Technical and Physical Feasibility Fact Sheet
Alternative 39: Desalination

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1. Definition of Alternative

Utilize technological advances for treating deep saline and brackish water for potable or non-potable use in the region.

2. Summary of the Alternative Analysis

Desalination can potentially provide a new source of water to the Middle Rio Grande (MRG) planning region (region) by using highly mineralized water that would otherwise have little practical use. Desalination is a water treatment process that converts brackish or saline water to fresh water by removing dissolved minerals (e.g., sodium and chloride ions) from the water. The terminology used for classification of water quality based on the total dissolved solids is presented in Todd (1980) (Table 39-1).

Table 39-1. Classification of Saline Groundwater

Classification	Total Dissolved Solids (mg/L)
Fresh water	0 - 1,000
Brackish water	1,000 - 10,000
Saline water	10,000 - 100,000
Brine	>100,000

mg/L = milligrams per liter

Supplies of brackish and saline groundwater in the MRG region have the potential to yield potable fresh water through desalination. A proven technology that has been used for many years, desalination is increasingly common in areas with scarce water supplies. However, because of its relatively high cost, it is generally used only if fresh water supplies are limited.

3. Alternative Evaluation

3.1 Technical Feasibility

Enabling New Technologies and Status

Desalination is being used increasingly in the U.S. and worldwide, indicating that it is a technically feasible alternative. Approximately 13,600 desalination units in 120 different countries currently produce 26 million cubic meters of fresh water each day (Reuters ENN, 2001). The U.S. has approximately 16 percent of world desalination capacity (Buros, 1999).

Desalination processes require large amounts of thermal or electric energy; however, advances in desalination technology continue to make these processes more efficient. Recent investigations have focused on the use of renewable energy to provide the required power for the desalination process, with the most popular renewable source being solar energy. Other alternative renewable energy sources available for desalination are wind-turbines, geothermal, biogas, and landfill gas-to-energy systems. Another approach is the use of dual-purpose plants, where the desalination plant is connected to a conventional electric power generating station and uses the waste heat from that station as an energy source (Buros, 1999; Goosen et al., 2000).

Infrastructure Development Requirements

Two main types of desalination processes are currently in use: (1) membrane methods and (2) thermal methods. Membrane technologies are constantly improving and a larger share of the new desalination plants being constructed, particularly in the U.S., use these technologies. The various types of membrane processes include:

- Reverse osmosis (RO), the most common membrane method, which passes pure water through a semipermeable membrane under pressure, leaving the dissolved salts (minerals) behind in a more concentrated brine solution.

- Nanofiltration membranes, a related technology that also uses membranes to remove salts, although removal is not as complete as with RO.

- Electrodialysis (ED), which uses charged electrodes to cause dissolved ions to pass through semipermeable membranes, leaving behind water of lower salinity.

The most well-known thermal process is distillation, in which saline water is heated to increase its vapor pressure, and subsequent condensation of the resulting water vapor yields fresh water. Thermal processes include (Buros, 1999):

- Multi-stage flash (MSF) distillation, in which water is boiled to produce steam, then passed through a series of low pressure vessels, causing the water to immediately boil.

- Multi-effect distillation (MED), which uses a series of vessels with a variety of designs of misters or water films to enhance the evaporation process.

- Vapor compression (VC) distillation, which uses an electric or diesel powered compressor to condense steam produced by spraying water on a heated surface.

Most existing desalination plants use RO and MSF processes (Ettouney, et al., 2002). Thermal processes are applied most often to water with high salinity; more than half of the world's sea water desalination plants use thermal processes (Buros, 1999). Membrane processes (RO or ED) are generally the preferred technologies for desalination where brackish water containing less than 10,000 parts per million dissolved salts is available. Treatment of brackish water by RO is the most commonly used desalination technology in the U.S. (Buros, 1999). In New Mexico, the preferred treatment would vary depending on the degree of source water salinity, with RO or ED most favorable for brackish water and thermal methods more favorable for highly saline water.

An emerging technology for smaller scale desalination systems is solar humidification. This process uses solar energy to evaporate fresh water, which is condensed on a cool surface and collected. Solar desalination systems are simple and easy to operate and maintain. They are also environmentally friendly because they do not require fossil fuels (Voivontas et al., 1999; Chaibi, 2000). In locations with abundant sunshine, such as New Mexico, solar desalination is a potentially viable option, especially for small-scale plants in remote locations.

Additional infrastructure required for a desalination project includes:

- Production wells in saline or brackish aquifers
- Pipelines from a supply well or well network to the treatment plant and to connect into existing water distribution network(s)
- Brine disposal systems

The specific characteristics of these infrastructure components will depend on the size and location of the desalination project.

Total Time to Implement

The time needed to implement a desalination project is highly variable depending on the nature and scale of the project.

- Small-scale projects involving the installation of commercially available RO equipment or solar humidification could be implemented in 1 to 2 years.
- Large-scale projects involving plant construction, bringing new power supplies on-line and drilling new wells could require 5 to 10 years.

Additional time may be needed to implement large-scale projects that require the investigation of saline aquifers, energy supply development, public involvement, regulatory permitting, or other issues.

3.1.1 Physical and Hydrological Impacts

Effect on Water Demand

In general, desalination will not affect water demand, except for possible minor reductions related to the relatively high cost for treatment (see fact sheet for A-21, *Urban Water Pricing*).

Effect on Water Supply (surface and ground water)

Sources of brackish and saline groundwater are available within the MRG planning region; however, the ability to develop these sources depends largely on whether pumping the brackish or saline groundwater will affect existing freshwater sources within the central Rio Grande Basin. This analysis focuses on identifying brackish and saline groundwater resources that are sufficiently isolated from the central basin to prevent adverse impacts on fresh water resources.

Pumping brackish or saline groundwater in the MRG region would constitute mining of a finite resource, although there may be sufficient quantities of saline and brackish water to make these depletions acceptable. The New Mexico Office of the State Engineer (OSE) will have authority over pumping of saline and brackish groundwater to prevent any possible impairment of existing water rights.

Potential source waters must be sufficiently disconnected from the MRG surface water and aquifer system to ensure that groundwater pumping will not further deplete the central basin. This means that sources should be located outside the defined boundaries of the Middle Rio Grande Administrative Area (MRGAA). This area was designated by the OSE for compliance with the Rio Grande Compact (NM OSE, 2000) and includes the areal extent of the alluvial aquifer known to be in hydrologic connection with the Rio Grande.

Most of the suitable brackish and saline aquifers that are sufficiently distant from the MRGAA are located in the western part of the MRG region, including portions of Sandoval, Bernalillo, and Valencia Counties. The following contain brackish and saline groundwater:

- Middle Rio Grande Basin; Santa Fe Group aquifer (Bexfield, 2001)
    - Rio Puerco drainage basin
    - Laguna Bench
    - Sierra Ladrones Formation Piedmont
- Glorieta Sandstone (Geoscience Consultants, 1986)
- San Andres Limestone (Geoscience Consultants, 1986)

Water Saved/Lost (consumption and depletions)

Desalination has the potential to make use of water that is currently unappropriated. An application to appropriate brackish or saline water for beneficial use may be filed with the OSE, if it can be shown that other water rights will not be impaired by the new appropriation. Water rights are not required by the OSE for saline groundwater (total dissolved solids [TDS] concentration exceeding 10,000 milligrams per liter [mg/L]) in deep aquifers more than 2,500 feet below ground surface (NMSA 1978, §72-12-25). However, brackish groundwater (TDS of 1,000 to 10,000 mg/L) is subject to the same New Mexico water law that governs the use of fresh water.

Impacts to Water Quality (and mitigations)

The major environmental concern for desalination is the disposal of brine, which is a byproduct of all desalination processes. Brine disposal must be conducted in a manner that protects water quality. Alternatives for disposal of brine include (Winter et al., 2000):

- Deep subsurface injection wells, which require permitting as either Class I wells (non-hazardous industrial wastewater) or Class V wells (other non-hazardous wastewater) under the New Mexico Environment Department's (NMED) Underground Injection Control (UIC) Program.

- Disposal to sanitary sewers, which is permissible if the flow is small enough to not cause a significant salinity change in the total flow to the wastewater treatment plant.

- Lined evaporation ponds, which are a simple approach where sufficient land is available. Depending on the site's hydrogeologic conditions, a groundwater discharge plan will most likely be required from NMED to protect underlying groundwater.

- Crystallization and landfill disposal, which has become increasingly popular due to the high technical and regulatory costs of surface or subsurface brine disposal.

A unique brine management approach used for some desalination projects in Texas is to mix the brine with irrigation water (Burkstaller, 2003). The blend of brine and irrigation water must be of suitable quality and managed to avoid negative effects on crop production or soil salinity.

An additional brine disposal option that may be feasible is discharging brine to one of the permitted and lined solid waste landfills in the region. This approach would use an emerging technology known as a "bioreactor landfill," in which water is added to degrade the solid waste, increasing methane production for a landfill gas-to-energy project. Development of a cogeneration desalination/gas-to-energy project would combine two emerging technologies and would use landfill gas to meet the energy requirements of desalination and groundwater pumping. This approach may prove feasible for the City of Albuquerque Cerro Colorado Landfill, which is currently developing a landfill gas collection system and also has brackish water resources available in the area.

Watershed/Geologic Impacts

A well planned desalination project should not cause any watershed or geologic impacts.

3.1.2 Environmental Impacts

Impact to Ecosystems

Local ecosystems will not be affected, aside from the immediate effects resulting from facility construction. Indirectly, the energy requirements for desalination could have an effect on ecosystems due to the associated power generation impacts, including the use of fossil fuel and air emissions.

Implications to Endangered Species

Desalination will not affect endangered species.

3.2 Financial Feasibility

3.2.1 Initial Cost to Implement

Several considerations influence the cost of desalination per volume of fresh water produced. These include: (1) feed water salinity, (2) energy costs, and (3) economies of scale. Costs rise significantly with increasing salinity of the feed water; the cost of desalting seawater (TDS of 35,000 mg/L) is three to five times higher than the cost of desalting lower-salinity brackish water from the same size plant (Buros, 1999).

RO plants are generally the preferred choice for desalting brackish water in most small to medium-size communities in the United States. In comparison to other desalination methods, RO plants offer simpler operation, lower energy consumption, and resultant lower fresh water unit costs (Glueckstern, 1999). RO of brackish water using solar energy is potentially the cheapest way to provide new fresh water resources in remote areas (McCarthy and Leigh, 1979; Voivontas et al., 1999).

Costs for desalination processes typically fall in the range of $1.90 to $4.43 per 1,000 gallons of water produced ($620 to $1,440 per ac-ft) (Ettouney, et. al., 2002). Costs reported for sea water desalination plants in Florida and California are in the range of $2.00 to $2.40 per 1,000 gallons (Krishna, 2002). These costs do not typically include pipeline costs of the magnitude that may be required for the MRG planning region, where saline and brackish water sources are located at considerable distance from the areas of water demand. At present, costs for traditional water supplies generally remain lower than the cost of desalination. However, the gap between the two might narrow with (1) reductions in the cost of desalination (e.g., through reduced energy costs or increased energy efficiency) and/or (2) increases in the cost of traditional water sources.

3.2.2 Potential Funding Source

Potential funding sources for desalination projects include:

- New Mexico Legislative appropriation
- New Mexico Finance Authority loan
- NMED Construction Programs Bureau loan
- U.S. Department of Agriculture Rural Utilities Service
- Local financing (revenue bonds)
- Public private partnerships

The U.S. EPA is providing $7 to $21 million to help fund the Hueco Bolson desalination project to serve El Paso, Texas. Funding for this project is also being provided by the U.S. Department of Defense, in return for additional capacity to serve Fort Bliss, an adjacent military installation (Burkstaller, 2003).

3.2.3 Ongoing Cost for Operation and Maintenance

Operation and maintenance (O&M) costs are directly affected by the quality of the feed water (Morin, 1999). In practice, energy costs often represent 50 to 75 percent of operating costs

(Mesa et al., 1996), and energy costs are directly linked to feed water quality. Membrane processes are often more attractive than distillation because they typically have the lowest energy requirements (Sackinger, 1982; Glueckstern, 1999), and rising energy prices tend to increasingly favor RO or ED.

Ongoing costs for brine disposal are a significant component of desalination O&M costs. Disposal of brine in lined evaporation ponds can be relatively inexpensive in arid regions where land is readily available. Brine evaporation ponds in Texas add costs of $0.05 to $0.25 per 1,000 gallons of fresh water (U.S. Congress, 1988). Brine disposal using deep injection wells is often more expensive, and the feasibility of injection wells depends on whether existing geologic conditions can confine the brine. Salt crystallization and solid waste disposal can result in additional costs of $1.15 to $1.85 per 1,000 gallons of fresh water produced (U.S. Congress, 1988).

3.2.4 Cost Evaluation Scenarios

To provide a preliminary cost feasibility analysis for desalination projects in the region, two representative cost evaluation scenarios were developed. These cost scenarios are based on hypothetical small- to large-scale projects that may be used to augment water supplies for communities in the region. The cost evaluation scenarios, which are not intended for use as a complete feasibility analysis, are described below. Table 39-2 summarizes preliminary project cost estimates.

Comment: Table 39-2 Preliminary Cost Projection, Cost Evaluation Scenarios for Desalination Projects, Mid-Region Council of Governments

Small-scale project. The cost evaluation scenario for a small-scale desalination project is based on an RO system, which is intended to supplement the water supply available to a small community. The desalination system would add an additional capacity of 100,000 gallons per day (gpd) (112 acre-feet per year [ac-ft/yr]), enough to serve approximately 300 additional households. The small-scale scenario includes costs for the following project components:

- Brackish water supply well: 1,000 feet deep drilled into an aquifer containing water with a TDS concentration of 5,000 mg/L

- Commercially available RO treatment plant, along with ancillary facilities (building, roadways, electric connections, system controls, chlorination facilities, storage tank, connection to existing supply system, etc.)

- Evaporation ponds covering 5 acres, lined with high-density polyethylene (HDPE) for brine disposal

- Purchase of a 40-acre tract of land

- Engineering design and permitting

- Operation and maintenance costs for electric power (for plant operation and pumping of groundwater and treated water), labor, parts, chemicals, equipment, and other expenses.

Large-scale project. The cost evaluation scenario for a large-scale desalination project considers a major infrastructure project, assumed to provide 20 million gpd of treated water to the region's urban corridor. This water supply rate is equivalent to 22,400 ac-ft/yr or approximately 20 percent of the City of Albuquerque's total annual water use of 120,000 ac-ft/yr. The treated water would go to urban rather than agriculture uses because of the relatively high cost of the water supply. The large-scale scenario considers costs for the following project components:

- Wellfield consisting of 30 supply wells drilled into a saline aquifer to a depth of 3,000 feet, producing water with a TDS concentration of 25,000 mg/L at a rate of 500 gallons per minute.

- RO treatment plant constructed using a series of commercially available RO units, with all ancillary facilities (building, roadways, system controls, chlorination facilities, storage tanks, power supply to the plant and wells, etc.)

- Evaporation ponds covering 320 acres, lined with HDPE for brine disposal, with evaporation rates enhanced by a misting sprayer system.

- Conveyance pipeline, 30 miles long with two pump stations constructed from the western part of the region to the central region urban corridor

- Purchase of a 640-acre tract of land and lease agreements for the wellfield and pipelines

- Engineering design and permitting
- Operation and maintenance costs for electric power (for plant operation and pumping of groundwater and treated water), labor, parts, chemicals, equipment, and other expenses.

3.2.5 Cost Summary

The cost evaluation scenarios are summarized in Table 39-2. This preliminary cost evaluation for desalination projects provides an initial estimate of representative costs. Initial estimates range from $9.76 per 1,000 gallons ($3,180 per ac-ft) for a small-scale project to $3.98 per 1,000 gallons ($1,300 per ac-ft) for a large-scale project. These costs are relatively high as compared to reported costs for sea water desalination because the latter does not include the added costs for well installations, groundwater pumping, evaporation ponds, and pipelines. Desalination costs are much higher than current water prices; augmenting existing water supplies with desalinated water would be costly.

The cost estimates are intended only for the purpose of a preliminary evaluation of the desalination option as compared to other water supply alternatives considered. Therefore, the cost estimates for each alternative are for 2003 costs, and adjustments for present worth have not been considered. Much additional study is needed to develop desalination plans more fully before a complete feasibility analysis can be made for specific projects.

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