Optimizing the Use of New Mexico's Renewable Energy and Water Resources

Presentations at the north campus of Hummingbird Camp

Discussing possible synergies with the Pueblo of Jemez (Walatowa)

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IWG Dates: August 12-14, 2016

IWG Locations: Hummingbird Music Camp, Jemez Springs, Pueblo of Jemez

1. Summary

1.1 Objectives

We brought together a team of experts in hydrology, geophysics, geochemistry, engineering, environmental science, applied education, and social sciences to explore the challenges associated with the shift toward diminishing water supplies and the widespread use of renewable energy in New Mexico. Our main goal was to identify ways to take advantage of our geothermal, solar, and wind resources, in combination with bioalgal and other water treatment technologies, to effectively and responsibly use unconventional water resources.

1.2 Key Questions and Ideas

We considered three main questions and also discussed additional concepts, data, and models that might be needed to address these questions

Question 1: What are the spatial distributions of renewable energy resources and water uses within NM? How much of each resource is available for sustainable use?

Question 2: What kind of synergies can be used to optimize energy generation and water resources use within NM?

Question 3: What is the best way to educate New Mexico citizens about effective use of each renewable technology?

Question 1: Where and how much?

A number of maps of the distribution of individual energy and water resources have been produced by various federal and state agencies during recent years, but a comprehensive merging and analysis of these maps has not yet been done. Shari Kelley pointed out that the National Renewable Energy Laboratory has created maps showing the best areas for wind farm and solar development in New Mexico. Jim Witcher has put together a simple map of known and potential geothermal resources in New Mexico (see Appendix) and more detailed information about known geothermal resources is available through a database managed by the New Mexico Bureau of Geology.

Martha Cather shared information about the production and injection of oil field brines for the Permian, the San Juan, and the Raton basins in New Mexico. Operators in the major oil producing basins in New Mexico are required to report the amount of water produced and injected during the extraction of oil and gas (see Appendix). Although the volumes of water are recorded by the Oil Conservation Division of EMNRD, little information is available from operators about water quality, or disposition (injected for a purpose vs recycled vs disposed). The PRRC and WRRI have recently compiled the available water quality data into a database and an interactive map.

Vince Tidwell presented the results of a recent study completed by Sandia National Laboratory. Tidwell et al. (2014) gathered data from a variety of sources to map water availability, consumptive use, and treatment/delivery costs for unappropriated and appropriated surface water and groundwater, municipal wastewater, and brackish groundwater in the western United States. The information was compiled at a watershed-level scale and includes New Mexico. Produced water was not considered in this analysis.

As a group, we generally agreed that the estimated amount, variable quality, exact location, and possible sources of brackish water in deep rift basin aquifers are poorly constrained. Most analyses of brackish water resources are limited to depths <760 m, the depth of most water wells in the West because drilling and treatment costs typically increase at greater depth (Tidwell et al., 2014). Land (2016) compiled TDS data for groundwater in New Mexico from wells that are <2500 m (most are <500 m) in the rift basins. One of the more interesting observations to come out of the Land (2016) study was a measured decrease in salinity with depth in several New Mexico basins. This decrease is attributed to linkage of shallow groundwater systems to losing streams and irrigation return flow that are affected by evapotranspiration and to dataset bias toward shallow wells. Jim Witcher noted that relatively fresh water resources might be present in volcanic rocks that are deeply buried in basins in southwestern New Mexico. He told us about a very productive volcanic aquifer that he discovered near Willcox, Arizona and about reports of fresh water in the Paleozoic section found during petroleum exploration southwest of Deming. Sam Fernald advised us to consider the responsible use of brackish water as a bridging resource. Brackish water should only be used in times of need to prevent mining in closed basins. He asked us to consider, “What is the replenishment time scale of this resource?”

Similarly, the heat content (geothermal resources) of deep rift basins is poorly known. Most of the shallow geothermal resources are known and are used for recreational and agricultural purposes, but deep blind geothermal resources are likely present in the rift basins of southern New Mexico. Geophysical (electromagnetic, seismic, heat flow) and geochemical methods are the primary techniques that need to be applied to locate and quantify the potential of these hot, brackish waters. Mark Person discussed important, fundamental scientific questions about the nature of the plumbing of gravity-driven geothermal systems. Are parts of the plumbing located within the Proterozoic basement, which is typically thought to be impermeable? If parts of the system are in the basement, are the fluids moving along faults, through fracture networks, or through more diffuse fracture systems? What is the source of the salinity in geothermal/brackish fluids (connate, paleo-recharge during pluvial intervals, continuous recharge)?

We also noted that the thermal and fluid resources of the deep petroleum basins of New Mexico are better known than those of the rift basins because of the large number of oil and gas wells that have been drilled in these areas (Appendix). However, important questions about produced fluid water quality remain unanswered at the moment (Appendix). That information is needed in order to design appropriate water treatment systems.

Question 2: Synergies

We continued discussion of ideas that came up during an IWG held in Truth or Consequences in October 2015 that centered on using the natural heat of oil field brines to reduce the energy needed treat the water (Appendix). As a group, we feel that there is a tremendous opportunity to use the natural heat of water coming out of the ground, solar-thermal and humidification-dehumidification technologies, and osmatic membranes, combined with bioalgal and other water treatment methods to desalinate and clean brackish and produced waters. Some graphs that illustrate the thermal and salinity structure of the petroleum basins in New Mexico are presented in the Appendix.

Daren Zigich from the NM Energy, Minerals and Natural Resources Department talked about modification of regulations, particularly in the geothermal sector, to facilitate exploration and use Earth’s heat. Streamlining and updating regulations that cover ownership, storage, and disposal of produced and brackish water are essential to optimizing their use.

Frank Huang has been working with Jim Witcher to simultaneously extract heat and water from the geothermal production well at the Radium Springs. He is using hollow fiber technology to remove dissolved solids from the produced geothermal water to irrigate the plants in the greenhouse. A pilot-scale geothermal membrane distillation system will be field tested at Radium Springs this fall. Alternative treatment methods that could be applied to similar purposes are also available (Pei Xu).

A focal point of discussion was the possible use of known geothermal resources on the Pueblo of Jemez to heat a greenhouse that will be used as a workforce-training center. Pueblo member and SFCC student Jerimiah Star made a presentation of his ideas and took us on field trip to look at his land near the geothermal well.

Question 3: Education

The students and faculty from the Santa Fe Community College made several presentations highlighting their excellent workforce training program aimed at educating the next generation of energy and water users. Training in the construction and use of solar, greenhouse, and water treatment facilities are just a few of their program offerings. Our group felt that education of the next generation is an important step in developing effective strategies that combine renewable energy and water treatment. Equally important is facilitating the transition of the community college students into a university setting, where the students can continue to build on the skills that they learned at SFCC.

Continuing on that theme, discussion turned to developing renewable energy business incubators and research/training facilities elsewhere in the state. We agreed learning institution campuses across our state (including UNM, NMT, NMSU) must be transformed to include renewable energy into existing and new buildings. Campus facility manger/workers must buy-into the process.

Taylor Dotson, who is an expert in researching technological risk and organizational mistakes, explained the need to proceed incrementally with novel innovations at the water-energy-food nexus, given that some of the impacts may not become visible until the technologies are more widely deployed. He also encouraged us to take care when engaging the public, emphasizing the importance of recognizing the power of the "framing" of language both in oral and in written presentations to lay people and decision makers and the risks of presuming that ignorance of the facts causes public skepticism of emerging technologies. Vince Tidwell, who has had a lot of experience recently interacting with water managers across the West, said that identification of public needs and barriers and education of decision makers are important. He pointed out that most people who attend meetings often have a middle view on a topic and don't necessarily voice their opinion, in contrast to people on the polar opposite ends of the opinion scale. He suggested using social media to interact with the public so they don't have to go to long (and sometime contentious) meetings. Thus, the middle group can still express their opinion on an issue – bring the opportunity to them.

2. Outcomes

2.1 Proposals

A common theme that ran through the presentations and the discussion during the meeting is a need for more and better data. During the last decade, numerous databases, maps, and other tools (e.g. the statewide water budget) have been created to refine our understanding of the distribution or renewable energy and unconventional water resources (e.g., NREL, NMBGMR, PRRC, WRRI, SNL). Despite these great efforts to compile old data and provide some new data, significant gaps remain in our knowledge. Although we have a good handle on the volumes of produced waters, we have limited information about the tremendously variable water quality of these waters. The water quality data that we do have are often incomplete, lacking analyses of important trace and organic constituents that are needed to help design effective water treatment systems. Although we recognize the need for these data, we did not develop a specific plan to find funding for a project that would include a GIS analysis of existing maps to determine current optimal use of our resources and collection of additional data to refine our optimization. Such a project is a bit too applied for NSF, so seeking funding from other Federal (BOR, DOE), state and local agencies seems to be a better option.

The largest gap in our knowledge is the location and quantity of brackish water in the rift basins of New Mexico. Although recent studies (Tidwell et al., 2014; Land, 2016) have gone a long way toward mapping out shallow brackish water supplies, the nature of the deep resources is less well known. Important scientific questions about the existence of possible hot, brackish water supplies in the Proterozoic basement beneath the rift basins need to be answered. This latter set of questions will be the topic of a Hydrology Program NSF proposal.

The Department of Agriculture and the Bureau of Indian Affairs both have programs that might assist the Pueblo of Jemez in their effort to use their geothermal resource to heat a greenhouse. The purpose of the greenhouse is not simply to grow food, but to provide workforce training and opportunities to conduct experiments in connecting geothermal resources with bioalgal and other lines of scientific research. Thus, we will investigate funding through the INFEWS and SEES programs at NSF.

2.2 Papers

We did not specifically discuss writing papers. A recent issue of *Earth Matters*, a Bureau of Geology publication aimed at decision makers and the general public, summarized our current understanding of brackish water resources. We should write a follow-up *Earth Matters* article to stimulate interest in incorporating renewable resources in the state into brackish water treatment plans using some of the analysis discussed in the Appendix.

2.3 Participants

Name	Affiliation	Areas of expertise	Email
Shari Kelley	NMBGMR	Geothermal	Shari.Kelley@nmt.edu
Mark Person	NMT, Hydrology	Geothermal and modeling	Mark.Person@nmt.edu
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Jeri Sullivan Graham	LANL	Brackish Water	ejs@lanl.gov
Frank Huang	NMT, Civil & Env. Eng.	Desalination, membranes	huang@nmt.edu
James Witcher	James Witcher & Associates	Geothermal and hydrology	jimwitcher@zianet.com
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Karl Karlstrom	UNM, Earth & Plan. Sci.	Regional geology	kek1@unm.edu
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Martha Cather*	PRRC	Produced water	martha.cather@nmt.edu
Sam Fernald*	WRRI	Water	afernald@nmsu.edu
Taylor Dotson	NMT, CLASS	Social sciences related to energy	tdotson@nmt.edu
Daren Zigich	NMED	Geothermal	DarenK.Zigich@state.nm.us

*- could not attend at the last minute, but submitted slide presentations

References

Land, L. “Overview of fresh and brackish water quality in New Mexico.” New Mexico Bureau of Geology and Mineral Resources, Open-file Report 583 (2016).

Tidwell, V.C., J. Macknick, K. Zemlick, J. Sanchez, and T. Woldeyesus. “Transitioning to zero freshwater withdrawal in the U.S. for thermoelectric generation.” *Applied Energy 131* (2014): 508-516.

Optimizing the Use of New Mexico's Renewable Energyand Water Resources
New Mexico EPSCoR IWG, Hummingbird Music Camp, August 12-14, 2016

Agenda

Friday, August 12

2 pm	Meet at the Camp at 2 pm; Brief introductions
3-6 pm	Tour geothermal features at Jemez Springs or Jemez Pueblo
6-7 pm	Dinner
7 pm -?	Social time

Saturday, August 13

7-8 am Breakfast

8-10 am Introductory Remarks and Presentations

We ask you to prepare 5 slides, using the attached template, and send them to us by August 8, 2016. Each of you will have an opportunity to speak for 10 minutes maximum.

Slide 1: What are your areas of expertise? How do you plan to contribute to this IWG and to the associated IWG report?
Slide 2: We are considering the following questions:

1) *What are the spatial distributions of renewable energy resources and water uses within NM? How much of each resource is available for sustainable use?*

2) *What kind of synergies can be used to optimize energy generation and water resources use within NM?*

3) *What is the best way to educate New Mexico citizens about effective use of each renewable technology?*

Prepare a slide with ideas (3 or more bullets) that address some or all of these questions.

Slide 3: What is missing? Are there additional questions that we should be asking?
Slide 4: Do you know about currently available or needed data sets that we can use to address these questions?
Slide 5: Do you know about currently available or needed models that we can use to address these questions?

10-10:20 am	Break
10:20-12 am	Finish presentations
	Begin synthesis of common themes and new ideas from the presentations
Noon-1pm	Lunch
1 pm-3 pm	Finish synthesis
	Data availability and data gaps
	Available models and modeling challenges
3-3:20 pm	Break
3:20-5 pm	Discuss possible synergies
	Discuss socio-economic and technical challenges
5-6 pm	Break
6 pm-?	Dinner at Los Ojos in Jemez Springs

Sunday, August 14

7-8 am	Breakfast
8-10 am	Synthesis of the IWG report and publication for general audience (Earth Matters or EOS or GSA Today)
10-10:20 am	Break
10:20-noon	Future collaborations and proposal possibilities
	Science-based proposals
	Education-based proposals
Noon-1 pm	Lunch
	End of Meeting

Appendix

Geothermal-produced water synergy

Figure 1 is a slightly modified version of a map created by Jim Witcher showing the location of different types of geothermal systems in New Mexico. The deep conductive basins hold untapped geothermal potential and the Paleozoic and Mesozoic basins are also the source of large volumes of produced waters (Table 1, Figures 2 and 3).

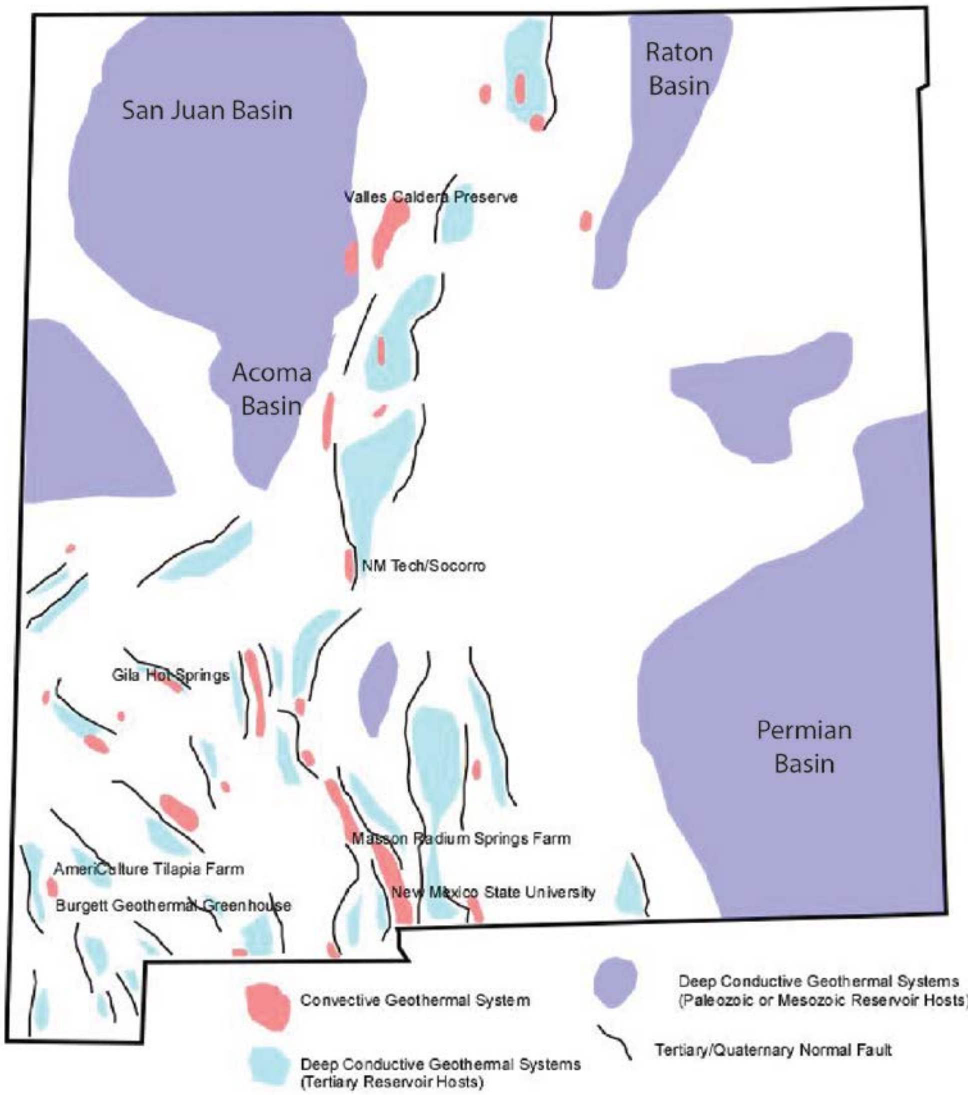

Figure 1. Map of known and probable geothermal systems in New Mexico from Jim Witcher.

County	# Wells reporting	Cum Produced Water	Produced Water 2015 (bbls)	Cum Injected Water	Injected Water 2015 (bbls)
LEA	22742	14,911,655,238	547,003,360	8,801,585,510	460,955,275
EDDY	18766	4,550,990,803	275,632,806	2,584,658,020	133,626,980
CHAVES	3549	482,204,659	22,239,549	160,216,907	8,153,933
ROOSEVELT	787	169,945,814	1,932,074	81,317,697	1,632,277
SAN JUAN	15940	756,526,438	25,147,076	379,076,669	14,674,602
RIO ARRIBA	10224	182,146,216	8,946,089	69,595,486	2,242,891
MCKINLEY	431	476,574,674	4,292,805	110,937,854	4,010,734
SANDOVAL	563	93,313,032	1,788,306	23,996,867	20,380
COLFAX	855	211,622,695	12,887,168	124,359,068	9,171,011
HARDING	402	849,698	49,942	-	
UNION	401	2,270,394	80,956	1,572,478	83,880

Table 1. Volumes of produced and injected water by county, cumulative totals and 2015 totals. Counties are grouped by basin, with Permian, San Juan, and the Raton/Bravo Dome area being the major basins. From Martha Cather

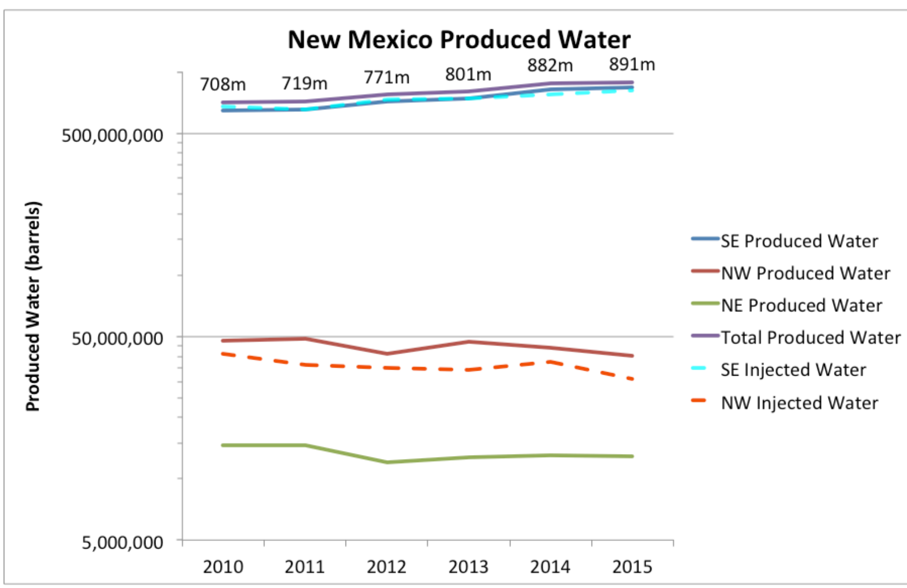

Figure 2. Volumetric trends of water production and injection in New Mexico, 2010-2015

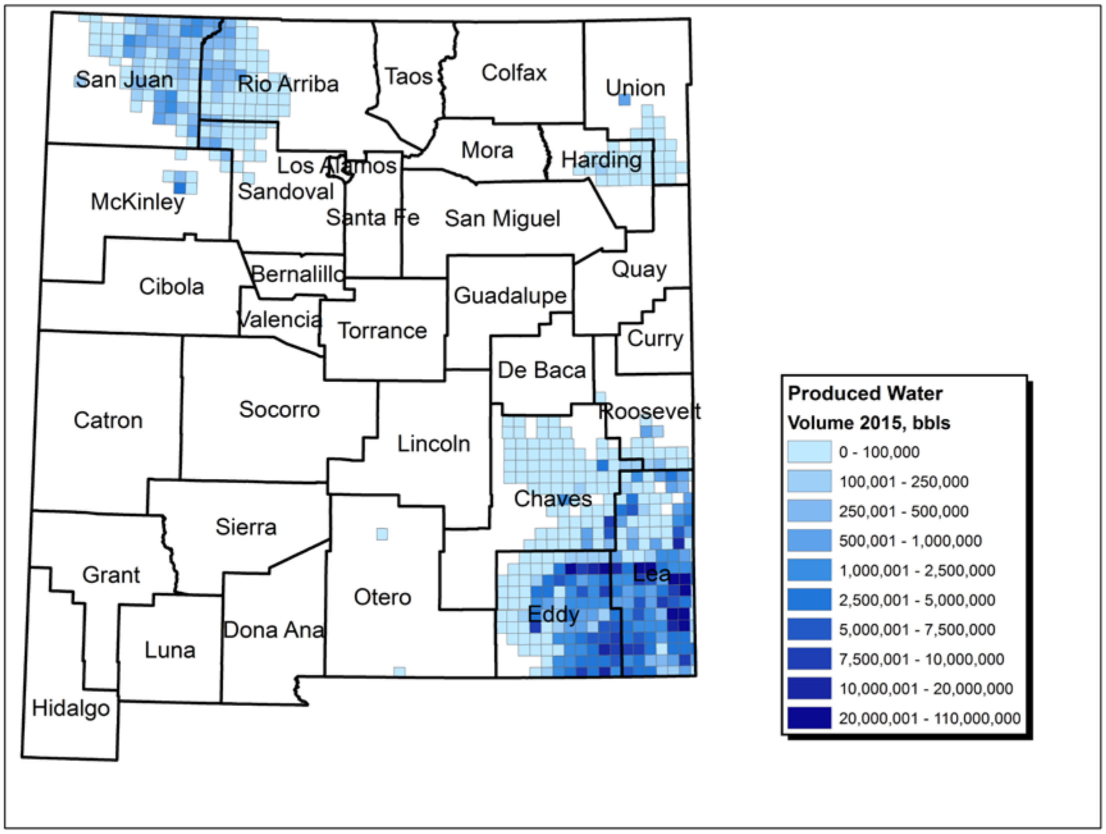

Figure 3. Volumes of produced waters in New Mexico from Martha Cather.

Figure 4 illustrates the differences in geothermal potential among the three major oil-producing basins in New Mexico. The geothermal gradient derived from uncorrected bottom hole temperatures (BHTs) from the Permian Basin are low (24°C/km) and are higher (33°C/km) in the Raton Basin. Temperatures in the Raton Basin just south of the NM-CO state line are 135°C at depths <2500 m. Produced waters from the Permian Basin are saline (up to 250,000 mg/l) compared to those in the San Juan Basin (Figure 5). An analysis of salinity and temperature by formation in the Permian Basin (Figure 6) reveals that the waters in the Pennsylvanian and Devonian units are relatively fresh and warm compared to other produced waters in the basin and thus might be good targets for effective water treatment.

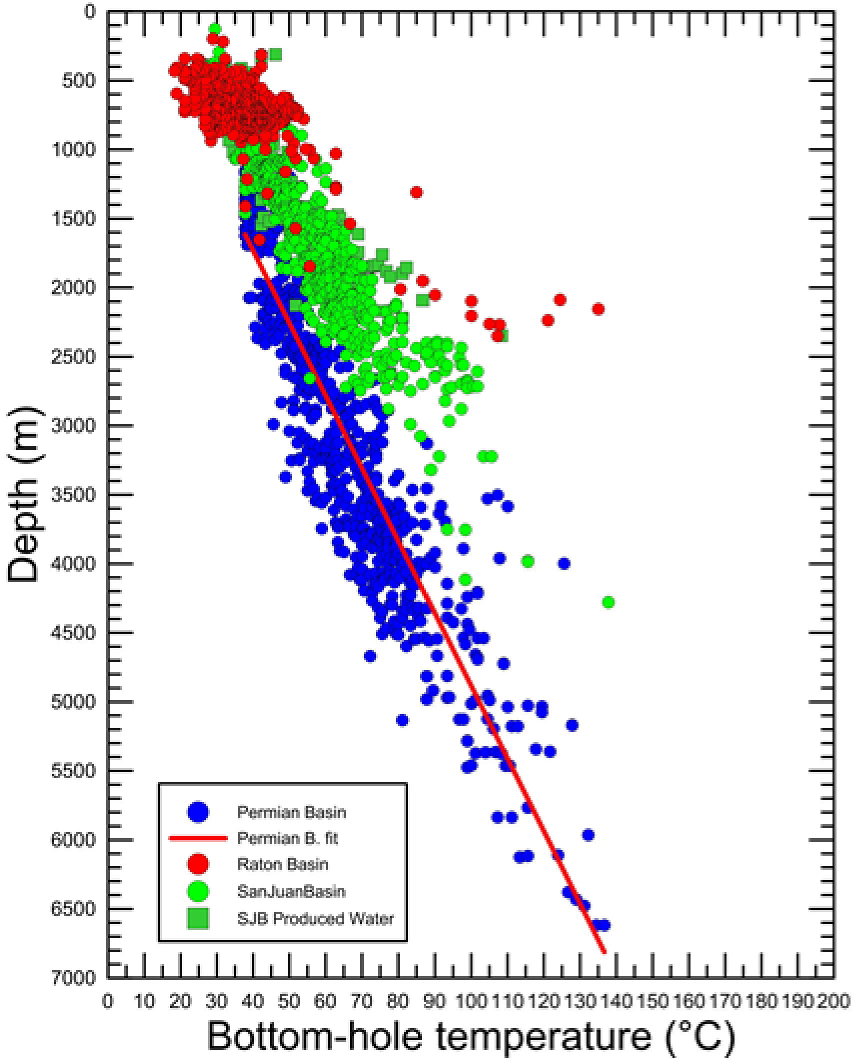

Figure 4. Comparison of the bottom-hole temperatures of the three oil-producing basins in New Mexico from Shari Kelley.

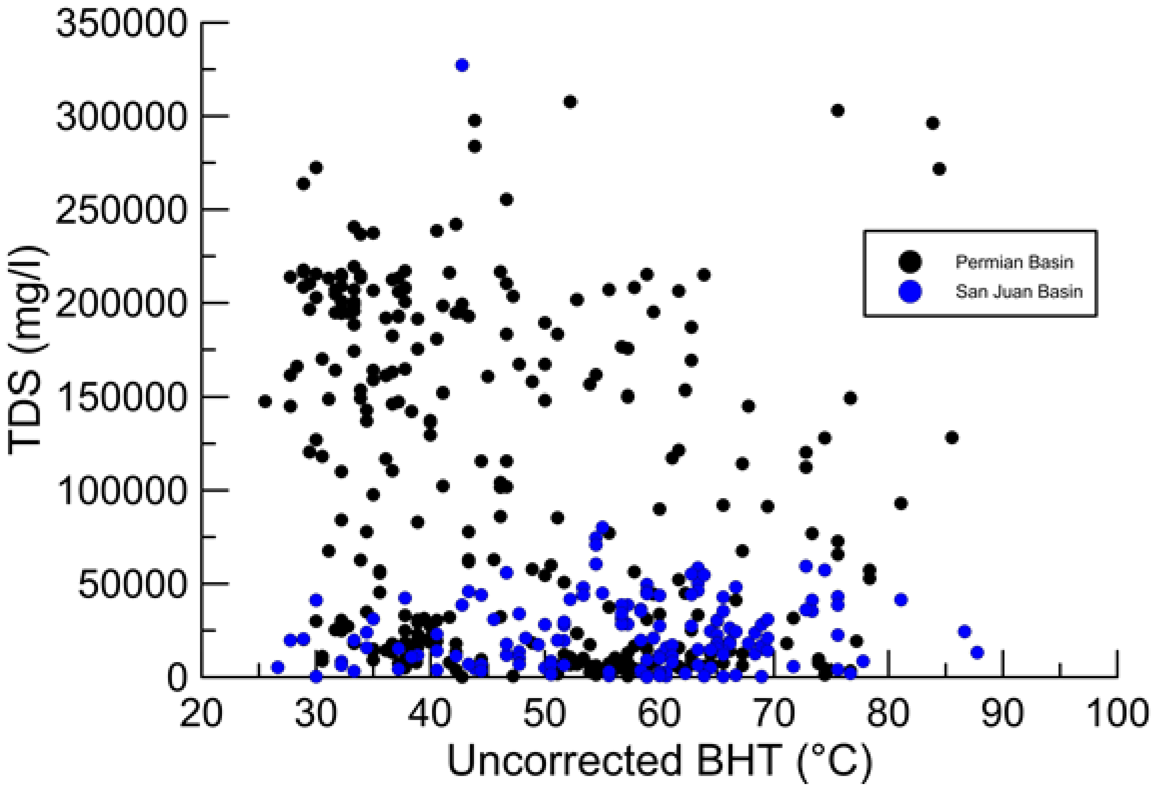

Figure 5. A plot of TDS and BHT for the Permian and San Juan basins. TDS data are from the USGS produced water web page and the BHT data are from NMBGMR files. The produced waters from both basins have a similar temperature range, but the waters from the San Juan Basin are generally less saline. Plot from Shari Kelley.

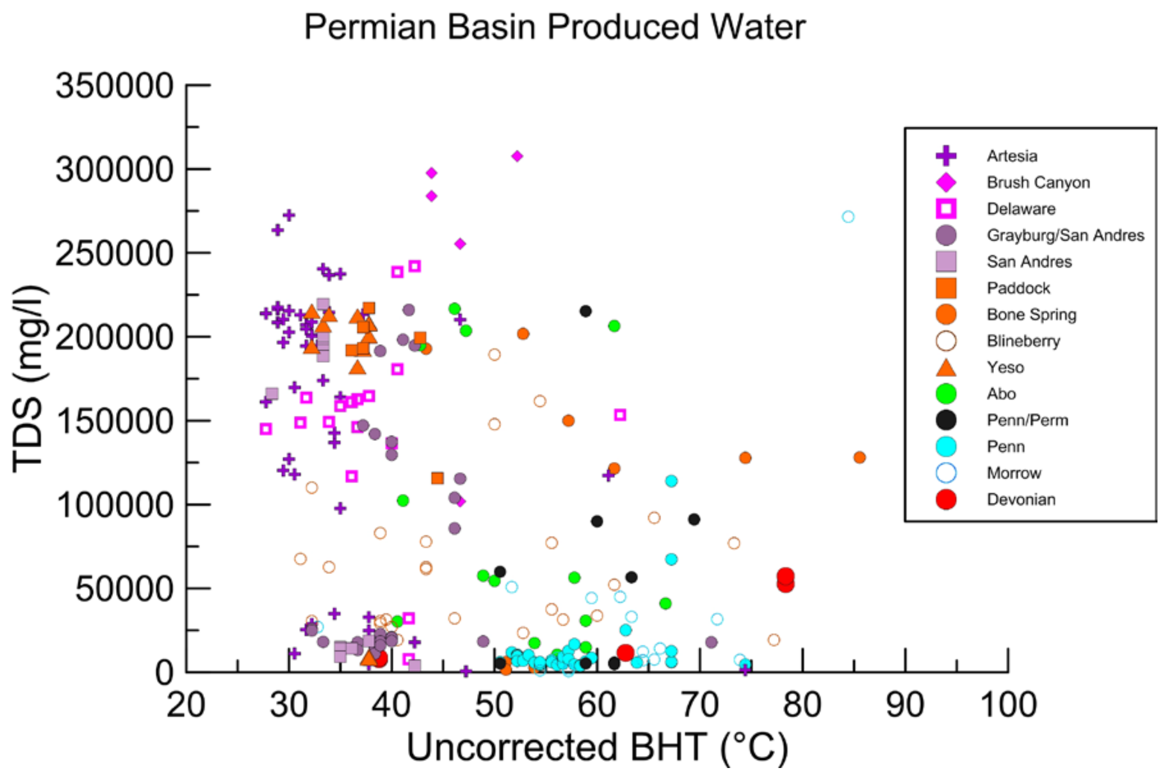

Figure 6. Plot of TDS and temperature for individual formations in the Permian Basin. The formations in the legend are listed in stratigraphic order, with younger units at the top and older units at the bottom. TDS data are from the USGS produced water web page and the BHT data are from NMBGMR files. The produced waters from the Pennsylvanian and Devonian sections in the Permian Basin are relatively fresh and warm. Plot from Shari Kelley.