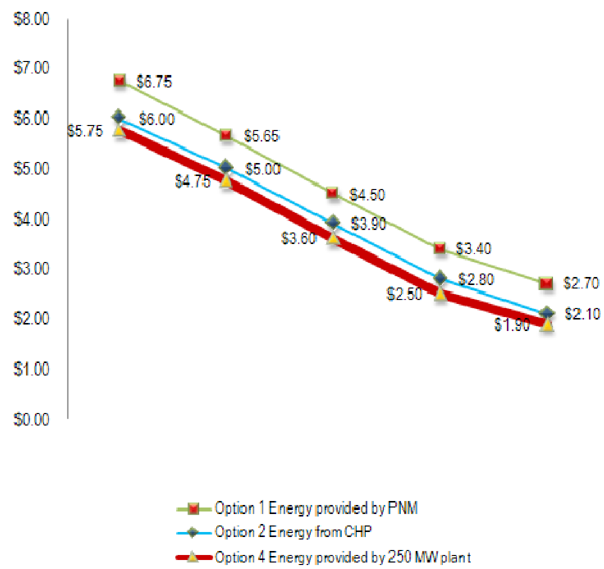
Figure 1–3 Operations and Maintenance Costs Breakdown



- The above annual costs assume no significant grant contributions beyond the current Water Trust Board contribution. It is assumed that the project would be funded using tax-exempt debt amortized over 20 years at an average annual interest rate of 4.5%.
- Financial Assumptions
  - 10% debt coverage
  - 1 year capitalized interest
  - 18 months of interest during construction

B. Price Sensitivity – The project financing is sensitive to the amount of grants ultimately obtained. At this time only the current Water Trust Board grant has been considered in the pro forma. Figure 1-4 illustrates the resulting cost of water with higher grant funding.

Figure 1–4 Wholesale Water Rate vs. Grant Contribution



The graph shows that the water rate with only the current Water Trust Board grant contribution and Option 4 Energy scenario would be $5.12/1,000 gallons. With a 50% grant contribution this rate would fall to $2.91/1,000 gallons. Energy cost savings from a collocated gas fired power plant is equivalent to obtaining a 20% grant.

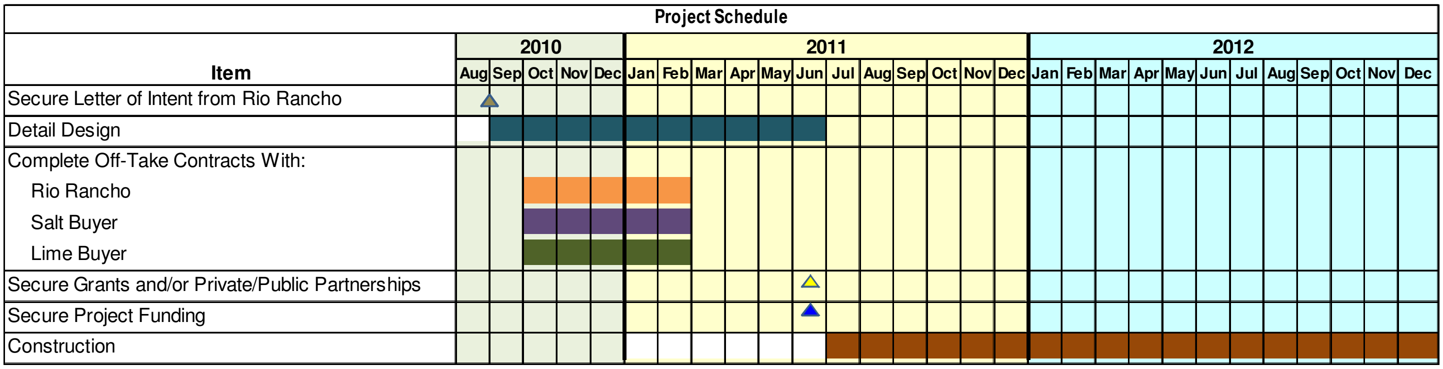
Additionally, the project is sensitive to the average cost of electricity and gas. While this is discussed further in the “energy” section of this report.

1.12 RECOMMENDED IMPLEMENTATION PLAN

- Based upon the above conclusions it is recommended that:
  1. The County immediately submit this report (PER) to NMED for review;
  2. the County simultaneously seek a letter of interest from the City of Rio Rancho;
  3. the County begin discussions with “off-take” buyers of lime, salt and magnesium;
  4. the County authorize UAM to supervise a Request for Proposals (RFP) process to solicit detailed design services;
  5. the County authorize UAM to solicit Statements of Interest (SOI’s) from private companies to provide lime recovery and salt processing;
  6. the County aggressively partner with Native Energy Development LLC for the co-location of a 250 MW power plant;
  7. the County engage their financial advisor and legal counsel in the development of a financing plan;
  8. the County aggressively seek grant assistance to reduce the overall wholesale water price;

- Figure 1-5 shows the recommended project schedule.

Figure 1-5
Preliminary Project Schedule



SECTION 2
PROJECT PLANNING AREA

2.1 PROJECT LOCATION

The project planning area is located in southern Sandoval County. Figure 2-1 is a general location map showing Sandoval County relative to the New Mexico State boundaries and the neighboring counties. Figure 2-2 is a vicinity map showing the planning area along the central part of Sandoval County's southern border. The planning area is bounded by Highways 528 and 550 on the east, the Laguna Pueblo on the west, Bernalillo County on the south, and the Zia Pueblo on the North.

The planning area is generally the area designated for development in State, Regional, and County plans. The planning area is principally comprised of unincorporated lands under Sandoval County jurisdiction. A part of the planning area is within the City of Rio Rancho city limits, and is therefore not under Sandoval County jurisdiction for water use and development issues. No other incorporated municipal entities are within the planning area; this water supply project is not intended to address water issues outside the planning area.

Figure 2-3 is a topographic map of the planning area. The City of Rio Rancho is outlined in blue on the eastern side of the planning area. Rio Rancho Estates is outlined in green in the center of the planning area. It is platted but largely undeveloped. Rio West is outlined in orange in the southwest portion of the planning area. It has not been platted and is undeveloped.

Figure 2-4 is a broader topographic map of the surrounding area. Natural boundaries around the planning area include Mesa Prieta and the Rio Puerco to the west and the Jemez River and Rio Grande to the northeast, east, and southeast. The north boundary is irregular but generally follows the Zia Pueblo and the Santa Anna Pueblo boundaries, as well as Highway 550. No significant natural features provide a discrete southern boundary.

The area is largely undeveloped and sparsely populated. Infrastructure is limited to a few livestock watering facilities. The undeveloped land is abundant and relatively affordable.

While this is a fairly broad planning area, southern Sandoval County is one of the fastest growing areas of New Mexico. As it will be described in the following report sections, there are a number of large developments planned within the project planning area.

2.1.1 Planning Periods

Planning for this regional water project considers a 2-year and a 20-year planning horizon as outlined in Table 2-1.

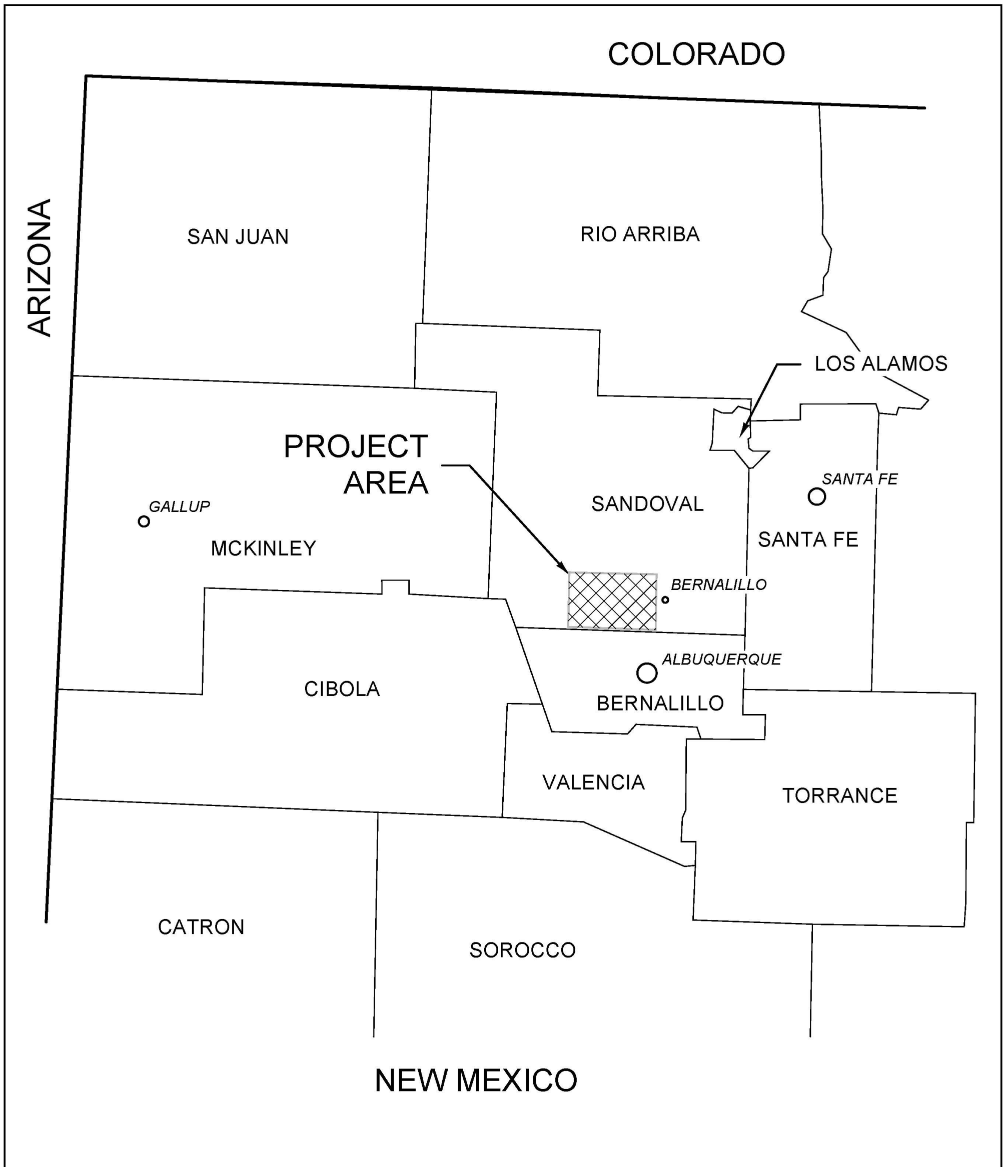
Table 2-1 – Planning Horizons

Horizon	Planning Time		Interval (years)
	Begin	End	
Immediate	2011	2013	2
Long Term	2011	2031	20

The immediate phase addresses the City of Rio Rancho's immediate need for supplemental water supply. Their present need arises from many factors, including the growing cost of buying water rights and the unpredictable schedule of those rights becoming available at auction.

The 2-year planning horizon also supports rapid economic development in the service area in the event that the Rio Rancho supply agreement fails to materialize. Whether within Rio Rancho or in the undeveloped service area, Sandoval County is committed to supplying the water necessary for economic growth in the planning area.

The 20-year project horizon addresses the economic development in the planning area anticipated by Bureau of Business and Economic Research (BBER) and the Mid–Region Council of Governments (MRCOG). The design life of all equipment and systems considered in this PER is also 20 years.



SANDOVAL COUNTY
DESALINATION TREATMENT FACILITY

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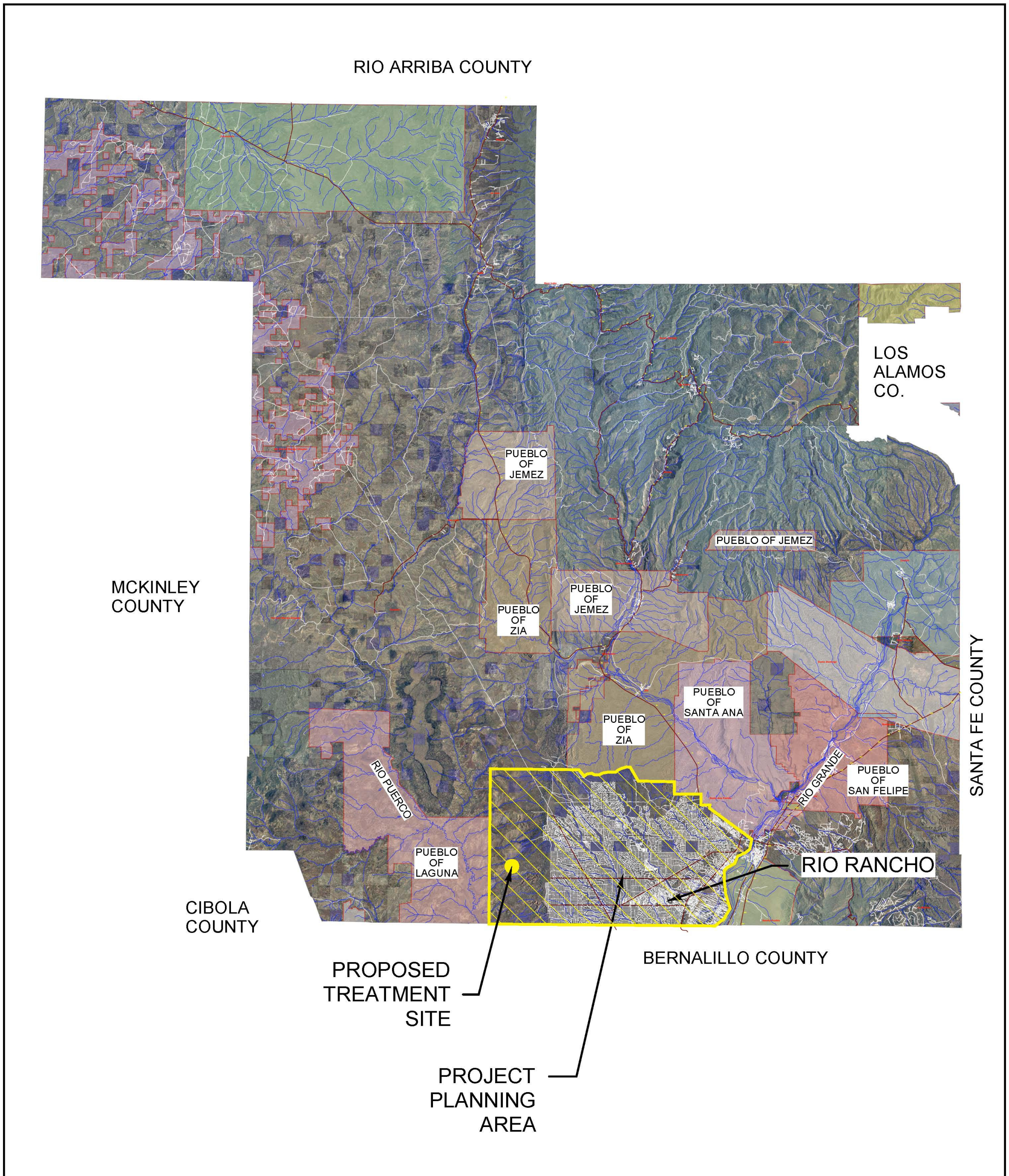
LOCATION MAP	FIGURE 2-1



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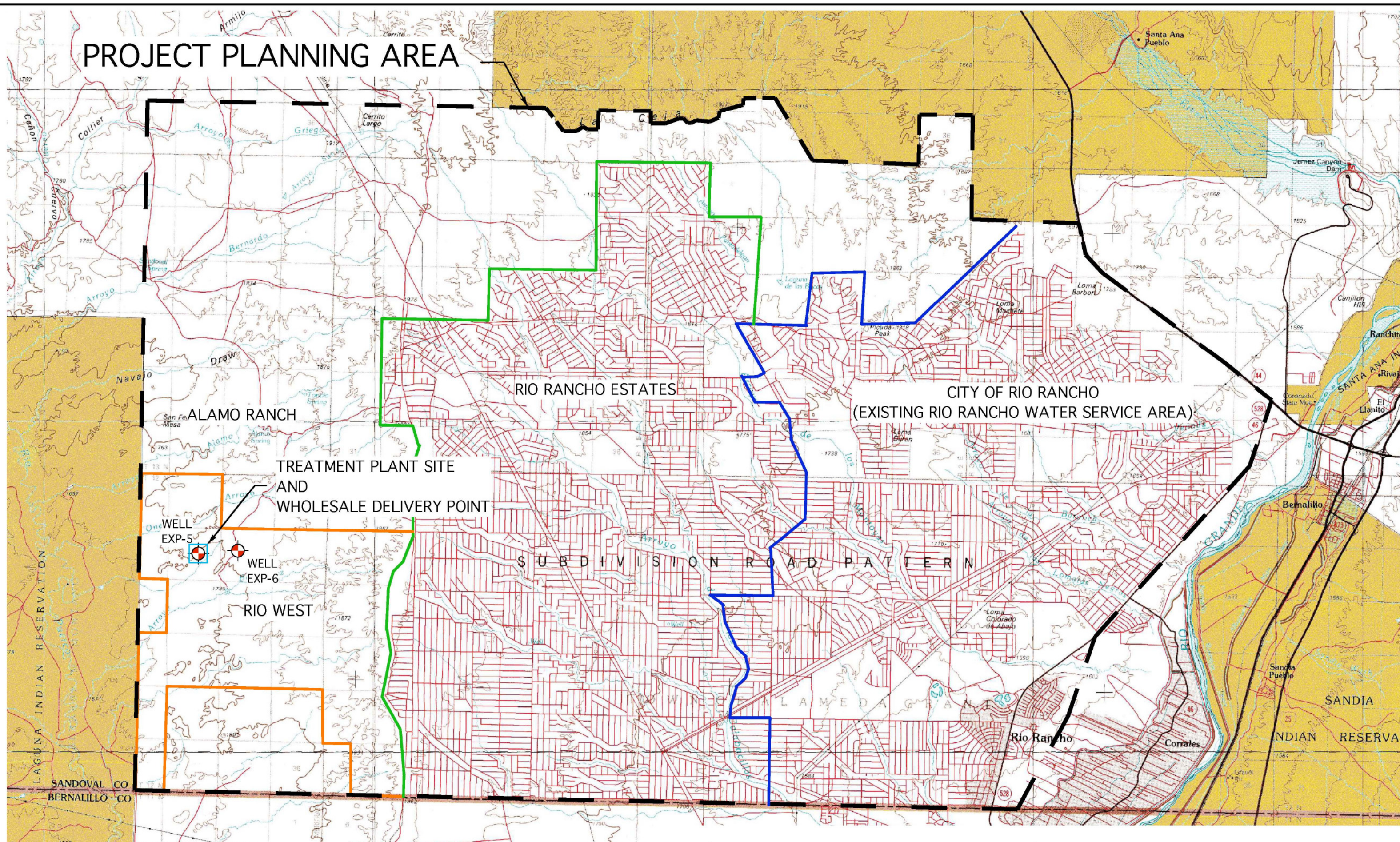
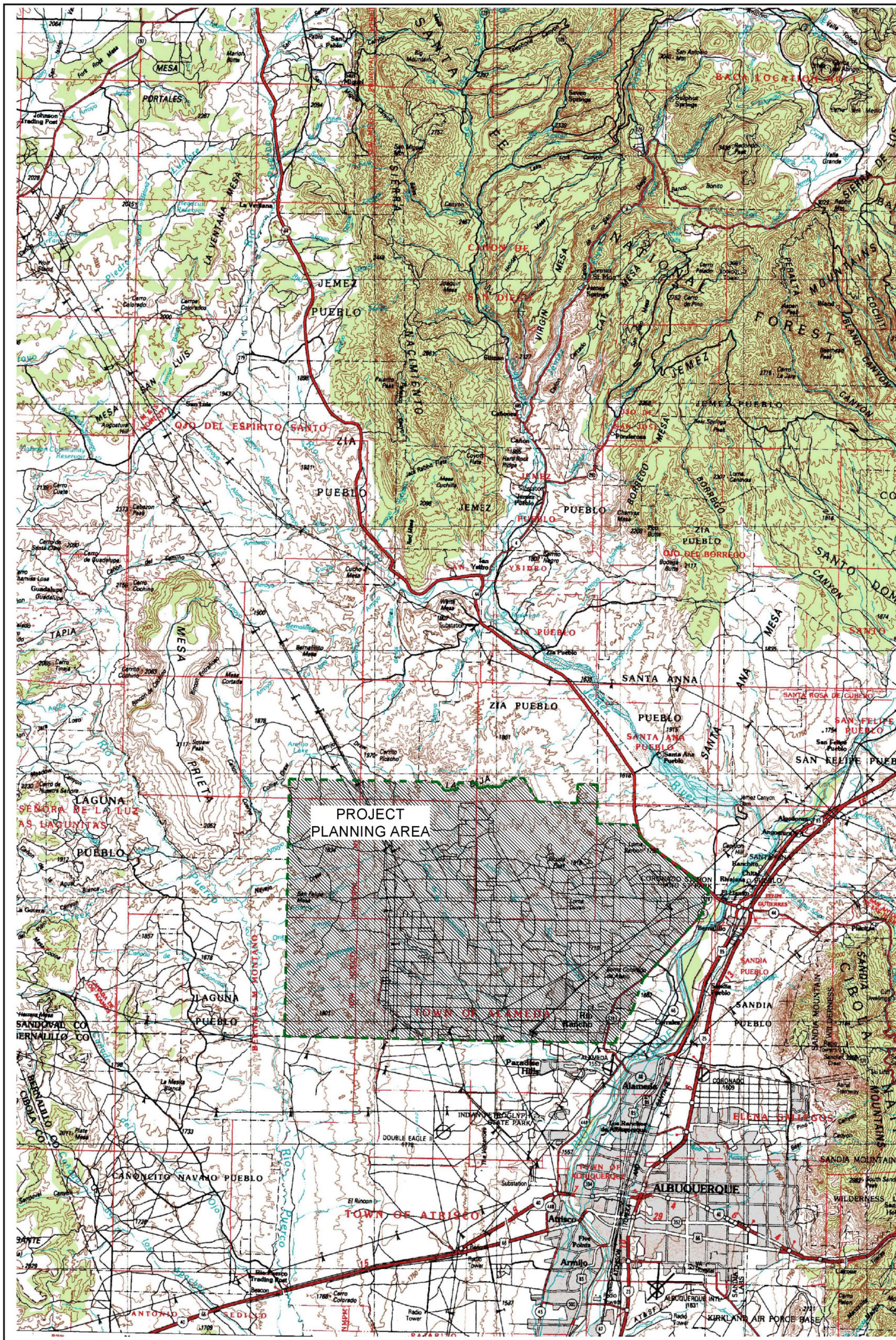
SANDOVAL COUNTY DESALINATION TREATMENT FACILITY	
VICINITY MAP	FIGURE 2-2



SANDOVAL COUNTY DESALINATION TREATMENT FACILITY	
PLANNING AREA MAP	FIGURE 2-3



REF: UNITED STATES GEOLOGICAL SURVEY, 1983, ALBUQUERQUE, NM 1:250,000 1 X 2 DEGREE TOPOGRAPHHIC MAP

SANDOVAL COUNTY DESALINATION TREATMENT FACILITY	
TOPOGRAPHIC MAP	FIGURE 2-4

2.2 REGIONAL GEOLOGIC CONDITIONS

Figure 2-5 shows a geologic map of the planning area. The planning area is generally in the broad Rio Puerco valley, east of the river and west of the badland escarpment.

Topography is characterized by northeast-southwest trending ridges and valleys formed by outcrops of folded and faulted Mesozoic-age rocks, then later downcut by southwest-trending arroyos. Precambrian bedrock is about 4,000 feet deep. Younger, generally soft, sedimentary rocks are exposed in uplifted ridges or downcut arroyos, and are covered by thin accumulations of granular soils.

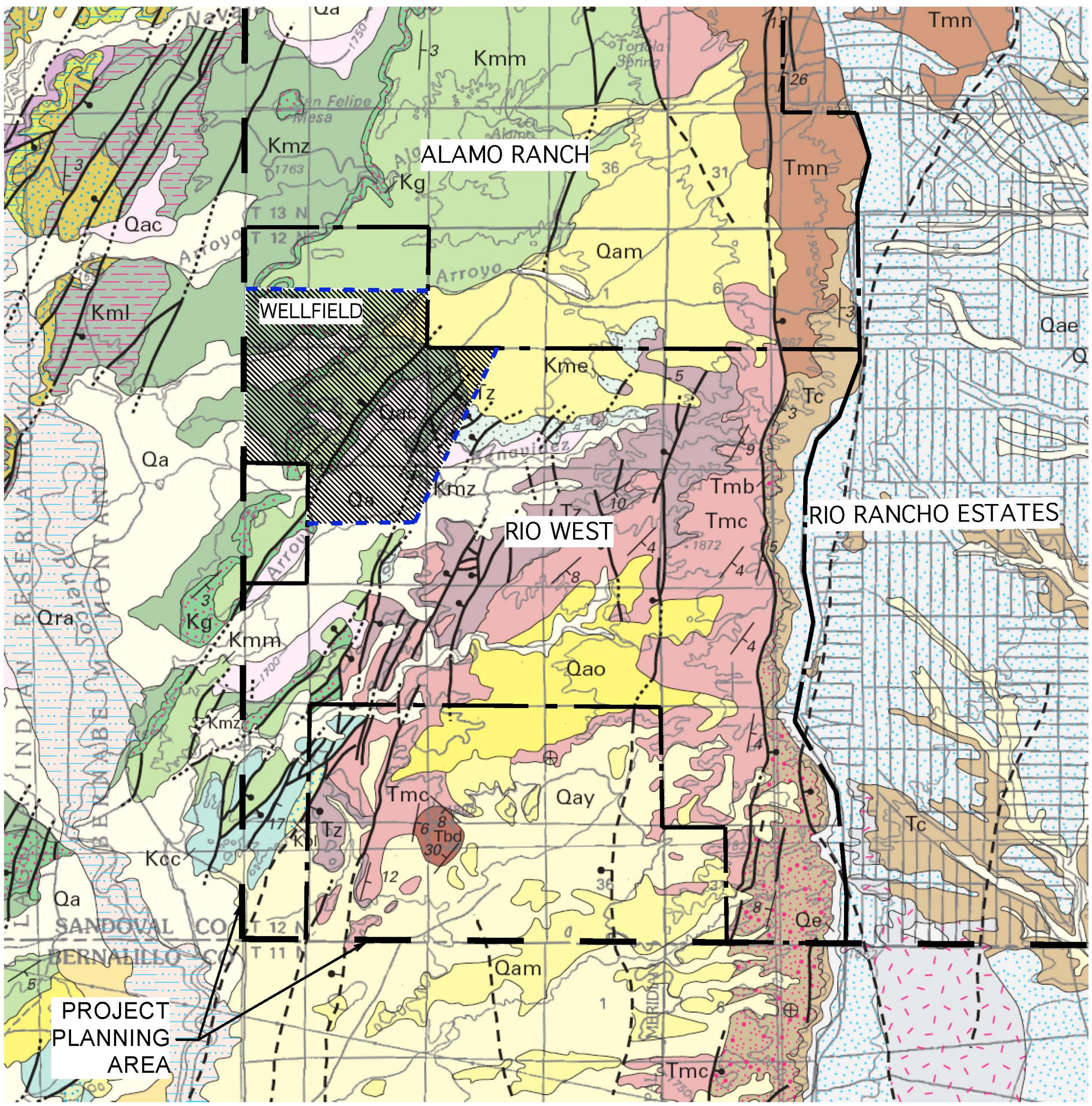
Groundwater is 3,500 feet deep or more, though small quantities may be found in the shallower depths.

Appendix B has a copy of the Natural Resource Conservation Service (NRCS) soil report for the area. Despite the number of differentiated units, the prevailing soils are all described as loamy fine sands and fine sandy loams. The soils throughout the study area are predominantly:

- Granular
- Well drained
- Non-expansive
- Unsaturated
- Easily excavated

The majority of the planning area is clear of the Rio Puerco flood hazard areas. The flood hazard areas are limited to arroyos and drainage channels for the most part. If the recommendations of this report, outlined in Section 7, are implemented, the Phase I construction area will be in the northwest portion of the Rio West development area, and outside of any arroyos.

Figure 2-6 shows the FEMA Flood Rate Insurance Map for the central portion of the Phase I area. The site is located well outside the Rio Puerco flood hazard area. Flood hazard is limited to the One Arroyo and Arroyo Benavidez drainage channels, which are narrow and easily avoided in site selection and design.



REF: WILLIAMS, P.L, AND J.C. COLE, 2007, GEOLOGIC MAP OF THE ALBUQUERQUE 30' X 60' QUADRANGLE, NORTH-CENTRAL NEW MEXICO

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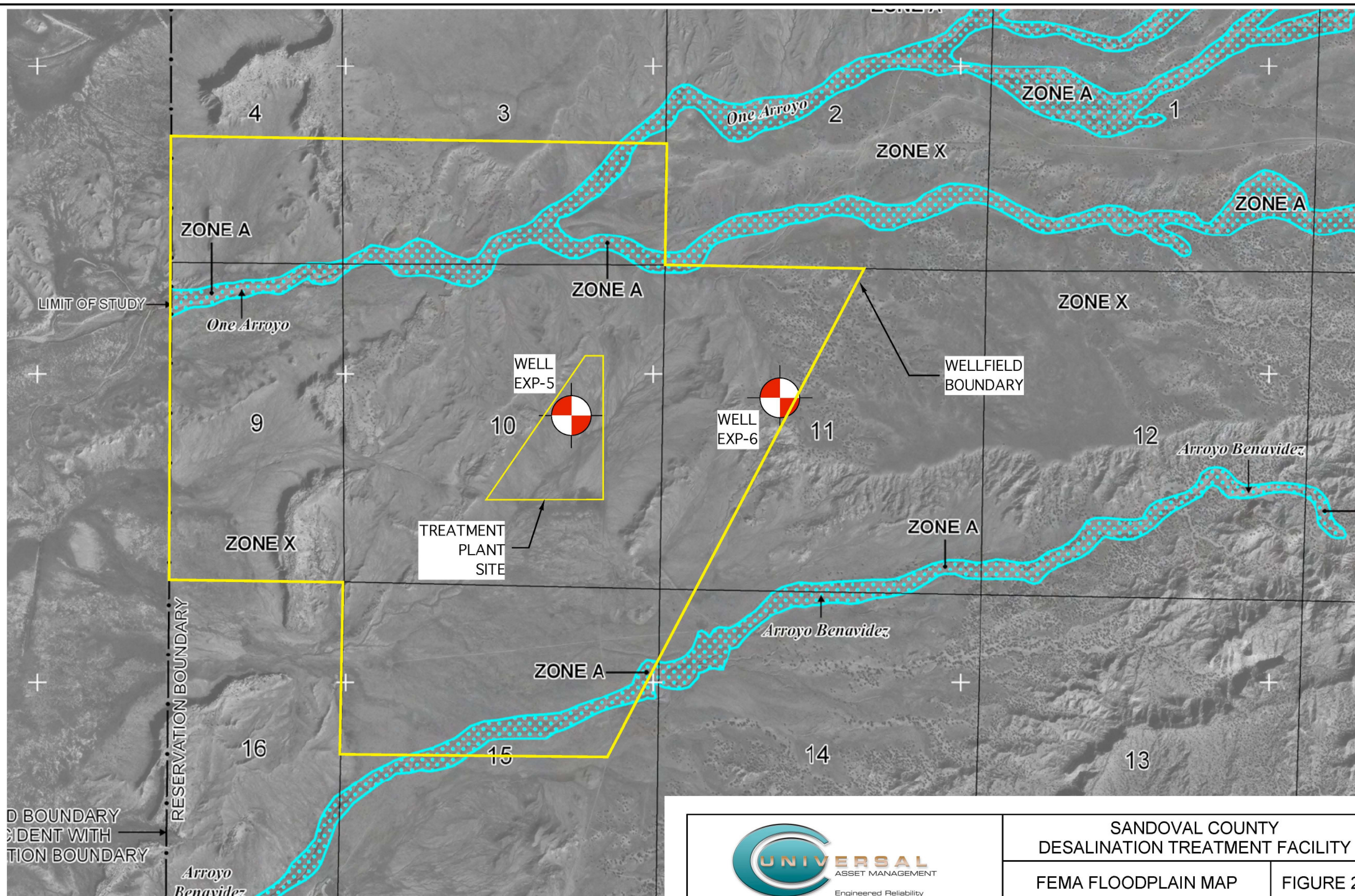
SANDOVAL COUNTY
DESALINATION TREATMENT FACILITY

GEOLOGIC MAP

FIGURE 2-5



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SANDOVAL COUNTY DESALINATION TREATMENT FACILITY	
FEMA FLOODPLAIN MAP	FIGURE 2-6

2.3 OTHER WATER USES

The western majority of the planning area is presently used as rangeland with low livestock density. A few low volume shallow wells produce water for the existing residents. The Benavidez well, typical of other wells in the area, is 114 feet deep and provides water to a stock tank and one residence. The shallow water source tapped by the Benavidez well is insufficient for the expected population growth and should not be affected by the project.

There is no commercial-scale irrigated agriculture within the planning area. Similarly, there are no municipal water supplies within the planning area nor are there surface water intakes or uses.

2.4 ENVIRONMENTAL RESOURCES PRESENT

Detailed environmental studies have not been completed at the time of this report. The following paragraphs summarize the resources that will be evaluated by the future report.

2.4.1 Important Land Resources

The lands within the planning area have poor sandy soils and no water, and are presently used for low-intensity ranching.

- There is no irrigation or farming.
- Recreational uses are infrequent, including fossil hunting and all terrain vehicle (ATV) tours.
- The site does not include wetlands and is not located in a floodplain.

2.4.2 Historic and Cultural Sites

The New Mexico State Register of Cultural Properties lists 94 properties in Sandoval County, none of which are within the planning area. Table 2-2 lists the closest historical and cultural sites.

Table 2-2 - Nearby Historic and Cultural Sites

File No.	City	Name
226	Laguna Pueblo	Masonry Dam of the Rio Puerco
1383	Rio Rancho	Corrales North Archaeological District

Appendix C includes an excerpt from the State Register document. Sandoval County properties are listed on pages 108 - 115.

2.4.3 Endangered Species and Critical Habitats

Appendix D summarizes the listed and sensitive species in Sandoval County, as published by the US Fish and Wildlife Service. The planned water development project is not expected to affect threatened or endangered species or important habitat. Environmental studies will accompany the detailed design phase. Appropriate avoidance or mitigation will be included in the design.

2.5 GROWTH AREAS AND POPULATION TREND

Continued economic development within the planning area is the primary project goal. Sandoval County's companion goal is containing that economic development adjacent to the City of Rio Rancho and preserving the County's rural character elsewhere. Water supply in the planning area is necessary for that growth, and leading the effort to supply that water increases the County's influence in facilitating compact, well-planned growth.

2.5.1 Demographic Data Sources

Population projections for the planning area were derived from these sources:

1. University of New Mexico Bureau of Business and Economic Research (UNM BBER), who publish statistical projections based on past population growth. The most recent BBER data

were obtained from http://bber.unm.edu/demo/table1.htm. The countywide projection was then modified to exclude projected population growth in the (generally small) communities outside the planning area.

2. The Mid-Region Council of Governments of New Mexico "2030 Socioeconomic Forecasts" (Publication S-07-01, 2007), a copy of which is available at: http://www.mrcog-nm.gov/content/view/190/265/.
3. Sandoval County Community Development Department's study of land use in the Rio Rancho Estates subdivision titled "Water and Wastewater Issues in Rio Rancho Estates Area" (August 2009) that includes a nodal analysis of long-term population growth for the Rio Rancho Estates part of the planning area.
4. The approved Master Plan and Development Agreement for the 11,673-acre Rio West planned community, modified to accommodate present economic conditions.
5. Extensive demographic analyses prepared by Sandoval County Community Development that addresses planned communities in the planning area that are not considered by the other sources.

2.5.2 Growth in Sandoval County

Southern Sandoval County has experienced significant economic development and related population growth, and is planning to accommodate further growth adjacent to the developed areas. According to the US Census Bureau, the Sandoval County population was estimated to be 89,908 in 2000 (recorded in the 2000 census[3]). Sandoval County experienced a 36% population increase between 2000 and 2008, resulting in a 2008 population of approximately 122,298 people. This equates to a population growth rate of approximately 3.9% per year over the previous eight years.

2.5.3 Growth in the Planning Area

The planning area is the fastest growing area in New Mexico. Sandoval County supports this growth but has a commitment to protecting a rural lifestyle outside of the areas slated for urban development. This section describes growth projected by State and Regional agencies for the planning area in terms of new dwellings and also new population.

2.5.3.1 Projected New Dwellings in the County

The Sandoval County Community Development Department maintains updated projections for significant development projects planned in the County. Table 2-3 summarizes the identified projects within the planning area.

Table 2-3 – Planning Area Development Projects

Project Name	Expected 20-year New Dwelling Units
Rio Rancho Estates	6,159
Rio West	22,073
Rancho Grande	4,197
Breezy Point	612
Quail Ranch	13,641
Total	**46,682**

[3] http://quickfacts.census.gov/qfd/states/35/35043.html

About 43,000 new dwelling units are planned to be located in unincorporated Sandoval County. The exceptions are about half of the new dwelling units in the platted (but still largely undeveloped) Rio Rancho Estates subdivision, which now happen to be located within the City of Rio Rancho.

The proposed 5 MGD project will supply approximately 14,300 dwelling units, or about 31% of the demand arising from the expected growth. Sandoval County proposes this water supply project to promote, and exert control over, general economic development in the County. The Project does not intend to serve all prospective future development that Regional and State plans assign to this part of the County.

The developers of the master planned communities listed in Table 2-3 are responsible for securing a 100-year water supply for their projects. This proposed project is the first of likely several 100-year supplies. Numerous similar supply projects will be necessary to realize the BBER growth projections for the planning area. Sandoval County, by building the first such project, intends to facilitate an integrated long-term water supply strategy for the planning area.

2.5.3.2 Projected New Population in the County

Table 2-4 summarizes the projected new population for the planning area communities referenced in Table 2-3, assuming an average of 2.33 people per dwelling.

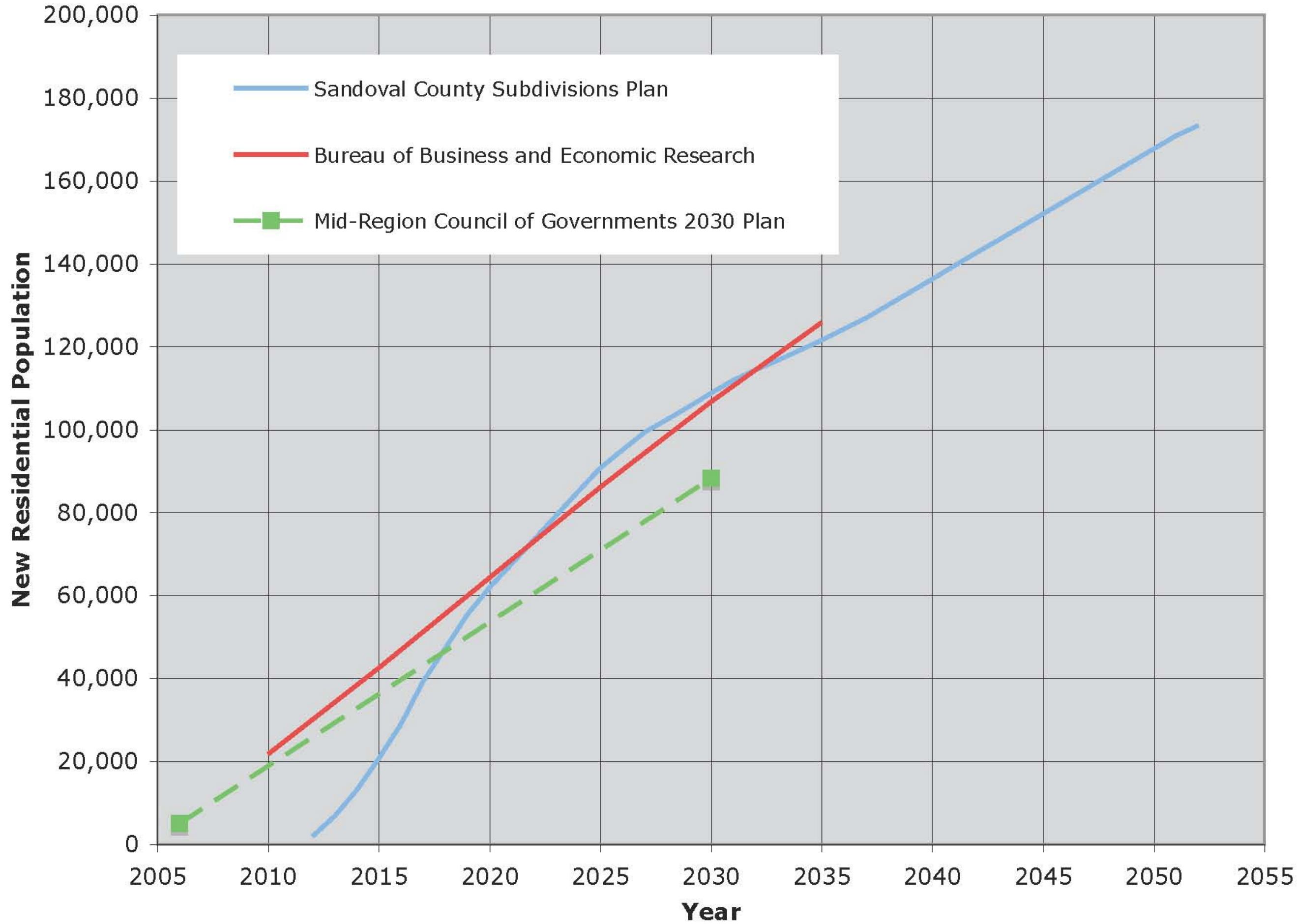
Table 2-4 – Population Projections

Community	2031 Population
Rio Rancho Estates	14,350
Rio West	51,430
Rancho Grande, Quail Ranch, and other Communities	42,989
Total	**108,769**

Figure 2-7 illustrates the population projections compiled by Sandoval County, the Bureau of Business and Economic Research (BBER), and the Mid-Region Council of Governments (MRCOG) 2030 plan. It is apparent that the Sandoval County projection is in line with the BBER population projection and is also similar to the MRCOG projection for the planning area.

This Preliminary Engineering Report adopts the Sandoval County population model because it generally agrees with the statistical projection models, but includes additional data and finer resolution. The Sandoval County projection accounts for all planned growth in the planning area, including some of the undeveloped land on the west end of the City of Rio Rancho. The planning area generally excludes the growth potential from infill projects in Rio Rancho’s urban areas.

Figure 2-7 - Population Growth Projections



2.5.4 Growth in the City of Rio Rancho

As a customer of the planned wholesale water plant, Rio Rancho's water requirements are an important consideration in determining population trends in the planning area.

Rio Rancho is the third-largest city in New Mexico and the fastest growing community in the state. Population in 2008 was estimated to be approximately 79,000, and is projected to reach 96,800 in 2014[4].

As documented within the City of Rio Rancho's Water Resources Management Plan, there is a general concern that growth within the City could outstrip the City's ability to provide water to new customers. The City is presently implementing a buy-and-retire rights acquisition program to eliminate that gap (refer to Section 5 for additional details). Competition for existing water rights is causing rapidly escalating costs. Furthermore, Rio Rancho has no control over the rate at which rights are offered at auction, and the recent availability of water rights has lagged behind the City's need.

The City of Rio Rancho has expressed interest in working with Sandoval County with regard to a wholesale water supply agreement (reference the Letter of Interest in Appendix E). The City indicates an immediate need for 5 MGD of potable drinking water to accommodate near term commitments. This demand is discussed further in the next sub-section.

2.5.5 Water Demand in the Planning Area

The planning area is largely undeveloped (excluding the City of Rio Rancho adjacent to the east), so there is not an appreciable history of domestic or commercial water demand. The master planned communities will have a character similar to the City of Rio Rancho, and the Wholesale Water Utility plans to implement similar water conservation policies.

It is therefore anticipated that annual water demand for the new developments will be similar to the Rio Rancho consumption profile. A 2007 study in Rio Rancho (Appendix F) indicates that the average annual water consumption is 150 gallons/person/day, with a max day to average day factor of 1.42. The projected demand is based on a typical demand per person of between 100 and 115 gal/person/day plus an allowance for commercial, small industrial, and school system demand.

Table 2-5 outlines the projected water demand for the 2030 and 2050 planning period. As discussed above, and outlined within Table 2-4, the City of Rio Rancho has an immediate need for 5 MGD of wholesale water. With an executed wholesale supply agreement, the City of Rio Rancho would be the sole wholesale customer for the entire project.

Table 2-5 – Water Demand Projections

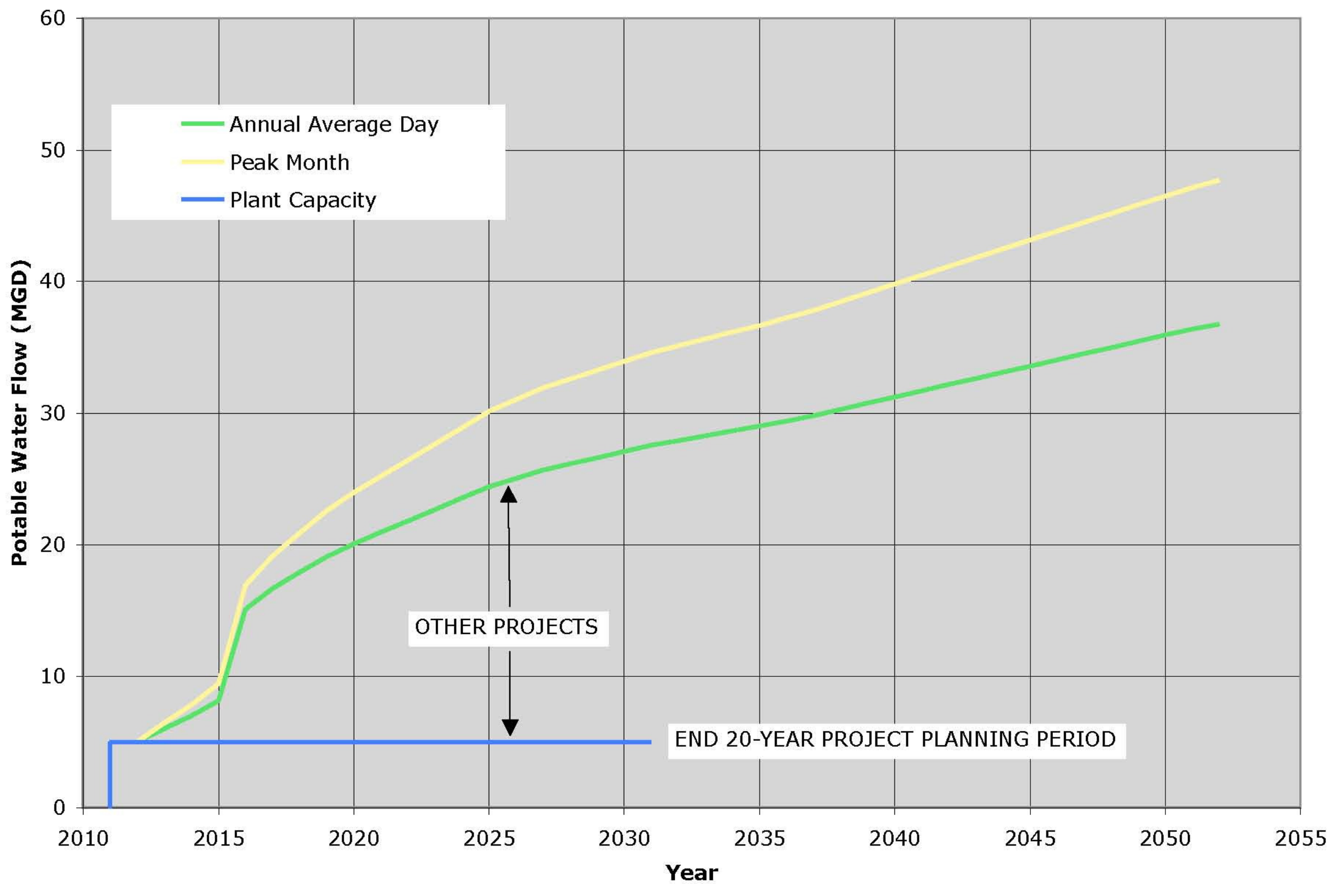
Community	Projected Demand (Gal/Day)	
	Year 2012	Year 2030
City of Rio Rancho	5,000,000	10,750,000
Rio Rancho Estates	-	2,152,500
Rio West	-	7,714,500
Rancho Grande, Quail Ranch, and other Communities	-	6,448,350
Total	**5,000,000**	**27,065,350**

Figure 2-8 shows the annual average day water demand based on the projected population growth.

[4] http://www.rredc.org/rrprofile/demographics.html

- The initial demand is 5.0 MGD based on meeting the immediate needs of the City of Rio Rancho.
- Population growth creates a new 5.0 MGD demand around 2015.
- In those 5 years, Rio Rancho has bought and retired other water rights and transitions away from buying water from the proposed Wholesale Water Utility.
- Combined demand increases to 27 MGD by the year 2030. Other projects will be necessary to meet this demand. The proposed project, although modular, is limited to 5 MGD and a 20-year planning horizon.
- The ultimate demand projection for the planning area (in the year 2050) is approximately 36 MGD. While 6 additional modules of 5.0 MGD could be developed, such water supply planning should be linked to future development and attendant water demand.

Figure 2-8 - Water Demand Projections



SECTION 3
EXISTING FACILITIES

3.1 HISTORY AND DESCRIPTION OF EXISTING SYSTEMS

The proposed Sandoval County Wholesale Water Utility is a new, independent, wholesale water supply system. Two exploratory wells installed in 2007 for the purpose of aquifer testing are the only existing water infrastructure. The planning area is not served by paved roads and does not have any existing utility facilities or services.

3.2 LOCATION MAP

Figure 2-2 shows the planning area relative to the Sandoval County. Figure 2-3 shows a closer view of the various planned developments. The project proposes to sell wholesale water from the vicinity of the Rio West community. Connection routes to client water utilities outside of Rio West will be determined by the client utilities, and are likely to follow transportation and utility corridors.

3.3 HISTORY

The western half of the planning area is presently undeveloped and has no existing water service. The expected development pattern throughout the planning area is similar to the Rio Rancho land use mix. The client communities are planned to have these water system users:

1. Residential Consumption – Residential uses are the majority of the expected water demand. Rio Rancho Estates is already platted and could have up to 12,532 new homes and 28,992 new dwelling units.
2. Commercial Uses – Rio Rancho Estates has a few large parcels planned for commercial development. Rio West will include commercial development appropriate for the planned residential occupancies. The smaller communities like Rancho Grande and Breezy Point are expected to have less commercial use.
3. Community Uses – The client communities are large enough to require schools, parks, community buildings, and public safety buildings.
4. Industrial Uses – Rio West includes a moderate light industrial component and a proposed airport.

The project will adopt the Rio Rancho water conservation program and require client communities to conform to the conservation practices.

3.4 CONDITION OF FACILITIES

Two exploratory wells were drilled to explore the potential ground water source. The brackish water wells are in good working condition. These wells are exploratory (not production) wells; some aspects of drilling, casing, and development vary from conventional water well details.

There are no other permanent facilities yet at these sites so all central collection, treatment, storage, and distribution facilities will be constructed specifically for the project.

The facility is not producing potable water, and so has no history of Safe Drinking Water Act and State regulations compliance. The raw water, like other groundwater supplies in New Mexico, has naturally occurring levels of various pollutants that must be removed by the treatment process. This is described further in Sections 6 and 7.

3.5 FINANCIAL STATUS OF ANY OPERATING CENTRAL FACILITIES

The project has no active facilities and the operating entity was only recently incorporated. A copy of Sandoval County's Bylaws, and Ordinance, is provided in Appendix G. The project will be owned by

Sandoval County and therefore the project's financial status is tied to that of an "A" credit rating. This credit rating will allow the project to earn a significantly low interest rate on the debt. Appendix H includes the most recent financial statements from Sandoval County.

SECTION 4
NEED FOR PROJECT

The proposed 5.0 MGD wholesale water supply project satisfies two needs:

- Facilitate the City of Rio Rancho meeting their immediate need for water supply. This would be a purely commercial, though mutually beneficial, transaction between the Sandoval County Wholesale Water Utility and the City of Rio Rancho, the County fulfilling the City's need and in return using the City's financial commitment to secure project financing.
- As Rio Rancho, over time, acquires water supply through their buy-and-retire program, transition the same 5.0 MGD supply over to new developments in the planning area. The Rio West master planned community comprises 11,700 acres entirely within the service area, and is therefore the likely candidate to create a client water utility that will buy water from the wholesale water project.

The following paragraphs describe the project's ability to comply with three principal project motivators.

4.1 HEALTH, SANITATION, SAFETY, AND SECURITY

There are no present health, sanitation, safety, or security issues affecting the undeveloped planning area. The proposed centralized project provides a managed water supply that replaces individual wells, and associated overdraft and wellhead protection issues, intrinsic to the original Rio Rancho Estates subdivision.

4.2 SYSTEM OPERATION & MAINTENANCE

There are no O&M issues in the undeveloped planning area. The proposed wholesale water plant will include appropriate automation and monitoring equipment that minimizes operation and maintenance costs while retaining full-time oversight of the treatment plant. The plant will also be designed to accommodate a full-featured asset management plan and reliability centered maintenance (RCM) program, a reliability tool for leveling operating costs, preventing service interruptions, and reducing overall costs. Appendix I includes additional information about the RCM program.

4.3 GROWTH

Population in the planning area is growing faster than any other community in New Mexico. The City of Rio Rancho has successfully pursued a strategy of aggressive growth and has created significant economic opportunities within City limits. The City, Sandoval County, and the Mid Region Council of Governments intend that this rapid economic development continue west into the unincorporated County lands.

Providing centrally managed water supply increases the County's ability to manage future growth, balance economic and lifestyle goals, relieve development pressure in rural areas, and assure public safety in an area where BBER, MRCOG, and the County all expect future rapid growth.

SECTION 5
WATER SOURCE ALTERNATIVES

Three alternative strategies are considered for providing 5.0 MGD of potable water to the planning area by 2012 in order to support economic development and population growth:

1. New Brackish Groundwater Source – Drill wells to develop the artesian, brackish groundwater directly beneath the planning area. Rights to this water are available at no cost, but the pretreatment process is relatively complex and minerals removed require re-processing to create useful derivative products.
2. Buy-and-Retire Rights in the Middle Rio Grande Basin – Acquire 5,600 acre-feet/year rights from the Middle Rio Grande basin. Such rights are costly and come available in small blocks, but the treatment process would be conventional and transmission from the point of diversion would be about 21 miles.
3. Buy-and-Retire Extra-Regional Rights – Acquire 5,600 afy rights from a different source outside the Middle Rio Grande Basin. We assumed that large blocks of water rights could be purchased from customers of the Fort Sumner Irrigation District, similar to the Berrendo project currently being discussed. Water treatment would be conventional and rights costs would be moderate, but the 175-mile long transmission pipeline and pumping would be costly.

Table 5-1 summarizes the three viable alternatives.

Table 5-1
Water Source Alternatives

Description	Intake Type	Point of Diversion	Transmission
Brackish Groundwater	5 Deep Wells	Below Service Area	½ -mile Collector Pipelines
Buy & Retire Middle Rio Grande Rights	River Intake w/ Pump Station	West Bank Rio Grande	21-mile Pipeline
Buy & Retire Pecos River Rights	River Intake w/ Pump Station	Lake Sumner	175-mile Pipeline

The following sections provide additional detail for the three alternatives:

5.1 Alternative 1 - Brackish Groundwater Development

Alternative 1 considers developing the untapped brackish water aquifer that underlies the service area. This alternative has no water rights costs and is entirely contained within the service area, but the treatment process is complex relative to Alternatives 2 and 3. The rest of this section describes the features of the Brackish Groundwater water source alternative.

5.1.1 Design Criteria

The design criteria for all three alternatives are identical: By 2012, Provide 5.0 MDG potable water for wholesale delivery to client water utilities at a central location in the service area. Treated water will comply with all federal and state regulations that pertain to potable water.

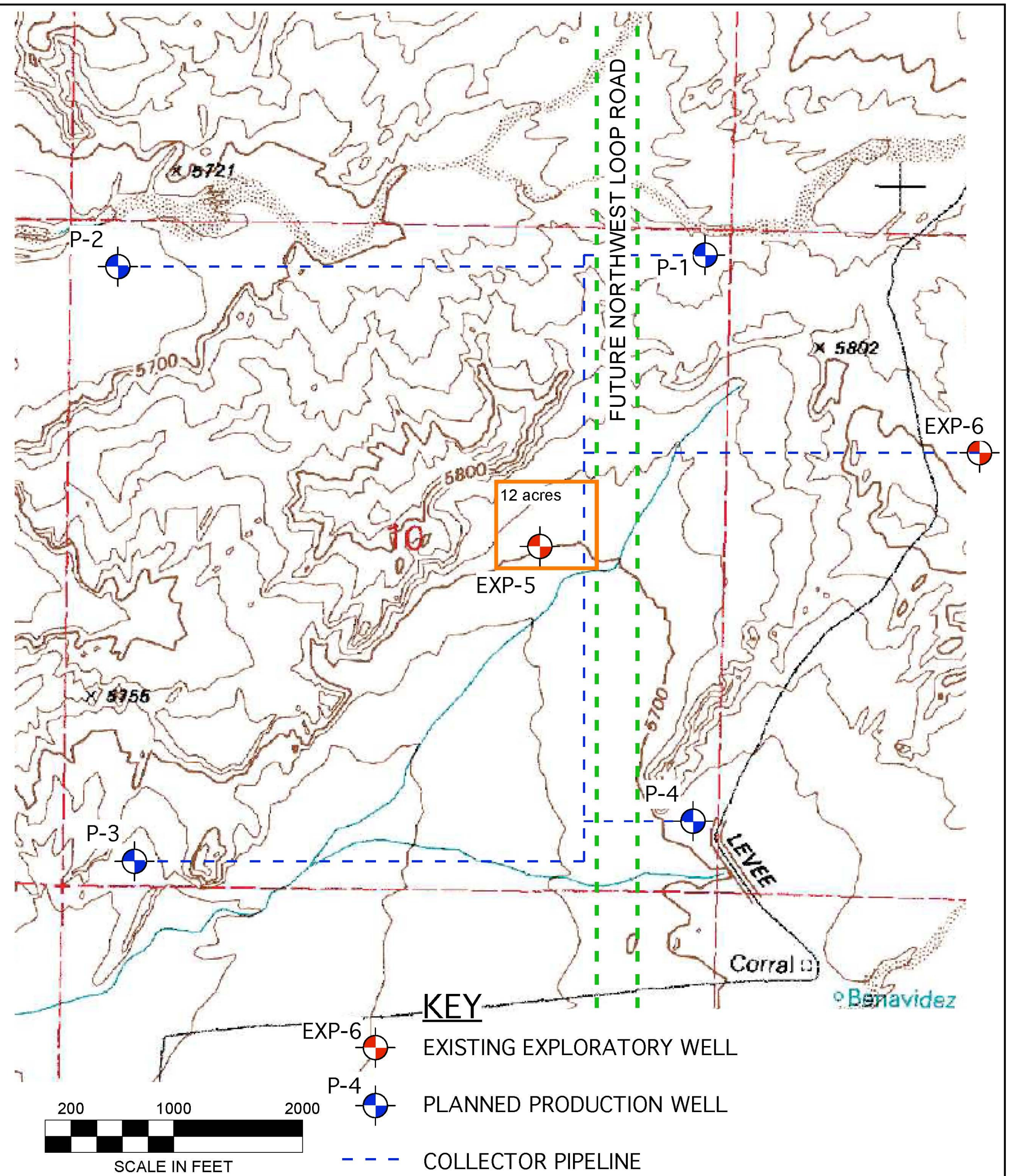
5.1.2 Description

This alternative involves the Sandoval County Wholesale Water utility:

- Drilling 5 production wells that tap the brackish groundwater aquifer directly beneath the service area,

- Processing the brackish water through a series of pretreatment stages that culminates with reverse osmosis,
- Processing derivative products removed from the brackish water to create building materials, and
- Delivering the water into an adjacent 5.0 MG storage tank from which client utilities can draw.

Figure 5-1 shows a preliminary arrangement for Alternative 1.



REF: USGS, 1990, "SAN FELIPEMESA QUADRANGLE, NEW MEXICO - SANDOVAL COUNTY, 7.5-MINUTE SERIES (TOPOGRAPHIC)

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DESALINATION TREATMENT FACILITY

ALTERNATIVE 1 PLAN	FIGURE 5-1

5.1.3 Soil and Groundwater Conditions

Figure 5-2 shows the overall extent of the aquifer that supplies Alternative 1, with the planning area located in the southeastern corner.

Soil conditions within the planning area are generally favorable for trenching between wellhead and treatment plant and also for foundations at the treatment plant site. The following paragraphs summarize the important site condition aspects.

5.1.3.1 Geologic Setting

The site is located in the broad Rio Puerco valley, east of the river and west of the badland escarpment that separates this region from the Rio Grande watershed. The surface trace of the Moquino Fault, which is down-dropped on the eastern side, cuts the valley from northeast to southwest. This fault is recognized as the western structural margin of the northern Albuquerque basin and has over 2,000 feet of vertical throw based on published unit thicknesses.

In the 4,000 feet of interest to the production wells, geologic units include Mesozoic sedimentary formations ranging from Cretaceous to Triassic in age. An isolated permeable layer named the Red Tanks and Atrasado Formations, sandwiched between older impermeable units about 5,400 to 5,800 feet deep. Precambrian bedrock, below the permeable units, lies at a depth of about 6,300 feet on the west side of the Moquino fault, and as deep as 8,300 feet on the east side (under Rio Rancho Estates).

Figure 5-3 is an aquifer/geologic cross section showing the rock layers, their relative thicknesses, and the permeable zones. Appendix J includes a copy of the aquifer test report that provides a detailed summary of the geologic conditions throughout the planning area and the pertinent aspects of geology on the groundwater resource.

5.1.3.2 Geotechnical Conditions

The available treatment plant sites are located on the broad eastern terrace of the Rio Puerco valley. The geologic map of the area (Figure 2-5) shows five geologic deposits underlying the proposed well field and plant, none of which present difficult trenching or foundation conditions.

The prevailing rock units are two members of the upper Cretaceous Mancos Shale:

- Mulatto Tongue Shale (Kmm) - Described as a dark- to light-gray and olive-gray shale, silty and sandy shale, and fine-grained ripple-marked sandstone.
- Montezuma Valley Member of the Mancos Shale (Kmz) - Described as gray to olive-gray, well indurated, slightly silty-sandy calcareous shale.

A thin band of Gallup sandstone is shown separating these two shale units. The Gallup is a yellowish-gray and yellow, medium to coarse grained, cross bedded sandstone

In addition to the three older rock deposits, younger unconsolidated materials mantle the flatter areas:

- Colluvium and Alluvium (undivided) Qac – Poorly sorted, poorly consolidated mixture of sand, silt, and angular gravel derived from mass movement slope processes and rain wash.
- Alluvium Qa – Unconsolidated light brown to yellow-brown sand, silts, and gravel.

5.1.3.3 Foundation Conditions

Foundation conditions at the planned water plant are favorable, as are trenching conditions between the plant and the planned wellheads. Unconsolidated materials may be loose, but the granular nature indicates they can be compacted to a dense condition before building foundations.

5.1.3.4 Groundwater Elevations

Groundwater is over 100 feet deep in the planning area, much deeper than the excavation depths required for the planned construction.

5.1.3.5 Watershed and Relation to Water Source

The planned construction is in the Rio Puerco watershed. The planned water source is a 3,500 feet deep aquifer separated from the Rio Puerco valley by 1,500 feet of low-permeability Chinle formation materials. The brine injection layer is an additional 1,600 feet deep below low permeating Yeso formation rocks

The Santa Fe National Forrest watershed likely recharges the aquifer. The planned construction should have no effect on the recharge area, and good stormwater design should preserve water quality in the Rio Puerco.

5.1.4 Water Resource Data

5.1.4.1 Population Trends

The planning area is undeveloped and sparsely inhabited, but is also on the western edge of the fastest growing part of New Mexico. Demographic projections indicate that population in the planning area will grow as fast as water can be supplied. The Rio West master planned community, which surrounds the planned wholesale water delivery point, is approved for 28,992 dwelling units, or about twice the capacity of the proposed 5.0 MGD plant. The BBER 2050 demographic projection predicts that the planning area population will expand, assuming available water, to require the equivalent of seven modular 5.0 MGD water projects.

5.1.4.2 Present Water Consumption

Present consumption is zero because no infrastructure exists in the planning area. Extrapolating from demographic and consumption profiles in Rio Rancho, the service area is expected to have 2.33 residents per household who demand an annual average 150 gallons per person per day. Peak demands will be met through storage provided by the client water utilities. Under this consumption profile, the 5.0 MGD project will serve 33,333 people or about 14,300 new households.

5.1.4.3 Water Availability Assessment

Sandoval County has the necessary rights for Alternative 1. Planning for the proposed brackish water development project started in the mid-2000's, when New Mexico Statutes Annotated (NMSA) Section 72-12-25 still excluded from regulations water more than 2,500 feet deep and with salinity above 1,000 mg/l. That exclusion was cancelled in the first session of the 2009 New Mexico State Legislature, creating a new regulatory authority for the State Engineer over this water source.

The landowner in 2007 filed Notices of Intent (NOI) to drill several exploratory wells for the brackish water development project, two of which (EXP-5 and EXP-6) were used to characterize the target aquifer. The Office of the State Engineer has affirmed that the NOI's are not affected by subsequent changes in state law.

5.1.4.3.1 Aquifer Characteristics

The Alternative 1 water source is the San Andreas/Glorieta (SAG) unit, a confined aquifer located at a depth of about 3,500 feet in the southeastern portion of the San Juan Basin. The aquifer underlies an 80-mile-long north/south corridor that is over 17 miles wide, for an area of approximately 2,000 square miles.

The aquifer is bounded on the east by a fault and on the west by plutonic bedrock. It is open on the north to the central San Juan Basin and on the south to the Acoma Sag. Figure 5-2 shows the exploration well locations relative to the aquifer boundaries. Figure 5-3 shows a geologic section drawn from the two exploratory wells that Sandoval County drilled for this project.

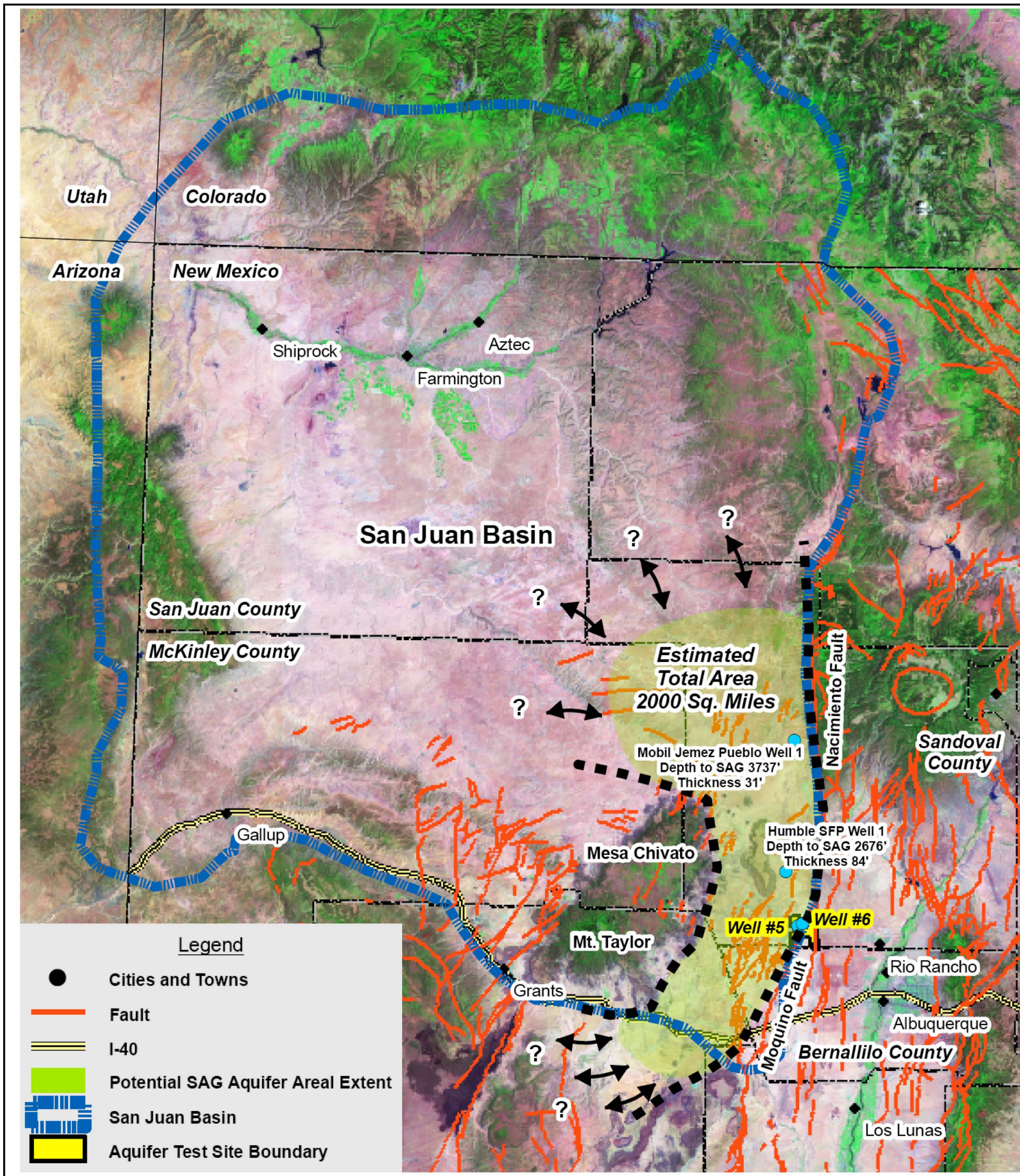
A copy of the aquifer test report prepared for this project is provided in Appendix J. The report includes detailed descriptions of geologic and hydrogeologic conditions around the aquifer, geologic cross sections, and water chemistry test results, along with the results of long-term well tests that were performed to characterize the aquifer and evaluate its suitability as a water source. Table 5-2 summarizes the pertinent aquifer characteristics.

Table 5-2 – Brackish Aquifer Characteristics

Wellhead Elevation (Feet MSL)	5,815
Phreatic Surface Elevation (feet MSL)	6,150
Water Bearing Layer Thickness (feet)	121
Water Bearing Material Types	Sandstone and Limestone
Well Test Flow Rate	150 & 250 gpm/well
Storativity (S)	6.92×10^{-4}
Transmissivity (T)	0.669 m^2/sec
Existing Production Wells	None
Typical Well Yields (gpm)	600-1200 gpm/well

5.1.4.4 Historic Aquifer Yield

The aquifer is presently undeveloped and has no historic yield or drawdown data. The available literature suggests that there have been no prior uses of this aquifer, so the historic yield is, by definition, zero.



REF: INTERA, 2008, DRAFT AQUIFER TEST REPORT, RIO PUERCO BRACKISH WATER DEVELOPMENT PROJECT

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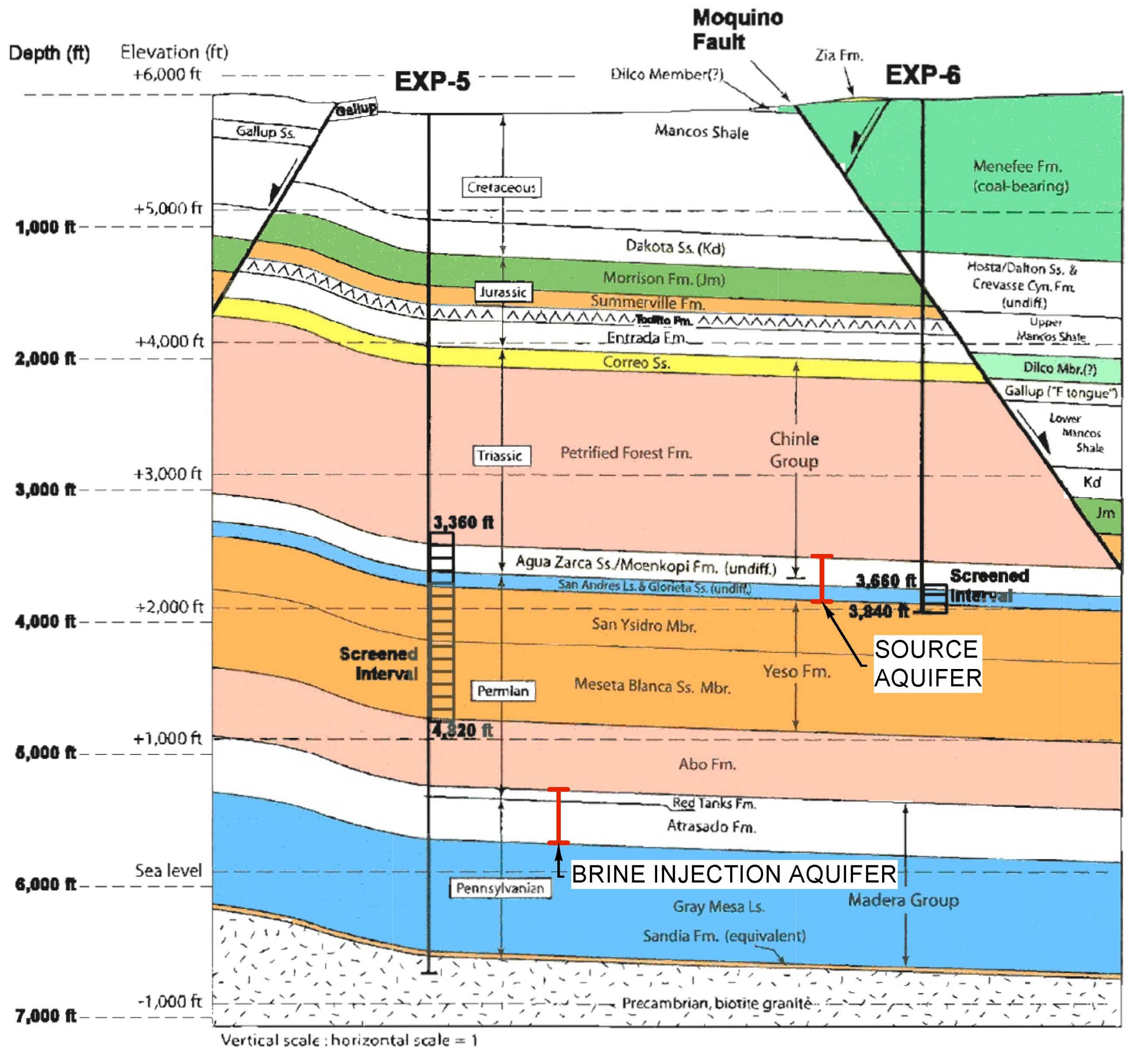
DESALINATION TREATMENT FACILITY

AQUIFER BOUNDARIES MAP | FIGURE 5-2



Adapted from Van Hart, 2007

REF: INTERA, 2008, DRAFT AQUIFER TEST REPORT, RIO PUERCO BRACKISH WATER DEVELOPMENT PROJECT

UNIVERSAL ASSET MANAGEMENT Engineered Reliability	SANDOVAL COUNTY DESALINATION TREATMENT FACILITY	
	AQUIFER SECTION	FIGURE 5-3

5.1.4.5 Reservoir Capacity

The well test and subsequent analyses reveal that the aquifer stores at least 576,000 acre feet and likely more than 2.6 million acre feet of recoverable water. The range is caused entirely by uncertainty in hydraulic connectivity between the discrete aquifer units. This issue should be better understood after the production wells are installed and operating for a prolonged period.

5.0 MGD demand is equal to 5,600 acre-feet per year, so the lower bound reservoir estimate of 576,000 acre-feet volume represents a 103-year supply for the 5.0 MGD project under worst-case conditions, and neglecting aquifer recharge. The computed reservoir capacity could be revised up significantly when future wells are completed successfully in the Aqua Zarca member of the Chinle formation.

5.1.4.6 Aquifer Sustainable Yield

The well test program yielded useful information for computing well productivity, but the 2,000 square mile aquifer area is large relative to the area that could be tested by a single well flowing at a few hundred gallons per minute. The hydrologic report in Appendix J provides a detailed hydrogeologic assessment of the aquifer's ability to support long-term growth beyond the levels addressed by this 5.0 MGD project.

Because of the very large scale, the real aquifer capacity can be proven only by withdrawing very large quantities of water over a much longer duration. The sustainable yield of other productive aquifers, in fact, is generally only demonstrated by observing the water level drops that indicate unsustainable withdrawal. The sustainable yield of an undeveloped aquifer is only as much as the test was able to withdraw, unless the test was uncommonly large relative to the aquifer capacity.

Sustainable yield information will be confirmed, therefore, using data collected from the five production wells as they withdraw 1,100 gpm each during the first several months or years of plant operation. This much larger aquifer test, actually a byproduct of withdrawing from the aquifer at a rate known to be within the sustainable yield proven by the test in Appendix J, will have enough influence on the aquifer that a higher sustainable yield estimate can be made.

Until such data are available, groundwater recharge estimates can be used to indicate sustainable yield. Ground water recharge to the San Juan Basin takes place primarily through streambed infiltration and infiltration of precipitation in the basin-margin outcrop areas. The margin outcrops of the San Andreas and Glorieta units, 3,500 feet deep at the site, are far from the planned well field. The Unites States Geological Survey published a 1996 report[5] indicating groundwater recharge for the entire basin, both brackish and freshwater elements, is about 85,700 GPM (138,300 ac-ft/yr or 123.4 MGD).

5.1.5 Flow Requirements

The project provides 5.0 MGD constant output to the client water utilities. Client utilities will provide fire flow and peaking capacity.

[5] Kernodle, J. M., 1996, Hydrogeology and steady-state simulation of ground-water flow in the San Juan Basin, New Mexico, Colorado, Arizona, and Utah: U.S. Geological Survey, Water-Resources Investigations Report 95-4187, 117 p

5.1.6 Sewerage System Available

The service area is presently undeveloped and has no infrastructure. While the planned wholesale water project will not distribute to individual customers, it is expected that the master planned communities ultimately served by the wholesale water utility will have standard sewerage.

5.1.7 Sources of Water Supply

Water for Alternative 1, the Brackish Aquifer source, will come from wells drilled at advantageous locations around the service area. Specific locations for the necessary five production wells had not been selected at the time this report was prepared, but there are no apparent difficulties integrating five half-acre wellhead sites in the Rio West master planned community.

The water supply is confined and protected by a 1,500-foot thick shale layer (low permeability Chinle formation) that creates confinement sufficient for 145 lb/in2 artesian pressure. Contamination from surface sources is not a credible threat. The resource is not tapped by other production wells and has very few exploration holes. Water production wells would all be associated with the proposed project so wellhead protection could be managed centrally.

5.1.8 Proposed Treatment Processes

Constituents of concern in the Alternative 1 water source include carbon dioxide, arsenic, radium, dissolved salts, total dissolved solids, hardness, and alkalinity. Section 6 of this report provides a detailed alternatives analysis of feasible treatment technologies for the brackish water. The results of that evaluation indicate this treatment process:

- Recovery of heat and pressure energy that can be used productively later in the treatment process.
- Stripping dissolved gasses and collection of CO_2 that can be put to productive use elsewhere in the process.
- Pretreatment to selectively remove arsenic and radium.
- Warm lime softening and collection of precipitate for recalcination.
- Filtration
- Zeolite metals removal
- Reverse osmosis

In addition to the core water treatment processes, Alternative 1 includes these supplemental facilities

- A small natural gas fired kiln for recalcining lime. The regenerated quicklime will be used in the plant for softening, and excess will be sold as a building material.
- Sodium chloride from the RO brine will be separated from sodium sulfate, crystallized into salt, and sold.
- Magnesium carbonate will be separated, crystallized, and sold.

5.1.9 Waste Disposal

Water treatment processes will remove a wide range of materials from the brackish water. Most of the removed compounds will be processed into residual products that have commercial value. Specifically heat, carbon dioxide, calcium, magnesium, and sodium chloride will be used as raw materials for manufacturing activities collocated with the water treatment plant.

A few substances present in the raw water cannot be commercialized. Specifically:

- Pretreatment will remove approximately 1,315 tons/year arsenic and radionuclides that will be disposed of in a hazardous waste landfill located in Andrews, TX.
- The reverse osmosis brine will be processed to crystallize sodium chloride for use as industrial salt. The remaining sodium sulfate brine, about 870 gpm, has no commercial value and will be reinjected to a deep aquifer under a permit approved by the New Mexico Ground Water

Quality Bureau. Solar evaporation ponds and landfilling will be used for brine disposal if an injection well is disallowed.

Section 7.4 provides additional detail on residual management processes associated with Alternative 1. The cost for disposing of these wastes, including the costs if no markets can be found for commercialized residual products, is included in Section 5.1.17.

5.1.10 Automation

The proposed wholesale water plant will include modern automation and monitoring equipment that reduces the potential for future operating and maintenance issues. The estimated cost includes training funds so that plant operators can accomplish all routine maintenance.

The project will have a full-featured asset management plan and reliability centered maintenance (RCM) program to reduce the risk of equipment breakdowns or expensive servicing. Through good training and professional management of routine issues, an RCM program levels operating costs, prevents service interruptions, and reduces overall costs. Appendix I includes additional information about the RCM program.

5.1.11 Treatment Plant Sites

A 12-acre treatment plant site is required for Alternative 1, along with five 1-acre well sites and easements for the collector pipes. Figure 2-3 shows the general treatment plant site relative to the planning area and service area boundaries. This location is preferred because of its proximity to the three prospective client utilities, Rio West master planned community surrounding the plant and to the south, the Rancho Grande community to the north, and the Rio Rancho Estates subdivision to the east. Also it appears possible to convert Well EXP-5 into a brine disposal well, which would be convenient to have on the treatment plant site.

The wholesale water utility has great flexibility in delineating a 12-acre site from the thousands of undeveloped acres in the service area. Essentially any 12-acre site, generally level and free of environmental and cultural resources, would suit the project. Considering that all of the land in the treatment plant vicinity is undeveloped, uncontaminated, out of the flood plain, lacks existing neighbors, and is generally suitable for supporting the planned construction, the principal site selection criterion is compatibility with the surrounding master planned community.

Sandoval County and the Rio West developer have started the process for selecting a site, a process that should be concluded early in design. All land and easements required for Alternative 1 will be acquired by purchasing from private owners. No federal lands are required.

5.1.12 Future Extensions

The wholesale water project could be expanded beyond 5.0 MGD by purchasing additional water rights, paralleling the transmission pipeline, and building additional water treatment plants. The proposed plant is compact and modular, so the efficient approach would be to place additional plants closer to client utilities rather than clustering them at the end of the 21-mile pipeline.

The New Mexico Bureau of Business and Economic Research predicts 168,000 new residents in the planning area by 2050. At 150 gpd per capita, the wholesale water utility could be asked to deliver 36 MGD, or about 7 modules of 5.0 MGD. The necessary water rights for ultimate buildout, assuming a buy-and-retire strategy meets all water needs in the planning area, are 39,200 afy. At that size, the Sandoval County Wholesale Water Utility would be the third largest water user on the Middle Rio Grande, surpassed only by the City of Albuquerque and Inca Construction.

Assuming the 450 afy per year acquisition rate that Albuquerque has experienced remains true, it would require 87 years to buy up enough rights to satisfy the demand expected in 40 years. This preliminary analysis suggests a significant weakness of pursuing a pure buy-and-retire strategy for supplying water to the planning area.

5.1.13 Process Flow Diagram

Figure 5-4 shows the Alternative 1 process flow diagram for treating brackish water. This process was selected through an extensive evaluation that included benchtop and pilot testing. Section 6 of this report provides a detailed description of that evaluation.

5.1.14 Environmental Impacts

Environmental studies will be completed once specific well locations and pipeline routes are selected, a process that requires coordination with the road and open-space alignments in the still-evolving Rio West community plan that surrounds the wholesale water project. This report section provides an overview of environmental issues that will be resolved before proceeding with the project.

Sewer Discharge – The planning area is largely undeveloped and currently has no sewage collection or treatment facilities. Isolated dwellings within the planning area are on individual systems.

The proposed project is intended to facilitate managed development within the planning area. Such development will require sewerage system availability in accordance with local, state, and federal regulations.

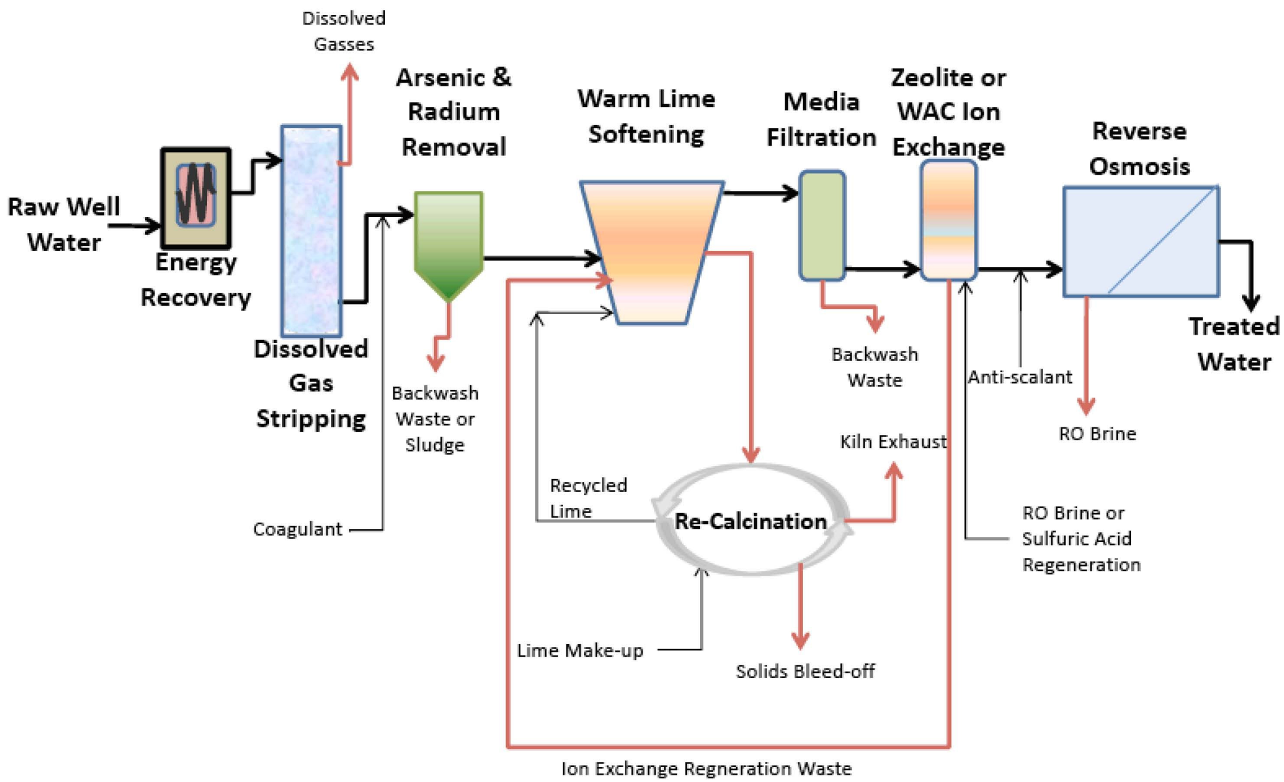
- In the Rio West community, the sewerage works are described in the Master Plan.
- In the Rio Rancho Estates area, Sandoval County is working on methods for avoiding construction of new individual wastewater systems. The centralized water available from the proposed plant is an important part of offering the full suite of municipal utilities to the lots.
- Other communities do not yet have an approved Master Plan. These pending developments will require sewerage service in conformance with Sandoval County, state, and federal requirements.

All treated water will be distributed through the City of Rio Rancho water utility or the distribution system of another client utility operating in the service area. Assuming that the water supplied will ultimately return to the Rio Grande through one of the Rio Rancho wastewater treatment plants, approximately 4.0 MGD could be ultimately discharged into the river (assumes 20% loss due to line losses, irrigation, and fire flow). The source water is not hydraulically connected to the Rio Grande (or other surface waters); therefore there would be a net increase in river flow. Future project phases could potentially contribute surface water flow to the Rio Puerco as well.

The project has not completed an EID. Avoidance and mitigation measures will be developed for each project phase as the preliminary plans are completed and the affected resources are identified.

Treatment Plant Site – The planned treatment plant site comprises 12 acres of relatively flat ground traversed by a southwest-flowing intermittent drainage way that flows onto the site through a (likely) culvert crossing under the future Northwest Loop Road. The final arrangement of the treatment plant and appurtenant facilities will accommodate the environmental resources that are found to occupy the site.

Pipeline Alignments – The raw water pipelines connecting wells to the treatment plant site are intended to run under or beside planned roads in the Rio West community. Roadways will also affect any environmental resources impacted along the pipeline routes, so a joint mitigation strategy will be pursued where mitigation is necessary. None of the collector pipelines is required to cross a named arroyo as planned and shown in Figure 5-1. Minor drainage crossings will likely be required. Drainage way crossings, where required, will be made by deep trenching, armoring over the pipe, and then restoring the drainage way to previous conditions.



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	ALTERNATIVE 1 FLOW DIAGRAM	FIGURE 5-4

Well Sites – The project creates four new 1.0-acre well sites that will be sited to minimize impact on the surrounding development. The well sites are relatively large to accommodate drilling fluid handling facilities, and may be reduced in area after the wells are installed. The new well sites will be permitted through the same process that was used to site the exploration wells EXP-5 and EXP-6.

Well Development Water – Brackish water discharged during well development will flow through aboveground temporary pipes to a permitted disposal system. It is unlikely that the development volumes will be large enough to require agricultural-scale irrigation equipment, as was used for the 30-day aquifer test. Subject to permit review and approval, development waters from each well will be sprayed through agricultural irrigation guns onto relatively flat ground far from drainage ways. The permitting process followed for exploration well drilling will likely also govern the production wells, including the environmental resource evaluation of the land application area.

Calcination Kiln – The lime regeneration kiln will have exhaust gasses that require an air permit. The project is not in an air quality limited area, and the lime sludge will be free of listed contaminants, so the design and permitting process should be relatively straightforward. Furthermore, planned heat and carbon dioxide reclamation from the exhaust gasses for on-site reuse reduce the net impact. Additional studies and designs will be completed to resolve detailed issues and to satisfy permitting and operating requirements.

Hazardous Waste Stream – Only one residual product from the water treatment process is hazardous and requires special handling. Arsenic and radionuclides will be removed by precipitation early in the treatment process in order to separate them from other, useful, residual products. The precipitate will be dewatered to the minimum practical volume, placed directly in shipping containers, and disposed of in a licensed hazardous waste landfill. The concentrated stream will not be exposed to air or soil, and the handling facilities will have appropriate secondary containment and segregation from other parts of the treatment plant.

Injection Well (option) – Approximately 19% of the raw water that enters the treatment plant is expected to be discharged as non-hazardous waste brine. The salts will be either mainly sodium sulfate or mixed sodium chloride, depending on the selected residual product strategy. Well EXP-5, located at the planned treatment plant site, may be converted for brine injection into the top of the Madera group formation at a depth of about 5,400 feet (1,600 feet below the raw water source aquifer.) Additional injection wells may also be required, depending on final brine volume and aquifer transmissivity. Additional studies will be conducted to demonstrate the Madera group groundwater is as salty and hard as anticipated, and also to confirm the present geologic interpretation that the Madera does not juxtapose against or connect to the Santa Fe group or other potable water resource. This concept is discussed further in section 6.11.5.

5.1.15 Land Requirements

Alternative 1 requires the purchase of a 12-acre treatment plant site, five 1-acre well sites, and easements for collector pipelines connecting the wells to the plant. All land being considered is privately owned and will be purchased by the project.

The 5.0 MGD treatment plant and water tank can be located on a 12-acre site anywhere convenient near the center of the service area. This site would be within the Rio West master planned community, approximately as shown on Figure 2-3.

Sandoval County is in the process of acquiring the necessary land from RECORP Partners Inc. Development Company LLC, the owner of the Rio West master planned community.

The five well site locations are advantageous because they all have:

- Very large separation from potential pollutant sources.
- Adequate space for well drilling and construction
- Broad buffers from future development
- Good easements for raw water supply pipes connecting to the treatment plant.

The land required for the construction of the recommended 5.0 MGD treatment plant is the 12-acre site shown on Figure 5-1. Future phases of the water project, if any, would be sited on similar parcels adjacent to this proposed site.

It is anticipated that a 40-acre site would provide enough land for future expansions up to the ultimate demand of 36 MGD (BBER's year 2050 projection), without the need for additional easements or land acquisition. Drawing C-1 (Appendix A) shows the 5.0 MGD treatment plant with residual processing facilities on the 12-acre site.

The selected 12-acre parcel for this facility allows for continual site access for general operations and maintenance, as well as potential process expansions. The allotted acreage allows for appropriate setbacks from any property boundaries. The water treatment plant site is located on the east side of the well field, generally centered on the initial 5-well layout that is also convenient to future phases, if any.

Because existing development is sparse and planning for the Rio West community is still in the early stages, the water plant location is a particularly favorable site. The site advantages include:

- Gently sloping ground
- No hard rock exposures
- Arroyo boundary on the northwest side providing a buffer from future non-industrial development
- Good access to the planned Northwest Loop Road
- Central location relative to the planned 5 wells.

The project area is entirely within the Rio West master plan area. Specific zoning has not been adopted, but will be consistent with the Master Plan and is expected to include residential, commercial, and light industrial uses. The area around the water plant, most likely, will be designated light industrial so that future uses are consistent with the water plant use. The wellheads will be located within a range of zones and will receive aesthetic treatment to blend consistently with surrounding use.

5.1.16 Construction Problems

This alternative has minimal exposure to construction problems. The planning area generally exhibits favorable construction conditions as follows:

- The candidate well and treatment plant sites are not affected by troublesome geologic conditions, such as hard rock or steep slopes
- Groundwater levels are much deeper than trench depths
- Exposed rock, if any, is relatively soft and can be excavated with conventional equipment
- None of the soils are expansive or subject to collapse

The following aspects will receive careful attention during design and permitting:

- The disturbed areas are larger than one acre; one or more SWPPP's will be obtained as a part of the design.
- The collector pipelines flowing from the wells may cross one or more arroyo. Arroyo crossings will be designed to accommodate future erosion.
- A detailed environmental and cultural resource assessment will be performed early in the design process so that the project can avoid encroaching on habitat and other resources.

5.1.17 Cost Estimates

Table 5-3 summarizes the estimated cost of Alternative 1. Additional detail is in Appendix K.

Table 5-3 – Alternative 1 Cost Estimate

CATEGORY	ITEM	COST
Construction	Water Rights	$0
	Wells and Collector Pipes	$14,456,300
	Treatment Plant	$58,413,400
	5.0 MG Storage Depot	$4,122,500
	Total Construction Cost	**$76,992,200**
Non-Construction	Design, Permitting & Bonds	$28,148,050
Annual O&M	Personnel	$1,246,000
	Chemicals & Maintenance	$333,325
	Total Annual O&M	**$1,579,325**
Whole Life Cost	Total Whole Life Cost	$244,261,478
	Total Whole Life Cost per Household	$17,081
	Estimated Water Rate[1] (per thousand gallons)	**$6.01**

Note 1: The water rate estimate is the quotient of the annual revenue requirement (debt service, including reserve, plus total operations and maintenance) divided by the annual water production (1.825 x 10^6 kgal/year).

Avoided waste disposal costs and revenue from selling residual products have significant influence on the water rate. While all residual products are widely used commodities, and furthermore the value assumptions are backed up by letters of interest in Appendix R, a supplemental cost estimate was performed that assumed the most costly brine disposal option and waste disposal fees for unwanted lime, magnesite, and salt. The worst-case water rate is $11.76/thousand gallons. Appendix L provides additional detail of the worst-case residuals disposal analysis.

5.1.18 Advantages and Disadvantages

Alternative 1 is the best choice considering the rapid need and the relatively large water demand. The expected rate is about half that of the other two alternatives, mainly because the water rights in Alternative 1 have no cost.

The principal Alternative 1 disadvantage is the multi-stage pretreatment process, though no new or rare technologies are required. There secondary project risks include:

- The cost estimates assume revenue from wholesaling commodities like table salt and quicklime made from minerals extracted by the pretreatment processes. Commodity prices will vary over time, though in all cases the cost of marketing the derivative products is less than the cost of landfill disposal.
- The treatment plant is expensive and takes up more room than the conventional plants that Alternatives 2 and 3 require. This higher cost, though, is still much less than the cost of water rights, and the land costs are very low in the presently undeveloped service area.

- Operating costs are high because of the additional personnel required in the treatment plant and in the residual processing facilities. Sandoval County considers this an advantage, though, because the project's personnel costs arise from the new manufacturing jobs that the project creates.
- It is possible that the public may be slow to accept potable water created from a new source, particularly a brackish source known to require extensive treatment.

Table 5-4 rates Alternative 1 on each significant aspect of the project and computes a weighted value for each criterion. Rankings are assigned values between 1 and 10, and the weighting sums to 100, so the maximum score is 1,000.

Table 5-4 – Alternative 1 Rating

Criterion	Comment	Rating (1 – 10)	Weight (100 total)	Score
Resource Capacity	More than 5,600 afy for 100 years	10	10	100
Raw Water Quality	Extensive pre-treatment required	6	10	60
Schedule	3 years	9	15	135
Future Extensions	Likely very easy	8	5	40
Operational Constraints	Residual processing	7	5	35
Public Concerns	New source acceptance	5	10	50
Health Issues	None after treatment	9	20	180
Environmental Issues	Easily mitigatable	9	5	45
Water Rate	$6.01 /kgal	7	15	105
Whole Life Cost	$17,081 /household	6	5	30
			Alternative 1 Rating	**780**

Under worst-case conditions for residual product disposal, the rate increases to $11.76/kgal, the rating for cost drops from 7 to 3, and the Alternative 1 worst-case rating drops 60 point to 720.

5.2 Alternative 2 - Buy and Retire Rights in the Middle Rio Grande Basin

Alternative 2 considers drawing raw water from the Middle Rio Grande basin (MRG) and transporting it west to the service area. This alternative has high water rights cost and moderate transmission costs, but water treatment would be conventional and inexpensive. The rest of this section describes the features of the MRG water source alternative.

5.2.1 Design Criteria

The design criteria for all three alternatives are identical: Provide 5.0 MDG potable water for wholesale delivery to client water utilities at a convenient location within the presently undeveloped service area. Treated water will comply with all federal and state regulations that pertain to potable water.

5.2.2 Description

This alternative involves the Sandoval County Wholesale Water utility:

- Buying 5,600 afy of existing rights from within the Middle Rio Grande basin,
- Transporting the water from the point(s) of diversion to the service area,
- Treating the river water to meet potable standards, and
- Delivering the water into an adjacent 5.0 MG storage tank from which client utilities can draw.

Figure 5-5 shows a preliminary arrangement for Alternative 2.

This buy-and-retire alternative causes Sandoval County directly to compete with Albuquerque, Rio Rancho, and other municipalities implementing water rights purchasing programs. It also causes competition with Intel, the largest private employer in Sandoval County. After acquiring the necessary rights, the Sandoval County Wholesale Water Utility would become the 9th largest rights holder on the Middle Rio Grande, just behind Bernalillo County and the City of Santa Fe, and ahead of the Public Service Company of New Mexico and Kirtland Air Force Base.

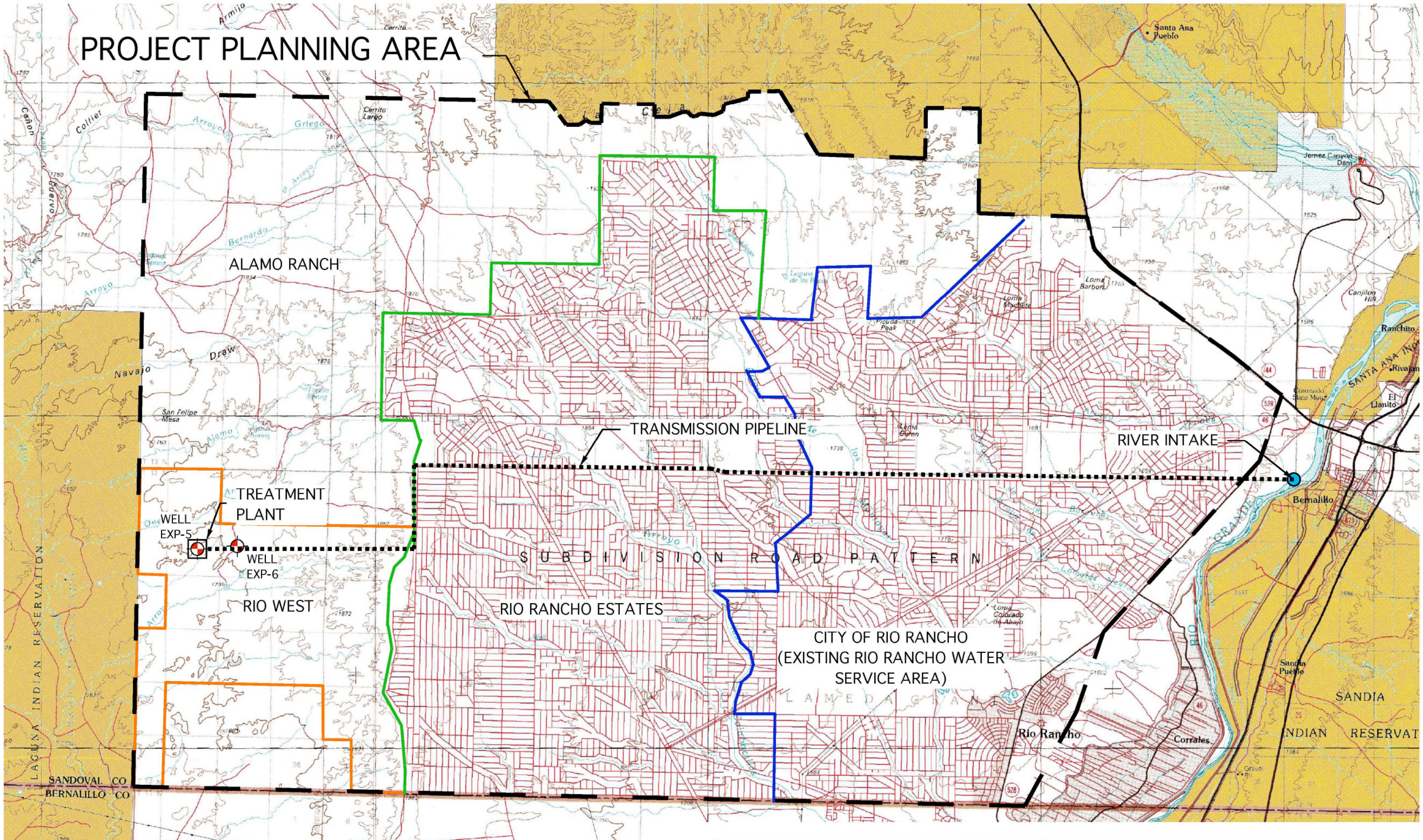
5.2.3 Soil and Groundwater Conditions

Soil conditions are generally favorable for trenching along the transmission pipeline alignment and for foundations at the treatment plant site. The following paragraphs summarize the pertinent soil, groundwater, and watershed conditions.

5.2.3.1 Geologic Setting

The service area is located in the broad Rio Puerco valley, east of the Rio Puerco itself and west of the badland escarpment that separates this region from the Rio Grande watershed. The surface trace of the Moquino Fault, which is down-dropped on the eastern side, cuts the valley from northeast to southwest. This fault is recognized as the western structural margin of the northern Albuquerque basin and has over 2,000 feet of vertical throw based on published unit thicknesses.

In the upper 5 feet that affects the transmission pipeline and treatment plant, geologic units include Mesozoic sedimentary formations ranging from Cretaceous to Triassic in age along with shallow alluvium deposits along the arroyos.



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	ALTERNATIVE 2 PLAN	FIGURE 5-5

5.2.3.2 Geotechnical Conditions

The available treatment plant sites are located on the broad eastern terrace of the Rio Puerco valley. The geologic map of the area (Figure 2-5) shows five main geologic deposits, none of which present difficult trenching or foundation conditions.

The prevailing rock units are two members of the upper Cretaceous Mancos Shale:

- Mulatto Tongue Shale (Kmm) - Described as a dark- to light-gray and olive-gray shale, silty and sandy shale, and fine-grained ripple-marked sandstone.
- Montezuma Valley Member of the Mancos Shale (Kmz) - Described as gray to olive-gray, well indurated, slightly silty-sandy calcareous shale.

A thin band of Gallup sandstone is shown separating these two shale units. The Gallup is a yellowish-gray and yellow, medium to coarse grained, cross bedded sandstone

In addition to the three older rock deposits, younger unconsolidated materials mantle the flatter areas:

- Colluvium and Alluvium (undivided) Qac – Poorly sorted, poorly consolidated mixture of sand, silt, and angular gravel derived from mass movement slope processes and rain wash.
- Alluvium Qa – Unconsolidated light brown to yellow-brown sand, silts, and gravel.

5.2.3.3 Foundation Conditions

Foundation conditions at the planned water plant are favorable, as are trenching conditions between the plant and the water intake 21 miles away at the Rio Grande. Unconsolidated materials may be loose, but the granular nature indicates they can be compacted to a dense condition before building foundations.

5.2.3.4 Groundwater Elevations

Groundwater is over 100 feet deep in the planning area, much deeper than the excavation depths required for the planned construction.

5.2.3.5 Watershed and Relation to Water Source

The planned construction is in the Rio Puerco watershed, which joins the Rio Grande south of Albuquerque. The planned water source is the Middle Rio Grande Basin itself, so on a broad scale treated effluent from Alternative 2 returns eventually to the source water body.

Because this alternative involves buying and retiring existing water rights, Alternative 2 has no effect on the watershed upstream from the point of diversion. Water Resource Data

5.2.4 Water Resource Data

5.2.4.1 Population Trends

The planning area is undeveloped and sparsely inhabited, but is also on the western edge of the fastest growing part of New Mexico. Demographic projections indicate that population in the planning area will grow as fast as water can be supplied. The Rio West master planned community, which surrounds the planned wholesale water delivery point, is approved for 28,992 dwelling units, or about twice the capacity of the proposed 5.0 MGD plant. The BBER 2050 demographic projection predicts that the planning area population will expand, assuming available water, to require the equivalent of seven modular 5.0 MGD water projects.

5.2.4.2 Present Water Consumption

Present consumption is zero because no infrastructure exists in the planning area. Extrapolating from demographic and consumption profiles in Rio Rancho, the service area is expected to have 2.33 residents per household who demand an annual average 150 gallons per person per day. Peak demands will be met through storage provided by the client water utilities. Under this consumption profile, the 5.0 MGD project will serve 33,333 people or about 14,300 new households.

5.2.4.3 Water Availability

Water rights are not available in the Middle Rio Grande basin at the rate required by the Project. Albuquerque has been able to acquire approximately 8,000 afy of rights in the MRG basin over the past 18 years, for an average transfer rate of about 450 afy/year. At that rate, the project would require about 12 years to acquire the necessary rights. The MRG water rights market cannot realistically accommodate the Project's 5,600-afy demand in 3 years without the Project being forced to pay an unsupportable price increase.

Once purchased, water rights that supply this alternative are subject to the same availability constraints that affect Santa Fe, Rio Rancho, Intel, Albuquerque, New Mexico Tech, Kirtland AFB, and other major users on the Middle Rio Grande.

5.2.5 Flow Requirements

The project provides 5.0 MGD constant output to the client water utilities. Client utilities will provide fire flow and peaking capacity.

5.2.6 Sewerage System Available

The service area is presently undeveloped and has no infrastructure. While the planned wholesale water project will not distribute to individual customers, it is expected that the master planned communities ultimately served by the wholesale water utility will have standard sewerage.

5.2.7 Sources of Water Supply

Water for Alternative 2, the Middle Rio Grande source, will come from the Points of Diversion associated with each water rights purchase. For planning purposes we assume that the Office of the State Engineer will allow a single diversion point for the aggregate diversion. Any site near the Rio Grande that could host an intake structure and that is reasonably well protected from contamination would serve.

Water rights cost and availability are the principal issues affecting the Middle Rio Grande's ability to satisfy existing and future demand. The rate that water rights come available for purchase, or the premium required to motivate sellers on the Project's schedule, is likely to be a greater obstacle than the Rio Grande's ability to provide water that can be pumped west to the service area.

The Office of the State Engineer will determine the point of diversion for each of the 40 to 100 individual rights purchases necessary for this alternative. For planning purposes, we made the favorable assumption that a single river intake could be constructed adjacent to the Rio Grande. This assumption avoids the political issue of locating wells in the area that Rio Rancho considers within the City's wellfield and also avoids the operation and maintenance issues of a distributed wellfield system. Assuming a river intake is allowed, the transmission system would extend approximately 21 miles from the river to the treatment plant and would have about 500 feet of total dynamic head to lift the water from the Rio Grande valley up and over the escarpment that marks the eastern edge of the service area.

5.2.8 Proposed Treatment Processes

Treatment of raw water from the Middle Rio Grande would be conventional for a surface water source and include these processes:

- Chemical Feed
- High Speed Mixing
- Flocculation
- Sedimentation
- Microfiltration
- Disinfection

Some water supply wells generally proximal to the intake have excessive arsenic. For the purposes of this alternative, arsenic removal was not considered necessary on the assumption that raw water would come from a single 3,500-gpm intake in or at the margin of the Rio Grande and not from wells that, in some locations, have elevated arsenic concentrations.

5.2.9 Waste Disposal

The conventional water treatment plant produces minimal waste, mainly flocculated sludge and backwashed filter solids, which will be dried and sent to landfill. No hazardous or liquid wastes are produced in this alternative.

5.2.10 Operational Considerations

The proposed wholesale water plant will include modern automation and monitoring equipment that reduces the potential for future operating and maintenance issues. The estimated cost includes training funds so that plant operators can accomplish all routine maintenance.

The project will have a full-featured asset management plan and reliability centered maintenance (RCM) program to reduce the risk of equipment breakdowns or expensive servicing. Through good training and professional management of routine issues, an RCM program levels operating costs, prevents service interruptions, and reduces overall costs. Appendix I includes additional information about the RCM program.

5.2.11 Treatment Plant Sites

An 8-acre treatment plant site is required for Alternative 2, in addition to easements for the 21-mile pipeline between the Point of Diversion at the Rio Grande and the treatment plant. Figure 2-3 shows the general treatment plant site relative to the planning area and service area boundaries. This location is preferred because of it's proximity to the three prospective client utilities, Rio West master planned community surrounding the plant and to the south, the Rancho Grande community to the north, and the Rio Rancho Estates subdivision to the east.

The wholesale water utility has great flexibility in delineating an 8-acre site from the thousands of undeveloped acres in the service area. Essentially any 8-acre site, generally level and free of environmental and cultural resources, would suit the project. Considering that all of the land in the treatment plant vicinity is undeveloped, uncontaminated, out of the flood plain, lacks existing neighbors, and is generally suitable for supporting the planned construction, the principal site selection criterion is compatibility with the surrounding master planned community.

Sandoval County and the Rio West developer have started the process for selecting a site, a process that should be concluded early in design. All land and easements required for Alternative 2 will be acquired by purchasing from private owners or from the City of Rio Rancho, which has control over some of the pipeline easement. No federal lands are required.

5.2.12 Future Extensions

The wholesale water project could be expanded beyond 5.0 MGD by purchasing additional water rights, paralleling the transmission pipeline, and building additional water treatment plants. The proposed plant is compact and modular, so the efficient approach would be to place additional plants closer to client utilities rather than clustering them at the end of the 21-mile pipeline.

The New Mexico Bureau of Business and Economic Research predicts 168,000 new residents in the planning area by 2050. At 150 gpd per capita, the wholesale water utility could be asked to deliver 36 MGD, or about 7 modules of 5.0 MGD. The necessary water rights for ultimate buildout, assuming a buy-and-retire strategy meets all water needs in the planning area, are 39,200 afy. At that size, the Sandoval County Wholesale Water Utility would be the third largest water user on the Middle Rio Grande, surpassed only by the City of Albuquerque and Inca Construction.

Assuming the 450 afy per year rights acquisition rate that Albuquerque has experienced remains true, it would require 87 years to buy up enough rights to satisfy the demand expected in 40 years. This preliminary analysis suggests a significant weakness of pursuing a pure buy-and-retire strategy for supplying water to the planning area.

5.2.13 Process Flow Diagram

Figure 5-6 shows a process flow diagram for the conventional water treatment plant.

5.2.14 Environmental Impacts

The principal environmental impact from this project is removing 5,600 acre-feet per year from the Middle Rio Grande basin. All of the water is presently diverted by existing water rights, which would be acquired for this alternative. Only the point of diversion would be modified, and the Office of the State Engineer would confirm that any point of diversion changes had minimal environmental impacts.

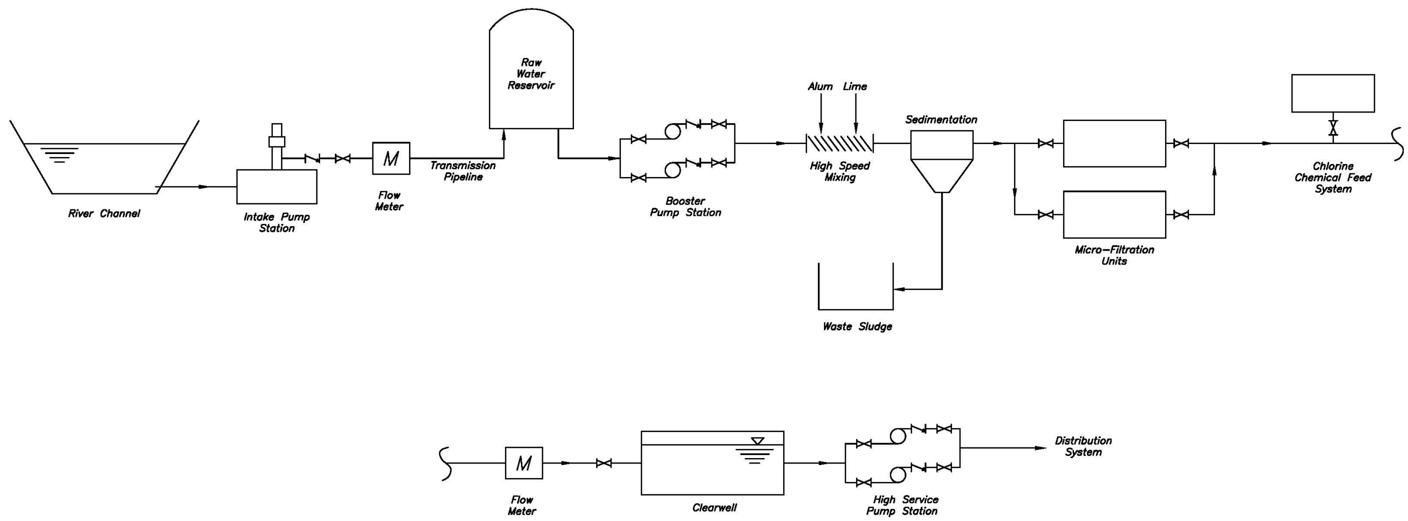
Environmental studies will be completed once a specific intake location and pipeline alignment are selected, a process that requires coordination with the road and open-space alignments in the still-evolving Rio West community plan that surrounds the wholesale water project. This report section provides an overview of environmental issues that will be resolved before proceeding with the project.

Sewer Discharge – The planning area is largely undeveloped and currently has no sewage collection or treatment facilities. Isolated dwellings within the planning area are on individual systems.

The proposed project is intended to facilitate managed development within the planning area. Such development will require sewerage system availability in accordance with local, state, and federal regulations.

- In the Rio West community, the sewerage works are described in the Master Plan.
- In the Rio Rancho Estates area, Sandoval County is working on methods for avoiding construction of new individual wastewater systems. The centralized water available from the proposed plant is an important part of offering the full suite of municipal utilities to the lots.
- Other communities do not yet have an approved Master Plan. These pending developments will require sewerage service in conformance with Sandoval County, state, and federal requirements.

All treated water will be distributed through the City of Rio Rancho water utility or the distribution system of another client utility operating in the service area. Assuming that the water supplied will ultimately return to the Rio Grande through one of the Rio Rancho wastewater treatment plants, approximately 4.0 MGD could be ultimately discharged into the river (assumes 20% loss due to line losses, irrigation, and fire flow). Future project phases could potentially contribute surface water flow to the Rio Puerco as well.



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DESALINATION TREATMENT FACILITY

ALTERNATIVE 2 FLOW DIAGRAM

FIGURE 5-6

The project has not completed an EID. Avoidance and mitigation measures will be developed for each project phase as the preliminary plans are completed and the affected resources are identified.

Treatment Plant Site – The planned treatment plant site comprises 8 acres of relatively flat ground traversed by a southwest-flowing intermittent drainage way that flows onto the site through a (likely) culvert crossing under the future Northwest Loop Road. The final arrangement of the treatment plant and appurtenant facilities will accommodate the environmental resources that are found to occupy the site.

Pipeline Alignment – The 21-mile long transmission pipeline traverses developed and undeveloped lands generally along an existing roadway. The last few miles, west of the Rio Rancho Estates boundary, would be parallel to a new paved roadway that connects the service area to the developed lands to the east. It is possible that environmental impacts may require mitigation, most likely near the arroyo crossings. Detailed environmental studies and mitigation plans will be completed for the selected alternative during the design phase.

5.2.15 Land Requirements

Alternative 2 requires the purchase of an 8-acre treatment plant site, a 3-acre site at the Rio Grande for the intake, and a 21-mile easement through Rio Rancho and County jurisdictions for transmission. The two parcels are privately owned and will be purchased by the project. Easements will be along transportation corridors under City, County, or State jurisdiction. No federal lands are necessary.

The 5.0 MGD treatment plant and water tank can be located on an 8-acre site anywhere convenient near the center of the service area. This site would be within the Rio West master planned community, approximately as shown on Figure 2-3. Sandoval County is in the process of acquiring land for the treatment plant and storage facility, and would also acquire a transmission pipeline easement along a County road, preferably, as a part of detailed design.

Because existing development is sparse and planning for the Rio West community is still in the early stages, the water plant location is a particularly favorable site. The site advantages include:

- Gently sloping ground
- No hard rock exposures
- Arroyo boundary on the northwest side providing a buffer from future non-industrial development
- Good access to the planned Northwest Loop Road

The treatment plant is in the Rio West master plan area, where specific zoning has not been adopted. The area around the water plant, most likely, will be designated light industrial so that future uses are consistent with the water plant use.

5.2.16 Construction Problems

This alternative has minimal exposure to construction problems. The planning area generally exhibits favorable construction conditions as follows:

- The candidate pipeline alignment and treatment plant sites are not affected by troublesome geologic conditions, such as hard rock or steep slopes
- Groundwater levels are much deeper than trench depths
- Exposed rock, if any, is relatively soft and can be excavated with conventional equipment
- None of the soils are expansive or subject to collapse

Despite the generally favorable conditions, this alternative does include a 21-mile long pipeline through urban, suburban, and rural lands. Issues associated with transmission pipeline and water treatment plant construction, not specific to any site, include:

- Traffic control issues within or adjacent to established transportation routes
- Encountering an unknown utility or conflicting existing utilities
- Public opposition to the facility or location
- Discovery of unknown or unidentified cultural resources
- Discovery of hazardous materials

The following aspects will receive careful attention during design and permitting:

- The disturbed areas are larger than one acre; one or more SWPPP's will be obtained as a part of the design.
- The transmission pipeline may cross one or more arroyo. Arroyo crossings will be designed to accommodate future erosion.
- A detailed environmental and cultural resource assessment will be performed early in the design process so that the project can avoid encroaching on habitat and other resources.

5.2.17 Cost Estimates

5.2.17.1 Water Rights Cost

Table 5-5 summarizes the published information available for water rights prices in the Middle Rio Grande basin.

Table 5-5
Middle Rio Grande Water Rights
Cost Summary

Year	Source	Reported Cost
2002	F. Lee Brown[6]	$4000
2003	Rio Rancho	$11,000
2007	F. Lee Brown[2]	$20,000 to $35,000
2010	Dr. William Turner[7]	$15,000

Rio Rancho paid $11,046.51 /afy in 2003 for 172 afy on the Jemez River. Intel is reportedly acquiring about 60 afy this year for about $15,000 /afy, which seems to be the present rate for opportunistic acquisition. The 375% increase from 2002 to 2010 represents an 18% average annual increase, suggesting that opportunistic acquisitions over the next decade have significant exposure to price escalation. Making a concerted effort to purchase 5,600 afy in 2 years or less could reduce exposure to escalation, but would require significant price.

The overall composite water rights cost for Alternative 2 was estimated using a flat-topped and asymmetrical triangular price distribution between $11,000 /afy and $30,000 /afy, centered around $18,000 /afy. Appendix M provides additional detail. The projection yielded an average price of $19,554.62 /afy, generally consistent with the expected 2011

[6] F. Lee Brown, 2007, "Market Prices as Measures of Water Scarcity in New Mexico and the West," in Beyond the Year of Water: Living Within our Water Limitations, New Mexico Water Resources Research Institute, November.

[7] Dr. William Turner, WaterBank.com, 2010, personal communications on July 8.

cost allowing for normal escalation. The expected cost to buy and retire 5,600 afy of existing rights on the Middle Rio Grande is $109.5 million.

Table 5-6 summarizes the estimated cost of Alternative 2. Additional detail is provided in Appendix M.

Table 5-6 – Alternative 2 Cost Summary

CATEGORY	ITEM	COST
Construction	Water Rights	$109,505,882
	Intake and Pipeline	$31,005,250
	Treatment Plant	$11,977,500
	5.0 MG Storage Facility	$4,122,500
	Total Construction Cost	**$156,611,132**
Non-Construction	Design, Permitting & Bonds	$57,643,894
Annual O&M	Personnel	$444,500
	Chemicals & Maintenance	$398,944
	Total Annual O&M	**$843,444**
Whole Life Cost	Total Whole Life Cost	$266,503,953
	Total Whole Life Cost per Household	$18,637
	Estimated Water Rate[1] (per thousand gallons)	**$11.54**

Note 1: The water rate estimate is the quotient of the annual revenue requirement (debt service, including reserve, plus total operations and maintenance) divided by the annual water production (1.825 x 10^6 kgal/year).

5.2.18 Advantages and Disadvantages

Alternative 2, buying water rights in the MRG Basin and transporting water 21 miles west to the service area, has the ability to meet the design requirement and has adequate water resource for the 5,600 afy project requirement. Like the Pecos River water source evaluated in Alternative 3, the Rio Grande water source is inexpensive to treat using conventional filtration technology.

The principal disadvantage of the MRG water source, is the unsupportable $11.54 /thousand gallons water rate needed to retire the debt incurred by buying the necessary water rights. Alternative 2 also has significant schedule risk, effectively ceding control over Sandoval County's economic growth to the present owners of necessary water rights in the MRG basin. Other disadvantages include:

- The likelihood that water rights costs will exceed that estimate because of upward pressure the 5,600-afy project demand will create in the water rights market.
- The likelihood that 5,600 afy of existing water rights will not be offered for sale in the next 2 years without offering an exorbitant price premium.
- Water rights cost and availability constraints severely curtailing future expansions.

- Moderate public opposition is expected to diverting more agricultural water to support growth and economic development of a new urban and suburban area.
- The 21-mile long pipeline through Rio Rancho and unincorporated Sandoval County is costly and subject to delays associated with obtaining easements, clearing existing underground utilities, and securing environmental permits.

Table 5-7 rates Alternative 2 on each significant aspect of the project and computes a weighted value for each criterion. Rankings are assigned values between 1 and 10, and the weighting sums to 100, so the maximum score is 1,000.

Table 5-7 – Alternative 2 Rating

Criterion	Comment	Rating (1 – 10)	Weight (100 total)	Score
Resource Capacity	More than 5,600 afy for 100 years	10	10	100
Raw Water Quality	Conventional treatment	9	10	90
Schedule	12 years	1	15	15
Future Extensions	Likely difficult and slow	2	5	10
Operational Constraints	None	9	5	45
Public Concerns	Agricultural water competition	6	10	60
Health Issues	None after treatment	9	20	180
Environmental Issues	Mitigatable	7	5	35
Water Rate	$11.54 /kgal	3	15	45
Whole Life Cost	$18,637 /household	5	5	25
			Alternative 2 Rating	**605**

5.3 Alternative 3 - Buy and Retire Extra-Regional Rights

Alternative 3 considers drawing raw water from the Pecos River using rights associated with either the Carlsbad Project or the Fort Sumner Project and transporting it west to the service area. This alternative is approximately equal to the 6,424-afy project that Berrendo LLC has proposed to bring additional water to Santa Fe. This alternative has moderate water rights cost and very high transmission costs, but water treatment would be conventional and inexpensive. The rest of this section describes the features of the Pecos River water source alternative.

5.3.1 Design Criteria

The design criteria for all three alternatives are identical: By 2012, provide 5.0 MDG potable water for wholesale delivery to client water utilities at a central location within the service area. Treated water will comply with all federal and state regulations that pertain to potable water.

5.3.2 Description

This alternative involves the Sandoval County Wholesale Water utility:

- Buying 5,600 afy of existing rights from an irrigation district or other rights holder outside the Middle Rio Grande basin. For this alternative the existing water rights were assumed to be from either the Carlsbad District or the Fort Sumner District because of the similarity to the 6,424 afy Berrendo Project currently being evaluated by the Office of the State Engineer.
- Transporting the water from the point of diversion in Lake Sumner 175 miles west to the service area,
- Treating water to meet potable standards, and

- Delivering the water into an adjacent 5.0 MG storage tank from which client utilities can draw.

Figure 5-7 shows a preliminary arrangement for this alternative.

This buy-and-retire alternative causes Sandoval County directly to compete with the Berrendo Project and the prospective customer water systems that include Santa Fe, Rio Rancho, and possibly private water users.

5.3.3 Soil and Groundwater Conditions

Soil conditions are generally favorable for trenching along the transmission pipeline alignment and for foundations at the treatment plant site. The following paragraphs summarize the pertinent soil, groundwater, and watershed conditions.

5.3.3.1 Geologic Setting

The service area is located in the broad Rio Puerco valley, east of the river and west of the badland escarpment that separates this region from the Rio Grande watershed. The surface trace of the Moquino Fault, which is down-dropped on the eastern side, cuts the valley from northeast to southwest. This fault is recognized as the western structural margin of the northern Albuquerque basin and has over 2,000 feet of vertical throw based on published unit thicknesses.

The transmission pipeline traverses about 175 miles of New Mexico across the northern boundary of the Chihuahua desert. Numerous different geologic materials will be encountered along the alignment, similar to the materials that have been encountered by the existing natural gas pipelines that cross this terrain. None of the materials along the alignment are particularly hard, and none are saturated at shallow depth. Pipeline trenching is expected to be typical for long cross-country pipelines.

In the 5 feet of interest to the treatment plant foundation, geologic units include Mesozoic sedimentary formations ranging from Cretaceous to Triassic in age along with shallow alluvium deposits along the arroyos.

5.3.3.2 Geotechnical Conditions

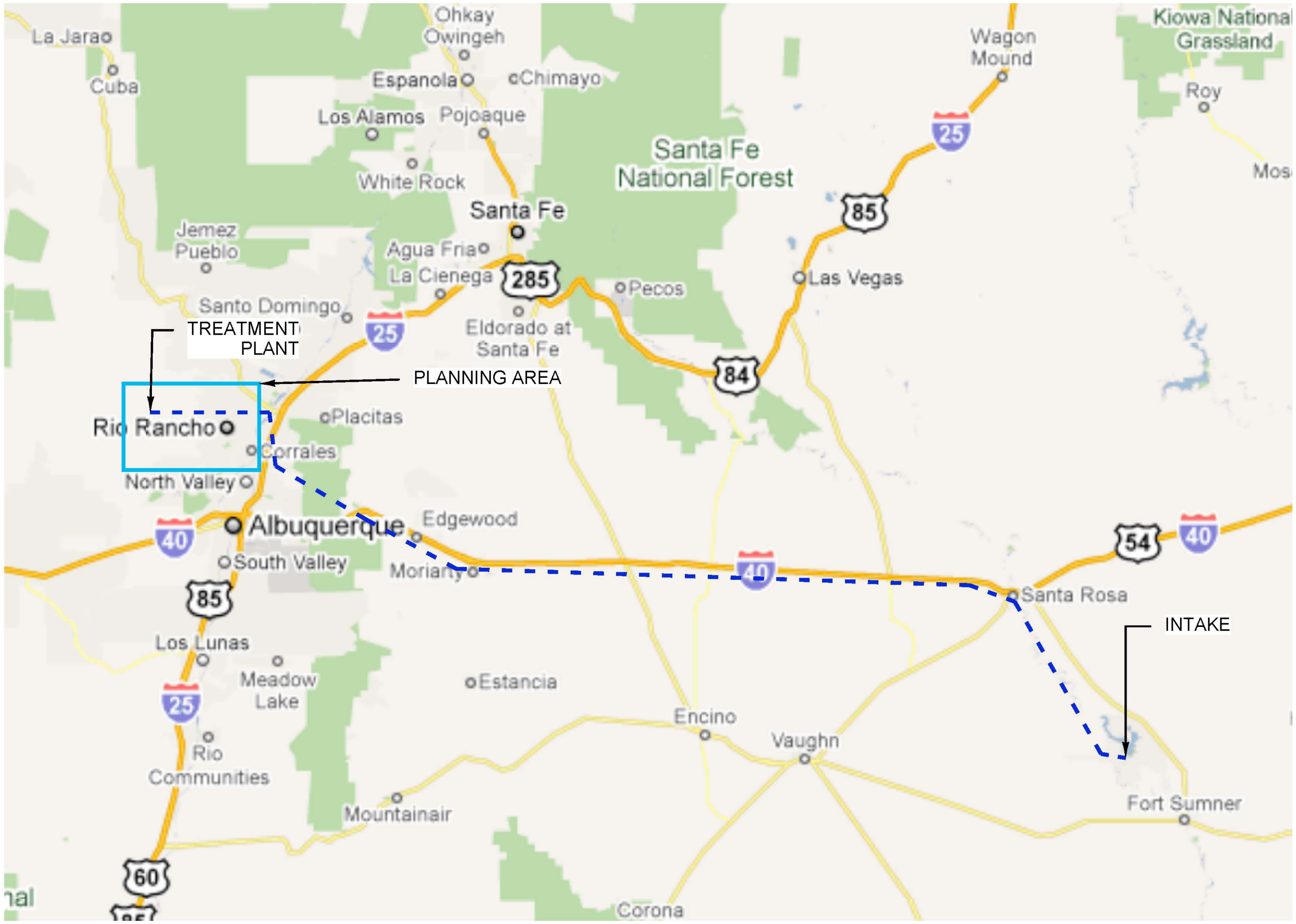
The available treatment plant sites are located on the broad eastern terrace of the Rio Puerco valley. The geologic map of the area (Figure 2-5) shows five main geologic deposits, none of which present difficult trenching or foundation conditions.

The prevailing rock units are two members of the upper Cretaceous Mancos Shale:

- <u>Mulatto Tongue Shale (Kmm)</u> - Described as a dark- to light-gray and olive-gray shale, silty and sandy shale, and fine-grained ripple-marked sandstone.
- <u>Montezuma Valley Member of the Mancos Shale (Kmz)</u> - Described as gray to olive-gray, well indurated, slightly silty-sandy calcareous shale.

A thin band of Gallup sandstone is shown separating these two shale units. The Gallup is a yellowish-gray and yellow, medium to coarse grained, cross bedded sandstone

In addition to the three older rock deposits, younger unconsolidated materials mantle the flatter areas:



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ALTERNATIVE 3 PLAN

FIGURE 5-7

- Colluvium and Alluvium (undivided) Qac – Poorly sorted, poorly consolidated mixture of sand, silt, and angular gravel derived from mass movement slope processes and rain wash.
- Alluvium Qa – Unconsolidated light brown to yellow-brown sand, silts, and gravel.

5.3.3.3 Foundation Conditions

Foundation conditions at the planned water plant are favorable, as are trenching conditions between the plant and the Rio Grande River crossing 21 miles to the east. Unconsolidated materials may be loose, but the granular nature indicates they can be compacted to a dense condition before building foundations.

5.3.3.4 Groundwater Elevations

Groundwater is over 100 feet deep in the planning area, much deeper than the excavation depths required for the planned construction.

5.3.3.5 Watershed and Relation to Water Source

The planned construction is in the Rio Puerco watershed, which is the west lobe of the Middle Rio Grande Basin. The planned water source is the Pecos River, which does not join the Rio Grande until reaching Amistad Reservoir halfway down the Texas / Mexico border.

Because this alternative involves buying and retiring existing water rights, Alternative 3 has no effect on the Pecos River watershed upstream from the point of diversion.

5.3.4 Water Resource Data

5.3.4.1 Population Trends

The planning area is undeveloped and sparsely inhabited, but is also on the western edge of the fastest growing part of New Mexico. Present consumption is zero because no infrastructure exists in the planning area. Assuming 2.33 residents per household and 150 gallons per person per day (with peaks being met by storage provided by the client water utilities), the 5.0 MGD project can serve 33,333 people or about 14,300 new households.

Demographic projections indicate that population in the planning area will grow as fast as water can be supplied. The Rio West master planned community, which surrounds the planned wholesale water delivery point, is approved for 28,992 dwelling units, or about twice the capacity of the proposed 5.0 MGD plant. The BBER 2050 demographic projection predicts that the planning area population will expand, assuming available water, to require the equivalent of seven modular 5.0 MGD water projects.

5.3.4.2 Water Availability

Because of the need to buy existing water rights for this alternative, the 5,600 afy is subject to supply and demand in the marketplace. Rights are as available as market conditions dictate in the irrigation districts near the Rio Grande. Once purchased, water rights that supply this alternative are subject to the same availability constraints that affect the farmers presently irrigating with the water.

Large blocks of water rights appear to be available, judging from the five farmers who have agreed to sell their 6,424 afy of rights to the Berrendo Project. Whether or not an additional 5,600 afy of rights can be made available is uncertain, but the likelihood increases by raising the price that Sandoval County Wholesale Water Utility is willing to pay. The Carlsbad Project has about 62,000 afy, depending on Pecos River conditions, and the Fort Sumner District has about 15,000 before selling 6,424 afy for the Berrendo Project. It seems not unreasonable that, for the right price, enough farmers could be induced to sell 5,600 afy of existing water rights and fallow their fields.

5.3.5 Flow Requirements

The project provides 5.0 MGD constant output to the client water utilities. Client utilities will provide fire flow and peaking capacity.

5.3.6 Sewerage System Available

The service area is presently undeveloped and has no infrastructure. While the planned wholesale water project will not distribute to individual customers, it is expected that the master planned communities ultimately served by the wholesale water utility will have standard sewerage.

5.3.7 Sources of Water Supply

Water for Alternative 3, the Pecos River source, will come from the Points of Diversion associated with each water rights purchase. For planning purposes we assume that the Office of the State Engineer will allow a single diversion point on the west bank of Lake Sumner for the aggregate diversion.

This alternative circumvents the slow pace and high price of water rights in the Middle Rio Grande basin. Such schedule and capital savings are offset by the need to build a pipeline to the service area and pump water from the Pecos River to the west side of the Rio Grande, almost as far as the Rio Puerco.

It was assumed that Sandoval County could share a pipeline with the 6,242-afy Berrendo Project, which will supply water to Santa Fe, Rio Rancho, and possibly Albuquerque. The pipeline segments include:

- 47% responsibility for a 24” diameter pipeline is that follows existing transportation corridors 143 miles from Sumner dam to a convenient point east of the Rio Grande and north of Albuquerque.
- 80% responsibility for an 18’ diameter pipeline 12 miles long that serves Rio Rancho, including a Rio Grande crossing.
- 100% responsibility for the last 12 miles of 18” pipeline traversing Rio Rancho and extending out to the treatment plant.

Water rights availability and the cost of pipeline transportation are the principal issues affecting the Pecos River’s ability to satisfy existing and future demand. The rate that water rights come available for purchase is likely to be a greater obstacle than the predictable cost of pumping water more than 175 miles west to the service area.

5.3.8 Proposed Treatment Processes

Treatment of water from the Pecos River would be conventional for a surface water source and includes these processes:

- Chemical Feed
- High Speed Mixing
- Flocculation
- Sedimentation
- Microfiltration
- Disinfection

5.3.9 Waste Disposal

The conventional water treatment plant produces minimal waste, mainly flocculated sludge and backwashed filter solids, which will be dried and sent to landfill. No hazardous or liquid wastes are produced in this alternative.

5.3.10 Operational Considerations

The proposed wholesale water plant will include modern automation and monitoring equipment that reduces the potential for future operating and maintenance issues. The estimated cost includes training funds so that plant operators can accomplish all routine maintenance.

The project will have a full-featured asset management plan and reliability centered maintenance (RCM) program to reduce the risk of equipment breakdowns or expensive servicing. Through good training and professional management of routine issues, an RCM program levels operating costs, prevents service interruptions, and reduces overall costs. Appendix I includes additional information about the RCM program.

5.3.11 Treatment Plant Sites

An 8-acre treatment plant site is required for Alternative 3, in addition to easements for the 175-mile pipeline between the Point of Diversion at Lake Sumner and the treatment plant. Figure 2-3 shows the general treatment plant site relative to the planning area and service area boundaries. This location is preferred because of it's proximity to the three prospective client utilities, Rio West master planned community surrounding the plant and to the south, the Rancho Grande community to the north, and the Rio Rancho Estates subdivision to the east.

The wholesale water utility has great flexibility in delineating an 8-acre site from the thousands of undeveloped acres in the service area. Essentially any 8-acre site, generally level and free of environmental and cultural resources, would suit the project. Considering that all of the land in the treatment plant vicinity is undeveloped, uncontaminated, out of the flood plain, lacks existing neighbors, and is generally suitable for supporting the planned construction, the principal site selection criterion is compatibility with the surrounding master planned community.

Sandoval County and the Rio West developer have started the process for selecting a site, a process that should be concluded early in design. All land required for the Alternative 3 treatment plant will be acquired by purchasing from the Rio West master planned community owners. It is possible that easements across federal lands will be necessary for the 175-mile long pipeline, though the alignment will stay within existing transportation corridors where possible.

5.3.12 Future Extensions

The wholesale water project could be expanded beyond 5.0 MGD by purchasing additional water rights, paralleling the transmission pipeline, and building additional water treatment plants. The proposed plant is compact and modular, so the efficient approach would be to place additional treatment plants closer to client utilities rather than clustering them at the end of the 175-mile pipeline.

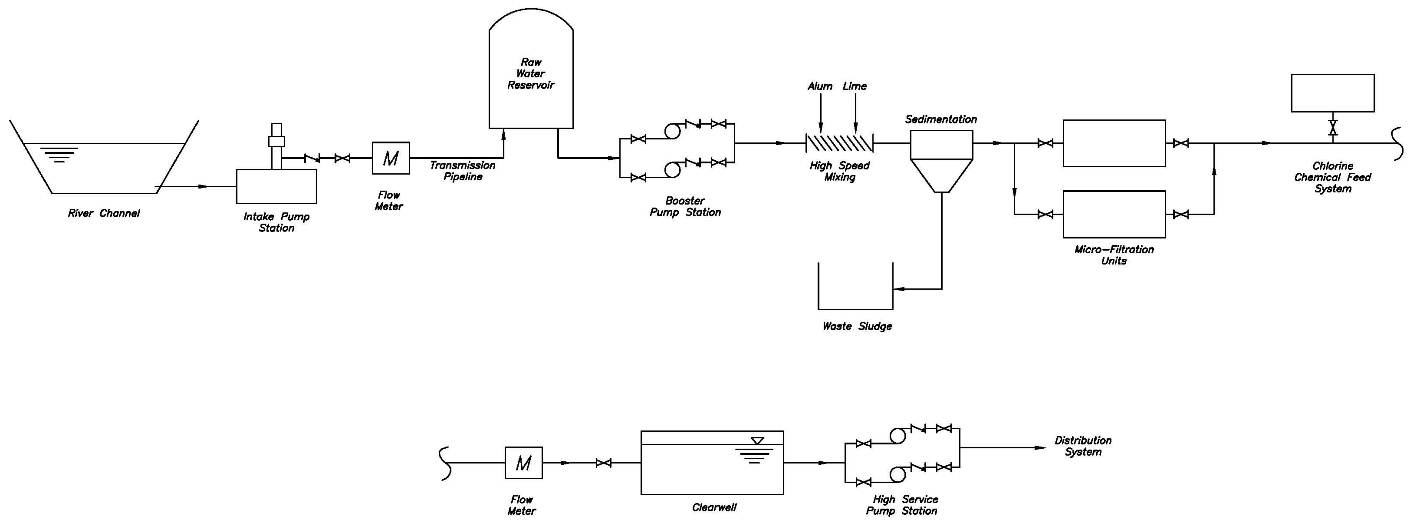
The New Mexico Bureau of Business and Economic Research predicts 168,000 new residents in the planning area by 2050. At 150 gpd per capita, the wholesale water utility could be asked to deliver 36 MGD, or about 7 modules of 5.0 MGD. The necessary water rights for ultimate buildout, assuming a buy-and-retire strategy meets all water needs in the planning area, are 39,200 afy. At that size, the Sandoval County Wholesale Water Utility would have purchased about two-thirds of the water rights from the Carlsbad Project.

5.3.13 Process Flow Diagram

Figure 5-8 shows a process flow diagram for the conventional water treatment plant.

5.3.14 Environmental Impacts

The principal environmental impact from this project is removing 5,600 acre-feet per year from the Pecos River and moving it over to the Rio Puerco part of the Middle Rio Grande basin. All of the water is presently diverted from the managed river flow according to established rules. Only the point of diversion would be modified, and the Office of the State Engineer would confirm that any point of diversion changes had minimal environmental impacts.



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ALTERNATIVE 3 FLOW DIAGRAM

FIGURE 5-8

Environmental studies will be completed once specific intake locations and pipeline routes are selected, a process that requires coordination with the road and open-space alignments in the still-evolving Rio West community plan that surrounds the wholesale water project. This report section provides an overview of environmental issues that will be resolved before proceeding with the project.

Sewer Discharge – The planning area is largely undeveloped and currently has no sewage collection or treatment facilities. Isolated dwellings within the planning area are on individual systems.

The proposed project is intended to facilitate managed development within the planning area. Such development will require sewerage system availability in accordance with local, state, and federal regulations.

- In the Rio West community, the sewerage works are described in the Master Plan.
- In the Rio Rancho Estates area, Sandoval County is working on methods for avoiding construction of new individual wastewater systems. The centralized water available from the proposed plant is an important part of offering the full suite of municipal utilities to the lots.
- Other communities do not yet have an approved Master Plan. These pending developments will require sewerage service in conformance with Sandoval County, state, and federal requirements.

All treated water will be distributed through the City of Rio Rancho water utility or the distribution system of another client utility operating in the service area. Assuming that the water supplied will ultimately return to the Rio Grande through one of the Rio Rancho wastewater treatment plants, approximately 4.0 MGD could be ultimately discharged into the river (assumes 20% loss due to line losses, irrigation, and fire flow). The source water is not hydraulically connected to the Rio Grande (or other surface waters); therefore there would be a net increase in river flow. If the Rio Rancho water purchase agreement fails to develop, the project's water would likely flow through treatment plants serving Rio West and into the Rio Puerco.

The project has not completed an EID. Avoidance and mitigation measures will be developed for each project phase as the preliminary plans are completed and the affected resources are identified.

Treatment Plant Site – The planned treatment plant site comprises 8 acres of relatively flat ground traversed by a southwest-flowing intermittent drainage way that flows onto the site through a (likely) culvert crossing under the future Northwest Loop Road. The final arrangement of the treatment plant and appurtenant facilities will accommodate the environmental resources that are found to occupy the site.

Pipeline Alignment – The 175-mile long transmission pipeline traverses developed and undeveloped lands generally along existing transportation corridors. The last few miles, west of the Rio Rancho Estates boundary, would be parallel to a new paved roadway that connects the service area to the developed lands to the east. It is likely that environmental impacts may require mitigation, most likely near the arroyo crossings. Detailed environmental studies and mitigation plans will be completed for the selected alternative early in the design phase.

5.3.15 Land Requirements

Alternative 3 requires the purchase of an 8-acre treatment plant site, a 3-acre site at Lake Sumner for the intake, and a 175-mile easement through multiple jurisdictions for transmission. The treatment plant parcel is privately owned and will be purchased by the project. Lake Sumner is under federal jurisdiction, so an intake will have to be coordinated with the Bureau of Reclamation.

Easements will be along transportation corridors under multiple jurisdictions that may include the Interstate Highway system.

The 5.0 MGD treatment plant and water tank can be located on an 8-acre site anywhere convenient near the center of the service area. This site would be within the Rio West master planned community, approximately as shown on Figure 2-3. Sandoval County is in the process of acquiring land for the treatment plant and storage facility, and would also acquire a transmission pipeline easement along a County road, preferably, as a part of detailed design.

Because existing development is sparse and planning for the Rio West community is still in the early stages, the water plant location is a particularly favorable site. The site advantages include:

- Gently sloping ground
- No hard rock exposures
- Arroyo boundary on the northwest side providing a buffer from future non-industrial development
- Good access to the planned Northwest Loop Road

The treatment plant is in the Rio West master plan area, where specific zoning has not been adopted. The area around the water plant, most likely, will be designated light industrial so that future uses are consistent with the water plant use.

5.3.16 Construction Problems

This alternative has minimal exposure to construction problems. The planning area generally exhibits favorable construction conditions as follows:

- The candidate pipeline and treatment plant sites are not affected by troublesome geologic conditions, such as hard rock or steep slopes
- Groundwater levels are much deeper than trench depths
- Exposed rock, if any, is relatively soft and can be excavated with conventional equipment
- None of the soils are expansive or subject to collapse

Despite the generally favorable conditions, this alternative does include a 143-mile long cross country pipeline and an additional 21-mile long pipeline through urban and suburban lands. Issues associated with transmission pipeline and water treatment plant construction, not specific to any site, include:

- Traffic control issues within or adjacent to established transportation routes
- Encountering an unknown utility or conflicting existing utilities
- Public opposition to the facility or location
- Discovery of unknown or unidentified cultural resources
- Discovery of hazardous materials

The following aspects will receive careful attention during design and permitting:

- The disturbed areas are larger than one acre; one or more SWPPP's will be obtained as a part of the design.
- The transmission pipeline will cross arroyos, rivers, and mountains. Arroyo crossings will be designed to accommodate future erosion.
- A detailed environmental and cultural resource assessment will be performed early in the design process so that the project can avoid encroaching on habitat and other resources.

5.3.17 Cost Estimates

The cost of water rights on the Pecos River is difficult to determine because there are so few transactions. The cost estimate for this alternative assigns $8,000 /afy for the necessary 5,600 afy. The expected cost to buy and retire 5,600 afy of existing rights on the Middle Rio Grande is $44.8 million.

Table 5-8 summarizes the estimated Alternative 3 cost. Appendix N provides additional detail.

Table 5-8 – Alternative 3 Cost Summary

CATEGORY	ITEM	COST
Construction	Water Rights	$44,800,000
	Intake and Pipeline	$105,377,902
	Treatment Plant	$11,977,500
	5.0 MG Storage Depot	$4,122,500
	Total Construction Cost	**$166,277,902**
Non-Construction	Design, Permitting & Bonds	$66,907,255
Annual O&M	Personnel	$444,500
	Chemicals & Maintenance	$534,631
	Total Annual O&M	**$979,131**
Whole Life Cost	Total Whole Life Cost	$336,071,434
	Total Whole Life Cost per Household	$23,501
	Estimated Water Rate[1] (per thousand gallons)	**$13.74**

Note 1: The water rate estimate is the quotient of the annual revenue requirement (debt service, including reserve, plus total operations and maintenance) divided by the annual water production (1.825×10^6 kgal/year).

5.3.18 Advantages and Disadvantages

Alternative 3, buying water rights in the Pecos River Basin and transporting water over to the service area, has the ability to meet the design requirement and has adequate water resource for the 5,600-afy project requirement. Like the MRG water source evaluated in Alternative 2, the Pecos River water source is inexpensive to treat using conventional filtration technology.

The principal disadvantage of Alternative 3 is the insupportable $13.74 per thousand gallons water rate necessary to pay the debt from the 175-mile pipeline, plus the operating costs arising from the 3.23 MW pumping requirement. Other disadvantages include:

- The $45 million cost of acquiring water rights.
- The difficulty in bringing this project to construction concurrent with the Berrendo Project so that pipeline costs can be shared. The pipeline costs about $180 million if the Berrendo water supply project proceeds separately.
- The permitting issues and litigation risk associated with 175-mile long pipeline projects.
- The likelihood that water rights costs will exceed the estimate because of upward pressure the 5,600-afy project demand will create in the water rights market.
- The likelihood that 5,600 afy of existing water rights will not be offered for sale in the next 2 years without offering an exorbitant price premium.

Table 5-9 rates Alternative 3 on each significant aspect of the project and computes a weighted value for each criterion. Rankings are assigned values between 1 and 10, and the weighting sums to 100, so the maximum score is 1,000.

Table 5-9 – Alternative 3 Rating

Criterion	Comment	Rating (1 – 10)	Weight (100 total)	Score
Resource Capacity	More than 5,600 afy for 100 years	10	10	100
Raw Water Quality	Conventional treatment	9	10	90
Schedule	10 years	2	15	30
Future Extensions	Likely difficult and slow	2	5	10
Operational Constraints	None	9	5	45
Public Concerns	Long interbasin transfer	5	10	60
Health Issues	None after treatment	9	20	180
Environmental Issues	Probably mitigatable pipeline conflicts	5	5	25
Water Rate	$14.42 /kgal	2	15	30
Whole Life Cost	$23,493 /household	3	5	15
			Alternative 3 Rating	**585**

5.4 WATER SOURCE SELECTION

Table 5-10 summarizes the alternatives ratings from Tables 5-4, 5-7, and 5-9. Color coded dots are used to simplify the overall ratings:

- A green dot indicates that the issue is readily addressed using conventional technologies or operations, and that the performance on that criterion meets typical expectations for a public water utility project.
- A yellow dot indicates that adequate performance on that criterion requires more than typical effort, or that the resulting outcome is slightly outside normal expectations.
- A red dot indicates a significant issue on the project that cannot be resolved using the resources available to a typical public water utility project.

Table 5-10 –Water Source Rating Summary

Criterion	Alternative 1	Alternative 2	Alternative 3
Source	Brackish Groundwater	Buy-and-Retire MRG	Buy-and-Retire Pecos River
Overall Score	780	605	585
Resource Capacity	🟢	🟢	🟢
Water Quality	🟡	🟢	🟢
Schedule	🟢	⊗	⊗
Operational Constraints	🟢	🟢	🟢
Public Concerns	🟡	🟡	🟡
Health Issues	🟢	🟢	🟢
Environmental Issues	🟢	🟡	🟡
Water Rate	🟡	⊗	⊗
Whole Life Cost	🟡	🟡	🟡
Number of Fatal Flaws	0	2	2

Table 5-10 shows how the cost and schedule of the two buy-and-retire water source alternatives fail to accomplish the project objectives, mainly because the Sandoval County Wholesale Water Utility cannot control simultaneously the cost and the schedule of water rights transactions, regardless of water source.

Even under worst-case residual product disposal conditions, the Alternative 1 rating is 720, still clearly better than the other water source alternatives.

The preferred water source, therefore, is the one that the Project already controls. The cost, siting issues, and extra jobs created by treating the water and processing residual projects are tolerable relative to the cost of paying down debt from expensive water rights or transmission pipelines.

SECTION 6
TREATMENT ALTERNATIVES ANALYSIS

The preferred water source for the Sandoval County Wholesale Water Utility is brackish groundwater from the artesian aquifer deep beneath the service area. The raw water chemistry is complex and does not lend itself to a conventional treatment process. This section of the report describes a detailed alternatives analysis performed to identify an effective and economical treatment process.

Several combinations of pretreatment and treatment technologies were evaluated, at the benchtop and pilot scale, to identify viable treatment alternatives and select a recommended treatment process for the proposed water treatment plant.

6.1 TREATMENT PROCESS DESIGN CRITERIA AND EVALUATION

This subsection describes the design criteria and treatment technology alternatives.

6.1.1 Treatment System Design Capacity

Section 2 presented the project water demands in Sandoval County for the 20-year planning period. The County deliberately limited the Project to 5.0 MGD because the aquifer test (Appendix J) was able to demonstrate a 100-year supply at this flow from a wellfield close to the center of the service area.

The County intends to design and construct a water treatment plant with an initial production capacity of 5 MGD that is expandable in increments of 5 MGD based on future water demands and additional aquifer characterization.

6.1.2 Water Chemistry

Appendix O includes the raw water laboratory analyses and an initial assessment of treatment challenges associated with the warm, hard, and brackish raw water. The objective of our treatment configuration for this raw water is to economically accomplish with the following treatment goals:

- Reduction of total manganese levels to below the secondary maximum contaminant level (MCL) and to the treatment goal of <0.02 mg/l
- Reduction of total iron levels to below the secondary MCL, and to the treatment goal of <0.05 mg/l
- Reduction of turbidity levels to below 0.1 NTU in combined filter effluent and plant effluent
- Reduction of arsenic to below10 ppb
- Provision of a disinfection system that achieves at least 0.5-log inactivation of *Giardia* cysts and 2-log inactivation of viruses
- Reduction of total dissolved solids to below 500 mg/l
- Confirmation that herbicides and pesticides in the raw water remain below MCL levels
- Reduction of radio-nuclides to below 0.03 mg/l for uranium
- Removal of natural organic matters prior to chlorination to prevent the formation of trihalomethanes (THM's), haloacetic acids (HAA's) and other disinfection byproducts (DBP's)
- Production of stable and non-corrosive water that will comply with the Lead and Copper Rule and minimize corrosion, precipitation, and deposition within the distribution system
- Reduction of tastes and odors to the lowest practical level.
- Production of finished water that is aesthetically pleasing to the customer and consistently meets all primary and secondary drinking water standards.
- Reduction of total hardness to 100 mg/l measured as $CaCO_3$

In addition to the proposed treated water quality stated above, several additional treatment goals are also taken into account. These treatment goals are established to meet the upcoming federal drinking water regulations, short-term (Stage 1) and long-term (Stage 2) Disinfectant/Disinfection Byproduct (D/DBP) rule and to enhance the finished water quality.

- Limit trihalomethane compliance values to less than 40 ppb, proposed Stage 2 D/DBP Rule MCL standard.
- Limit haloacetic acid compliance values to less than 30 ppb, proposed Stage 2 D/DBP Rule MCL standard.

Water from the wells is very high in total dissolved solids (TDS), hardness, and alkalinity, and contains high levels of carbon dioxide gas, as well as arsenic and radionuclides. The water is under static artesian pressure at approximately 150 pounds per square inch (psi) at a temperature of approximately 150° Fahrenheit (F) in the well column.

The quality of the raw water produced by the deep brackish supply wells in Sandoval County presents a formidable challenge for any water treatment process. The arsenic and radionuclides are considered to be hazardous in high concentrations. Others, such as hardness and alkalinity, affect the efficiency and recovery of the treatment process. Brackish water is typically treated using reverse osmosis (RO) and this process is sensitive to constituents in the water. The constituents in the water from Well EXP-6, along with the corresponding United States Environmental Protection Agency (EPA) primary and secondary drinking water standards, are presented below in Table 6-1. Constituents that are **bold** exceed drinking water standards.

Table 6-1
Well EXP-6 Water Chemistry

Parameter	Well EXP-6 Water	Primary Drinking Water Standard	Secondary Drinking Water Standard
Alkalinity (mg/l) as $CaCO_3$	1,800	N/A	N/A
Arsenic (mg/l)	**0.634**	**0.01**	**N/A**
Bicarbonate (mg/l)	1800	N/A	N/A
Boron (mg/l)	9.7	N/A	N/A
Calcium (mg/l)	450	N/A	N/A
Carbon Dioxide (mg CO_2/l)	1900	N/A	N/A
Chloride (mg/l)	**3,100**	**N/A**	**250**
Fluoride (mg/l)	**4.8**	**4.0**	**2.0**
Gross Alpha (pCi/l)	**209**	**15**	**N/A**
Hardness (mg/l as $CaCO_3$)	1,500	N/A	N/A
Iron (mg/l)	**3.3**	**N/A**	**0.3**
Lead (mg/l)	ND	0.015	N/A
Magnesium (mg/l)	97	N/A	N/A
Phosphorus (mg/l)	0.29	N/A	N/A
pH	7.05	N/A	6.5-8.5
Radium 226+228 (pCi/l)	**85**	**5**	**N/A**
Salinity (unitless)	10.4	N/A	N/A
Silica (mg/l)	32	N/A	N/A
Sodium (mg/l)	3,600	N/A	N/A
Strontium (mg/l)	8.8	N/A	N/A
Sulfate (mg/l)	**4,400**	**N/A**	**250**
TDS (mg/l)	**12,000**	**N/A**	**500**
Temperature	150 F	N/A	N/A
Turbidity (NTU)	13	N/A	N/A
Thallium (mg/l)	**0.007**	**0.002**	**N/A**
Uranium (mg/l)	0.002	0.03	N/A

6.2 SELECTION OF TREATMENT PROCESSES

6.2.1 Treatment Challenges and Processes

The brackish water from the Rio Puerco Basin presents a number of difficult and unique treatment challenges that limit the viable processes available for treatment. These challenges include, but are not limited to, the following:

- TDS is over 12,000 mg/l, which is extremely high for brackish groundwater. For example, the brackish water source being treated in El Paso, Texas has a TDS concentration of 900 mg/l and discharges its concentrate at a concentration of 4000 mg/l.
- The water is extremely hard. At 1500 mg/l, the total hardness of the water is fifteen times the commonly accepted limit for total hardness (100 mg/l) in a drinking water supply.
- The concentration of arsenic is over 60 times the EPA MCL of 0.01 ppb
- The concentration of radium is over sixteen times the MCL of 5 mg/l
- Boron is present in the water at a concentration that is twice as much as the average concentration found in ocean water (9.7 mg/l versus 5 mg/l).
- Water temperature of 150° F exceeds that of normal groundwater sources in the area (70°-80°) and affects the solubility of many constituents.
- Water is artesian at elevated pressures approaching 150 psi (static). The design of this facility should consider taking advantage of this natural energy.
- Thallium and uranium were not detected in the pilot test water samples. If the raw water does exhibit trace amounts in the full scale plant, the softening process and/or RO process will provide sufficient removal.

Brackish water is typically treated using a reverse osmosis (RO) process, which will remove the majority of the challenging contaminants listed above as well as those listed in Table 6-1. However, some of the contaminants, primarily hardness and alkalinity, will seriously impact the efficiency of the RO process by limiting how much water can be produced, also known as recovery. RO will also remove arsenic and radionuclides; however, the waste stream containing these contaminants will be considered a hazardous waste and will require special handling and disposal.

During the evaluation of the chemistry of the water, it became apparent that it would require softening before the water was treated by the RO process. Due to the high concentration of hardness and TDS in the water, additional polishing processes would be required after softening to increase the efficiency and recovery of the RO process. It was also apparent that other pre-treatment steps would be required to selectively remove contaminants such as CO_2, arsenic, and radium before softening to minimize the hazardous waste streams and prevent contamination of the softening waste, which could possibly be recycled to reduce the amount of chemicals used in the softening process. To reduce energy costs, the treatment processes were evaluated to take advantage of the high temperature and pressure of the water.

Despite all of these challenges it is possible to treat this brackish water. There are a number of common water treatment processes that, used in combination with each other, can treat the water so it meets drinking water standards, utilizes the existing temperature and pressure of the water, and allow the RO process to operate efficiently and at a high rate of recovery. These processes are listed in Table 6-2:

Table 6-2
Viable Pre-Treatment Processes

Pre-Treatment Technology	Description
De-carbonation	Mass transfer process to remove dissolved gasses from water.
Gas scrubbing	Gaseous membrane filtration to separate CO_2 from de-carbonated air stream, followed by H_2S absorption to eliminate odorous air discharge.
Coagulation	Addition of chemical coagulant (typically metal salt) to reduce concentration of dissolved metals
Sedimentation	Process by which unwanted particles are settled and can be separated from the water
Warm Lime Softening	Addition of lime or caustic soda to increase pH of water to reduce hardness in water between 120°-140° F
Granular Media Filtration	Process by which fine-grained media is used to remove suspended solids
Ion Exchange	Process by which dissolved ions are removed from water using ion exchange with a resin
Nanofiltration	Alternative to warm lime softening. Membrane filtration process to remove hardness and higher valance ions

The pre-treatment processes listed in Table 6-2 were not evaluated individually. Rather, they were combined into three separate and distinct treatment process trains with RO serving as the primary treatment process. The common element to all of the pre-treatment processes is the softening step, which could be accomplished using chemical softening or nanofiltration. The treatment trains were evaluated on the following criteria:

- Effectiveness in removing target contaminants that could cause scale formation in the RO process, such as calcium, magnesium, sulfates, silica, and bicarbonate.
- Meet industry standard for brackish water RO recovery (80 percent).
- Ability to isolate hazardous constituents (arsenic and radionuclides) and minimize waste streams containing hazardous materials.
- Ability to isolate and selectively remove constituents in the water that could be recovered and potentially marketed as a usable product that could possibly offset the cost of operating the proposed treatment plant.

As part of the evaluation process, bench scale testing was conducted on water from Well EXP-6 to determine the recommended chemical dosages to reduce hardness, alkalinity, TDS, and the concentrations of arsenic and radium. The results of the bench scale testing were also used in developing guidelines for pilot testing the selected treatment train, primarily in determining the effectiveness of the process and the amount of sludge/by-product generated by the process.

6.2.2 Bench Scale Testing

Bench scale testing was conducted on water from Well EXP-6 in June 2009. A copy of the results of bench scale testing is included in Appendix P. Bench scale testing focused on the following parameters associated with the coagulation and softening pre-treatment processes:

- Increasing the pH of the raw water to a target range of 10-11 by stripping CO_2 and adding lime or caustic soda
- Evaluating the effectiveness of lime or caustic soda in the softening process
- Determining the dosages of coagulants needed to reduce hardness and TDS.
- Determine the effectiveness of hardness, TDS, alkalinity, arsenic, and radium removal

Qualitative observations of water quality, chemical dosage requirements, and well water behavior were made in the field during bench-scale testing. Samples from bench testing taken in the field were sent to a laboratory to verify field observations and yielded the following results:

- Stripping of CO_2 will be necessary to raise the pH of the water.
- Sulfate was not reduced by a significant amount in the softening process. This was expected as sulfate is a divalent anion that would typically be reduced in an ion exchange process or in the RO process.
- Lime was more effective than caustic soda in reducing alkalinity
- Hardness was successfully reduced in the process by increasing in pH
- Precipitation and softening did not reduce the concentration of arsenic to below the MCL of 0.01 mg/l. Additional treatment steps would be necessary to reduce the concentration of arsenic to below the MCL.
- Silica reduction was most effective at the highest pH, with caustic soda being slightly more effective than lime.
- Radium and gross alpha particle removal was extremely effective in the softening process.
- Warm Lime softening would require a dosage of 1500 mg/l, which equals approximately 72,000 lb/day of dry lime for a 5 MGD treatment facility.
- The warm lime softening process will generate an estimated 158,000 lb/day (dry weight) of sludge containing primarily calcium carbonate and magnesium hydroxide as well as arsenic and radionuclides.

The large amount of lime required in the process combined with the effectiveness of the arsenic and radionuclide removal in the softening process created cause for concern. To reduce the amount of lime that would have to be imported to the treatment facility, the lime waste could be recycled in a process called re-calcination. The re-calcination process consists of heating the calcium carbonate sludge to high temperatures to convert the carbonate (CO_3) to carbon dioxide (CO_2). The recycled lime could be reused in the softening process and could significantly reduce the amount of imported lime required for the softening process.

As a result of the bench scale testing, stripping of carbon dioxide, followed by warm lime softening is envisioned as being the preferred method of reducing the hardness and alkalinity of the raw water before it is treated by an RO system to remove dissolved solids.

6.2.3 Pre-Treatment Process Train Alternatives

Bench scale testing established the preferred pre-treatment processes that would be required before treatment by an RO system. As mentioned previously, these processes were combined into three separate configurations, with the method of softening and the polishing steps after softening being the differences between the configurations. All of the process train alternatives have arsenic and radium removal before the softening step and RO as the primary treatment process.

Each alternative is briefly discussed followed by a detailed discussion of the treatment processes. An evaluation matrix follows the discussion of the treatment processes and the preferred process train is presented after the matrix.

6.2.3.1 Process Alternative 1: Warm Lime Softening+ Media Filtration + RO

This process alternative, shown schematically below in Figure 6-1, includes energy (pressure) recovery, CO_2 and hydrogen sulfide (H_2S) removal via aeration, specific removal for arsenic and radium, warm lime softening, media filtration, heat recovery, and finally RO. The warm lime softening process would require a re-calcination system to allow for the reuse of lime at the treatment plant and to possibly generate a marketable product from excess lime produced.

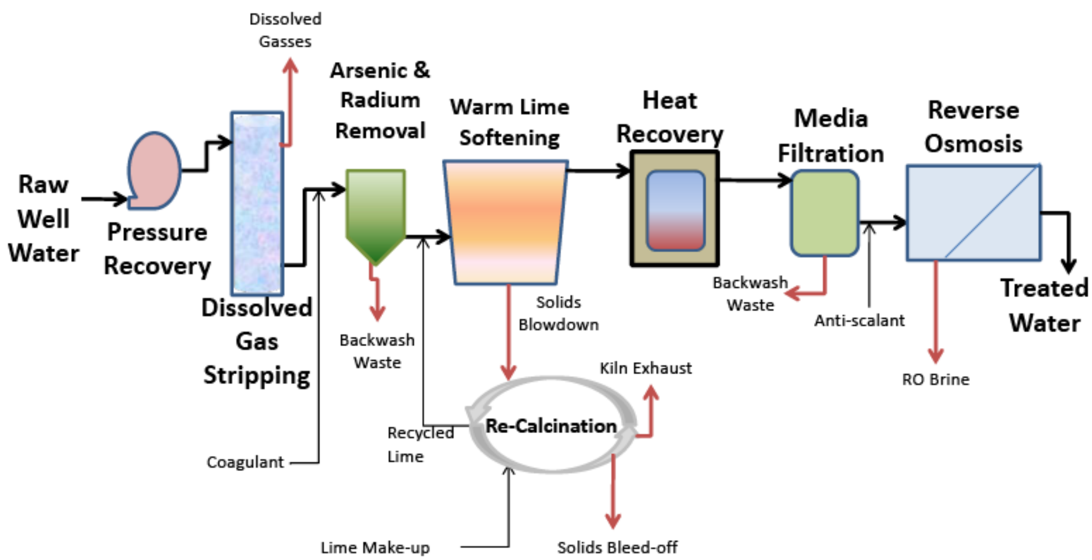


Figure 6-1 Process Alternative 1: Warm Lime Softening + Media Filtration + RO

6.2.3.2 Process Alternative 2: Warm Lime Softening + Media Filtration+ WAC Ion Exchange + RO

This process alternative, shown schematically below in Figure 6-2, includes energy (pressure) recovery, air stripping to remove CO_2 and H_2S, specific arsenic and partial radium removal, warm lime softening, media filtration for carryover particulates, ion exchange (IX) for polishing of remaining divalent cations (calcium, magnesium, barium, strontium), and RO. A re-calcination system would be required for the full-scale facility to allow for reuse of lime at the plant and generate excess lime as a marketable product. Arsenic and approximately 50 percent of the radium will be removed independently of the softening step to prevent contamination of the lime product.

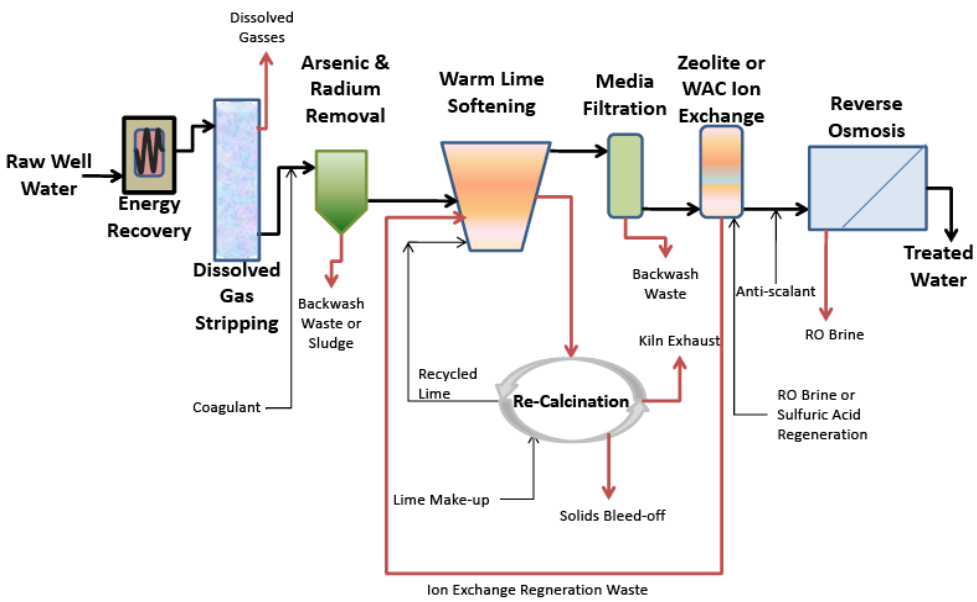


Figure 6-2 Process Alternative 2: Warm Lime Softening +Media Filtration + WAC Ion Exchange + RO

6.2.3.3 Process Alternative 3: Nanofiltration Softening +RO

This process alternative, shown schematically below in Figure 6-3, includes energy (pressure) recovery, aeration for CO_2 and H_2S reduction, specific arsenic and radium removal, nanofiltration softening instead of warm lime softening, and RO. The NF membrane would separate most of the remaining contaminants prior to the RO, only requiring the RO to remove mono-valent ions. The NF membrane reject water would be softened using IX or lime softening, with the softened water returned to the nano-filters. The RO brine would be a relatively pure, marketable product since the arsenic and radium would be removed upstream.

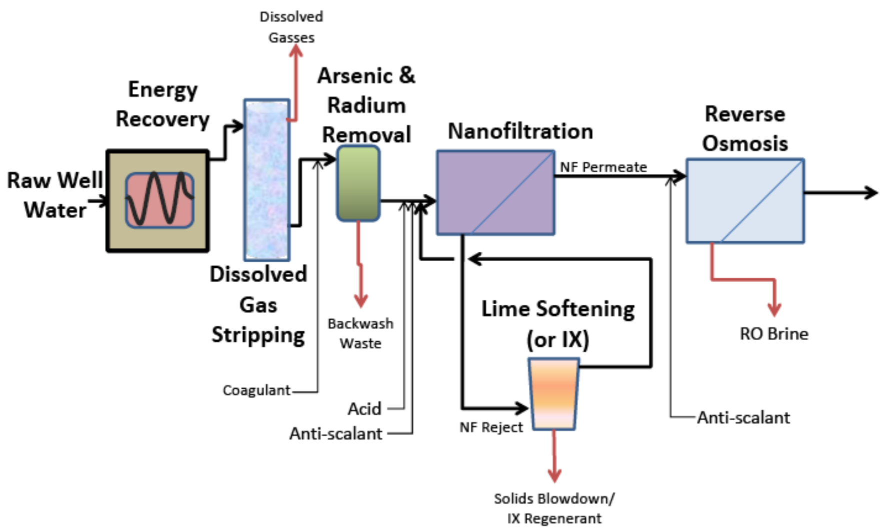


Figure 6-3 Process Alternative 3: Warm Lime Softening +Media Filtration + WAC Ion Exchange + RO

6.2.4 Process Descriptions

6.2.4.1 Aeration

Aeration is a mass transfer process that removes dissolved gases from water and oxidizes certain compounds via exposure to air in a controlled reaction. Aeration is achieved by either installing submerged air diffusers in an open tank or flowing water over a packed tower to achieve air-water contact. Due to the potential for scaling with this water, a scale inhibitor must be added to the water prior to treatment in a packed tower. A basin with coarse bubble aeration was considered, however it would be more difficult to collect the carbon dioxide (CO_2) off-gas for use in ancillary processes being evaluated for this Project. Therefore, a packed tower will be used for aeration.

Aeration will also oxidize iron and arsenic into higher oxidation state molecules that more readily adsorb with coagulants. A coagulant, used in the downstream treatment process, can be added downstream of the packed tower aeration step to take advantage of the additional mixing. The primary operational concern for aeration is scale build-up and provisions will be required in the full-scale facility for periodic acid cleaning.

A blend of air and CO_2 will be released out of the packed tower. Recovery and reuse of this stream will be discussed in later sections of this report.

6.2.4.2 Coagulation/Sedimentation

The main purpose of this step for the Project is to isolate and remove the arsenic and radium prior to the warm lime softening and RO processes so they are not concentrated in the lime waste or RO concentrate. This process would minimize the waste stream containing arsenic and radionuclides and may potentially allow for usable byproducts (lime, sodium carbonate, and/or sodium sulfate) to be recovered from the softening and RO process.

During the coagulation/sedimentation process, the addition of a coagulant such as ferric chloride is used to reduce the concentration of dissolved metals, dissolved organics and suspended particles from water. The metal salts destabilize these constituents and form large particles that facilitate removal by settling in an inclined plate settler.

Removal of radium and arsenic in the same treatment basin presents a challenge since arsenic removal is expected to occur in the treatment process at pH 7.5 and radium removal is more efficient at a higher pH. If radium were not reduced in this step, it would be removed in the softening step where the pH is much higher. The addition of potassium permanganate along with ferric chloride in this process will facilitate radium removal at a low pH and keep significant amounts of radium from being removed in the softening process. This will allow by-products from the softening process to be recycled and possibly recovered for re-use or sale.

The waste product from this process is coagulant sludge that would contain iron hydroxide sludge with additional iron, arsenic and radium. A 5 MGD facility will create approximately 2000 pounds per day (lb/d) dry weight of sludge using a ferric chloride dose of 30 mg/l as iron (87 mg/l as $FeCl_3$).

6.2.4.3 Warm Lime Softening

A softening process follows the coagulation/settling process and involves the addition of lime or caustic soda to increase the pH of water to reduce the solubility of calcium and magnesium, which are responsible for hardness. Softening also reduces the alkalinity of the water, and consequently the amount of acid needed to depress the pH of the softening effluent, and minimizes calcium carbonate scaling in the granular media filters and ion exchange feed water piping.

Warm lime softening has been selected for the Project since improved performance and lower chemical usage can be achieved if the precipitation reaction is carried out at elevated water temperature. A “warm lime” softening process can be used in treatment plants where there is excess heat available or the source water is naturally at a high temperature usually between 120° and 140° F. The warm lime process is highly effective since the solubility of calcium and magnesium are lower at higher temperatures and more easily removed in the precipitation process.

An alternative to using lime in the softening process would be to use sodium hydroxide or caustic soda. Caustic soda would reduce the settled solids volume for this Project by roughly two-thirds. While there would be a reduction in the volume of dry calcium carbonate solids with this approach, the sodium would be transferred to the RO brine waste stream as sodium bicarbonate. This would increase the sodium content in the RO feed water, which would increase the process operating pressures. Also considered for the Project is the production of lime from the softening process residuals, thus limiting the volume of commercial chemicals that require delivery to the site.

Bench-scale testing indicated a dose of 1500 mg/l of lime or 900 mg/l of caustic soda to achieve a pH of 9.5. However, lime softening was much more effective in reducing the alkalinity of water (caustic soda increased the alkalinity) and will be used in the full-scale plant. It is anticipated that lower chemical dosages will be realized at the full-scale facilities due to more effective stripping of CO_2 using aeration, which will further increase pH before chemical addition, and improve reaction kinetics achievable in a larger contact basin.

As with coagulation/sedimentation, softening is adversely affected by rapid changes in plant flow rates. Therefore, wide variation in plant production should be avoided in typical operation. Granular filters installed downstream from the chemical softening process can remove carry-over of solids during plant startup and process upsets.

6.2.4.4 Granular Media Filtration

Granular media filtration is a process in which sand, anthracite, or other fine-grained filter media are used to remove suspended solids that have previously been coagulated or precipitated through an upstream treatment process. Catalyzing media, such as greensand or pyrolucite, can also be utilized to improve iron and manganese oxidation, and adsorptive media, such as granular activated carbon (GAC) can be used for removal of dissolved organic compounds. Granular media filters would be used for this Project after lime softening to remove the small percentage of the solids that do not settle in the softening process.

Media filters must be backwashed periodically to removal the accumulated solids, and insufficient backwashing will result in breakthrough of these solids into the product water. The frequency and duration of backwashing will depend on the nature and quantity of the solids being removed. Catalyzing media and adsorptive media would also require regeneration or replacement to maintain functionality.

6.2.4.5 Ion Exchange

Ion exchange (IX) is a process by which dissolved ions are removed from water using natural or synthetic resins that exchange ions in the resin, such sodium or hydrogen, for higher ionic strength ions in the water. IX vessels must be periodically backwashed and regenerated using sodium chloride, acid, or base solutions to replace the sodium, hydrogen, or other exchange ion into the resin. Resins that are not regenerated effectively will result in breakthrough of the ions targeted for removal, often at concentrations exceeding those of the feed water. The effectiveness of IX is greatly reduced by the presence of suspended solids, which can create high head loss and resin fouling organic compounds, and metals, such as iron, manganese, and arsenic, making it cost effective to remove these before sending the water to ion exchange vessels.

The most common IX resin used for water softening is a sodium cation exchange or zeolite resin that exchanges sodium for calcium (Ca), magnesium (Mg), and other divalent cations. Typically the Ca and Mg ions are preferentially removed, so other cations are displaced as the resin bed becomes saturated with Ca and Mg. After the resin has reached its capacity for hardness removal, it must be regenerated with a 6 percent concentration sodium chloride solution, creating an intermittent brine waste stream. Sodium zeolite resins have limited exchange capacity, require frequent regeneration, and are not suitable for this Project given the high sodium concentrations that would inhibit the removal of hardness and increase Ca and Mg leakage.

An alternative to the sodium zeolite resin would be a weak acid cation (WAC) exchange resin, which is more efficient at removing hardness, allowing higher feed concentrations, lower product water hardness concentrations, and less frequent regeneration. WAC resins exchange hydrogen for calcium, magnesium, and other divalent ions, requiring regeneration with a dilute mineral acid solution rather than with salt. WAC resins do not add salinity, and they remove alkalinity from the treated water as a result of the exchange of hydrogen ions (H^+) for the cations.

WAC resins are still susceptible to interference from suspended solids, organics, and multi-valent cations (iron, manganese, and/or arsenic), but are more amenable for use for this Project because they reduce hardness to near-non-detect levels and have higher capacities. This will prevent potential scaling of calcium fluoride and magnesium hydroxide in the RO concentrate.

Use of IX would serve as a polishing step to remove trace levels of hardness after chemical softening, allowing the downstream RO process to operate at significantly higher recovery rates. Initial estimates indicate that regeneration of a WAC resin, treating previously softened water with residual calcium and magnesium concentrations of 40 mg/l each, would require regeneration approximately once per day, using 7,000 to 8,000 lb/day of hydrochloric acid (assuming a 5 MGD facility).

6.2.4.6 Nanofiltration

Nanofiltration (NF) membranes are a possible alternative to warm lime softening. NF membranes would preferentially remove hardness and other divalent and multi-valent ions from water, while retaining a much lower percentage of mono-valent ions, such as sodium, chloride, and bicarbonate in the product water. NF membranes operate at lower feed pressures than RO membranes, but, similar to RO membranes, are susceptible to fouling from the sparingly soluble salts and insoluble metal hydroxides. Antiscalants can be utilized to delay scaling of calcium, magnesium, silica and barium compounds when operating above the equilibrium saturation limits. However, the high concentrations of these constituents in the raw water exceed the capabilities of antiscalants, which would result in frequent cleaning of the membranes with acid and base solutions.

Membrane projections were evaluated using several NF membranes, and the results of the projections indicated that the membranes would remove up to 70 percent of calcium and 25 to 50 percent of bicarbonate, potassium, and barium, while passing the majority of the sodium, chloride, boron, fluoride, and silica, and removing more than 80 to 90 percent of the sulfate and magnesium. High concentrations of acid would be required to prevent scaling of NF membranes and to achieve recoveries between 50 to 70 percent. Chemical softening would then be required on the brine waste stream in order to remove calcium and magnesium before returning the treated waste stream to the head of the plant.

While NF softening does provide some benefit in its ability to remove sulfate and alkalinity from the feed water at much lower pressures than RO membranes, the NF membranes create a high volume waste stream that must be treated and then recycled. In addition, it allows calcium, magnesium, and bicarbonate to be split onto both sides of the membrane, resulting in partially pure waste streams. The partially pure waste streams make it difficult to remove and isolate useable solids, which was one of the evaluation criteria for this Project.

6.2.4.7 Reverse Osmosis

Reverse osmosis (RO) is a treatment process used to remove solutes from water. An RO process depends on the presence of a barrier or membrane that is selective so that solvent (water) can pass through the membrane while the solutes cannot. Osmotic pressure is the pressure required to prevent the flow of water through a semi-permeable membrane separating two solutions of different concentration. To separate water from dissolved salts in reverse osmosis, the water is pumped at high pressure across the surface of the membrane, which causes a portion of the water to pass through the membrane. Water passing through the membrane is called permeate and is relatively free of dissolved solutes while the remaining water, called concentrate, exits at the end of a pressure vessel. Brackish water RO systems are designed for a pressure range of 300-600 psi while seawater systems operate a pressures ranging from 800-1500 psi.

RO systems consist of 8-inch diameter by 40-foot long membrane elements with approximately 400 square feet of membrane surface area. The membrane elements are placed in series of 5-7 elements in long pressure vessels and the vessels are arranged in parallel, which is called a stage. Concentrate from one stage can be fed from one stage to another to increase recovery (a multi-stage system) or permeate from one stage can be fed to a second stage to increase solute removal (a two-pass system). Recovery is the ratio of permeate to feed water flow and is a measure of how much water is produced. Recoveries in seawater RO systems range from 40 to 50 percent while recovery in brackish water RO treatment systems is usually 80 percent.

RO membranes would be the main treatment step for this Project, and would remove the more soluble dissolved salts and produce a treated water with less than 500 mg/l TDS. Seawater RO membranes would be required to achieve the TDS reduction and to be compatible with the high feed pressures necessary to overcome the osmotic pressure of the high salinity water. The RO process will create a waste stream of concentrated brine that would contain any ions not removed in the upstream pretreatment processes. Ions in the brine stream would include sodium, chloride and small concentrations of boron, but may also include sulfate and bicarbonate, depending on the pretreatment processes selected for the Project.

Recovery of up to 80 percent of the feed water as low-TDS permeate may be achieved with a two stage RO system, provided upstream pretreatment processes remove divalent ions, such as calcium, magnesium, barium, and strontium, along with multi-valent metals, such as iron, manganese, aluminum, and zinc, all of which could foul or scale the membranes at high recovery rates. Periodic chemical cleaning using acidic and basic solutions would be required to remove inorganic scale. The cleaning frequency would be dependent on the efficiency of the upstream pretreatment processes. Less frequent high-pH cleaning may also be required to remove organic compounds, silica, and biological growth (if present) from the membranes.

6.3 TREATMENT PROCESS EVALUATION MATRIX

The matrix presented in Table 6-3 provides a comparison and evaluation of the three pre-treatment process trains. The primary goal for the pre-treatment train is to reduce hardness alkalinity, and divalent ions that could interfere with the RO process. The secondary goal of the pre-treatment process is to selectively remove contaminants to reduce the volume of hazardous waste generated. Selective removal may also allow the recovery of higher purity constituents, including salts and lime solids, which could possibly be sold for reuse or disposed of in a municipal solid waste landfill.

Table 6-3
Process Evaluation Matrix

Treatment Process	Advantages	Disadvantages	Target Contaminants Removal								Process Waste Stream
			Hardness , Ca, Mg	Anions: TDS, Cl, F, NO_3	Arsenic	Boron	Radium	SO_4,	Iron/Manganese	Uranium	
Aeration	Reduces CO_2 concentration and thus increases pH	Causes loss of residual pressure and heat in flow stream	+						+		None, unless GHG* is issue
Coagulation, Sedimentation	Effective for metals and organic carbon reduction when followed with filtration	Backwashing of media filters required			X		P		+	P	Settled solids and sludge
Warm Lime Softening	Reduces both alkalinity and hardness, may remove some metals and radionuclides	Large chemical volume required, generates significant waste stream	X		P		X		P	X	Lime solids blow-down
Media Filtration	Metals reduction when used with an oxidant	Does not reduce hardness or TDS, may scale; backwashing required	+		+		+		+	+	Backwash wastewater
Ion Exchange	Can selectively remove contaminants with media selection	Frequent regeneration Concentrated brine often hazardous	X	X	X	X	X	X	X	X	Regeneration Brine
Nanofiltration	Reduces both alkalinity and hardness, may remove some metals and radionuclides, smaller footprint	Higher capital cost, energy consumption, greater capacity risk due to fouling potential	X	P	P		P		X	P	Concentrated Backwash
Reverse Osmosis	Removes dissolved salts and modern RO treatment can be 90-98% efficient	Requires extensive pretreatment to avoid scaling and fouling of membranes	X	X	X	P	X	X	X	X	RO Reject Brine

* - Greenhouse gas
X - Method proven for contaminant removal
P - Method may partially reduce contaminant
+ - Method proven for contaminant removal in conjunction with other processes

6.4 RECOMMENDED TREATMENT PROCESS TRAIN

Process Alternative 2, lime softening with ion exchange, followed by RO, is the recommended treatment process train for the Project. This process alternative provides the following benefits:

- Arsenic and a portion of the radium are removed separately reducing the contamination of lime sludge or other treatment process by-products; arsenic and radium will be confined to low volume coagulation waste.
- Treatment Reliability – Multiple barriers are provided to achieve the treatment goals. The primary arsenic removal process is the ferric chloride precipitation process, and this is followed by the RO process, which can achieve greater than 95% rejection of any arsenic in the precipitation process effluent.

  There are also multiple barriers associated with reducing hardness and TDS. The lime softening process is the primary process, and this is followed by the RO process, which reduces hardness and TDS. The RO membrane consists of a semi-permeable film that prevents the passage of bacteria, pathogens, virus and suspended solids, and this serves has a final barrier in the treatment process.
- Equipment Reliability – The individual treatment processes are used extensively to treat brackish groundwater, and are considered well developed and reliable technologies for drinking water treatment. The only moving parts associated with the equipment are the pumps, mixers and valves, which reduced the potential for mechanical failures.
- Modular Components – The unit processes can be designed in multiple modules of 1-3 MGD that allow the treatment process to be phased and easily expanded as necessary. Many of the treatment processes and ancillary components, such as the de-carbonators, plate settlers, pressure filters, ion exchange systems, RO skids and cooling towers, can be factory assembled to reduce installation effort and coordination problems. This results in improved quality control and reliability. None of the technologies being considered are proprietary, which increases manufacturer competition in the supply, operation and maintenance of the equipment.
- Operability – All of the proposed treatment processes can be automated, and generally operate in a steady state condition after start-up. This reduces the staffing requirements associated with operating the treatment system.
- Site Conditions – The proposed treatment processes are generally compact, and there is minimal exposure of the operator to the water being treated. The de-carbonators, pressure filters, ion exchange system and RO skids are closed pipe systems, which reduces chances for contamination of the treated water or splashing that could result in added maintenance.

6.5 PRELIMINARY TREATMENT PROCESS OPERATING CRITERIA

Bench scale testing of the coagulation and softening processes discussed in Section 6.2.2 provided preliminary chemical feed rates of coagulant (ferric chloride) and lime for these processes. Estimates were also prepared of the chemical feed rates of hydrochloric acid used for regenerating the WAC ion exchange system and antiscalants used in the RO process. These preliminary chemical feed rates are presented in Table 6-4.

The chemical feed rates presented in Table 6-4 were used to prepare estimates of the volume of solids produced in each of the pre-treatment processes for a 5 MGD treatment plant. Modeling of the RO process was also performed to estimate the volume of dissolved solids in the RO concentrate. These estimated volumes are presented in Table 6-5.

Table 6-4
Estimated Preliminary Chemical Feed Rates[1]

Chemical	Dose (mg/l)	Purpose	Concentration	Usage (lb/day)	Usage (gal/day)
Lime (CaO)	1,500	Chemical Softening	Dry	72,000	NA
Ferric Chloride ($FeCl_3$)	87 (30 as iron)	Coagulation	40%	4,200	455
Hydrochloric Acid (HCl)	NA	IX Regeneration w/ 5% HCl solution	40%	7,800	790
Antiscalant	4	RO Scale Prevention	100%	185	22

1-Rates based upon bench-scale testing. Actual feed rates to be determined during pilot testing

NOTE 1: *As tested at the lab, the raw well water was not (and seldom is) in perfect chemical equilibrium. There could be any number of reasons for this, but it ultimately comes down to an imbalance or omissions in the measured concentrations of anions or cations in the water. Table 6-5 was prepared as a prediction of the estimated volume of solids produced by the selected treatment process and in order to run chemical prediction models or RO prediction software, the input water quality must be in equilibrium. This is achieved usually by adjusting the concentration in the model input parameters of an ion (in this case sodium) to achieve equilibrium artificially. Sodium was selected because its concentration has no real impact on process selection or system performance as opposed to adjusting the sulfate or chloride concentrations. Accordingly, the sodium concentration in Table 6-5 is different from that in the raw water. The sodium concentration represented in Table 6-5 is an adjusted value to bring the solution to equilibrium.*

NOTE 2: *The TDS values shown in Table 6-5 (next page) are "sum of ions" totals, which is the mathematical sum of the concentrations of all the ions in solution. This reflects any possible modifications to ion concentrations (as discussed above) of the solution in equilibrium. To correlate Table 6-5 and with Table 7-2, a line item for the laboratory measurement for TDS at 180 C has been added. However, the lab measurement is an evaporation method where a filtered water sample is kiln dried and the mass of the residue is measured and reported as TDS. The discrepancy in this case is that some (50%) of the bicarbonate mass is lost as CO_2 during the kiln heating process. In Table 6-5, the TDS at 180C reflects the estimated quantity of individual ions and accounts for the "missing" CO_2. This value is 13,100 mg/l, which is higher than the actual laboratory TDS @180C, which is approximately 12,000 mg/l. The concentration of the individual ions is generally used for the process calculations shown in Table 6-5, because it correlates to the water quality tests needed for the RO projection programs. We have used a TDS @ 180C value of 12,000 mg/l for Table 7-2 as we are only interested in the composite of all the major ions.*

Table 6-5 Solids Concentrations in Preliminary Process Streams

Stream ID	1	2	3	4	5	6	7	8	9	10	11	12	13
Description	Raw Feed	After Aeration	Clarifier Effluent	Dewatered Clarifier Sludge	Softener Overflow	Dewatered Lime Sludge	Sand Filter Backwash	Filtered Effluent	Total IX Waste	IX Effluent	After Cartridge Filters	RO Reject	RO Permeate
Flow (gpm)	3,941	3,940	3,940	na	3,893	na	191	3,889	56	3,889	3,889	388	3,500
pH	6.58	7.51	7.12	na	10.40	10.40	10.20	10.20	na	8.97	8.97	4.98	10.95
Specific Gravity	1.01	1.01	1.01	3-4	1.01	1.30	1.01	1.01	na	1.01	1.01	1.10	1.00
Temperature, Deg F	120	106	106	ambient	106	ambient	106	106	na	106	106	106	106
Commons (mg/l)													
Total Alkalinity as $CaCO_3$	1,800	1,803	1,713	na	463	na	408	408	na	223	223	142	226
Total Ammonia (N)	0.7	0.7	0.7	na	0.7	na	0.7	0.7	na	0.7	0.7	2.6	0.5
Total Silica (SiO2)	34.7	34.7	34.7	na	34.7	na	34.7	34.7	na	34.7	34.7	316.7	0.3
Total Boron (B)	8.7	8.7	8.7	na	8.7	na	8.7	8.7	na	8.7	8.7	78.0	0.3
Anions (mg/l)													
Bicarbonate	2,189	2,164	2,074	na	32	na	46	46	na	160	160	172	0
Carbonate	2	14	6	na	154	na	140	140	na	28	28	0	2
Chloride	3,100	3,101	3,160	na	3,160	na	3,160	3,160	5000	3,160	3,160	31,522	19
Fluoride	5	5	5	na	5	na	5	5	na	5	5	48	0
Sulfate	4,400	4,400	4,400	na	4,400	na	4,400	4,400	na	4,400	4,400	43,892	22
Cations (mg/l)													
Calcium	441	441	441	na	27	na	27	27	210	0.10	0.10	0.99	0
Magnesium	94	94	94	na	27	na	27	27	210	0.10	0.10	0.99	0
Potassium	140	140	140	na	140.0	na	140	140	108	140	140	1,355	5.6
Sodium	3828	3828	3828	na	3828	na	3828	3828	-	3880	3880	38800	125
Arsenic (+5)	0.645	0.645	0.010	4,477	0.010	na	0.010	0.010	-	0.010	0.010	0.099	0
Iron (+2)	2.97	0	0	0	0	na	0	0	-	0	0	0	0
Iron (+3)	0.00	2.97	0.30	23%	0.050	na	0.050	0.050	-	0	0	0	0
Radium, pC/l*10e-3	0.02	0.02	0.01	58.87	0.008	na	0.008	0.008	-	0	0	0	0
Strontium	8.90	8.90	8.90	na	6.00	na	6.00	6.00	40	0	0	0	0
Gases (mg/l)													
Ammonia	0.01	0.05	0.02	na	0.83	na	0.82	0.82	-	0.55	0.55	0	0.57
Carbon Dioxide	448	42.0	124.7	na	0	na	0	0	-	0.14	0.14	1,119	0
Other													
TSS (mg/l UNO)	-	-	6	30% Solids	20	35% solids	404	-		-	-	-	-
TDS (sum of ions) (mg/l)	14,250	14,250	14,250	na	11,800	na	11,800	11,800	5500	11,700	11,700	116,000	243
TDS (@180 ^{O}C)	13,100	13,100	13,200	na	11,700	na	11,700	11,700	5500	11,600	11,600	115,000	240
Weight Dry Solids (lb/day)	620,000	620,000	620,000	6,200	550,000	156,000	-	550,000-	30,000	540,000	540,000-	530,000	10,000

Key: "-" Negligible, but non-zero, concentration

6.6 PILOT TESTING

A detailed Pilot Testing Report is provided in Appendix Q. Testing of the selected pre-treatment processes and the RO system (Process Alternative 2) was conducted for 60-days during the period from September 21, 2009 to November 25, 2009. Pilot testing was conducted to confirm the following:

- The effectiveness and reliability of the recommended treatment process,
- The water quality projections for the product and waste streams from each unit process
- Identify design criteria and operating conditions for full-scale design.

6.6.1 Pilot Testing Treatment Process

The pilot process included aeration to reduce dissolved gasses from the well water and oxidize some dissolved metals, including iron and sulfide. Coagulation then destabilized the dissolved metals and warm softening with caustic soda addition removed hardness and other sparingly soluble divalent ions. Due to the scale of the pilot process the coagulation and softening processes take place in the same contact clarifier. These processes will take place separately in the full-scale treatment plant.

Following softening, granular media filtration removed remaining suspended particles and a weak acid cation remove remaining hardness and divalent ions. The RO process then removed or reduced the remaining dissolved metals and dissolved salts. The process flow diagram for the pilot test is shown below in Figure 6-4

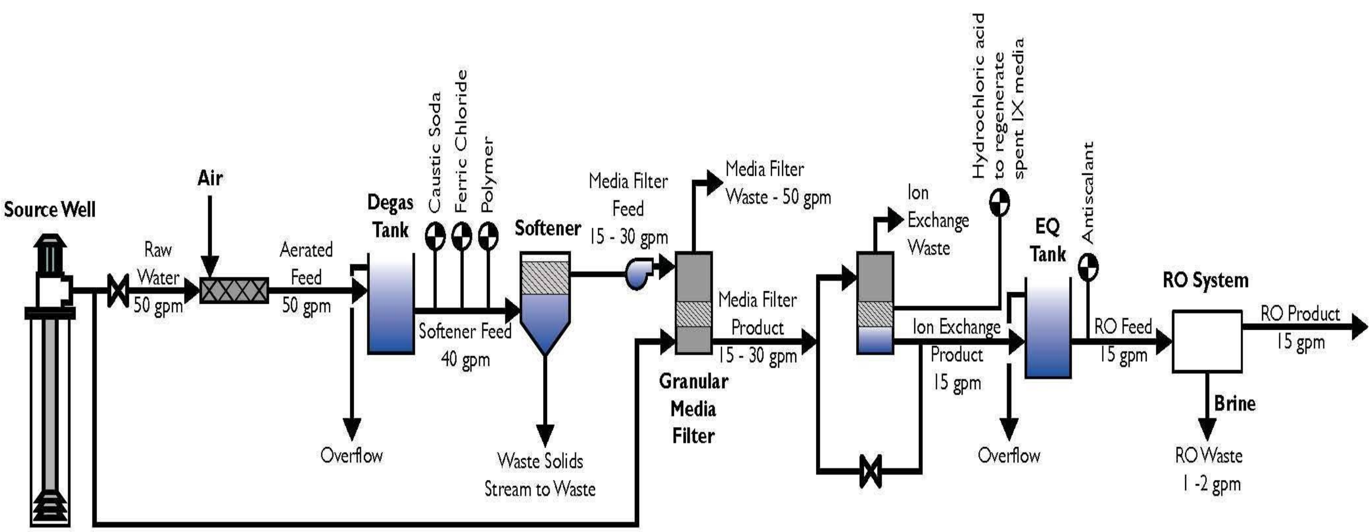


Figure 6-4 Process Flow Diagram for the Pilot Test

6.6.2 Pilot Testing Results

A 15 gpm pilot plant using coagulation for arsenic removal, high pH solids contact softening and high pressure reverse osmosis (RO) was operated to verify the treatment concepts described in Section 6.4 could be achieved. The objectives of the pilot test were to demonstrate that arsenic could be removed by co-precipitation with ferric chloride and the reverse osmosis process and that the hardness and TDS concentration of the water could be reduced to meet the secondary drinking water standard. The pilot plant was operated for approximately two months and the RO system operated approximately 350 hours during this period. Operating pressures, flow rates and water quality were monitored, and used to evaluate the fouling and scaling potential of the water and compatibility with standard commercial RO components. The operating pressures, treated water quality and flow rates generally conformed to the computer projections, and indicated a RO process could meet the project objectives. The trailer mounted RO system utilized for this pilot study is shown in the picture below.

The coagulation and settling process reduced the arsenic concentration to approximately 0.4 mg/l and the hardness to generally less than 200 mg/l as $CaCO_3$. The softened water was fed to the first stage of the RO system at 350-500 psi, and boosted to a pressure of 700-800 psi into the third stage. The RO system operated at an average flux of 11-13 gallons/day/square foot of membrane area (GFD) and a 75 to 80% permeate recovery ratio, which are both consistent with standard industry practice. The treated water quality was excellent with arsenic concentration consistently less than 2 ppb and total dissolved solids less than 300 mg/l.

A report summarizing the pilot testing program and results is in Appendix Q. The pilot testing results demonstrate:

1. Reverse osmosis treatment is feasible as described in Section 6.2.4.7 and in Table 6-3.
2. The proposed coagulation and settling pretreatment process with ferric chloride, lime softening, and granular media filtration before RO treatment is considered the best available technology (BAT) for the treatment of groundwater with high arsenic, hardness, and total dissolved solids concentrations to produce drinking water.
3. The proposed unit processes have the lowest capital and operational costs compared to other technologies that can address the water quality issues.

6.7 RESIDUALS MANAGEMENT AND RECOVERY OPTIONS

As stated in section 6.2.1, this particular water source exhibits several very challenging characteristics. The raw water exhibits artesian pressure (static), exhibits an elevated temperature, dissolved carbon dioxide gas, arsenic, radium, calcium carbonate hardness, and excessive dissolved salts. Many of the resulting residual products can be collected at various phases of the treatment process and put to productive use;

some returned to the water treatment process and others finished and sold. Most residual products can be marketed economically when considering avoided disposal costs.

The proposed treatment processes are designed to selectively remove these challenging constituents in a specific sequence. This is based on providing separate removal of the hazardous components (to minimize hazard waste handling and disposal conditions), and then sequenced removal of the remaining contaminants to not only optimize the treatment performance of the higher cost and energy consumption RO process, but also to optimize the reuse and disposal strategies of the residuals. The following sections further describe these residual products, their quantities; reuse potential, resale value, and disposal costs for those residuals with no marketable value.

6.7.1 Heat and Pressure

Heat and pressure are not residual products by definition, but they are (1) intrinsic to the raw water and (2) potentially valuable when put to productive use within the treatment plant.

- **Heat**

  According to the aquifer testing report, the raw water temperature in the wells is 150° F. This elevated raw water temperature represents a significant potential energy recovery opportunity. The natural heat can contribute to meeting the plant's total energy requirement.

  For the pre-treatment processes through warm lime softening, the warm water is beneficial to treatment efficiency. However, temperature reductions are required prior to the RO system where the residual raw water temperatures are too high for the RO membranes. This excess heat can be either (a) wasted into the atmosphere, or (b) collected with heat exchangers and put to productive use in a different part of the treatment plant. Preliminary analysis reveals that the residual temperature of the pre-treated water, after warm lime softening and prior to the RO system, will be approximately 130° F. The ideal feed temperature for the RO system is approximately 84°. The necessary temperature reduction is 46° prior to the RO system.

  This is a fairly significant energy reduction and recovery opportunity, and a reasonable location for an energy recovery device as most of the scale forming constituents will have been removed prior to the RO system. Financial analysis reveals that the value of reclaimed heat from the raw water justifies the cost of heat exchangers. That collected heat can be used in the sodium chloride brine concentrator and/or crystallizer processes, as discussed in a subsequent paragraph.

- **Pressure**

  According to the aquifer testing report, the aquifer at well EXP-6 is under artesian pressure and exhibits 150 psi static pressure at the surface, before drawdown and after recovery. The surface operating pressures were actually 120 psi (at 150 gpm well flow) and 106 psi (at 250 gpm well flow). The forward simulation of drawdown response over time (including the impact of a surrounding well field predicts that at 1000 gpm, the drawdown may be as much as 470 feet initially (about 203 psi). This is based on a very conservative analysis, but indicates that the well pressures at the surface may be negative at startup. If this is the case, the artesian pressure of the aquifer would not be sufficient to transport the raw water to the plant, and the wells would have to be supplied with submersible pumps. To be conservative, we have assumed that this will be the case and have included pumps in the cost estimate.

  It is possible that upon startup we may find that there is enough artesian pressure to deliver the raw water to the plant without pumping. We may also find that there is excess pressure that is available for energy recovery. We have conducted a preliminary evaluation of several energy recovery devices for this application, which could be considered in the event we find that there is excess artesian pressure at the wells upon startup.

There are several options for handling the excess pressure including (a) energy dissipation devices to waste the energy, (b) pump-style turbine generator to generate electricity on-site, or (c) pressure exchangers which use the high pressures in one portion of the process to boost pressure in a different portion of the process.

For this application, a pump-style turbine generator is preferred. Although the pump style turbine generator is less efficient than other micro turbine designs it has some distinct advantages. The primary advantage in comparison to other turbine designs is low initial capital cost and the ability to handle harsh water conditions without fouling or clogging. The pump style turbine generator can also easily adapt to changing water pressures and flow rates. Pump style turbine generators can be purchased in standard sizes offering the operator the ability to quickly order and exchange parts for the unit.

With this system, payback is generally achieved rapidly. Maintenance on the unit should be minimal and if the pump housing becomes fatigued due to the harsh water conditions it can be unbolted and exchanged for approximately $ 10,000-$ 12,000.

It is recommended that provisions be made at the plant for the possible installation of this type of energy recovery device, contingent on verification that there is in fact a residual artesian pressure available at the plant, after startup.

6.7.2 Carbon Dioxide Gas and H_2S

The raw water has a carbon dioxide (CO_2) concentration of 450 mg/l that must be removed before pretreatment. It also contains H_2S and other odorous gases. As discussed in section 6.2.4.1, a packed column is proposed for de-carbonation due to the more economical ability to recover CO_2 and control the release of other odorous gases.

The design of the packed column will require consideration to managing scaling; however, it has the distinct advantage of a concentrated discharge, which can be diverted to a CO_2 gas membrane separation system. This CO_2 can then be captured for beneficial reuse. The remaining gases would then be diverted to an H2S absorption tower (or iron sponge) to scrub the odorous gases prior to release into the atmosphere.

Four alternatives are considered for using/disposing of the collected carbon dioxide.

- **Atmospheric Venting**
  Carbon dioxide could be vented to the atmosphere, an alternative that has low infrastructure cost but also no productive use. This option would result in a significant odor problem to begin with, and may pose a carbon credit issue in the future.
- **Water Re-carbonation**
  The lime softening clarifier discharges at a relatively high pH. Re-carbonation is an optional treatment process designed to reduce the pH of the softened water in order to prevent continued floc formation in downstream processes. There is a second optional re-carbonation process on the lime sludge discharge. This process converts the precipitated magnesium hydroxide into magnesium bicarbonate solution to purify the calcium carbonate lime sludge prior to the re-calcination process. Carbon dioxide gas collected from the de-carbonation equipment could be used to supply these optional re-carbonation processes.
- **Carbon Black and Ozone**
  Carbon dioxide can be separated to produce carbon black and ozone, both having wide commercial uses. Production would include co-locating a 3rd party manufacturing plant and piping the collected CO_2 gas over to the carbon black facility. This alternative is not developed in detail because of high infrastructure cost relative to the product value at such small scale.

- **Algae Biomass**
  The collected CO_2 gas could be supplied to algae bioreactors growing biomass for anaerobic digestion and gasifying in an on-site combined heat and power (CHP) generating plant. Under this alternative use, collected CO_2 gas from the de-carbonation pretreatment process could be added to other CO_2 streams (from the lime regeneration kiln, described subsequently) and supplied to vertical photo bioreactors growing freshwater algae. The algae could be harvested, dewatered, and blended with other biomass in a co-located anaerobic digester system that produces methane for burning in a reciprocating generator. Carbon dioxide from the generator exhaust could then be collected and returned to the bioreactors, and heat from the exhaust stream is recovered and used in other parts of the treatment process. This optional component of the facility is described in more detail later in this report.

- **Treated Water Stabilization**
  The collected CO_2 gas could be re-injected into the finished water for pH adjustment.

According to the raw water analysis, there is 450 mg/l of CO_2 present in the raw water. At the raw water flow rate of 4610 gpm, there is 12.5 tons of CO_2 available per day for re-carbonation processes, treated water stabilization, and potentially algae growth.

6.7.3 Arsenic, Other Metals, and Radio-nuclides

A pre-treatment clarifier will remove arsenic and radio-nuclides by ferric chloride and polymer precipitation before all other treatment, effectively isolating the troublesome metals from other residual products and preserving re-use and marketability options.

The thickened and dewatered sludge discharges into suitable transportation containers so that there is no need for permanent sludge storage.

The waste stream from that clarifier flows at 0.6 gpm at 30% solids concentration. The projected 4,477 mg/l arsenic concentration requires this material to be disposed of in a hazardous waste landfill.

Waste Control Specialists will stabilize and dispose of this material in their Andrews, TX landfill for a projected disposal rate of $300/ton + $167/ton for trucking the containerized sludge to the Andrews landfill. The stabilization process will be determined based on the specific stream chemistry.

At 0.6 gallons/minute, the facility produces 315,360 gallons/year or approximately 1,315 tons/year, for an annual disposal cost of $614,129.

The United States Geological Survey reports that refined metallic arsenic sold for an average 98¢/lb in 2008. The anticipated 33 lb/day is worth, after refining, about $32/day or less than $12,000 per year. There is no domestic production of arsenic, so the refined metal would likely be shipped to Mexico to be added to an existing manufacturing process. Refining such small quantities to commodity grades is impractical, leaving aside the challenges of permitting an arsenic smelting or roasting plant. In this view, landfill disposal of the arsenic is probably the most practical option.

6.7.4 Hardness - Calcium and Magnesium Carbonates

Warm lime softening is the preferred method of removing excess carbonate hardness. Quicklime will be added to raise the water pH above 10 and precipitate calcium and magnesium, producing a sludge consisting primarily of calcium carbonate ($CaCO_3$) and magnesium hydroxide ($Mg(OH)_2$).

The raw water's high mineral concentration demands large quantities of quicklime and produces an abundance of lime sludge. The quick lime dosage required upstream of the softening clarifier is calculated to be a minimum of 1100 mg/l. This equates to approximately 31 tons/day of quick lime

(CaO) consumption. The softening process will generate lime sludge at an average rate of approximately 30 gpm at 35% solids, resulting in a total sludge production rate of approximately 156,000 lb/day (78 tons/day dry) calcium carbonate lime sludge ($CaCO_3$).

Given the substantial amount of quicklime required for the softening process, and the excessive amount of lime sludge produced, a lime re-calcination system is being considered.

A preliminary economic analysis was conducted to verify the economic viability of such a process against simply buying outsourced lime and disposing of the resulting lime sludge.

- **Option 1 (Outsourcing quick lime and Landfill Disposal of Lime Sludge):**
  At a quick lime feed rate of 31 tons/day, the plant would require 11,300 tons per year. Assuming a purchase rate of $145/ton, the annual cost of outsourced lime would be approximately $1,640,000, and would require two truck loads (at a 40,000 lb weigh limit) per day.

  At a sludge production rate of 78 tons/day (dry) and 35% solids concentration, the total sludge produced would be approximately 223 tons/day. Assuming a weight limit of 40,000 lb per truck load, approximately 12 trucks per day would be required to haul off the lime sludge. At a combined transportation and landfill disposal cost of $40/ton, the annual cost of lime sludge disposal would be approximately $3,250,000.

  Therefore, the annual cost of quicklime supply and lime sludge disposal would be approximately $5,000,000 million per year.

- **Option 2 (Lime Re-calcination Process):**
  An on-site re-calcination kiln would have the capability of converting the precipitated lime sludge (calcium carbonate) to quick lime (calcium oxide) for re-use in the softening process.

  This process will produce approximately 48 tons of quicklime (CaO) per day. With a required feed rate of 31 tons/day in the softening clarifier, 65% of the quick lime generated by the re-calcination process can be recycled back into the treatment process. This results in an excess quick lime production of 17 tons/day that Lhoist North America, New Mexico’s largest lime supplier, is interested in buying.

  The raw water contains several constituents that pose a potential problem for the re-calcination process including magnesium, silica, sulfate, sodium, and chloride. Accordingly, the re-calcination process would need to include a multi-stage pre-treatment system to remove these constituents and ensure that the granulated quicklime product meets ASTM standards for use in water softening, asphalt cement, and soil stabilization.

  Magnesium removal is accomplished by injecting CO_2 into the lime sludge (at the re-carbonation basin), which converts the precipitated magnesium hydroxide into magnesium bicarbonate solution. Once in solution, it is removed from the lime sludge by filtration.

  The filtered calcium carbonate solids continue on to the lime re-calcination process to produce Calcium Oxide. The magnesium bicarbonate solution is heated, aerated, filtered, dried, and finished to produce Magnesium Carbonate.

  The estimated capital cost of the entire lime re-calcination process, including magnesium separation, is $6.6 million, installed. This amortized at 4.5% over 25 years equates to an annual cost of approximately $450,000 per year. The annual electrical, heat, and O&M expenses are estimated to be less than $2 million per year. Therefore, the annual cost of a complete lime re-calcination process would be approximately $2.5 million per year, or approximately half of the outsourced lime supply and lime sludge disposal option. Therefore, it is economically advantageous to proceed with a lime re-calcination process.

In addition to this, the excess quick lime produced can be stored at the site and sold for commercial use by Lhoist North America, or an equivalent chemical supply company. Appendix R includes a copy of Lhoist's letter to Sandoval County expressing interest in commercializing the excess lime. ASTM standard quicklime is worth about $115/ton from Lhoist's Albuquerque depot.

The magnesium carbonate ($MgCO_3$, crude magnesite) recovered is also a marketable product. There are many common uses for this product including feedstock to magnesia (MgO) processing at Premier Chemicals LLC's Gabb, NV plant. It is also commonly used in fire extinguishing compositions, cosmetics, dusting powder, toothpaste, filler material, smoke suppressant in plastics, reinforcing agent in neoprene rubber, drying agent, laxative, color retention in food, antacid, etc. The project does not intend to re-calcine the magnesite into magnesia, despite the $350/ton value, due to the low throughput relative to capital costs.

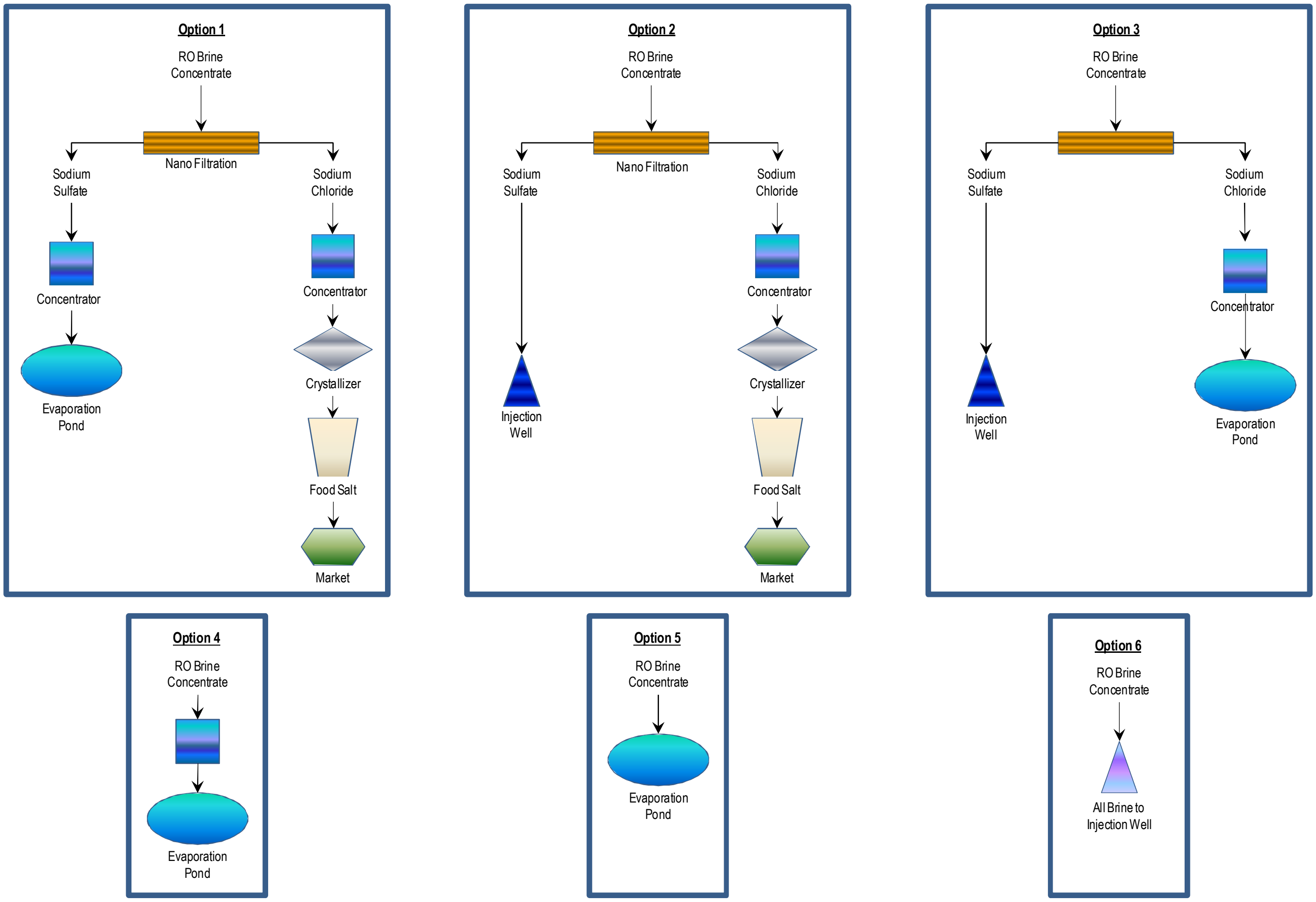
It is anticipated that approximately 7.4 tons of magnesium carbonate (at a 90% solids concentration) will be produced per day. The market value for this product is estimated to be approximately $40/ton.

6.7.5 RO Brine Reject

The raw water entering the treatment plant contains approximately 12,000 mg/l dissolved salts. The majority of this will be concentrated by the RO filtration system and rejected. The RO brine reject will consist of almost equal portions of sodium chloride (NaCl) and sodium sulfate ($NaSO_4$). The brine reject will be discharged at a continual rate of approximately 870 gpm and will contain approximately 270 tons/day (dry weight) dissolved salts. Economical reuse of sodium chloride is possible once it is separated from the sulfate.

Figure 6-5 shows the six alternative brine management strategies evaluated to determine the most economical method of handling the brine reject from the RO process. These six options are further described below.

Figure 6-5
RO Brine Reject Handling Options



Option 1 – Option 1 includes a sulfate rejecting nano-filtration membrane to separate the sodium sulfate brine from sodium chloride brine to achieve 99% purity in the sodium chloride stream. The sodium chloride brine continues on to a thermal brine concentrator then through a crystallizer. The processed sodium chloride product that meets food grade salt specifications can then be marketed. In this alternative, the rejected sodium sulfate brine stream passes through a thermal brine concentrator and on to an evaporation pond.

Option 2 – Option 2 is effectively the same as option 1, but the rejected sodium sulfate brine stream is discharged to an injection well, without utilizing thermal concentration.

Option 3 – Option 3 includes the sulfate rejecting nano-filtration membrane as Option 1. The sodium chloride brine stream passes through a thermal brine concentrator and then on to an evaporation pond. The rejected sodium sulfate brine stream is discharged to an injection well, without utilizing thermal concentration.

Option 4 – Option 4 consists of taking all of the RO system reject brine through a thermal brine concentrator, then on to an evaporation pond.

Option 5 – Option 5 consists of taking all of the RO system reject brine to an evaporation pond, without utilizing thermal concentration.

Option 6 – Option 6 consists of taking all of the RO system reject brine to an injection well, without utilizing thermal concentration.

The individual processes considered are further described below. The preliminary cost comparison for these alternatives is provided in Table 6-6 below:

6.7.5.1 Sodium Chloride Management

Selective nano-filtration, or an equivalent technology, can be used to separate the sodium chloride from the sodium sulfate in the RO brine reject stream. The separated sodium chloride brine stream would consist of approximately half of the total flow, or 435 gpm, and exhibit a chloride concentration of approximately 14,000 mg/l. This equates to about 121 tons/day of dry weight sodium chloride salt.

The following paragraphs describe productive use and commercialization of the sodium chloride salt.

- **Water Disinfection Chlorine**
  An on-site sodium hypochlorite generation system is proposed to utilize up to 200 lb/day of the recovered salt in an electrolytic process for the purpose of hypochlorite for disinfection. This use, while productive and cost effective, does not significantly deplete the available residual sodium chloride produced by the plant.
- **Commercial Food Grade, Industrial Grade, or Road Salt**
  Sodium chloride brine can be concentrated down to a solid, and sold as evaporative salt. Preliminary economic analysis indicates that producing industrial grade salt is economically feasible despite the energy-intensive crystallization process. Heat recovered from the raw water and from the on-site combined heat and power plant reduces these costs relative to a standalone salt making operation.

  In discussions with Compass Minerals, North American Salt Division (Lenexa, KS), the most advantageous market appears to be a direct sale to an industrial customer. Such a direct sale of evaporative salt product is estimated to yield a price of $90/ton. As an alternative, Compass Minerals has expressed an interest in buying this product direct, but in such a case, the value would be reduced to $50/ton. It is therefore recommended that the County seek a direct industrial market customer for this product.

6.7.5.2 Sodium Sulfate Management

After the selective separation process described above, the sodium sulfate brine stream would be approximately 435 gpm with a sulfate concentration of approximately 19,500 mg/l. This equates to a daily flow of 626,400 gpd; and 126 dry tons/day of sodium sulfate.

Sodium sulfate has a much lower market value than sodium chloride and as a result, has a much lower potential for productive reuse. Sodium sulfate is historically used as a carrying solid in powdered laundry detergent, but the industry trend toward liquid detergents has depressed prices and precludes this use. The following paragraphs describe various disposal options for the sodium sulfate brine.

- **Discharge to Wastewater Collection System**
  Disposal by dilution through a wastewater treatment plant is the most common disposal method for highly soluble sodium salts. The nearest large wastewater plant is the City of Rio Rancho Wastewater Treatment Plant No. 2, permitted for 5.5 MGD

discharge to the Rio Grande and generally operating around 4.0 MGD. Their current NPDES Permit No. NM0027987 does not have an alkalinity or salinity limit, as the presence of federally listed species in the receiving Rio Grande triggers a whole-effluent toxicity limit on the discharge.

Salinity already limits use of the Rio Grande waters, a problem severe enough to be prompting regional workshops for the stretch below Elephant Butte Reservoir (Truth or Consequences) and on down through El Paso, TX. Without a quantified limit, assume the maximum discharge concentration is equal to the irrigation season in stream salinity of 550 mg/l, (significantly higher than the natural value on this reach of about 40 mg/l), the entire 4.0 MGD discharge could absorb about 9 tons/day of the sodium salt assuming zero existing salt content. This discharge path, therefore, could accommodate only about 7% of the Project discharge. Considering the cost of the pipeline required to deliver this small fraction of the sodium sulfate brine and also the existing salinity problems on lower reaches of the Rio Grande, this alternative is considered untenable.

- **Dust Control**

  The Rio Rancho landfill, operated by Waste Management, Inc., and Sandoval County's own landfill, both use fresh water for dust control during dry weather. WMI reports an annual average consumption of about 20,000 gallons/day, and a previous landfill manager recalls the maximum daily consumption of about 80,000 gpd during hot, dry, windy weather. Sandoval County reports an average dust control consumption of about 40,000 gpd.

  NMED Solid Waste Bureau approval would have to be secured for the brine to be applied over the lined parts of the landfill operation. Assuming such approval is obtained, the two landfills have a combined capacity of 60,000 gpd, about 10% of the brine flow. The cost of disposal is undetermined at this point because the conditions of NMED approval are not known, but more than one truck would work full-time hauling brine and spraying it at the two landfills. The transport distance is greater than 15 miles from the plant to the landfill operations. While this option has the advantage of limiting fresh water consumption for a non-potable use, the cost and the relatively small consumption makes this option less preferred.

- **Solar Evaporation Ponds**

  Solar evaporation ponds were considered for reducing brine volume before final disposal. According to the United States Geological Survey, average annual rainfall in the area is approximately 8 inches and average annual evaporation is approximately 48 inches. Based on a net evaporation rate of about 40 inches, or 3.33 feet per year, at least 200 acres of lined ponds would be required to evaporate 702 acre-feet of water over the course of the year (based on a continual 435 gpm or 228 million gallons per year of sodium sulfate brine). This first approximation, though, assumes that the brine evaporates like potable water. Evaporation of water from a brine solution is much slower, decreasing in proportion to the vapor pressure of water in the fluid. Using a factor of safety of 2.0, approximately 400 acres of pond, therefore, would be required to evaporate the sodium sulfate brine from each 5.0 MGD project module. Planning for the ultimate 36 MGD build-out would require about 2,000 acres of lined ponds, a land use entirely incompatible with the planned Rio West development. Due to the excessive land requirement, solar evaporation ponds are not practical.

- **Thermal Crystallization**
  Lacking a productive use for most of the sodium sulfate brine, the material is anticipated to be disposed of as waste for the least cost. One disposal approach that minimizes the volume is to use thermal concentrators and crystallizers to convert the material to a solid that can either be disposed of at the Sandoval County landfill or, depending on trucking costs, hauled to one of the few remaining laundry powder manufacturing facilities. Energy costs make this alternative infeasible.

- **Injection Well**
  While it is recognized that an injection well is not the most desirable method of brine disposal, it is being considered here due to the severe limitations and costs associated with the other disposal methods. Consultation with Professor Kerry Howe of UNM, who assisted with the nanofiltration aspects of brine separation, confirms that we considered all available technologies for brine reduction before resorting to an injection well for the residual liquid.

  We have had preliminary discussions with geologists at the New Mexico Bureau of Geology and Mineral Resources and with hydrogeologists and the New Mexico Ground Water Quality Bureau regarding the viability of a sodium sulfate injection well in the Rio Puerco Valley. It was verified that a brine injection well is not specifically prohibited, but that it would be subject to the normal requirements of groundwater resource development. With a characterization of the receiving aquifer and confirmation that the brine will not adversely affect other developable resources, it appears to be a viable alternative in the eyes of the Bureau.

  Well EXP-5, constructed during the aquifer characterization phase of this project, is centrally located, and has disappointingly low water production in the source aquifer (even after fracturing). It extends 6,460 feet deep and terminates in basalt bedrock. Approximately 1,500 feet below the bottom of the water-bearing San Andreas and Glorieta (SAG) units, the well encountered permeable sandstone of the Red Tanks and Atrasado formations at the top of the Pennsylvanian Madera Group. This sandstone is confined by approximately 350 feet of low-permeability Abo formation mudstone, and is therefore isolated from the source aquifer. Regional mapping completed by the New Mexico Bureau of Geology and Mineral Resources[8] indicates that the Madera Group is not juxtaposed against the freshwater Santa Fe group in the Albuquerque basin, implying no communication between the brine injection layer and existing potable resources.

  The existing data indicates an 870 gpm injection well is feasible. Well EXP-5 would need to be rebuilt with a new casing and a screened interval in the appropriate formation, a relatively involved project but still less costly than drilling a new borehole 5,800 feet deep.

  Preliminary consultation with a brine injection geochemistry specialist raised several issues that should be addressed early in the design phase. Injecting concentrated brine into an aquifer, even a brackish one, will necessarily change the chemical equilibrium between water and formation in the receiving aquifer. Silica and calcium are the two constituents of principal concern. The risk of a problem from either is small, as silica has very low solubility and calcium is only present in clay minerals,

[8] Connell, S., 2008, "GM-78 – Geologic map of the Albuquerque-Rio Rancho Metropolitan Area and Vicinity, Bernalillo and Sandoval Counties, New Mexico," New Mexico Bureau of Geology and Mineral Resources.

which are sparse in a permeable sandstone unit. As a first step, simple tests could be performed on samples obtained from rock chips retained from drilling EXP-6, from outcrops, or from reference cores that may be available from the New Mexico Bureau of Geology and Mineral Resources.

Table 6-6 summarizes the cost comparison of the six alternative brine management strategies outlined above. The costs are presented as equivalent annual costs and include the annual debt service on the capital costs, annual maintenance, electrical costs, disposal costs, and revenues for products sold (industrial grade salt in options 1 and 2).

Table 6-6
RO Brine Reject Cost Comparison

Item	Description	Estimated Capital Cost	Annual Debt Service	Annual Operating Costs	Annual Revenue	Total Annual Cost
1	Nano-Filtration, With Concentrator For Sodium Sulfate to Evaporation Ponds, and Concentrator / Crystallizer for Sodium Chloride to Salt	$22,245,000	$1,500,181	$4,217,490	($3,960,525)	$1,757,146
2	Nano-Filtration, With Sodium Sulfate to Injection Well, and Concentrator / Crystallizer for Sodium Chloride to Salt	$17,050,000	$1,149,835	$1,803,844	($3,960,525)	($1,006,846)
3	Nano-Filtration, With Sodium Sulfate to Injection Well, and Concentrator for Sodium Chloride to Evaporation Pond	$32,225,000	$2,173,223	$3,371,484	$0	$5,544,706
4	All RO Brine to Concentrator Then to Evaporation Ponds	$13,445,000	$906,718	$4,276,616	$0	$5,183,333
5	All RO Brine to Evaporation Ponds	$11,890,000	$801,850	$4,198,866	$0	$5,000,716
6	All Brine to Injection Wells	$14,000,000	$944,146	$712,089	$0	$1,656,235

Based on the discussions of each alternative outlined above, and the cost comparison summarized in Table 6-6, Option number 2 is the most economical brine management strategy over the design life of the facility. This includes conversion of the existing Well EXP-5 to a 435 gpm sodium sulfate injection well and implementation of a sodium chloride brine concentrator and crystallizer system to produce industrial grade salt.

6.8 SUMMARY OF ADVANTAGES AND DISADVANTAGES

The treatment process alternatives were evaluated based upon several criteria, including County preferences and the following:

- Consideration of the ability to meet the County's needs within its financial, managerial, and operational resources.
- Consideration of regulatory compliance, including treatment processes that are sufficiently robust to meet water quality standards at all times, there are adequate safeguards should there be a problem with meeting regulatory requirements, and minimal regulatory risks or public objection.
- Compatibility with existing comprehensive area-wide development plans.
- The ability to satisfy public and environmental concerns, including public acceptance and the ability to achieve little or no adverse environmental impacts.
- Good access for construction and operation of facilities.
- Minimal impact to environment, cultural resources, residents, and businesses.
- Affordable construction and O&M costs.

- Ability to meet design and operating criteria.
- Reuse of residual products where economically viable.

Based on the evaluation of the process alternatives, it is recommended that the County treat the brackish water using de-carbonation, coagulation/sedimentation, lime softening, ion exchange, and reverse osmosis for the drinking water treatment plant for this Project. This recommended alternative, which will provide a cost effective solution for Sandoval County, is further detailed in Section 7.

SECTION 7
PROPOSED PROJECT

7.1 DESIGN CRITERIA

The selected project treats brackish water from a 3,500 foot deep brackish water aquifer in the Rio Puerco Basin. The project described in this report has level output of 5 MGD. The project is modular and scalable up to the projected 36 MGD of potable water demand in the planning area.

The project is comprised of these principal systems:

- Five ground water wells drilled to a depth of between 3,500 and 4,000 feet.
- Raw water pipelines transporting raw water from the well sites to a central treatment plant.
- A multi-stage desalination treatment plant.

Complementary facilities at the treatment plant include:

- A 250 MW co-located gas-fired power plant, or a natural gas-fired combined heat-and-power plant. This plant supplies waste heat to the various thermal processes in the treatment train to greatly reduce external energy requirements.
- A re-calcination kiln for lime regeneration and reuse.
- A sodium chloride brine concentration system including a thermal salt crystallizer for marketable salt production (only if sufficient grants are acquired for these elements).
- One or more sodium sulfate brine injection wells, for either sodium sulfate brine or mixed sodium sulfate and sodium chloride brine.
- A sodium hypochlorite generation system utilizing salt produced on-site.

The remainder of this section provides additional detail for the various project components.

7.2 TECHNICAL DESCRIPTION

The proposed treatment facility is designed to produce 5 MGD of treated water with less than 500 mg/l of TDS, less than 5 ppb of arsenic, less than 5 pCi/l of radium 226/228 as well as meeting all of the other primary drinking water standards. The general process consists of removing the carbon dioxide and hydrogen sulfide gas from the raw water, followed by coagulation and sedimentation to remove arsenic and radium. The water is then softened using lime, and polished with an ion exchange system to reduce the concentration of polyvalent cations that contribute to scale formation in the RO units. The RO units separate the feed water into a low TDS permeate and high TDS concentrate stream. The permeate will be stabilized with lime and carbon dioxide to reduce corrosion potential, and then cooled to approximately 75° F before being pumped into the distribution system. Three RO treatment trains each rated to produce 2.5 MGD of treated water are proposed for this facility and will provide a total treatment capacity of 5 MGD with a redundant unit.

The following paragraphs provide a detailed description of the treatment processes and follows the flow path of the water through the treatment plant as illustrated in the Process Flow Diagrams (Drawings P-1 and P-2, found in Appendix A). The identification number in parenthesis refers to the related process steam s identified in the process flow diagrams. Drawing C-1 in Appendix A shows a preliminary site plan. Appendix S has some of the preliminary equipment manufacturer drawings in more detail than can be shown on C-1.

7.2.1 Raw Water (1, 2, 3 - Refer to the Process Flow Diagram flow streams 1, 2, and 3 on Sheet P-1 and P-2 of Appendix A)

Water supply for the project comes from the brackish San Andreas and Glorieta (SAG) group aquifer via drilled wells spaced about 0.5 miles apart. Developing this 3,500 to 3,800 foot deep resource has no potential for adverse watershed effects. Further, there is no evidence for hydraulic connection with developed groundwater in the Santa Fe group. Appendix J includes a copy of the aquifer test report describing the aquifer in detail, including the results of aquifer tests that were performed for this project.

The aquifer comprises approximately 2,000 square miles extending north and west of the site farther than Four Corners. This aquifer is presently undeveloped, so large-scale parameters like recharge rate and sustainable yield are not well defined. Even omitting recharge, the 30-day well test performed for this project (Appendix J) indicates a minimum recoverable volume of 576,000 acre-feet, representing a 103-year supply at 5.0 MGD. Additional aquifer information is provided in the hydrogeologic report in Appendix J.

Five production wells with a capacity of 1,100 gpm each are required to supply the necessary raw water flow of 4610 gpm with one well out of service. The raw water flow of 4610 gpm (6.6 MGD) is required for a treated water capacity of 5.0 MGD at the expected recovery rates. The production wells will include redeveloping Well EXP-6 as a production well and installing four new wells. Multiple wells will provide supply redundancy in the event a well is shut down for maintenance. Control valves at the well head facilities will be used to isolate and control the flow from the wells. The well and supply pipelines will be equipped with flow and pressure monitors to reduce the potential that the untreated well water will be released in the event of a pipe break. Figure 7-1 shows the proposed well field layout for the production wells.

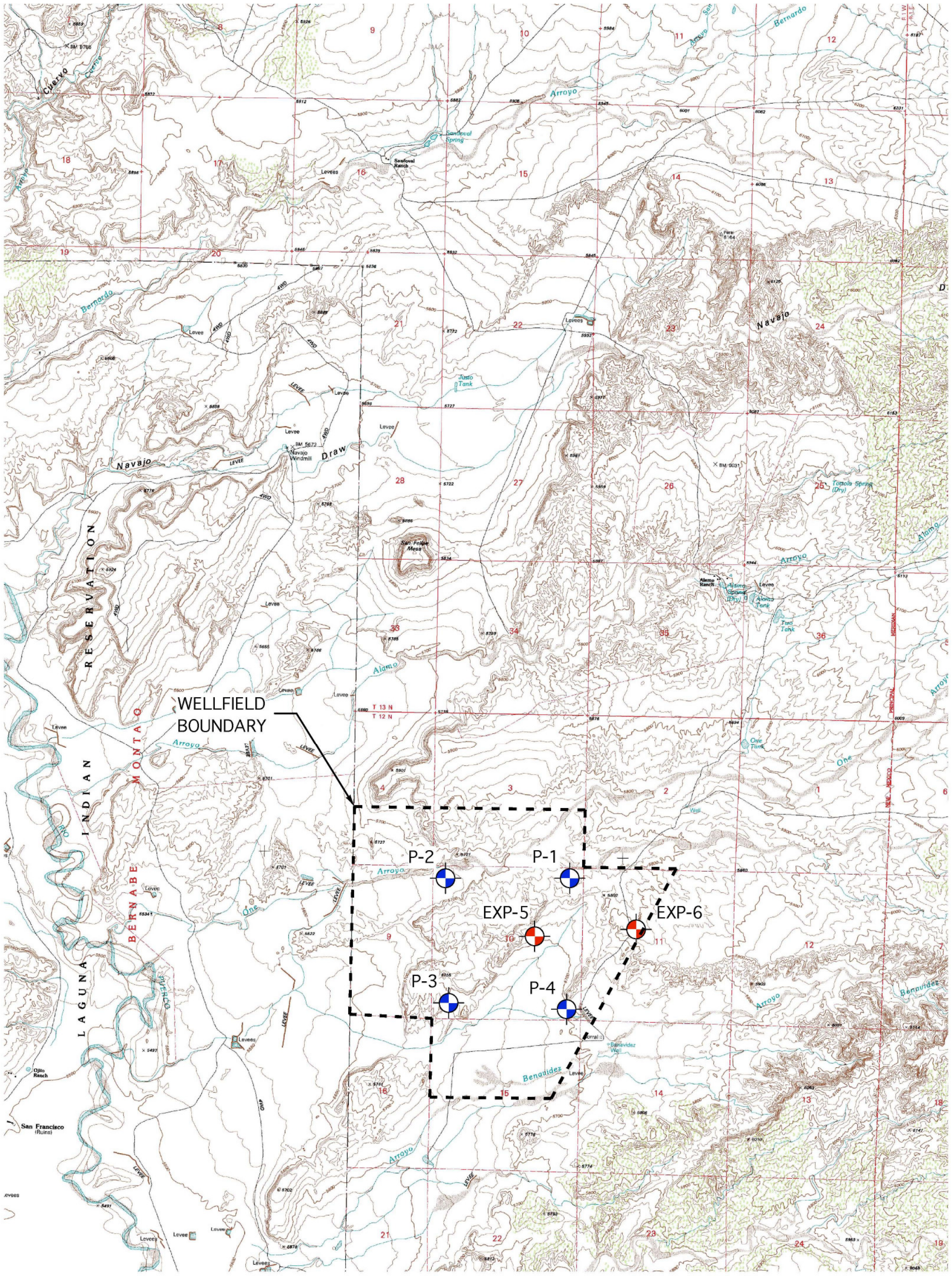
The new wells will be installed using different equipment and techniques than were used for the exploratory wells. The permitting process, though, will still comply with all pertinent requirements including well construction and land application of brackish development water. The resulting well productivity could exceed the 1,100 gpm target.

The installation details are selected to maximize well productivity, protect against artesian blowout risk, and facilitate modification as artesian pressures diminish over time. Figure 7-2 shows a typical production well schematic with the arrangement of these principal components:

- A 24” diameter pilot bore extending 200 feet deep and protected with a grouted casing. This upper casing accommodates the wellhead protection system that is required when drilling in artesian pressures.
- The second stage will be 17.5” diameter down to 2,000 feet. This stage will be drilled with conventional mud rotary equipment and completed with grouted casing. Mud rotary methods are effective in non-productive units that have artesian pressures, as the mud resists the uplift forces.
- The third stage, also drilled using mud-rotary techniques, will extend through the upper casing down to the top of the target aquifer, approximately 3,500 feet deep. This casing will be completed to the surface and grouted to protect against artesian pressures.
- Drilling will change to reverse circulation techniques in the productive units to avoid introducing drilling fluid into the aquifer pores. The advantage of reverse circulation is that the well develops as the borehole advances, significantly increasing yield and reducing development effort. The final stage of drilling is 300 feet of reverse circulation drilling down the 3,800 feet total depth.

- Louvered screen 300 feet long and 6” diameter will penetrate the aquifer from 3,500 to 3,800 feet deep. Above the screen the casing will be 9 5/8” diameter up to the ground surface.

Because of the elevated temperature and the corrosive nature of the water it is proposed to use stainless steel, fiber reinforced plastic, lined metallic pipe or polymerized concrete pipe to convey the raw water to the treatment plant.

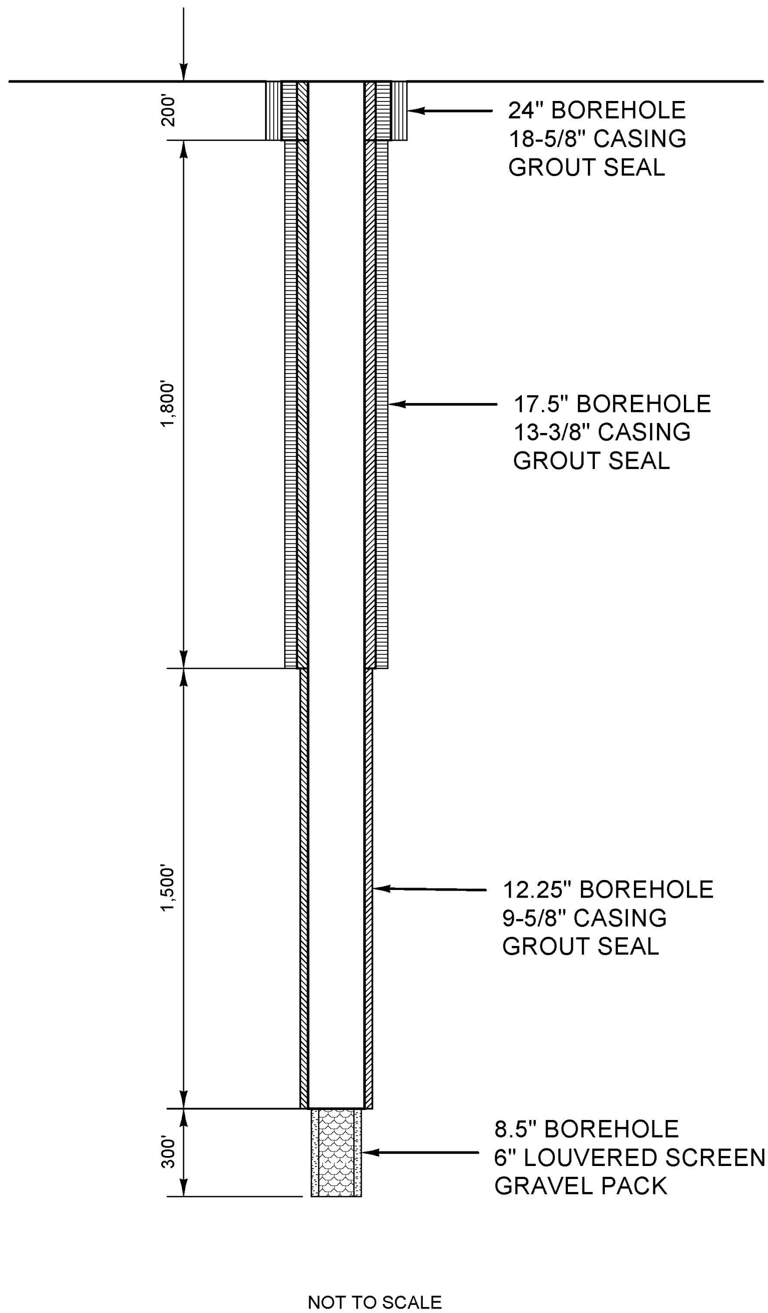


KEY

EXP-6 — EXISTING EXPLORATORY WELL

P-4 — PLANNED PRODUCTION WELL

UNIVERSAL ASSET MANAGEMENT Engineered Reliability	SANDOVAL COUNTY DESALINATION TREATMENT FACILITY
WELLFIELD MAP	FIGURE 7-1



UNIVERSAL ASSET MANAGEMENT
Engineered Reliability

SANDOVAL COUNTY
DESALINATION TREATMENT FACILITY

WELL SCHEMATIC

FIGURE 7-2

7.2.2 Pressure Recovery/Reduction (3, 4)

The untreated groundwater will reach the proposed treatment plant site at approximately 140 psi initially (prior to any long term pressure reduction in the aquifer). This pressure must be reduced before the pre-treatment processes that operate at atmospheric pressure. In order to provide 5 MGD of treated water, the raw water (pre-treatment) feed flow is approximately 6.6 MGD. At this flow rate, there is significant recoverable energy in the raw water. A pump-style, electrical generating turbine will be used to reduce the pressure to atmospheric pressure and recovery electrical energy. A by-pass line with an energy dissipation valve will be installed to allow the plant to operate when the turbine is off-line for maintenance.

7.2.3 De-carbonators (5, 6)

The high TDS groundwater has a large quantity of dissolved carbon dioxide (CO_2), which reduces the pH and keeps the carbonates, bicarbonates and sulfates in solution. The de-carbonators will remove the CO_2 and reduce the amount of lime needed in the subsequent softening process. The raw water has a significant scaling potential as the CO_2 is removed in the de-carbonator, so a standard drinking water antiscalant or scale inhibitor approved by the National Sanitation Foundation (NSF) will be added to the raw water ahead of the de-carbonator. Sodium hypochlorite will also be added to reduce the potential for bio-fouling of the packing material in the de-carbonator, and to oxidize As^{+3} to As^{+5}.

Raw water will be discharged at the top of a 25- foot high de-carbonator and flow downward through packing material to increase the surface area. Air is forced through the packing material at an air to water ratio of 25:1, which is designed to reduce the CO_2 concentration to less than 10 mg/l. This is expected to result in an equilibrium pH between 8 to 8.5 for groundwater with an alkalinity between 1500 and 1800 mg/l as $CaCO_3$ of alkalinity.

7.2.4 Arsenic and Radium 226/228 Removal (7, 8, 9)

After de-carbonation of raw water, ferric chloride will be added to form ferric hydroxide floc using three tapered stages of mechanical mixers, and adsorb dissolved arsenic from the raw water. The ferric floc with the adsorbed arsenic will be removed from the raw water with an inclined plate settler manufactured by Parkson, Jim Meyers & Sons, Meurer Research or equal operating at a maximum overflow rate of 0.2 gpm/sq ft of plate surface area. The settled floc will collect at the bottom of the gravity clarifier and will be periodically sluiced to a holding tank for thickening and dewatering. Dewatered solids will be transported to a regulated landfill for ultimate disposal.

The pilot scale testing demonstrated that the arsenic concentration can be reduced from approximately 830 μg/l to less than 8 μg/l. Gross alpha and radium isotopes are reduced by more than 99%, from as high as 84 pCi/l to below 0.5 pCi/l.

7.2.5 Lime Softening (11,12,13,14)

After arsenic and radium are reduced the raw water will be softened to remove calcium and magnesium. A warm lime softening process will use lime re-generated on-site. A lime slurry will be mixed in the effluent from the inclined plate settlers to increase the pH from approximately 7.8 to 10.4, and then the water flows into a solids contact clarifier manufactured by Wes-Tech, IDI or approved equal to complete the calcium carbonate and magnesium hydroxide precipitation process. A small dose of a standard cationic polymer will be added to the feed water to promote the flocculation of calcium carbonate and magnesium hydroxide.

Due to the high raw water hardness approximately 1,500 mg/l as $CaCO_3$ and the associated high lime dose 1100-1500 mg/l, the solids contact clarifiers are sized for a 90 minute detention time and maximum overflow rate of 1 gpm/sq ft to complete the reaction and reduce solids carryover.

Settled precipitates will be periodically removed from the solids contact clarifier and discharged to a gravity thickener and clarifier. The overflow from the thickener will be returned to the inlet pipe to the solids contact clarifiers along with backwash return flows and the pressate from the lime softening dewatering equipment.

7.2.6 Re-carbonation (13)

The discharge from the solids contact softeners is saturated with 5-30 mg/l of calcium carbonate, and therefore has a tendency to deposit mineral scale on the downstream equipment. Typically the pH of the discharge from a lime softening process is reduced slightly to return any lime residuals back to solution in the discharge in order to reduce the potential for scaling. The pH can be reduced with a strong mineral acid or with carbon dioxide. It is proposed to use CO_2 generated from the lime calcination process as primary pH reduction process. This will minimize the discharge of CO_2 to the atmosphere and the cost of treatment chemicals. If the CO_2 from the re-calcination process is not available, the pH will be reduced using hydrochloric acid, which can also be used to regenerate the weak acid cation exchange resin described in section 6.2.8.

The discharge from the softener will flow into a 25,000 gallon (15 ft 15 ft x 15 ft deep) square process tank with a coarse bubble diffusion system in the bottom. The tank will provide approximately 10 minutes of contact time to complete the CO_2 and lime reaction and dissipate any excess entrained CO_2 gas. One end of the re-carbonation basin will separated by a baffle and will be used as a wet well for the vertical turbine pumps used to supply water to the pressure filters, ion exchange columns and the RO inlet cartridge filters.

7.2.7 Granular Media Filtration (15, 16)

The ion exchange and RO processes downstream of the softening process are subject to rapid increase in head loss and fouling if there are any significant suspended solids in the feed water. Therefore a standard dual media filtration system by Tonka, Layne Water, Hungerford Terry or approved equal will be used to reduce the suspended solids and fine colloidal particles in the water. Since RO systems are sensitive to many types of polymers, it is proposed to feed a small dose of aluminum chlorohydrate (ACH) ahead of the filters to improve the solids capture. Because the groundwater is not under the influence of surface water the filters do not have to achieve any specific particle removal for disinfection credits, and it is proposed to operate the filters in the direct filtration mode.

There will be four 8 ft wide by 40 ft long filters operating in parallel, and under normal conditions the filters will operate at a maximum of 3.4 gpm/sq ft. If one of the filters is off-line for backwashing or maintenance the remaining three filters will operate at 4.6 gpm/sq ft. The RO process is sensitive to changes in feed water flow rate, so it is proposed to have a dedicated backwash supply system instead of using flow from the other on-line filters to backwash the filter. During backwashing the filter will be taken off-line and the filtration rate for the remaining filters will be increased to maintain the same flow to the ion exchange columns and RO system. The filter media will consist of 20 inches of 1 mm anthracite over 10 inch of 0.5 mm sand. The water's high chloride content requires the filter underdrain to be a fiber-reinforced plastic (FRP) air/water filter block with a sintered plastic bead porous cap.

7.2.8 Ion Exchange Polishing (17, 18)

The lime softening process is expected to reduce the total hardness to less than 200 mg/l as $CaCO_3$, which is normally acceptable for municipal drinking water. When the water is treated by RO to reduce the TDS, the residual calcium, magnesium and polyvalent cations become concentrated, and can react with silica, fluoride, sulfate and carbonates common to all natural surface and ground waters to form mineral scales in the membrane elements. The weak acid cation (WAC) exchange resin is designed to remove the polyvalent cations, and allow the RO system to operate at high recovery ratios needed for cost effective operation, but result in high concentrations of sodium, chloride, sulfate and silica in the reject stream.

The WAC resin works by exchanging a hydrogen ion (H^+) for the cations in the feed water because there is a stronger attraction for the sodium, calcium, magnesium, barium, potassium etc. than the hydrogen. During this phase the resin is in the hydrogen form and the pH and conductivity of the water is low. The resin initially exchanges all the cations including sodium, but when all the exchange sites have been taken the resin will start exchanging sodium for the polyvalent cations. During this phase the resin is in the sodium form and the pH and conductively of the feed water is not significantly changed. When all the sodium is displaced, the resin has to be regenerated with a dilute low-pH solution of hydrochloric acid to displace all the polyvalent cations and return the resin to the hydrogen form. The regeneration solution has a low pH, and high concentration of sodium and chloride as well as smaller amounts of calcium and magnesium. It is proposed to mix spent regeneration solution with the concentrate from the drinking water RO system for disposal.

7.2.9 Drinking Water RO System (19, 20, 22, 23)

A high-pressure seawater RO system will be used to reduce the TDS of the softened water to less than 500 mg/l to meet the secondary drinking water standards. A standard NSF approved drinking water scale inhibitor will be added to the feed water to reduce the potential that trace amounts of calcium, magnesium, barium, strontium will react with silica, sulfate or carbonates to form mineral scales in the RO unit. The feed water will be pressurized using a multiple stage vertical turbine pump to approximately 460 psi, and fed to the first stage of the RO unit, which has 40 pressure vessels in parallel. The high pressure forces the water molecules to diffuse through the surface of the RO membrane producing a low TDS permeate. Only about 50% of the feed water permeates through the membrane in the first stage, and the remaining 50% of the flow is collected from the entire first stage pressure vessel. This pressure of the high TDS stage 1 discharge is boosted using a vertical turbine pump to approximately 700 psi and fed to the stage 2 pressure vessels to produce more low TDS permeate.

The high TDS discharge from the second stage pressure vessels (stream ID 23) will be sent to a secondary nano-filtration RO process to separate sodium sulfate from sodium chloride, which will then be crystallized into salt for off-site sale.

7.2.10 Permeate Stabilization (24, 29)

The RO permeate has negligible hardness, and therefore is very corrosive to metallic pipes and cement mortar linings. A small amount of lime ($CaOH_2$) slurry will be pumped into the permeate discharge with a peristaltic pump to provide dissolved calcium to protect metal pipes from corrosion and dissolving cement mortar linings. This will increase the pH, so pressurized CO_2 gas solution will be injected downstream of the lime addition point to reduce the pH to between 8.5 and 9. This process results in the formation of bicarbonate alkalinity that will keep the water more stable in the distribution system. Sodium hypochlorite will also be injected into the stabilized permeate discharge pipe to obtain a 2 mg/l chlorine residual where the water enters the distribution system. Ammonia is also added to the finished water to convert the chlorine to chloramines.

The Cooling tower design will be two induced draft, counter flow 5 MGD trains (standby/duty) in a two loop system manufactured by Delta Cooling Towers Inc or approved equal. Each train will consist of four parallel cooling towers in each process train capable of reducing the finished water temperature from 81 F to 70°-75° F through evaporative cooling. The treated water will pass through the hot side of a closed heat exchanger and the cooling towers will constantly provide the cooled fluid to allow the heat exchange. Approximately 3% of the product water will be required for makeup water in the evaporative loop.

A two loop system will be utilized to avoid exposing treated water to the atmosphere and inviting biological growth. The evaporative loop will pass through the cool side of the heat exchanger to provide up to the 55 Million BTU's in cooling required at the 5 MGD max production rate.

7.2.11 Treated Water (30)

The proposed water project includes a finished water clearwell as well as a 5 MGD ground storage tank. The clearwell will be located at the treatment plant site. High service pumps will be provided adjacent to the clearwell for transporting the finished drinking water from the treatment site to the 5 MGD ground storage tank.

The 5 MGD ground storage tank will be optimally located for supply to all potential wholesale water supply customers at an approximate elevation of 5,700 feet MSL.

This project does not include water distribution. It is anticipated that wholesale water customers will be required to connect to the finished water storage tank and take responsibility for their own water transmission and distribution from that point.

7.2.12 On-site Hypochlorite Generation System

The on-site hypochlorite generation (OSG) system will produce a 0.8% sodium hypochlorite solution for feeding to the raw water and treated water to establish a free chlorine residual of 0.5 and 1 mg/l respectively. The OSG will be a 200 lb/day system, and will use the sodium chloride salt recovered from the brackish water treatment process as the raw material for the electrolytic cell that produces the hypochlorite. A five (5) ton brine making tank will be stored outside the chemical storage facility. This heated tank will be filled with dry salt and have a permeate feed that will be used to produce the 29% salt solution required for the electrolytic cells of the OSG system.

The 200 lb/day OSG system will produce 0.8% sodium hypochlorite that will be stored in two separate 4,000 gallon XLPE feed tanks. Two sets of peristaltic chemical feed pumps will send the 0.8% hypochlorite to two independent dosing points. Both the pretreatment dosing point and the finished water dosing point will require approximately 1 gpm of 0.8% sodium hypochlorite. The recommended 30 day storage of chemicals will be kept in the brine maker tank, and nearly two days of maximum chemical dosing will be stored in the 0.8% storage tanks.

7.3 FULL SCALE TREATMENT PROCESS OPERATING CRITERIA

Based on comprehensive computer modeling of the selected treatment process, with consideration of the pilot test findings, chemical feed rates for the full scale process have been estimated and are presented below in Table 7-1.

Table 7-1
Estimated Full Scale Chemical Feed Rates[1]

Chemical	Dose (mg/l)	Purpose	Concentration	Usage (lb/day)
Raw Water Hypochlorite	2 (residual)	Oxidation	12%	100
De-carbonation Tower Air	2400 scfm	Oxidation	Air	
Ferric Chloride	90 (as $FeCl_3$) 30 (as Fe)	Coagulation		5000
Lamella Plate Clarifier Polymer	1	Coagulation		50
Lime (CaO)	1,500	Chemical Softening	Dry	72,000
Solids Contact Clarifier Polymer	1	Coagulation		50
Softened Water Hydrochloric Acid	250	pH reduction to 9.8	40%	3300 gal/day
Granular Media Filter Polymer	1	Coagulation		50
WAC IX Hydrochloric Acid (HCL)		Resin Regeneration		
RO Antiscalant	4	Antiscalant		210
Treated Water Ammonia		Chloramine Disinfection		
Treated Water Hypochlorite	2 mg/l	Chloramine Disinfection	12%	80 lbs/day = 80 gal/day
Treated Water Lime	20	pH adjustment		800

Treated Water CO_2	30	Final pH=8.7, Alk=44 mg/l, CCPP=10 mg/l, LSI=0.9		800

1-Rates based upon computer modeling and pilot test findings.

These chemical feed rates were used to project the volume of solids produced in each of the full scale process streams for a 5 MGD plant. The full scale plant is expected to achieve a recovery rate of 82.5%, however, for the purpose of the PER and in the interest of being conservative, an 80% recovery rate is utilized in the full scale mass balance table. These data are provided below in Table 7-2.

Table 7-2 Solids Concentrations in Full Scale Process Streams

Parameter	Units	1-Well No. 6	2-Other Wells	3-RW High Press	4-RW Low Pres	5-Decarb feed	6-Decarb Eff	7-Clarifier Feed	8-Clarifier Eff	9-As Residual	10-As Res Pressate	11-Softener Feed	12-Lime Res Pressate	13-Softener Eff	14-Softener Res.	15-Filter Eff	16-Comb. Eff	17-WAC Feed	18-WAC Eff	19-Comb WAC Eff	20-RO Feed	22-RO Unit #1 Perm	23-RO Unit#1 Conc. @80% Recovery	24-Comb Perm	25-Net Pass#1 Perm Flow	27-NaCl Brine RO Permeate	28-NaCl Brine Evap. Cond.	29-Blended Prod Water	30-Dist Sys. Discharge
Flow	gpm	600	4010	4610	4610	2280	2280	2300	2280	20	19	2880	600	2250	630	1125	4500	900	870	4350	1450	1160	290	3480	3470	0	Note 1	3470	3470
Pressure	psi				10	10	9	8	7	7	8	6	7	5	4	1	1	80	40	40	460	10	650	10	10	na	10	10	100
pH	S.U.	6.0		6.0	6.0	6.5	8.0	7.8	7.8	7.8	7.8	10.4	10.4	10.4	10.4	10.2	10.2	10.0	7-10	9.8	9.8	10.0	9.5	9.5	9.5	na	6.0	8.7	8.7
Temperature	F	150		150	150	150	135	135	133	133	70	130	70	130	130	84	84	83	83	83	82	81	81	81	80	na	80	80	75
Hardness as CaCO3	mg/L	1500		1500	1500	1500	1500	1500	1500	1500	1500	1500	200	180	200	180	180	180	2	2	2	nd	10	10	2	na	2	40	40
TDS	mg/L	12,000		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	11,000	11,000	11,000	11,000	11,000	11,000	10,500	10,500	10,500	350	52,000	350	350	na	<5	400	400
Arsenic	ug/l	830		800	800	800	800	800	20	20 lb/dy	80	20	20	20	20	5	5	5	5	5	5	nd	25	nd	nd	na	nd	nd	nd
Radium 226/228	pCi/L	84		80	80	80	80	80	70	0.2 lb/dy	0	70	10	10	10	10	10	10	10	10	10	nd	50	nd	nd	na	nd	nd	nd
Silica	mg/L	30		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	1	150	1	1	na	nd	1	1
Dissolved Oxygen	mg/L	<0.5	<0.5	<0.5	<0.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	na	6	6	6
Hydrogen Sulfide Gas	ppm	2-3		2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	0	0	0
Carbon Dioxide Gas	ppm	450		450	450	450	40	40	40	40	40	0	0	0	0	20	20	20	20	20	20	20	20	20	20	na	5	2	2
Chlorine Residual	mg/L	0		0	2	2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0	0	0	0	0	0	0	0	na		2	2
Turbidity	ntu	10	10	10	10	10	30	30	3		20	na				0.5						<0.1				na		0.1	0.1
TSS	mg/L	10							5	na	20	1000				1						nd	nd			na		na	na
SDI	SU	na	na	na	na	na	na	na	na	na	na	na	na	na	na	<3	<3	<3	<2	<2	<1	<1				na		na	na
Dry Solids	lbs/day	86,000	560,000	650,000	650,000	325,000	325,000	325,000	325,000	6,200		400,000		310,000	160,000		590,000			550,000		na	180,000	14,600	14,600	na		na	na

7.4 RESIDUALS MANAGEMENT AND RECOVERY

7.4.1 General

Residual waste processing, marketing, or disposal contributes a significant cost to constructing and operating a water treatment plant. The residuals waste handling equipment proposed for the Treatment Plant are designed based on the preliminary evaluation of potential options. The design considerations include three aspects, technical feasibility, environmental acceptability and cost effectiveness.

The wastewater treatment system proposed at the plant includes an Equalization Basin, two Backwash Clarifiers and one Overflow Lagoon. The filter backwash and rinse (filter to waste) water will be directed to the Backwash Clarifiers for settling. The supernatant collected from this clarification process will be recycled to the plant influent and the settled sludge will be discharged to the Wastewater Equalization Basin. The settled solids from the solids contact clarifiers will be periodically blown down to the equalization basin. The waste streams discharged to the Wastewater Equalization Basin will be pumped to a plate and frame press for dewatering. An overflow lagoon is provided for emergency backup to capture overflows from process units.

7.5 RESIDUAL PRODUCTS SOURCES AND USES

- Raw Water Carbon Dioxide
  - At 450 mg/l of CO_2 present in the raw water, and a flow rate of 4610 gpm, there is 12.5 tons/day of CO_2.
  - Capture CO_2 and utilize for re-carbonation basins, treated water stabilization, potentially algae growth, and potentially for tertiary injection into gas wells proposed by the potential 250 MW power plant.
- Raw Water Excess Heat
  - The raw water temperature is 150° F. The anticipated temperature of the pre-treated water is 130° and the target temperature for the RO system is 84°. The necessary temperature reduction is 46° prior to the RO system.
  - Reclaim with heat exchangers and reuse on-site.
- Raw Water Artesian Pressure
  - While there is a static artesian pressure of 150 psi at the wells, it is anticipated that this pressure may subside to below the ground surface upon startup at the well design flow.
  - Make provision for pump-style turbine generators in final design, to be implemented upon verification of dynamic artesian pressure after plant startup.
- Arsenic and Radionuclides (Clarifier Sludge)
  - At 0.6 gallons/minute, the facility produces 315,360 gallons/year or approximately 1,315 tons/year.
  - This is classified as a hazardous material and therefore requires special handling, transport, and disposal in a licensed hazardous facility, such as the Waste Control Specialists' Andrews TX hazardous waste landfill.
- Lime (Softening Clarifier Sludge)
  - The quick lime dosage required upstream of the softening clarifier is calculated to be a minimum of 1100 mg/l. This equates to approximately 31 tons/day of quick lime (CaO) consumption.
  - The softening process will generate lime sludge at an average rate of approximately 30 gpm at 35% solids, resulting in a total sludge production rate of approximately 156,000 lb/day (78 tons/day dry) calcium carbonate lime sludge ($CaCO_3$)
  - The re-calcination process will produce approximately 48 tons of quicklime (CaO) per day. With a required feed rate of 31 tons/day in the softening clarifier, 65% of the quick lime generated by the re-calcination process can be recycled back into the treatment process. This results in an excess quick lime production of 17 tons/day, which can be sold for revenue.

  - It is anticipated that approximately 7.4 tons of magnesium carbonate (at a 90% solids concentration) will be produced per day, which can be sold for revenue.
  - Collect CO_2 from the re-calcination kiln flue gas and blend with de-carbonation tower CO_2 for re-carbonation basins, treated water stabilization, potentially algae growth, and potentially for tertiary injection into gas wells proposed by the potential 250 MW power plant.
- Ion Exchange WAC Regeneration Waste
  - The WAC regeneration waste will consist of an intermittent flow averaging approximately 2 gpm. It is proposed to blend this waste stream with the sodium sulfate brine.
- Salt Brine (Reverse Osmosis System Reject)
  - Separate sodium chloride with preferential nanofiltration
    - Sodium chloride brine will be concentrated, then crystallized to produce 121 tons/day of industrial grade sodium chloride salt.
    - This salt will also be utilized on-site for sodium hypochlorite generation and potentially for hydrochloric acid production.
    - The sodium sulfate brine is proposed to be disposed of in a deep aquifer injection well.

7.6 POWER SUPPLY ALTERNATIVE EVALUATION

This section of the report reviews several power supply alternatives for the recommended water supply and treatment process outlined above. Supporting documentation for this evaluation is included in Appendix T.

7.6.1 Power Supply Alternatives Considered

Several power supply alternatives are considered for the proposed desalination treatment facility. These are described further as follows.

- Electricity and natural gas provided by incumbent utilities at standard tariff rates.
- Natural gas fired combined heat and power (CHP) facility.
- Biogas-fired CHP facility
- Co-located 250 MW gas-fired power plant with CHP connections.

Refer to Appendix T for a complete evaluation of the energy supply alternatives for this project.

7.6.2 Recommended Power Supply Approach

The recommended power supply approach is to cooperate with the developers of a co-located 250 MW gas-fired power plant providing low cost electrical energy, and free heat, to the water treatment plant.

7.7 REQUIRED PERMITS

The tentative list of permits required for the proposed facility is outlined in Table 7-3.

Table 7-3
Draft Permitting Task List

Item No.	Permitting Entity	Required Permit or Approval/Regulation Name	Description of Permitting Process	Requirement Type/Regulation or Reference	Review Timeline	Potentially Critical Issues
Federal Requirements						
1	Federal Agency that is taking a *federal action* (e.g., providing funding or approving a permit)	National Environmental Policy Act (NEPA) Compliance	Depending on agency requirements, NEPA could consist of either a Categorical Exclusion (CE), Environmental Assessment (EA), or Environmental Impact Statement (EIS).	CE: Council on Environmental Quality (CEQ) Regulations for implementing NEPA §1508.4; EA: See § 1508.9; EIS: See § 1501.4 and 1502	CE: Completed within months; EA: completed within months-years; EIS: completed over course of years	Agreement between the federal agency and any other cooperating agencies on the scope of environmental review should be early in the permitting process. In addition, alternatives development for water source, treatment options, and supporting infrastructure is an important part of alternatives development. NEPA compliance documentation will need to dovetail with any ongoing technical work early in the planning process.
2	US Environmental Protection Agency	Construction General Permit	National Pollution Elimination System (NPDES) General Permit for Discharges from Large and Small Construction Activities (i.e., under 1 acre). Prepare storm water pollution prevention plan (SWPPP) and submit electronic Notice of Intent (eNOI).	Construction General Permit NMR100000	7 days from submission of eNOI	TMDL issues in discharge areas (e.g., tributaries to the Rio Puerco) could affect the permit requirements.
3	US Army Corps of Engineers	Section 404/401 Permit	Environmental consultant completes field survey for wetlands and non-wetland jurisdictional waterways of the United States, submits to Albuquerque District Office their NWP form for review.	Permit/Nationwide Permit No. 39; 33 CFR 325.2	Determination of complete application within 15 days of receipt or 30 days from Pre-Construction Notification; Approval w/in about 3 months based on recent experience with District Office	Review is often delayed until cultural resources survey of disturbed area is complete. If cultural resources are found, review will be further delayed until the State Historic Preservation Officer (SHPO) identifies the appropriate mitigation measures.

Table 7-3 - Draft Permitting Task List (Continued)

Item No.	Permitting Entity	Required Permit or Approval/Regulation Name	Description of Permitting Process	Requirement Type/Regulation or Reference	Review Timeline	Potentially Critical Issues
State Requirements						
4	NM Office of the State Engineer	Application for Permit to Drill Exploratory Well (WR-07) & Plan of Operations (for Artesian Wells)	If drilling exploratory wells for each notice of intent (NOI) on file with the OSE, Form WR-07 should be filed as specified for each well. See OSE File RG-88934.	Permit/19.27.4.31 NMAC	No timeline defined. Estimated to be 3-4 months with pre-filing notification as courtesy.	NM OSE will likely require special consultation with Senior staff regarding the County's well permits because District 1 staff do not often issue permits for deep-well production for municipal water supply.
5	NM Office of the State Engineer	Well Record and Proof of Completion of Well	Required after drilling an underground water well. Complete OSE Forms WR-20 and WR-11.	Not permits, but required after filing WR-07 or other permits to drill underground water wells	Submission only. No review.	NA
6	NM Office of the State Engineer	NOI to Appropriate Nonpotable Groundwater	File NOI to Appropriate Nonpotable Groundwater at Greater Depths than 2,500 feet using OSE Form, if not already on file with the OSE for a given well (See OSE File RG-88934).	NOI/NMSA 1978 §72-12-26	No timeline defined.	Note: Many NOIs are already on file with the OSE for specific locations for proposed wells. These locations should be considered during the engineering process, as changing the location of the well would include public notice and could be potentially difficult for the County.
7	New Mexico State Land Office	Application for Right-of-Way Easement	File application if Facility or supporting infrastructure (e.g., pipelines, extraction or injection wells, evaporation ponds, etc.) will not be located on State lands. File affidavit of completion within 60 days of completing construction.	Permit/NMAC 19.2.10	No timeline defined.	Needs to be coordinated with environmental review required by lead federal agency, if federal action associated with this project.
8	NMED Drinking Water Bureau	Application for Construction or Modification of Public Water System	Complete and file Construction Application Form ES-3 required for construction a Public Water System. Additional information required for new systems (see Appendix A of said form).	Permit/NMAC 20.7.10.201.D	Submission 30 days prior to advertising for bid or entering into a construction contract agreement.	NA
9	NMED Drinking Water Bureau	Utility Operator Certification	File operator certificate(s) with NMED with appropriate level of certification for the treatment type and service level.	Filling of Operator Certification with NMED/20.7.4.20 NMAC	Not defined.	NA
10	NMED Groundwater Quality Bureau - Pollution Prevention Section	NOI	NOI to discharge wastewater.	NOI/NMAC 20.6.2.1201	6 months in advance of discharging	NA
11	NMED Groundwater Quality Bureau - Pollution Prevention Section	Discharge Permit	Liquid waste permit, groundwater discharge, pollution prevention.	Permit/NMAC 20.6.2.3104	6 months in advance of discharging	NA
12	NMED Air Quality Bureau	New Source Review (NSR) Air Quality permit (Construction)	3 Options, depending on emissions during construction: (1) no permit required, (2) NOI for < 10 lbs/hr, or (3) Permit for >10 lbs/hr.	Emissions calculations submitted, NOI or Permit/NMAC 20.2.72	30 day-review period, then 30-day public notice period, permit issued within 90 days if not subject to 20.2.74 NMAC.	NA
13	NMED Air Quality Bureau	Air Quality Operating Permit	Complete Title V (TV) Permit Application for major sources with potential to emit >100 tons/yr of a criteria pollutant or landfills >2.5 million cubic meters. (Likely not applicable to this facility)	Permit/NMAC 20.2.74	30 day-review period, then 30-day public notice period, permit issued within 180 after if subject to 20.2.74 NMAC.	NA

Table 7-3 - Draft Permitting Task List (Continued)

Item No.	Permitting Entity	Required Permit or Approval/Regulation Name	Description of Permitting Process	Requirement Type/Regulation or Reference	Review Timeline	Potentially Critical Issues
State Requirements						
14	NMED Construction Programs Bureau	Special Appropriations Project (Grant Agreement)	Follow prescribed NMED process for contracting, planning, designing, and constructing water, waste water, and solid waste projects if seeking SAP funding from NMED.	Only required if applying for Special Appropriations Funds	Process can take up to a year (longer if federal funding is also involved)	Requires coordination with any federal funding sources, as each entity has their own environmental permitting requirements and process. Goal would be to have federal agency and Construction Programs Bureau agree to scope of environmental permitting requirements.
15	NMED Hazardous Waste Bureau	Hazardous Waste Characterization	Determine if treatment process is generating a Toxicity Characteristic Leaching Procedure (TCLP) to determine if treatment process is generating hazardous waste or not.	Analysis/See 40 CFR 261.24	Keep the TCLP analysis on file on site. No need to distribute to NMED. Only required to keep on file to demonstrate no hazardous waste, if inspected by NMED.	Assumes not storing waste for more than 90 days.
16	NMED Hazardous Waste Bureau	Hazardous Waste Generation	If Facility generates 220 lbs (100 kg) or less of hazardous waste (recycled and non-recycled) in any one month, qualifies as a Conditionally Exempt Small Quantity Generator (CESQG). If Facility generates more than 220 lbs (100 kg) but less than 2,205 lbs (1,000 kg) of hazardous waste (recycled and non-recycled) in any one month, qualifies as a Small Quantity Generator (SQG).	Submit RCRA Subtitle C Site Identification Form to EPA/40 CFR 261	NA	Likely conditionally exempt, but if a small quantity generator, then Facility will need to file said form.
17	NM Department of Homeland Security and Emergency Management	Tier II Filing	If Facility stores, uses or produces chemicals, requiring maintenance of Material Safety Data Sheets under the Hazard Communication Standard, that are present in the facility in excess of the appropriate threshold, and are not exempt under Title III, then you must submit Section 311 and Section 312 (Tier II) reports.	Filing/EPA Community Right-to-Know and Small Business, 9/88	NA	NA
18	NMED Radiation Control Bureau	General <u>or</u> Specific License for Source Material	<u>General License:</u> If the source material is greater than 0.05 percent by weight (or about 335 picocuries per gram [pCi/ g] for natural uranium), and the total amount in your possession at any time is less than 15 pounds or no more than 150 pounds in any one calendar year, Facility will have a "small quantity" of source material that is subject to a general license (10 CFR 40.22). <u>Specific License:</u> If the system exceeds this small quantity threshold, Facility must apply for a specific license from the NRC or Agreement State.	License/General License (NMAC 20.3.3.304); Specific License (NMAC 20.3.3.307)	Varies. See said regulations.	Disposal or transfer of source material requires the transferor to work with a licensed transferee to transfer and dispose of source material in compliance with Sec. 20.3.13 NMAC
19	NM Regulatory and Licensing Department - Construction Industries Division (CID)	Application for State Building Permit	Licensed contractor performing the construction for the County completes CID permit application .	Permit/Information available at NMCID website: <http://www.rld.state.nm.us/cid/index.htm>	No timeline defined.	NA
20	NM Dept. of Cultural Affairs Historic Preservation Division	Archaeological Permit	Compliance with Cultural Properties Act requires permit for excavating, destroying, or removing cultural properties on *state land.** County will contract with permitted cultural resources consultant to manage this requirement.	Regulatory Approval from State Historic Preservation Officer authorizing construction/NMSA 1978 §18-6-9	30 days	Cultural resources survey, if required by lead regulatory agency, should be coordinated with submission of USACE 404, NMDOT, and State Environmental Review Process to ensure concurrence between cultural resources specialists from each entity.
21	NM Dept. of Transportation	Application for Permit to Install Utility Facilities within Public Right of Way	Authorizes installation of utilities (e.g., waterlines) within NMDOT rights of way, including highway crossings. Project Engineer/Environmental Consultant will complete NMDOT form.	Permit/Form No. M-202	10 working days required (30 calendar days more realistic)	See comment above.

Table 7-3 - Draft Permitting Task List (Continued)

Item No.	Permitting Entity	Required Permit or Approval/Regulation Name	Description of Permitting Process	Requirement Type/Regulation or Reference	Review Timeline	Potentially Critical Issues
State Requirements						
Local Government Requirements						
22	Sandoval County	Zoning Approval	Sandoval County does not issue construction permits but County Development must approve State-issued permits to assure zoning compliance. Contact County in advance of submitting State Building Permit to obtain approval.	Permit/easement	No timeline defined.	Must be acquired before submitting Application for State Building Permit. Landowners also are encouraged to visit with County staff prior to considering development or subdivision of property.
23	Southern Sandoval County Arroyo and Flood Control Authority (SSCAFCA)	Application for New Development or Channel Crossings/SSCAFCA Drainage Policy § 1 et seq.	If waterlines or infrastructure are located within SSCAFCA jurisdictional boundaries, County will need to submit permit application for New Development to SSCAFCA.	Application should follow the SSCAFCA Development Process Manual/Drainage Policy § 1 et seq.	No timeline defined.	Waterline alternatives within SSCAFCA jurisdictional boundaries need to be identified by Project Engineer to evaluate any potential drainage concerns that may be encountered during the SSCAFCA permitting process. Changes in alignment may result in modification of permit application.
Private Requirements						
24	PNM	Utility permit	PNM Service Application for Commercial and Industrial Projects. Complete PNM-provided form.	Permit/Available online at www.pnm.com	No timeline defined.	NA
25	NM Gas Company	Utility permit	Application for Commercial and Industrial Mainline Extensions. Complete NMGCO-provided form.	Permit/Available online at www.nmgco.com	No timeline defined.	NA

NOTES:
*County land qualifies as *state land,* as regulated by the NM Department of Cultural Affairs - Historic Preservation Division, based on a personal communication with the Acting State Historic Preservation Officer in August 2009

7.8 TOTAL PROJECT COST ESTIMATE

The tables in Appendix K illustrate the results of the financial model including an opinion of capital cost, operating cost, and resultant cost of treated water. Table 7-4 summarizes the expected project cost.

Table 7-4 –Expected Project Cost

ITEM	AMOUNT
Total Estimated Construction Cost	$76,992,200
Total Project Cost	$105,140,250
Long-Term Debt Requirement	$106,740,985
Projected Water Rate	$6.01 /1,000 gallons

A copy of the Water Trust Board Application and Article of Resolution of the governing body authorizing an application to the Water Trust Board are included in Appendix U.

7.9 ECONOMIC ANALYSIS

The analysis is subject to the following key criteria:

- An acceptable contract can be negotiated with the City of Rio Rancho for the taking of 5 MGD every day delivered at a constant rate of 3,470 gpm. This would be a base load demand 365 days per year. The terms of the contract would require:
  - A “take or pay” provision
  - A provision that the City would be responsible for distribution and storage

This contract is important in that it will serve as the underlying security for the issuance of revenue bonds in support of the project. A sample water purchase agreement is included in Appendix V.

- An acceptable contract can be negotiated directly with an industrial client to purchase the sodium chloride salt produced by the plant (If a crystallization facility is implemented). The pro forma included with this report assumes a direct sale of this product at $90 per ton. The North American Salt Company has indicated that this would be the price for a direct sale. If such a company purchased this product for resale, the price would be reduced to $40 to $50 per ton. This would substantially impact the resulting water rate.

7.9.2 Project Financing

A. Review of Applicable Financing Methods

Most public projects such as water treatment are financed through debt instruments called bonds. Bonds are nothing more than a loan obtained by a public body in accordance with applicable state laws and U.S. tax codes. Specifics with regard to the manner in which bonds are sold and authorized by public bodies will vary depending upon state laws. In order to properly evaluate financing alternatives for a particular community, it is necessary to understand the applicable state law. An understanding of basic financing law focuses on two key elements of public financing, bonds, and grants:

- Bonds
  The procedure which a municipality, county, water district or sewer district must follow in order to properly authorize the sale of bonds: These procedures may vary with the type of public entity. The procedures, therefore, for a city may be different from that of a water district. It is important to understand the differences.

A determination of the tax-exempt status of bonds issued by public authorities: In general, public bodies may issue either taxable or tax-exempt bonds. For most of our projects, the bond issues will be tax-exempt. It has been beneficial to public entities to issue tax-exempt bonds because they command a lower interest rate.

There are several different forms of financing instruments that public entities may utilize in financing construction projects. The most common instruments are as follows: revenue bonds, general obligation bonds and special assessment bonds. In some states, such as Iowa, the term "bond" may be replaced by the term "loan," particularly where projects are being financed by loans secured by a local governmental body from a state or federal agency. There are three basic types of bonds available:

(1) Revenue Bonds – Revenue bonds are bonds whose principal and interest are solely financed through the revenues of an enterprise system such as a water system, sewer system, or electrical utility. Revenue bonds may be issued on any revenue-producing entity including swimming pools, sports arenas, toll roads, etc. In our work, revenue bonds are most closely associated with water and sewer systems. Important items to remember when evaluating the use of revenue bonds are the following:

(a) Adequate operation and maintenance and debt service costs must be evaluated to ensure that sufficient revenue will be generated by the proposed system in order to meet these costs. Revenue bonds generally require that operation and maintenance expenses are paid first from all revenue proceeds, followed by principal and interest payments, then followed by deposits into certain accounts including a bond reserve account, a depreciation account, and occasionally, a replacement account. The requirements of all these costs must be properly evaluated by the engineer in determining the revenue required to properly amortize a revenue bond.

(b) Revenue bonds generally require that a utility collect from 10 to 25 percent more revenue than is determined by the above calculations. This additional revenue is often referred to as "coverage." Coverage serves as assurance to the buyer of the revenue bond that there will be sufficient revenues to meet the above annual costs. For the purposes of this report, a 10% coverage test has been assumed.

(c) Most revenue bonds fail because of overly optimistic projections of revenues; as an example, the over exaggeration by the planning engineer of the number of users that will connect to a new water district. Projections of revenue must be very carefully analyzed by the engineer to avoid such overly optimistic projections do not occur.

(2) General Obligation Bonds – General obligations bonds, often referred to as G.O. bonds, are those bonds whose principal and interest are paid through a levy on property. This levy is often referred to as a "tax levy" and is usually stated in terms of dollars per $100 of assessed valuation.

Most communities, under state law, are restricted as to the number of G.O. bonds that can be issued. These restrictions most generally are stated in terms of a percentage of total community assessed valuation.

G.O. bonds generally command a lower rate of interest than revenue bonds. G.O. bonds are generally considered more secure by investors because they are supported by real property. In the event that a property owner fails to pay his taxes, the investor can protect his G.O. bond through foreclosure on such properties owned by the taxpayer.

Because of these extreme ramifications, in the event of bond default, most states have stringent laws restricting public bodies from issuing such bonds. This type of bond issue is typically used for the construction facilities that do not generate revenue. They are usually unpopular instruments because they result in a property tax. While it has been stated that G.O. bonds are retired through a levy on taxable properties, several states allow, under certain circumstances, G.O. bonds to also be paid through other revenues. One example is the use of a community sales tax. In all cases, where alternate revenues are used to pay G.O. bonds, if such revenues prove inadequate to meet debt service requirements, the community is required to levy a property tax in order to avoid default.

Special Bond Programs - The following special bond programs are applicable to this project. The Build America Bonds interest rate has been used for financial modeling purposes:

(a) *Tax-Exempt Bonds* – Given the public ownership and use of the project, tax-exempt bonds could be issued. A lease structure (via the issuance of Certificates of Participation ("COP's") is likely the most viable structure. COP's may be issued by the County and are not subject to voter approval. The COP's are likely to be issued with a Standard & Poor's rating of A+. For a twenty-year amortization period the average borrowing cost is estimated to equal 4.75%.

(b) *Build America Bonds* – Build America Bonds, also referred to as BAB's, were authorized by the American Recovery and Reinvestment Act of 2009 (ARRA) and extended into 2011. These are taxable bonds and may be issued by the County through 2011. BAB's pay the investor a taxable interest rate that is higher than a tax-exempt rate. The U.S. Treasury in turn pays the County a direct interest rate subsidy equal to 35% of the interest payment. There is no limit on the amount of BAB's that can be issued.

Under current market conditions, the issuance of BAB's will result in a lower net interest cost for bonds maturing from approximately 10 years and longer. Tax-exempt bonds still provide a lower interest cost in the first ten years. Depending on many variables, the use of BAB's may result in a lower borrowing cost of approximately 50 to 75 basis points.

(c) *Clean Renewable Energy Bonds – (Renewable Energy Component Only)* these bonds provide investors with a federal tax credit based on published rates provided by the U.S. Treasury. Generally a small supplemental interest payment (1% to 2%) is needed in order for investors to obtain a desirable overall return versus other potential investments. The maturity date is also determined by the U.S. Treasury and generally ranges from 14 to 16 years. The use of Clean Renewable Energy Bonds is limited for certain purposes. Further discussion is needed to determine if the County's project is eligible and the availability of an allocation from the IRS.

(d) *Qualified Energy Conservation Bonds – (Renewable Energy Component Only)* – Similar to Clean Renewable Energy Bonds, these are tax credit bonds. The primary difference is the types of projects that are eligible.

(3) Special Assessment Bonds – There are several instances in which public bodies such as a city may wish to construct a project which benefits only a few specific residences or taxpayers within their jurisdiction. In some instances, under state laws, such public bodies may develop what is referred to as “special benefitted districts.” An example would be a sewer district. Bonds issued specifically for the benefit of persons residing within these benefitted districts are usually a form of general obligation bonds. As with a general obligation bond, the principal and interest are paid and the bonds retired through some type of tax levy. Usually, this levy is referred to as a property tax assessment. The duration of these types of bonds are usually much shorter than those of an average G.O. bond. The assessment resulting from this type of G.O. bond is usually referred to as a lien on property, and the title of all properties within the benefitted district are encumbered by this lien. This type of mechanism is most commonly used to construct sewer collection systems in specific areas of a community, although they may also be used to construct sidewalks, streets, and storm sewers, as well as a myriad of other infrastructure items.

– Grants and Loans
There are grant programs available to this project. The following are programs that could contribute to this project.

(1) Water Conservation Challenge Grants – Water Conservation Challenge Grants provide cost-shared funding for the following types of on-the-ground projects: (a) water conservation and efficiency projects that allow users to decrease diversions and to use or transfer the water saved; (b) water marketing projects with willing sellers and buyers, including water banks, that transfer water to other uses to meet critical needs for water supplies; (c) projects that improve water management by increasing the use of renewable energy, by increasing operational flexibility (constructing aquifer recharge facilities or making system optimization and management improvements), or by addressing endangered species and other environmental issues; and (d) pilot and demonstration projects that address the technical and economic viability of treating and using brackish groundwater, seawater, impaired waters, or otherwise creating new water supplies within a specific locale.

Water Conservation Challenge Grants require a minimum of 50 percent non-Federal cost-share contribution. Grants are available to states, tribes, irrigation and water districts, and other entities with water or power delivery authority. In FY 2010, as in the past, the program will likely be limited to $300,000 in Federal funding for each project.

(2) Title XVI Water Reclamation and Reuse Program – Title XVI of P.L. 102-575, as amended (Title XVI), provides authority for U.S. Bureau of Reclamation’s water recycling and reuse program, titled “Title XVI.” The Title XVI program is focused on identifying and investigating opportunities to reclaim and reuse wastewaters and naturally impaired ground and surface water in the 17 western states and Hawaii. Under the program, USBTZ makes available cost-shared funding for planning, design, and construction water recycling projects, as well as research and demonstration projects.

For purposes of the Title XVI program, a water reuse project is a project (including the necessary facilities and features) that reclaims and reuses municipal, industrial, domestic, or agricultural wastewater and naturally impaired groundwater and/or surface waters. Consistent with State law, reclaimed water can be used for a variety of purposes, such as environmental restoration, fish and wildlife, groundwater recharge, municipal, domestic, industrial, agricultural, power generation, or recreation. Water reuse is an essential tool in stretching the limited water supplies in the West. Title XVI projects develop and supplement urban and irrigation water supplies through water reuse, thereby improving efficiency, providing flexibility during water shortages, and diversifying the water supply.

Title XVI funding is limited to 25% of the cost of a project or $20 million. Under law, USBTZ requires project-specific Congressional authorization before any construction funding can be provided. Project sponsors interested in the program typically work with their local Reclamation area office to determine whether an appraisal or feasibility study should be prepared and submitted to Reclamation as a first step. An outline of the process can be found here: http://www.usbr.gov/recman/wtr/wtr11-01-AppA.pdf. Requirements for a Title XVI feasibility study, which must be approved prior to any funding, are available here: http://www.usbr.gov/recman/wtr/wtr11-01.pdf.

(3) New Mexico Water Trust Board – Annually the Water Trust Board awards grants to eligible projects under a competitive process. This project has been awarded $3,500,000 for design. It will be eligible for additional funding under future competitions.

B. Project Financial Analyses

The attached tables provide a comprehensive analysis including the following:

- Operational Variables Summary
- Project Cost Summary
- Income Statement
- Debt Amortization Table
- Depreciation Table
- Balance Sheet
- Revenues Summary
- Fixed Maintenance Forecast
- Plant Personnel Summary
- Chemicals Required
- Electrical Demand Summary
- Heat or Gas Requirement Summary
- Mass Balance
- Brine Option Analysis

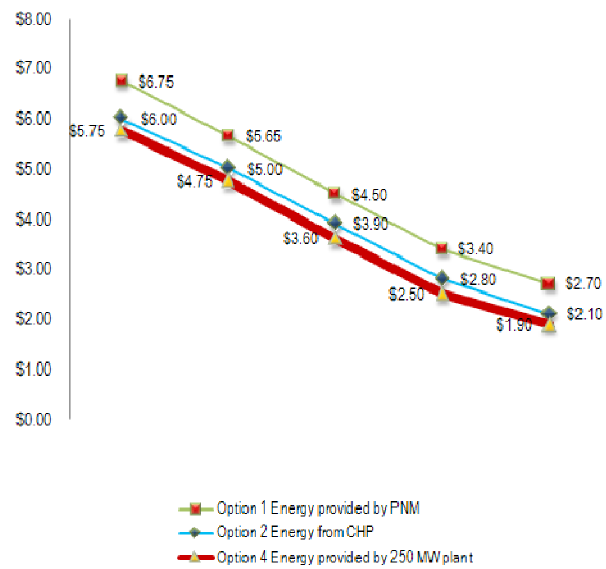
The pro forma statement includes the following basic financial assumptions:

- Energy Option 4 – 250 MW Co-Located Power Plant The Energy Source
- 4.5% Interest Rate On Debt
- 20-Year Amortization
- 1.10 Coverage Test
- Capitalized Interest During Construction (18 Months)
- One-Year Additional Capitalized Interest
- $90 Per Ton Sodium Chloride Sales
- $70 Per Ton Excess Lime Sales

C. Sensitivity

The project financing is sensitive to the amount of grants ultimately obtained. At this time only the current Water Trust Board grant has been accommodated in the pro forma. Figure 7-3 illustrates the resulting cost of water with different contribution of grant funds.

Figure 7–3 Wholesale Water Rate vs. Grant Contribution



Based upon the above graph it can be seen that the water rate with only the current grant contribution would be $5.75/1,000 gallons. With a 50% contribution this rate would fall to $3.60/1,000 gallons.

Additionally, the project is sensitive to the average cost of electricity and gas. This is discussed further in the "energy" section of this report (Appendix T).

SECTION 8
CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

Based upon the findings of this report the following conclusions have been determined:

- The City of Rio Rancho, New Mexico has a stated immediate need for 5 MGD of treated water.
- A reasonable modular water treatment template of 5 MGD output has been determined to be most cost effective.
- The 5.0 MGD flow is coincidentally equal to the proven 100-year aquifer supply.
- While the water quality of the brackish ground water is challenging, a pilot testing program determined that the selected treatment process is capable of meeting drinking water standards set by USEPA and NMED.
- Several of the residual products can be used within the treatment process, while some can be profitably marketed.
  - Excess quicklime will be sold to Lhoist North America, who will add it to their commodity lime business in New Mexico.
  - Sodium chloride will be crystallized to 99.8% purity and will most likely be sold into the industrial or swimming pool market where it will be converted to chlorine products (provided that sufficient grants are acquired to fund these elements).
  - Only the hazardous waste formed comprised of arsenic and radio-nuclides require special handling and disposal.
  - The conversion of Well EXP-5 will accommodate the disposal of Ion exchange waste and either sodium sulfate brine or mixed sodium sulfate and sodium chloride brine.
- The proposed 250 MW gas fired power plant to be built by Native Energy Development, LLC and co-located at the water plant site yields an unusual opportunity for highly efficient and low cost energy at the water plant.
  - In the event that the above power plant is delayed or canceled, the County has the option to purchase natural gas and construct its own gas fired generator using a combined heat and power (CHP) arrangement
  - If the County proceeds with a CHP model for provision of energy, it has the option of developing an on-site biogas plant. This plant would use special variety sorghum grasses as feedstock to an anaerobic digester.
- It is recognized that this water plant will produce CO_2 from the following sources:
  - Preliminary air stripping
  - Lime recalcination
  - Energy generation
- The plant has the opportunity to sequester this carbon dioxide in an algae reactor. The algae produced by this reactor would be either digested or gasified as a means of conversion to useful plant energy.
- The opinion of total project cost is $108,468,375
- The estimated wholesale price of water will be $5.75/1,000 gallons (with only the contribution of the existing Water Trust Board grant)

8.2 RECOMMENDATIONS

1. The County should immediately submit this PER to NMED for review
2. The County should simultaneously seek a letter of interest from the City of Rio Rancho
3. The County should begin discussions with “off-take” buyers of lime, salt and magnesium

4. The County should aggressively partner with Native Energy Development LLC for the co-location of a 250 MW power plant
5. The County should engage their financial advisor and legal counsel in the development of a financing plan
6. The County should seek to obtain grant assistance to reduce the overall wholesale price of produced water

8.3 RECOMMENDED PROJECT IMPLEMENTATION

The Sandoval County Desalination Treatment Facility Project is a complex effort requiring significant management of multiple tasks and vendors. Generally public projects of this variety are implemented in the following phases:

PHASE	DESCRIPTION
1.	Pre-feasibility
2.	Feasibility and Pilot Testing
3.	Design
4.	Environmental Clearance
5.	Permitting
6.	Funding
7.	Procurement (Bidding)
8.	Construction (Build)
9.	Commissioning (Start-up)
10.	Staff Training

Universal Asset Management, LLC has acted as the Owner's Engineer and provided both Phase 1 and 2 services to date. With the completion of the Preliminary Engineering Report (PER), the County's next step will be to implement Phases 3, 4, and 5 above in preparation for attracting project funding and ultimately procuring construction services.

The role of the Owner's Engineer is not to necessarily perform the services of each phase; but to assist in the management of the overall process.

An independent Owner's Engineer would perform the following functions:

1. Develop conceptual designs and feasibility studies.
2. Develop project cost estimates and schedule optimization.
3. Prepare Owner's design criteria and technical standards for use in detailed design engineering.
4. Develop Requests for Proposals for detailed design engineering including:
   - Hydrogeologic design of production and injection wells, aquifer chemical desalination and well field optimization
   - Water plant detail design
   - Energy systems detail design
   - Water Transmission and storage design
5. Develop Requests for Proposals for private-public partnerships:
   - Lime re-calcination (Recovery)
   - Carbon dioxide liquefication
   - Salt recovery
   - Magnesium Recovery
6. Develop Requests for Proposals for the disposal of wastes i.e. arsenic, radio nuclides, etc.
7. Assist in the negotiation of water purchase contracts
8. Provide management and monitoring of detailed design including:
   - Design reviews

  - Value engineering
  - Life expectancy evaluations
  - Project cost control
9. Oversee and manage environmental, safety and health issues
10. Provide project design, bidding, and construction oversight including:
    - Administering bidding process
    - Preparation of bid packages
    - Equipment submittal reviews
    - Technology assessments
    - Review all proposals and contracts to determine if County's requirements are being met
    - Provide expertise and advice to County during the evaluation of RFP submissions
    - Consult with regulatory officials to confirm the acceptability of the project
    - Review all engineering drawings including architectural/landscaping drawings from pre-design through to final construction and record drawings in hard copy and/or electronic format
    - Ensure that the County's environmental management plan is being implemented properly and all environmental/permitting conditions are being met
    - Verify, review and monitor implementation of all plans, manuals and programs required by the contract to assure compliance
    - Review and comment on all material changes to the plans and manuals
    - Verify and review all reporting requirements are provided by Contractors and that the reports fulfill the obligations of the Contractor under the Project
    - Provide on-site monitoring and reporting of construction progress, Quality Assurance and Quality Control (QA/QC) and material usage as per standard construction practice
    - Represent County at commissioning of each system
11. Represent County's technical interests in any dispute resolution procedures
12. Provide verification of progress reports to assist authorization of progress payments

The next tasks to be completed will be the implementation of Tasks 3 through 8 above. The following project check list has been developed as a guide to track the progress of this project:

PRELIMINARY PROCESSING CHECKLIST

Step I - Pre-Design

Item No.	Document or Action
SITE IDENTIFICATION, EVALUATION, AND SELECTION	
1*	Identify Land to be used for Plant Location
2	Initial Meetings with Site Representatives and Land Owner
3	Identify Project Development Team
4	Project Site Identification and Cadastral Survey of Site
5*	Gather Available Maps (Topographic and boundary)
6*	Topographic mapping
7*	Site Survey Information
8*	Existing utilities mapping
9*	Evaluate plant Layout/Footprint, access roads, rail, etc.
10	MOU or LOI to Secure Land or Land Option
11	Site Application
PROJECT COMPANY FORMATION AND DEVELOPMENT	
12	Form Legal Entity (Articles of Organization)
13	Develop Project Company Operating Agreement
14	Draft and Project Participant Acceptance of Applicable Business Plan
15	Statement of Applicable Insurance/Risk Mitigation Plan
16	***Contracts with Project Participants*** Legal Counsel Engagement
17	Accounting Firm Engagement
18*	Fuel Supply Consultant Engagement (for purposes of fuel supply chain analysis/development)
19*	Conduct Feasibility Study as to Fuel Supply, Utilities, Logistics, etc. (may involve multiple studies and third parties)
20*	Independent Engineer
21*	RFP for Detail Design
22	Contract terms a. Detail Design (1) Raw Water Wells
	(2) Water Plant
	(3) Energy
	(4) Transmission and Storage
23*	Permitting / Environmental Consultant Engagement (consult with Legal Counsel)
24*	Site Lease and Applicable Easements
25*	Engineering, Procurement and Construction ("EPC ") Agreement (if turn-key) Confirm Scope of Services
26*	Contract terms a. Construction of Wells
	b. Construction of Plant
	c. Construction of Energy Plant
	d. Construction of Transmission and Storage
27*	Confirm Performance Guarantees (water usage, output, emmissions, specs for permitting, etc.)
28*	Confirm Bondability
29*	Design Services Agreement (if applicable - see EPC)
30*	Conduct Preliminary Feasibility Study
31*	Preliminary engineering feasibility report
32*	Preliminary cost estimate

PRELIMINARY PROCESSING CHECKLIST

Step I - Pre-Design

Item No.	Document or Action
33*	Equipment Purchase, Fabrication and Installation Agreement (if applicable - see EPC)
34*	Initial Meetings with Propspective Off-takers/Suppliers (Power, Ash, Water, Steam, Wastewater, etc.)
35*	Energy Management (Agreement for power/natural gas to the site if applicable)
36*	Biomass or Fuel Supply Agreement
37*	Letter of Intent (If application is from a Utility or a "Behind the meter user")
38*	Letters of Intent a. Power
	b. Lime
	c. Salt
39*	Power Purchase Agreement
40*	Interconnection Agreement
41*	Complete Power Purchase Agreement
42*	Schedule of Connection
43	Operations and Maintenance Agreement ("O&M ")
SITE DEVELOPMENT	
44*	Perform land TOPO / ALTA survey
45*	Develop Plan for access to the Plant (easements, etc.)
46*	Soil testing and soil borings Identify and Secure Water source agreements and Offset agreements (if applicable)
47*	***Utility Services*** Initial drawings of Site Layout with Plant footprint and Logistic Ingress/Egress (roads)
48*	Initial Meetings with Utility Providers
	Water
49	Water Quality testing complete
50	Use and Consumption Rates Agreements
51	***Electric*** Discuss method of providing temp construction power to site
52	***Gas*** Proposal for permanent power to site.
53	***Sewer*** On-Site Disposal Permit
54	***Property Acquisition or Property Lease*** Submit Local Applications for Permits/Zoning
55	Deed
56	Bill of Sale/Lease Agreement with applicable Easements a. Land Acquisition
	b. Right-of-Way easement (as to form)
57	Closing
58	Initial Plant Design Complete
59	Development Details to Local and/or County Commissioners
60	Final Site Plan to State Transportation Department (If Applicable)
61	Fire Prevention and Storage Plan

PRELIMINARY PROCESSING CHECKLIST

Step I - Pre-Design

Item No.	Document or Action
	Transport. Plans and Costs Finalized/Bid (if Applicable)
62*	Initial Meeting with local Municipal/County Leaders
63*	Review of Permit Status and Public Hearings
	a. County
	b. State
	c. Federal
64*	Finalize Plan and Funding Sources
65*	Prepare Public Announcement of Intent
PERMITTING (CONSIDER BOTH FEDERAL AND STATE)	
66*	Provide Site and Technology Specifications to Permitting Service / Consultants (if Applicable)
	Water Discharge and Treatment
67*	NPDES Construction Storm Water Permit
68*	NPDES/SDS Individual Discharge Permit for Utility Water Discharges
69*	NPDES Industrial Storm Water Permit
70	General Permit for Dewatering and Hydrostatic Testing
	Water Supply
71*	Water Appropriation permit
72*	Public Water Supply System Permit
73*	Well Construction Variance / Well Installation Permit / Water Offset Program
74*	Section 404 Water Quality permit
75*	Section 401 Water Quality Certification
	Air Permits
76*	Air Quality Permit - Minor Source
77*	Air Quality Operating Permit
78*	Air Emissions Modeling
	Environmental Review
79*	Environmental Review
80*	Air Emissions Risk Analysis
81*	Environmental Compliance & Permits
82*	N.E.P.A.
	a. Cat exclusion w/o environmental assessment
	b. Cat exclusion with environmental accessment
	c. Public notice requirements finding of no significant impact
	d. Site Previous N.E.P.A. Report (Yes / or No)
83*	Historical Commission
84*	Wetlands and Migratory Bird Act
85*	Wetlands Survey
86*	Commission Environmental Quality (Air, Water, Soil)
87*	U.S. Army Corps of Engineers Release
88*	Fish and Wildlife
89*	County / Municipality Zone I.D.
90*	Federal Threatened and Endangered Species Consultation
91*	State Threatened and Endangered Species Consultation

PRELIMINARY PROCESSING CHECKLIST

Step I - Pre-Design

Item No.	Document or Action
92*	Historical and Archeological
93*	Architectural Resources Consultation / Section 106 Review
94*	***Other*** Flammable Liquid Above Ground Storage Tank Installation Permit, Registration, and Plan review
95*	Small Quantity Hazardous Waste Generator Notification
96*	Oil Spill Prevention Control and Countermeasures (SPCC) Plan
Project Financing	
97*	***Project Entity and Project Level Financial Documents*** Develop Sources and Uses Documents for the Project Entity
98	Draft Capitalization Table for the Project Entity
99	Draft financial predictions and Project level Proforma
100*	Preparation of Project Financials
101	***Secure Debt Financing*** Initial meetings with potential debt lenders
102	Follow up meetings with Debt lenders
103	Term sheet
104	Commitment letter
105	a. Operating budget
	b. Final construction cost estimate
	c. Design organizational report
	d. Project fund analysis
	e. Letter of conditions
	f. Request for obligation of funds
106	Required finance terms
107	Borrower certification
	a. Finance plan
	b. Asset management plan
	c. Draft terms and conditions finance
	d. Draft terms and conditions insurance
108	Structure of possible bond offering
109	***Identify public funding sources and tax incentives*** Investigate Public Funding Sources
110	Submit applications for state and local financing and or grants
111	State and local sources
112	Federal sources
LAND ANNEXATION AND TIF (IF TAX INCREMENTAL FINANCING IS APPLICABLE)	
113	***Re- Zoning*** Application Filed
114	Application Approval
115	***Conditional Use Permit*** Application to County

PRELIMINARY PROCESSING CHECKLIST

Step I - Pre-Design

Item No.	Document or Action
WRAP UP TO MOVE TO CONSTRUCTION	
116*	Finalize Construction Timeline and Responsible Parties
117	Close Financing
118*	Identify element in construction contracts regarding notice to proceed - confirm owners scope and expectations
119*	Proceed to Construction Phase
120*	Design standards
121*	Drawing standards

Step II - Design

Item No.	Document or Action
122*	Finalize Off take agreements
123	Written evidence of acceptable accounting system and method of accounting to be used
124	Construction Permit from County of Engineer
125*	Stormwater Permit
126*	Final contract documents, specs, and drawings and approval agency
127*	Construction management plan
128	Right-of-way and title examination (submit a. through c. simultaneously) a. Right-of-way map (color coded & all real estate sites noted
	b. Right-of-way opinion
	c. Owner's title commitment/preliminary title opinion for the following real estate sites (1)
	(2)
	(3)
	(4)
129	Attorney's opinion on adequacy of insurance coverage, including property, liability, fire, flood, worker's compensation, fidelity bond, etc. (list types and amounts)
130	Approval of finance agreement
131	Receipt and review of closing instructions
132*	Project Budget
133*	Final construction budget
134	Closing worksheet

PRELIMINARY PROCESSING CHECKLIST

Step III - Construction

Item No.	Document or Action
135*	Bid letting/contract award
	a. Contractors
	b. Equipment supply
136	CPA engagement letter
137	Executed construction contracts including project attorney's opinion and notice to proceed
138	a. Notice to contractors and applicants
	b. Pre-construction conference
139*	Final inspection

Step IV - Final Closing

Item No.	Document or Action
140*	Contractor's lien waivers
141	Final rental agreement transcript with closing documentation
142*	Maintenance agreements
143*	Insurance (EMI)
	a. As-built drawings
	b. Warranties
	c. O&M Manuals
144*	Engineer send as-built drawings to owner with copy of transmittal letter to CC
145	Evidence of P&C insurance coverage/required surety
146*	Asset management system

* *Items to be managed by independent Owner's Engineer*

APPENDIX A
PROCESS FLOW DIAGRAMS (P-1 & P2) AND OVERALL SITE PLAN (C-1)

APPENDIX B
NATURAL RESOURCE CONSERVATION SERVICE (NRCS) SOILS REPORT

APPENDIX C
NEW MEXICO STATE REGISTER OF CULTURAL PROPERTIES

APPENDIX D
US FISH & WILDLIFE SERVICE LISTED AND SENSITIVE SPECIES

APPENDIX E
CITY OF RIO RANCHO LETTER OF INTEREST

APPENDIX F
RIO RANCHO WATER RESOURCE MANAGEMENT PLAN

APPENDIX G
BYLAWS AND ORDINANCE

APPENDIX H
SANDOVAL COUNTY FINANCIAL STATEMENTS

APPENDIX I
ASSET MANAGEMENT PLAN OVERVIEW

APPENDIX J
AQUIFER TEST REPORT

APPENDIX K
ALTERNATIVE 1 COST ESTIMATE
EXPECTED CASE FOR RESIDUALS HANDLING

APPENDIX L
ALTERNATIVE 1 COST ESTIMATE
WORST CASE FOR RESIDUALS HANDLING

APPENDIX M
ALTERNATIVE 2
COST ESTIMATE

APPENDIX N
ALTERNATIVE 3
COST ESTIMATE

APPENDIX O
RAW WATER LAB ANALYSIS AND EVALUATION MEMO

APPENDIX P
BENCH SCALE TESTING SUMMARY MEMO

APPENDIX Q
PILOT TESTING REPORT

APPENDIX R
LHOIST NORTH AMERICA LETTER OF INTEREST (LIME COMMERCIALIZATION)

APPENDIX S
PRELIMINARY EQUIPMENT MANUFACTURER DRAWINGS

APPENDIX T
ENERGY SUPPLY ALTERNATIVE EVALUATION

APPENDIX U
WATER TRUST BOARD APPLICATION AND RESOLUTION

APPENDIX V
SAMPLE WATER PURCHASE AGREEMENT