New Mexico Brackish Groundwater Assessment Program Workshop

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Report of Findings and Recommendations

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EXECUTIVE SUMMARY

The New Mexico Brackish Groundwater Assessment Program Workshop was convened to provide a forum for the discussion and development of an approach and roadmap to be utilized by the state to quantify and develop brackish groundwater resources that can help supplement existing fresh water supplies. Workshop attendees included interested parties from state and federal agencies, New Mexico's national laboratories, private consulting firms, industry, water agencies, communities and municipalities, and academic institutions. The workshop directed attention on developing a strategy that would result in cooperative efforts, specify the key information components needed, and identify priority aquifers.

The workshop program included a series of presentations on various engineering and earth science aspects of desalination technology and saline aquifer characterization. Most of the visual presentations are available for viewing on the workshop web page at <http://wrri.nmsu.edu/conf/brackish>.

Recommendations generated by workshop attendees in discussion sessions show that there is much to do in order to prioritize saline aquifers for development and define what data are needed to fully characterize them. However, a framework for developing a roadmap for economic development of saline water resources in New Mexico was established. This roadmap includes several recommended steps, both short and long term, that address issues of immediate concern and also allow various levels and scales of study by several agencies. Below are the recommended steps for development of saline water resources in New Mexico:

Short Term (6 months to 2 years):

1. The New Mexico Office of the State Engineer (NMOSE) should establish a Brackish Water Task Force to expand understanding and expertise in the area of brackish water resource development, ensure communication among the state's experts, and provide a forum for review and evaluation of proposed projects and aquifer prioritization.
2. The NMOSE, working with the Brackish Water Task Force, should establish a decision matrix that prioritizes saline aquifers and communities or groups of communities in need of water supply.
3. The NMOSE should work with other appropriate state and federal agencies to compile and review existing data and identify data needs for characterizing and evaluating suitability of potential aquifers.
4. The NMOSE should work with other agencies to develop a saline aquifer web page as a clearinghouse for saline groundwater information accessible to the public.
5. The NMOSE, in cooperation with appropriate state and federal agencies, should prepare a summary report of saline aquifer resources.
6. If indicated, the NMOSE working with other agencies should develop a hydrogeologic characterization and computer model to support an impact assessment and feasibility study.

Long Term (2 to 5 years):

1. The NMOSE, in cooperation with other agencies, should work to collect any additional data needed for proper evaluation of potential aquifers.
2. If indicated, the NMOSE working with other agencies should develop a hydrogeologic characterization and computer model to support an impact assessment and feasibility study.
3. The NMOSE, working with subject communities, should pursue plant design and pilot project.

INTRODUCTION

Water is critically important to the quality of life in New Mexico. Adequate and dependable supplies of water are necessary for future economic development and to accommodate population growth. New Mexico today has limited surface and groundwater resources that can be readily used, and in most areas of the state demand already exceeds supply. This situation is exacerbated by drought conditions, which show no signs of abatement. Treating brackish water may be the only significant source of "new water" available for the future.

We know that New Mexico has significant quantities of brackish water underlying the state, as much as a billion acre-feet. What we do NOT know is how much of that is really accessible for development, how much can be economically and hydrologically tapped to enhance our water supplies.

New Mexico needs to make strategic investments in water development infrastructure to secure adequate supplies into the future, but we do not currently know enough about this resource to make educated decisions about where desalination should be developed and what technologies will be required for particular brackish aquifers. There has been excellent work by Sandia National Laboratories and others to improve desalination technology. Both large and small-scale desalination, including wellhead installations, are on the horizon, and we have planned a SMALL SCALE DESALINATION OPPORTUNITIES WORKSHOP on March 22-23, 2004 (in conjunction with the New Mexico Rural Water Association annual conference).

Governor Bill Richardson recently announced his INVEST NEW MEXICO plan for improving the state's infrastructure. Of the seven "foundations" identified for investment in that plan, water infrastructure is the first because it is so critical to all aspects of life in our state. As manager of the state's water resources and Chair of the Water Trust Board, the State Engineer is in a leadership role to help guide investments in water conveyance and delivery systems, and in development of new water supplies.

The Governor and the State Engineer believe that we need to be investing NOW to increase our water supplies before shortages increase. The problem is that we do not have adequate information to devise an appropriate strategy for those investments. That is the reason for this workshop. We need the assistance of New Mexico's experts in the research community and the private sector to help develop a practical framework to guide these investments and to identify additional research needed to support those investments.

This workshop is thus very focused on a very practical outcome. We invited as many technically knowledgeable individuals as we could locate to participate in this discussion. It is designed to compile information that:

---water purveyors need to know about brackish aquifers;

---what characteristics of brackish aquifers do we need to know;

---where are brackish aquifers that can realistically, economically, and practically be developed.

All of this is very important if we are to design a strategic investment plan that focuses our limited fiscal resources on development in areas that hold the greatest potential for serving the most people and the most needs.

The breakout groups reflect this very practical focus. They are designed to:
---determine what technical data we already know and what we still need to know about our brackish aquifers;
---describe how best to make technical data available for development planning;
---identify where brackish water resources are located;
---propose how we can prioritize research to generate the technical information not now available; and
---what entities or organizations would be best suited to "fill in the blanks" of our knowledge of our brackish water resources.

There is clearly some urgency to this task. The expeditious development of New Mexico's brackish water resources is critical to insuring the state's "water future". And compiling the basic data necessary for that development as quickly as possible is necessary for development of a strategic infrastructure investment plan.

So we have a confluence here of needs and opportunities. The Governor is ready to push for large investments in infrastructure to secure the water supply needed to maintain the quality of life and economic vitality of the state. Our congressional delegation, especially Senators Domenici and Bingaman, are well positioned and anxious to assist with project funding. And the drought is adding to the urgency as well as raising the awareness and commitment by New Mexicans to investing in water development.

This workshop is designed to develop the information needed for both infrastructure investments and for further research to support those investments. Thanks to funding from the U.S. Bureau of Reclamation and to the fast work of the Water Resources Research Institute to organize this workshop, we will today take a big step in the development of a roadmap for brackish water development in New Mexico.

BACKGROUND

The Resource

Access to adequate supplies of fresh water is becoming an increasingly critical issue in many parts of the world. In arid and semi-arid regions of the southwestern U.S., diminishing water supplies and extended periods of drought have generated an interest in non-traditional water resources, and the development of new technologies to exploit them. New Mexico has limited supplies of fresh water, but very large reserves of saline groundwater. As conventional water supplies become locally depleted, desalinated groundwater may become an important alternative source of fresh water for many communities.

Saline water is formally defined as water containing greater than 1,000 milligrams per liter (mg/l) total dissolved solids (TDS) (U.S. Public Health Service, 1962). Saline waters are further classified by TDS content as follows[1] (USBOR, 2003):

Mildly brackish	1,000 - 5,000 mg/l
Moderately brackish	5,000 - 15,000 mg/l
Heavily brackish	15,000 - 35,000 mg/l
Seawater and Brine	> 35,000 mg/l

For comparison, average seawater salinity has a dissolved solids content of 35,000 mg/l. Although water with TDS >1,000 mg/l is not recommended for human consumption, slightly to moderately saline water is often used for domestic stock and irrigation.

Until recently, desalination has been thought of as a costly last resort option for developing additional supplies of fresh water, although pilot plants and some small systems have operated in New Mexico in the past. The economics are changing, however, and desalting of saline water could likely become a significant resource to supplement existing limited fresh water supplies in the southwest as the cost of fresh water continues to increase and technical improvements continue to reduce the cost of desalination.

Economics of desalination are influenced by energy costs, the size of the plant (economies of scale), and the concentration of dissolved solids, among other factors. Because desalting of saline water becomes increasingly difficult and expensive at higher TDS levels, the cost of desalination depends to a large extent on salinity of the feedstock waters. Typical costs at inland desalination facilities are approximately $3 – $5 per thousand gallons of water produced.

Concentrate disposal is an important factor in the economics of desalination in inland areas. Every desalination process yields a concentrate as a byproduct, which must be managed in an environmentally appropriate manner. In coastal areas, the concentrate stream is usually returned to the ocean where it is diluted with seawater. In landlocked areas such as New Mexico, concentrate management options include evaporation ponds, deep subsurface injection, or byproduct recovery. These methods can significantly increase the cost and environmental impact of inland desalination operations.

Distribution of saline water resources in New Mexico

Approximately three-quarters of the groundwater in New Mexico is saline and requires treatment prior to use (Reynolds, 1962). In general, less is known about the hydraulic properties of saline aquifers than their fresh water counterparts because of the smaller number of wells and aquifer tests completed in saline aquifers or the saline portions of otherwise fresh aquifers.

[1] The following definitions are used by the industry for desalination applications. The U.S. Geological Survey has traditionally used slightly different salinity values to classify saline water (U.S. Public Health Service, 1962).

The potential contribution of desalination to the water supply in New Mexico has been discussed by Morris and Prehn (1971) and Stucky and Arnwine (1971). Hood and Kister (1962) presented detailed information on the distribution and potential yield from saline-water aquifers of Pennsylvanian through Holocene age in New Mexico. Moderate (100 – 300 gpm) to large (>300 gpm) yields of saline water are available from the following units:

- Undifferentiated rocks of Pennsylvanian age on the flanks of the southern Sangre de Cristo Mountains and uplifts of the Basin and Range province.
- The Permian Yeso Formation in the eastern Basin and Range province.
- The San Andres Limestone in the lower Pecos valley and in the vicinity of the Zuni Uplift.
- The Capitan Reef Limestone in Eddy and Lea Counties, southeast New Mexico.
- Lower and upper Cretaceous sandstones and coal seams in the Raton/Las Vegas and San Juan Basins.
- The Tertiary Ogallala Formation of the Southern High Plains.
- Santa Fe Group alluvial fill sediments contained in intermontane basins of the Basin and Range province.
- Quaternary alluvium in the Pecos and Rio Grande valleys.

Kelly et al. (1970) and Kelly (1974) presented detailed maps showing the general extent and thickness of aquifers in the Rio Grande Basin of Colorado, New Mexico and Texas that contain saline water resources ranging from slightly saline to high concentration brines. Those resources identified as being most suitable for development include brackish or saline waters in the:

- Tularosa Basin
- Albuquerque Basin
- San Juan Basin
- Roswell Artesian Basin
- Estancia Basin
- Capitan Reef Limestone
- Jornada del Muerto Basin

(See figure 1, end of document, for location of basins and aquifers.)

McLean (1970) presented a detailed study of the hydrologic characteristics and distribution of saline water resources in Pennsylvanian through Holocene rocks in the Tularosa Basin with emphasis on the basin-fill aquifer, which is composed primarily of Santa Fe Group sediments. Products of this study include maps showing the extent and depth of occurrence of slightly, moderately, and very saline water in the basin-fill aquifer. In general, salinity of groundwater in the basin fill increases basinward and with increasing depth.

Most saline groundwater in the Basin and Range province of New Mexico has sulfate or chloride as the dominant anion (Thompson et al., 1984b). Hood and Kister

(1962), Kelly et al. (1970), McLean (1970), and Kelly (1974) provide chemical analyses from selected areas throughout the state that can be used to help determine the suitability of saline groundwater for desalination. Available literature does not discuss the potential effects of withdrawal of saline water on water levels or water movement in adjoining or overlying fresh water aquifers.

Only generalized mapping of saline water resources in New Mexico has been accomplished with the general distribution of saline groundwater broadly understood in many parts of the state. However, gaps exist in our understanding of the extent of some brackish aquifers and the three-dimensional distribution of salinity of most aquifers. The type of detailed information needed to utilize brackish or saline water aquifer resources could be gathered from a combination of existing well data and from new and existing geophysical surveys and boreholes. More detailed knowledge of the subsurface distribution of aquifer salinity and yield will be essential for the economic development of saline water resources in New Mexico.

WORKSHOP PROGRAM

This workshop was convened to provide a forum for the discussion and development of an approach and roadmap to be utilized by the state to quantify and develop brackish groundwater resources that can help supplement existing fresh water supplies. Workshop attendees included interested parties from state and federal agencies, New Mexico's national laboratories, private consulting firms, industry, water agencies, communities and municipalities, and academic institutions. The workshop directed attention on developing a strategy that would result in cooperative efforts, specify the key information components needed, and identify priority aquifers.

The workshop program included a series of presentations on various engineering and earth science aspects of desalination technology and saline aquifer characterization. A summary of the presentations follows. The visual presentations are available for viewing on the workshop web page at <http://wrri.nmsu.edu/conf/brackish>.

1. *What we need to know and why* – Anne Watkins, Special Assistant to the New Mexico State Engineer.

2. *Considerations for Brackish Groundwater Use as a Water Supply for Small Water Systems and Municipalities* – Eddie C. Livingston, Livingston Associates, P.C. This presentation provides a detailed description of desalination with a focus on the most commonly used process in the US, reverse osmosis (RO), including: (1) Basic design features; (2) Desalination terminology; (3) RO membrane ion rejections and example performance specifications; (4) RO membrane scaling issues and problem salts; (5) Issues surrounding concentrate management; (6) Descriptions of RO equipment and desalination projects in the southwest; (7) Typical capital and operating and maintenance costs versus plant capacity; (8) Desalination cost considerations; (9) Brackish groundwater quality data needs and

impacts on desalination costs; and (10) Possible strategies for implementation of desalination technology.

3. *Natural Resources Issues in the Use of Saline Groundwater in New Mexico – an Overview of What We Know* – Rick Huff, U.S. Geological Survey. This presentation discusses five major issues associated with use of saline groundwater: (1) Location and hydrologic properties of aquifers containing saline water, including references for site-specific studies; (2) Accurate three-dimensional representations of salinity and chemical composition of groundwater; (3) Effects of withdrawal of saline water (changes in hydraulic head in aquifers, changes in saline water composition with time, movement of saline-fresh water interfaces); (4) Chemical suitability of saline water for use with existing and anticipated desalination technologies; and (5) Location of suitable geologic formations for potential deep-well injection of desalination concentrate.

4. *Regional issues and hydrologic properties* – John Shomaker, John Shomaker and Associates, Inc. This presentation raises numerous issues surrounding the development of saline aquifers in New Mexico, including: (1) Practical constraints on development of brackish water supplies vis-à-vis the market demand; (2) Assessment of the volumes of recoverable saline water in the southern San Juan Basin, relative to volumes of recoverable fresh water and a discussion of what "recoverable" means; (3) A discussion of what "sustainable" development of saline water means in the spectrum of hydrogeologic settings (mining vs. salvaging evapotranspiration vs. intercepting baseflow to rivers) and the problems and consequences of development specific to each setting; (4) Issues surrounding disposal of the concentrate; and (5) A brief summary of saline water occurrence in various aquifers and geologic formations in New Mexico (bedrock under the High Plains aquifer, the Capitan Reef aquifer, deep groundwater in the Middle Rio Grande basin, the Tularosa basin, the Jornada del Muerto basin, and aquifers in the San Agustin basin, Salt basin, and Southwestern Closed basins) and site-specific issues and problems

5. *Hydrogeologic Mapping and Assessment of Saline Aquifers* – Peggy Johnson, New Mexico Bureau of Geology and Mineral Resources. This presentation introduces a template for hydrogeologic investigation of aquifers in New Mexico, including methods specifically applicable to saline aquifers. Critical elements include: geologic mapping, geophysical studies (gravity, aeromagnetic, and seismic surveys, and time-domain electromagnetic (TDEM) soundings), hydrogeologic data collection and characterization (water levels, hydrologic properties, and hydrogeochemistry), development of hydrogeologic conceptual models, hydrologic computer models, and application of all of the above to planning and public policy.

6. *Geophysical Mapping of Coastal Plan Aquifers Using the Time Domain Electromagnetic Method* – Lewis Land, New Mexico Bureau of Geology and Mineral Resources. This presentation described an approach to mapping saline

waters and characterizing hydrostratigraphy using the geophysical method of time domain electromagnetic sounding. A case study from the coastal plain aquifers in North Carolina is presented together with a discussion of potential applications of the method to saline aquifers in New Mexico.

DISCUSSION SESSIONS

Five breakout groups, consisting of approximately 10 to 15 workshop attendees per group, were convened to address a series of questions focusing attention toward a strategy for identifying and using New Mexico's brackish water resources. The approach identified included emphasis on cooperative efforts for data collection, aquifer prioritization, and recommendations for expediting data collection. The questions developed by the steering committee to be addressed by the workshop participants in the discussion sessions included:

I. What data do we need to plan for development of brackish water resources? (this was a technical discussion)

  a. What types of data are needed to develop a brackish aquifer? (i.e., what data needs to be available before development decisions can be made and therefore should be given priority for research funding)

  b. What methods or approaches are available to collect these data quickly?

  c. How should data be compiled to make it most useful for development planning? (where should the repository be; how can it be usable to both technical and planning personnel; who should have access; etc.)

II. Can we identify priority areas for work to develop that foundation for making investment decisions? (this was a locational discussion)

  a. What are the best candidate locations for development based on our current knowledge? Which are nearly ready to go and which need just a bit more work? (need general map locations)

  b. What locations appear to have potential for development but still have major unknowns? What do we still need to know? (need general map locations)

  c. Can priority areas for data collection be assigned based on both aquifer potential and geographic location viz. a viz. community water systems? (ideally. generate a target priority list)

d. Who is already working on the aquifers identified above? (i.e., who has expertise that could be "dumped" into the database mentioned in I-c above, and might be the best candidates for the next level of research)

e. How should the state proceed in the data collection effort to generate expeditiously what is necessary to proceed with investments? (cooperative agreements with interested federal, state and local agencies along with private firms? contracts with the private sector? other structures?)

SUMMARY OF WORKSHOP FINDINGS AND RECOMMENDATIONS

This section summarizes the recommendations generated in response to the questions addressed in the discussion sessions. The question is shown in bold italic, and a summary of recommendations follows.

I. What data do we need to plan for development of brackish water resources?

a. What types of data are needed to develop a brackish aquifer? (i.e., what data needs to be available before development decisions can be made and therefore should be given priority for research funding)

A high priority should be assigned to an inventory, compilation and evaluation of existing data, literature and databases (include existing well coverages) for all major and minor saline aquifers of New Mexico. Data requirements from the following list need to be filled either by existing data or new data collection. Thus, a preliminary assessment of existing data will identify data gaps and those areas where new data are required on a site-specific basis. The following is a complete list of the types of data required, grouped as to immediate need or long-term need:

Immediate data needs (prior to development plan):

- Development of a criteria matrix to apply to available information for every saline aquifer or basin in New Mexico, and that assists in prioritizing aquifers for further investigation
- Location, hydrologic properties (specific yield, storativity, hydraulic conductivity, transmissivity) of saline aquifers, and volumetric assessment (areal extent, thickness, and recoverable storage) of saline water supplies based on existing data and generalized aquifer characteristics
- Define geologic framework (general structural and stratigraphic framework of basin) at an appropriate scale and level of detail for stage of development
- Basic groundwater conditions and water availability (water table map, general flow conditions, areas of recharge and discharge, productivity)
- Chemical suitability of saline water for desalination technologies (TDS, conductivity, pH, temperature, major cations/anions, iron, manganese, aluminum, and silica)

- Suitable geologic formations for injection of concentrate or other suitable concentrate disposal options
- Accurate 3-dimensional representation of the salinity and chemical composition of groundwater
- Basic cost-benefit analysis (identify demand, end users, potential alternatives)

Long-term data needs (prior to implementation plan):

- Simulate effects of withdrawal of saline water (transient changes in hydraulic head, chemical composition in three dimensions (x, y, z) and movement of the freshwater-saline water interface) with variable density groundwater flow model
- Large scale water budgets (recharge, discharge, and flow characterization) for basins of interest, including groundwater modeling and geochemical modeling
- Understanding of the thermal regime, particularly for basins in or adjacent to the Rio Grande Rift
- Information regarding necessary supporting infrastructure (energy resources for plant, pipelines, pump stations, etc)
- Evaluation and ranking of potential environmental risks associated with saline water development (subsidence, potable water degradation, drying of playas and ecosystem impact)

b. What methods or approaches are available to collect these data quickly?

Compile and review data ("Data Mining") from existing databases, libraries and archives

- Ground water Site Inventory (GWSI) -- U.S.G.S. groundwater database
- New Mexico Water Resources Research library of reports
- U.S. Geological Survey water resource reports
- Petroleum databases -- Bureau of Geology (NMT), Petroleum Recovery Research Center (NMT), consultants
- Water well databases -- Office of State Engineer WATERS
- Geologic databases -- Bureau of Geology (NMT) geologic logs, core, cuttings, and geologic maps and reports
- Water quality databases -- N.M. Environment Department/EPA STORIT, Bureau of Geology Water Quality Lab
- Consultant and federal or state agency reports, conference proceedings.

Geophysical Data

- aeromagnetic, gravity, and seismic surveys for characterization of overall geologic framework (structural and stratigraphic)
- electromagnetic (TDEM) and resistivity soundings to determine location and volume of saline water
- thermal geophysics and temperature logging for defining thermal and heat flow regime and aquifer characteristics

Subsurface Data

- boreholes and monitoring wells for lithologic, stratigraphic, water level, and water quality data

- borehole geophysics for correlation with surface geophysical data
- aquifer tests for aquifer properties (transmissivity and storativity)

Water Quality Data

- measure water quality from existing wells and from new monitoring wells if existing network does not provide sufficient data

c. How should data be compiled to make it most useful for development planning? (where should the repository be; how can it be usable to both technical and planning personnel; who should have access; etc.)

The New Mexico Office of the State Engineer, in cooperation with appropriate state and federal agencies, should compile a summary report of saline aquifers in New Mexico that contains the basic information for all the major and minor saline aquifers in the State, including volume estimates, development potential, and site prioritization as previously discussed in response to question I.a. The format and content used by the Texas Water Development Board in its Brackish Groundwater Manual (LBG-Guyton Associates 2003) could serve as a template. The initial summary report should be made available in the public domain via a web page built and maintained by the New Mexico Water Resources Research Institute. This web page should also provide the following:

- Web links to and directories for computerized databases available on line from existing state and federal agencies and institutions (WATERS, GWSI, STORET, NMBGMR geologic data).
- Summaries, descriptions, and accessibility to key data sets, libraries, and archives that are not available in electronic format, and which possess data relevant to saline aquifers or their development of the type summarized in 1A and B above.
- Complete bibliography on location, nature and extent of saline waters in New Mexico, desalination technologies, economic and environment issues associated with development.

Following the initial report, subsequent geologic investigation, water quality and quantity data collected should be compiled by the Office of the State Engineer and appropriate state and federal agencies to develop an improved understanding of New Mexico's brackish water resources, availability, and quality.

II. Can we identify priority areas for work to develop that foundation for making investment decisions?

a. What are the best candidate locations for development based on our current knowledge? Which are nearly ready to go and which need just a bit more work? (need general map locations) (Figure 1, end of document)

Eastern Tularosa Basin (East of Jarilla Fault):

A high level of knowledge of the nature and extent of saline resources and their suitability for development and a moderate level of knowledge of the geology exists in the Eastern Tularosa Basin (McLean, 1970). The central part of the basin is largely uncharacterized because it is associated with military land and the saline water here is likely in low-yield aquifers.

Roswell Artesian Basin:
A high level of knowledge of the geology, hydrology, and water quality of the Roswell Basin exists. The location is appealing because infrastructure exists in the area to treat oil-field produced water, and the technology may be transferred to the treatment of saline groundwater. In the 1960s a pilot desalination plant operated in Roswell and for a time provided desalinated groundwater to the community (American Hydrotherm Corporation, 1966a, 1966b, 1967).

Capitan Reef in Eastern Eddy and Lea Counties:
A high level of knowledge of the geology, hydrology, and water quality exists in the Capitan Reef aquifer (Hiss, 1975a, 1975b, 1976). More work is required to characterize aquifer properties (which are very erratic), and evaluate suitability of saline water quality for desalination. Assessment of impacts to current users and the Pecos River would be required.

San Juan Basin:
A high level of knowledge of the geology and the nature and extent of saline resources exists for the San Juan Basin.

Salt Basin:
A moderate to high level of knowledge of the geology, hydrology, and water quality of the Salt Basin exists and water availability in the basin is high. Groups within New Mexico and Texas are interested in developing the water resources in this area for transport to other regions for utilization. An assessment of future demand and sustainable supply would be required to evaluate suitability of a project at this location.

Mesilla Basin:
A moderate level of knowledge of the geology and the nature and extent of saline resources exists for the Mesilla Basin. This transboundary aquifer may receive extreme pressure in the near future for utilization by New Mexico, Texas, and Mexico. An assessment of potential demand, alternative supplies, and the potential for conservation should be completed before moving ahead with plans to develop saline water resources.

b. What locations appear to have potential for development but still have major unknowns? What do we still need to know? (need general map locations)

Estancia Basin:
A moderate level of knowledge of the geology, hydrology and water quality of the Estancia Basin exists. There is a high potential for development of brackish water resources in the basin, a considerable interest in a desalination project, a preliminary plan, and a regional need for additional water resources.

Western Margin of the Albuquerque Basin:
The western side of the Albuquerque Basin has potential for development of saline resources, to supplement a growing demand in the area. Aquifer properties may not be sufficient for large-scale development, depth of the resource may prohibit extraction, and streamflow depletion issues must be addressed. Temperatures associated with this deep resource are elevated, and potential exists for coupling development of geothermal and saline waters.

Raton and Las Vegas Basins:
A high level of knowledge of the geology exists for the Raton and Las Vegas Basins. Limited knowledge exists regarding the hydrology and the nature and extent of saline resources, but there is a very high demand for supplemental or new water resources in these regions. The regional stratigraphic framework is consistent with occurrence of saline water resources.

Bedrock aquifers beneath the Southern High Plains:
A moderate level of knowledge of the geology exists for the bedrock aquifers beneath the Southern High Plains, but little is known of the hydrology or nature and extent of saline resources of these aquifers, particularly regarding their hydrologic connection with the overlying Ogallala aquifer. There may be some potential to supplement domestic or municipal supplies from the Ogallala through development and treatment of waters from the underlying Santa Rosa and Dewey Lake Formations. Much additional research is required.

Jornada del Muerto:
A low to moderate level of knowledge of the geology, hydrology and water quality of the basin exists. An assessment of demand and supply, and additional hydrogeologic and chemical data would be required to assess suitability of a project at this location. Drawdown in the southern end of the basin may be close to the limit with continued pumping under existing rights.

Southwest Closed Basins (Mimbres, Playas, San Agustin, Lordsburg):
These basins may have potential for development but major unknowns exist regarding the nature and extent of supplies, the geology, the hydrology, and the regional need for additional water supplies.

c. Can priority areas for data collection be assigned based on both aquifer potential and geographic location viz. a viz. community water systems? (ideally. generate a target priority list)

The highest priority recommendation from the workshop steering committee is to develop a process or set of defensible criteria for prioritizing data collection and further investigation of saline aquifers in New Mexico. This method should entail a decision matrix that includes level of knowledge (see response to question II.a and II.b above) and community or regional water demand. Priority areas for data collection should focus on those basins where there is a fairly high level of knowledge, a high demand for new supplies, and a potential for large volumes of saline water resources. While it is imperative that this decision-making process follow a defensible set of criteria that have not yet been developed, the steering committee can provide a preliminary target list of priority aquifers that includes the following areas:

Eastern Tularosa Basin: The Eastern Tularosa Basin has the highest priority for development of brackish water resources in the very near future. This site requires a better assessment of impacts to freshwater resources and sustainability or lifespan of the project.

Roswell Artesian Basin: More work should be done to characterize the nature and extent of the saline water resources (update and expand Welder, 1983) and their suitability for development. There may be a need to evaluate suitability of saline water quality for desalination. Assessment of impacts to current users and the Pecos River would be required.

San Juan Basin: An assessment of project sustainability or lifespan should be completed, as development would essentially mine the saline resource. Specific investigation should be applied to relatively fresh or slightly saline waters currently being produced from coal-bed methane projects and reinjected. These waters represent a slightly saline water resource that is essentially being wasted.

Estancia Basin: Insufficient knowledge exists regarding thickness of the alluvium, and the nature and extent of saline resources in the Eastern Estancia Basin, near the active playa lakes. Additional hydrogeologic investigations should be completed in that area. Based on a highly variable salinity distribution, there is also a concern for impacts to current users and fresh water supplies. An assessment of potential impacts should be completed.

Western Margin of the Albuquerque Basin: There is a high demand for additional water resources in this area due to population growth in the City of Albuquerque. Aquifer properties may not be sufficient for large-scale development. More research is required to characterize aquifer properties, and nature and extent of the saline resource.

Mesilla Basin: This transboundry aquifer may receive extreme pressure in the near future for utilization by New Mexico, Texas, and Mexico along the border region. An assessment of potential demand, utilization impacts on the Rio Grande and fresh water resources should be completed before moving ahead with plans to develop these saline water resources.

d. Who is already working on the aquifers identified above? (i.e., who already has expertise that could be "dumped" into the database mentioned in I-c above, and might be the best candidates for the next level of research)

Eastern Tularosa Basin: U.S. Geological Survey, Private Consultants (John Shomaker, Livingston & Assoc.), New Mexico State University (Jim Witcher), New Mexico WRRI, Sandia National Laboratories, U.S. Bureau of Reclamation, New Mexico Bureau of Geology (Dave Love, Bruce Allen), City of Alamagordo, Holloman AFB

Roswell Artesian Basin: New Mexico Office of the State Engineer and Contractors or Consultants (INTERA, Hydrosphere, Daniel B. Stephens & Assoc., Kay Havenor), New Mexico Bureau of Geology/New Mexico Tech (Lewis Land, Geraldo Gross), U.S. Geological Survey, Pecos Valley Artesian Conservancy District

San Juan Basin: U.S. Geological Survey, New Mexico Bureau of Geology (Brian Brister, Ron Broadhead, Marshall Reiter), Consultants (John Shomaker), New Mexico Office of the State Engineer

Estancia Basin: New Mexico Bureau of Geology (Bruce Allen, Ron Broadhead), Consultants (John Hawley, John Hernandez), New Mexico Office of the State Engineer (Nabil Shafike),

Western Margin of the Albuquerque Basin: New Mexico Bureau of Geology (Sean Connell, Bruce Allen, Dave Love), Consultants (John Hawley, Mike Kernodle), U.S. Geological Survey, New Mexico Office of the State Engineer

e. How should the state proceed in the data collection effort to generate expeditiously what is necessary to proceed with investments? (cooperative agreements with interested federal, state and local agencies along with private firms? contracts with the private sector? other structures?)

This report makes specific recommendations regarding needed work products and basin-specific research. The following work products and research should be prioritized via the means mentioned:

- Develop a process or set of defensible criteria for prioritizing data collection and further investigation of saline aquifers in New Mexico
- Summary Report of Saline Aquifer Resources or Brackish Groundwater Manual – cooperative agreements and contracts with private consultants and/or federal and state agencies knowledgeable in New Mexico hydrogeology to compile existing brackish water information necessary for utilization by a community or municipality for planning or resource development.
- Saline aquifer web page – New Mexico Water Resources Research Institute and New Mexico Office of the State Engineer cooperative agreement.
- Additional research and data collection in priority basins described in II.c through cooperative agreements or contracts with private consultants and/or federal and state agencies knowledgeable in the specific localities to collect the geologic, aquifer, and water data needed to utilize brackish water effectively in New Mexico.

Finally, the State of New Mexico should initiate and maintain a Brackish Water Task Force of interdisciplinary experts experienced in brackish aquifer characterization and desalination technologies. The Task Force would operate under oversight of the State Engineer. The purpose of the Task Force would be to expand our understanding and expertise in the area of brackish water resource development, ensure communication among the state's experts, and provide a forum for review and evaluation of proposed projects and priority aquifers.

RECOMMENDED STEPS FOR DEVELOPMENT OF SALINE WATER RESOURCES IN NEW MEXICO

Recommendations generated by workshop attendees in discussion sessions show that there is much to do in order to prioritize saline aquifers for development and define what data are needed to fully characterize them. However, a framework for developing a roadmap for economic development of saline water resources in New Mexico was established. This roadmap includes several recommended steps, both short and long term, that address issues of immediate concern and also allow various levels and scales of study by several agencies. Below are the recommended steps for development of saline water resources in New Mexico:

Short Term (6 months to 2 years):

1. The NMOSE should establish a Brackish Water Task Force to expand understanding and expertise in the area of brackish water resource development, ensure communication among the state's experts, and provide a forum for review and evaluation of proposed projects and aquifer prioritization.
2. The NMOSE, working with the Brackish Water Task Force, should establish a decision matrix that prioritizes saline aquifers and communities or groups of communities in need of water supply.
3. The NMOSE should work with other appropriate state and federal agencies to compile and review existing data and identify data needs for characterizing and evaluating suitability of potential aquifers.
4. The NMOSE should work with other agencies to develop a saline aquifer web page as a clearinghouse for saline groundwater information accessible to the public.
5. The NMOSE, in cooperation with appropriate state and federal agencies, should prepare a summary report of saline aquifer resources.
6. The NMOSE, in cooperation with other agencies, should work to collect any additional data needed for proper evaluation of potential aquifers.
7. If indicated, the NMOSE should work with other agencies to develop a hydrogeologic characterization and computer model to support an impact assessment and feasibility study.

Long Term (2 to 5 years):

1. The NMOSE, in cooperation with other agencies, should work to collect any additional data needed for proper evaluation of potential aquifers.

2. If indicated, The NMOSE should work with other agencies to develop a hydrogeologic characterization and computer model to support an impact assessment and feasibility study.
3. The NMOSE, working with subject communities, should pursue plant design and pilot projects.

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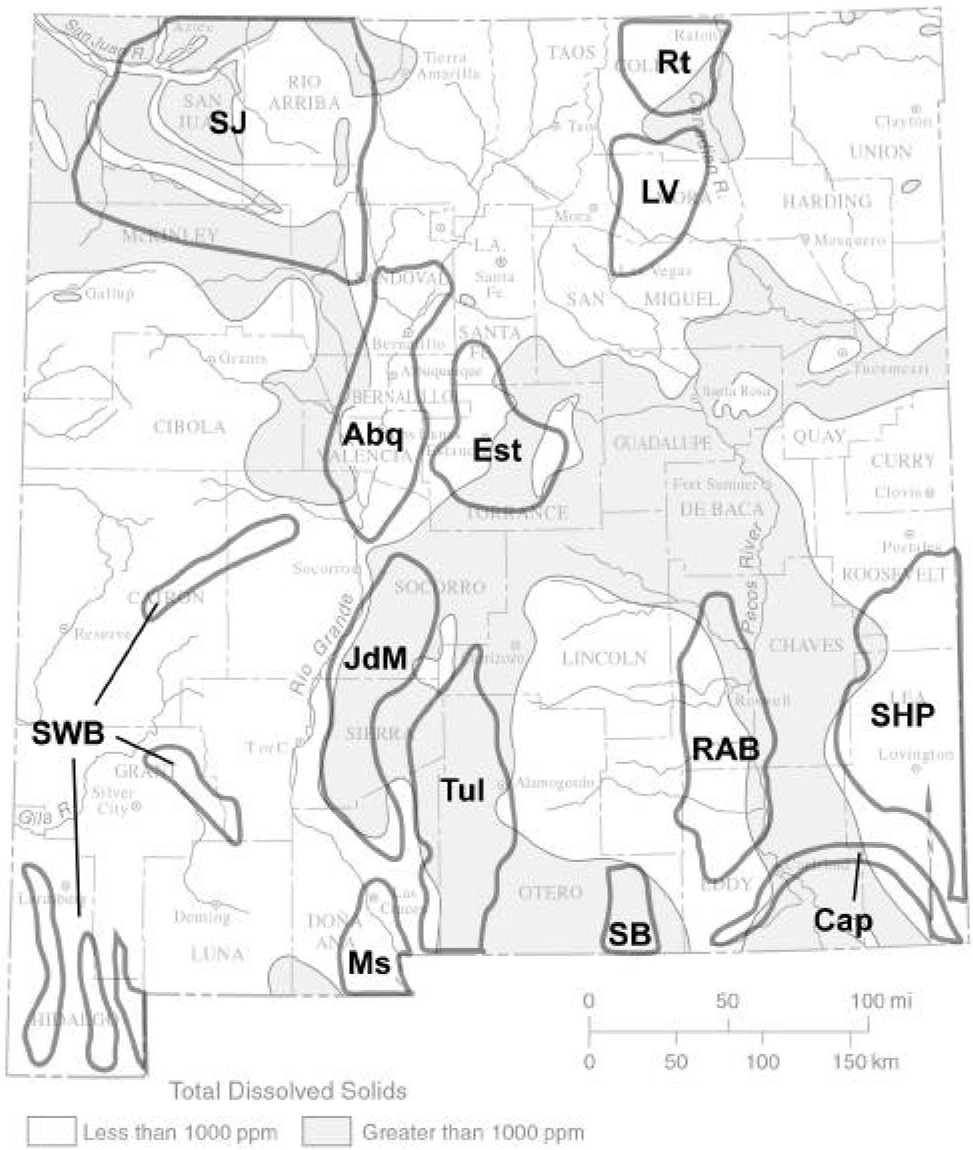

Figure 1: New Mexico sedimentary basins and aquifers discussed in report with potential for desalination of brackish water. Abq – Albuquerque Basin. Cap – Capitan Reef aquifer. Est – Estancia Basin. JdM – Jornada del Muerto Basin. LV – Las Vegas Basin. Ms – Mesilla Basin. RAB – Roswell Artesian Basin. Rt – Raton Basin. SB – Salt Basin. SHP – Southern High Plains aquifer. SJ – San Juan Basin. SWB – Southwest closed basins. Tul – Tularosa Basin.