Characterization of Produced Water in New Mexico: the NM WAIDS Database

Martha Cather, NM Petroleum Recovery Research Center, NM Tech

Martha Cather has worked on many research projects at the Petroleum Recovery Research Center of NMIMT since 1987, and her research has included topics as varied as reservoir characterization, fluid/rock interactions, and petrographic image analysis for reservoir modeling. Much of her work in recent years has focused on data acquisition and data access, technology transfer, and project management with national organizations such as PTTC and RPSEA. She has collaborated with various New Mexico state agencies and industry partners to make a variety of data available online including oil and gas production, price data, NM state lease data, water quality information, and many other smaller projects. The websites developed by Martha Cather and the outreach group she leads at PRRC include Go-Tech, SLO data access, and NM WAIDS. Martha Cather holds B.S. and M.A. degrees in Geology from the University of Texas at Austin.

ABSTRACT

Our recently funded WRRI project undertakes an update of the NM WAIDS database and website. This website is a portion much larger Go-Tech website maintained by the PRRC. Major goals are to bring the database online, provide GIS user-friendly functionality and analysis tools, and identify and attempt to fill in data gaps in newly active plays in the San Juan and Permian basins. This presentation will provide background on volumes and quantities of produced water in New Mexico, along with an analysis of current problems and needs to address when updating the database.

- Water produced as a byproduct of oil and gas production represents a large and almost untapped potential water source in New Mexico. In 2013, industry reported production of over 800 million barrels of water, or over 100,000 acre-feet.
  - o Significant resource but very dispersed, largely uncharacterized, and extremely variable water source.
  - o >90% reinjected BUT a significant amount potentially available for other uses IF economic, regulatory, and technological hurdles can be overcome.
- Beginning about 2001, the Petroleum Recovery Research Center (PRRC), a division of the New Mexico Institute of Mining and Technology, began compiling data on quality and quantity of produced water into the NM WAIDS database. The project was eventually funded through a US DOE-funded project (solicitation DE-PS26-01BC15300, Identification and Demonstration of Preferred Upstream Management Practices) and was completed in 2005. Work funded under this contract produced the NM WAIDS website which:
  - o Comprised NM produced water quantity/quality data: encompassed information on water quality/quantity in various producing regions of the state with a variety of sources including existing databases and paper documents supplied by producers.
  - o Purposes = providing online access to information regarding volume, geographical location, and quality of produced water; crucial to support the design of water systems that might utilize produced water.
  - o Contained data on produced and\groundwater quality, produced water volumes
  - o Had a large section devoted to issues of scale and corrosion, including an online manual of corrosion and various online tools that could be useful to those concerned with such questions.

The original work was completed about nine years ago and was maintained as a static online resource until late 2013 when it was taken offline due to concerns about the security of the web pages and queries that accessed the database. In the ten years that have elapsed since the database was first put online, cyber security has become an increasingly important consideration and the old interface was becoming highly vulnerable.

- Current work on the website is funded in part by the WRRI and efforts funded include:
  - o Revision and recoding of website to meet modern web design and internet security standards.
  - o Analysis of existing data to identify and attempt to fill in data gaps in more recently active plays in the San Juan and Permian basins.
  - o Provide GIS user-friendly functionality and analysis tools to the public

Introduction

According to the NM Oil Conservation Division Rulebook, produced water is defined as "those waters produced in conjunction with the production of oil or gas and commonly collected at field storage, processing or disposal facilities including lease tanks, commingled tank batteries, burn pits, lease ACT units and community or lease salt water disposal systems and that may be collected at gas processing plants, pipeline drips and other processing or transportation facilities.[1]"

Water is the largest volume waste stream associated with oil and gas production.[2] Historically, produced water has been typically seen as an unavoidable liability to be disposed of in the most cost efficient and environmentally sound manner possible.[3] Water costs money to bring to the surface, money to dispose of, and money to treat for almost any kind of alternative reuse. In 2013, industry reported production of over 800 million barrels of water[4] - over 33 billion gallons or 100,000+ acre-feet (Figure 1 and Table 1).

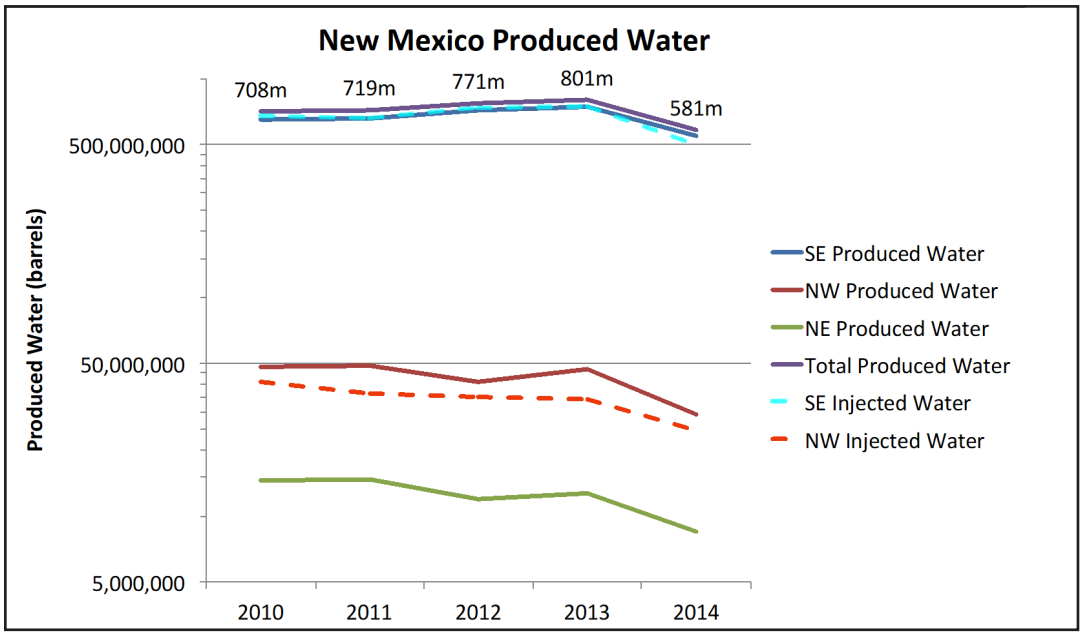

Figure 1. Produced and Injected water volumes for New Mexico, 2010-2014. Data is from NM Oil Conservation Division statistics. Over 90% of total is produced in the Permian Basin, with the remainder from the San Juan and Raton Basins.

Table 1. Detailed water production statistics for 2013. Data from NM OCD.

2013 Statistics	County	Water Production (bbls)	# of Active Wells	total acre-feet	Avg/well (bbls)	Avg/well (acre-feet)
Permian Basin	Chaves	17,096,543	2,548	2,204	6,710	0.86
	Lea	479,771,358	13,180	61,839	36,401	4.69
	Eddy	247,090,417	13,470	31,848	18,344	2.36
	Roosevelt	3,263,814	474	421	6,886	1
		747,222,132	29,672	96,312	25,183	
San Juan Basin	McKinley	4,023,765	190	519	21,178	2.73
	Rio Arriba	9,148,142	8,739	1,179	1,047	0.13
	San Juan	32,219,735	13,026	4,153	2,473	0.32
	Sandoval	1,728,537	367	223	4,710	1
		47,120,179	22,322	6,073	2,111	
"Other"	Colfax	12,713,823	837	1,639	15,190	1.96
	Harding	52,084	316	7	165	0.02
	Union	72,127	349	9	207	0.03
		12,838,034	1,502	1,655	8,547	

Currently, over 95% of produced water is reinjected, either back into an appropriate geological formation on site or trucked/pipelined to larger injection or saltwater disposal wells, and this disposal represents a cost of a few cents to several dollars per barrel. Advances in treatment technology, increasing severity of drought in the western U.S., and concerns over water use in many regions of the country have turned perception of produced water from a liability to a potential asset in many regions. It is clear that if even a small fraction of our state's produced water was available for reuse, it could have a significant impact on water resources in a drought-prone region. A significant amount of produced water could potentially be diverted to other uses if economic, regulatory, and technological hurdles can be overcome. One major step in overcoming these hurdles is simply having a better understanding of the resource.

Produced water is a very dispersed, largely uncharacterized, and an extremely variable water source. Much of it is of high salinity, high total dissolved solids, or contains organic compounds; yet some can be used for stock water without any treatment. Not only do we observe large variations in water quality and volume across different producing formations and regions, but also even in the same formation with time. Clearly, more knowledge of basic facts such as volumes, locations, geological formations, and water quality information is crucial. In 2001, the Petroleum Recovery Research Center (PRRC), a division of the New Mexico Institute of Mining and Technology, began compiling data on quality and quantity of produced water into the NM WAIDS database. The project was funded through the US DOE's solicitation DE-PS26-01BC15300, Identification and Demonstration of Preferred Upstream Management Practices (PUMP). The project involved several different components, and part of the project entailed compiling a produced water quality database and GIS system that were made available online via the PRRC's Go-Tech website.

Distribution of Produced Water in New Mexico

A clearer understanding of produced water in New Mexico can be obtained by creating some fairly basic maps. Figure 2 shows cumulative water production aggregated by township (block of land typically about 36 mi^2) for 2013. Two things are immediately apparent. First, there is significantly more water produced in southeastern New Mexico in the Permian Basin. Second, water production is not evenly distributed within the basin but is concentrated in a few areas that correspond to some of the more active oil plays. There are many reasons that the Permian Basin has more water production. The region has significantly more overall oil production. The volume of water per barrel of oil produced is much higher (avg about 7.6 bbls water/bbl oil in southeast vs 2.6 in northwest for wells classed as oil wells). Much oil and gas in southeast New Mexico comes from conventional production, which generally has more water production associated with it. Unconventional tight sands tend to produce less water and parts of several producing plays in the San

Juan basin are classed as tight reservoirs. The exception to this general rule is coalbed methane, which does produce abundant water in the San Juan and Raton Basins – 54.3 million barrels in 2013. However, current economic conditions favor oil production so the southeast part of the state has been by far the most active region of the state; coalbed methane production has been declining since about 1999.

A detailed look at San Juan Basin (Figure 3) shows again that water production is at least an order of magnitude lower than that in the Permian basin, and also that production is fairly evenly distributed through the basin. The higher production near the Colorado border probably reflects water produced from the Fruitland Coal wells in that area. Figures 4 and 5 are more detailed views of water production in the Permian Basin. In Figure 4, water production is aggregated by township. In Figure 5, cumulative water production by well is overlaid onto pool boundaries for some of the more active plays in the region.

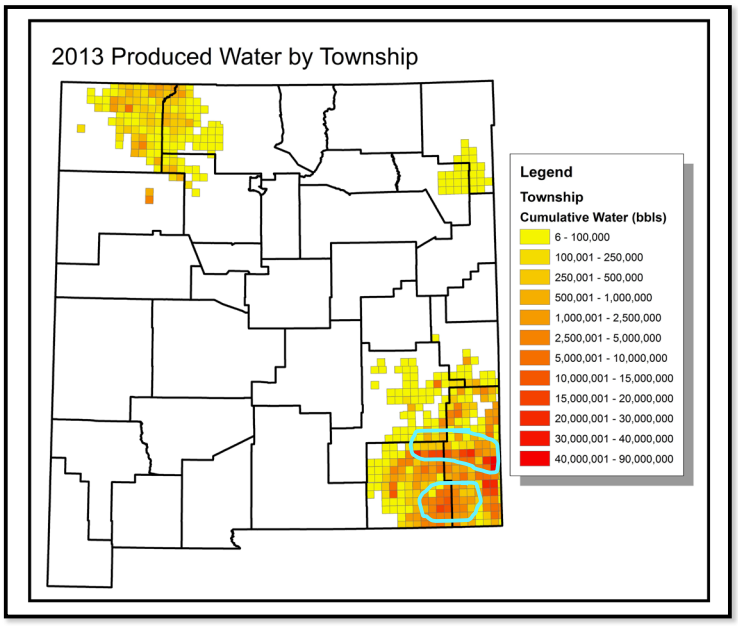

Figure 2. Produced water volumes in New Mexico for 2013, aggregated by township. The two areas of major water production in southeast New Mexico are the Delaware Basin and the Central Basin platform.

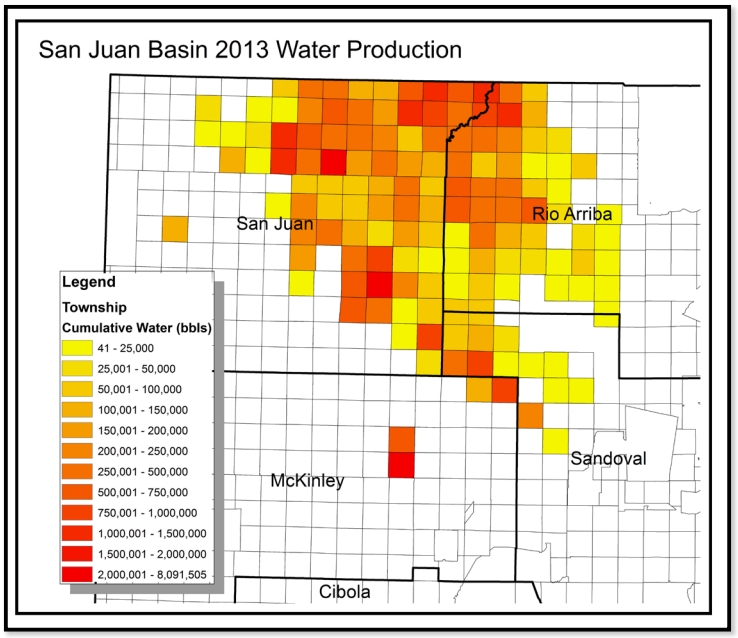

Figure 3. San Juan Basin produced water volumes for 2013. Much water is likely associated with Fruitland Coal wells, with a secondary region of high water production in Gallup-Dakota wells.

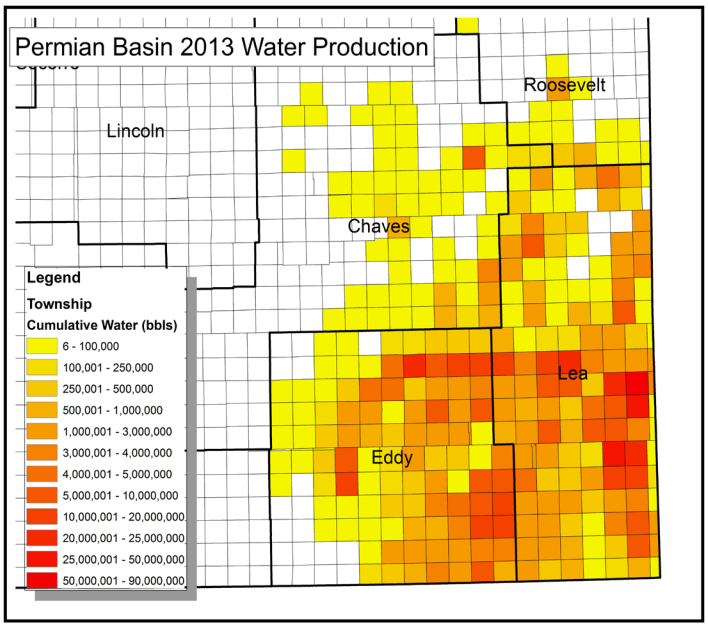

Figure 4. Permian Basin produced water volumes for 2013.

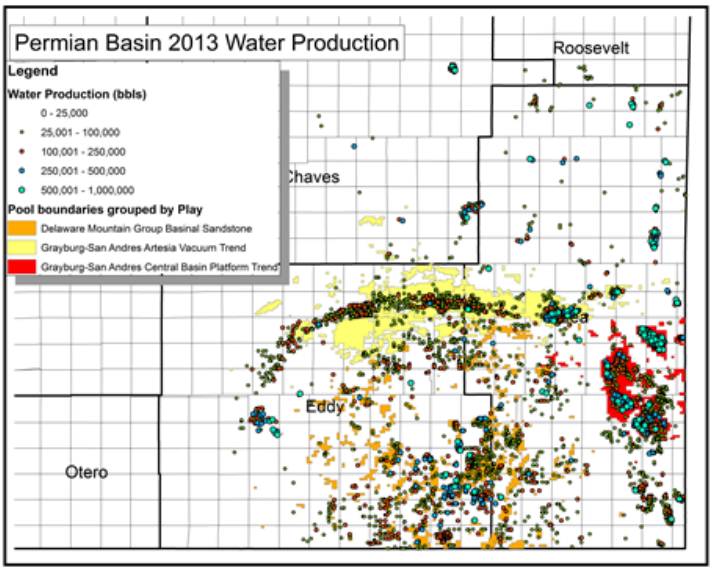

Figure 5. 2013 Permian Basin water production showing individual well production overlying pool boundaries for some of the active plays in this region. It can be seen that much of the water is contributed by wells in various San Andres-Grayburg and Delaware Mountain group pools. Particularly high volumes are seen in the Eumont-Hobbs area.

Water Injection

Current law within New Mexico states "Persons disposing of produced water shall use one of the following disposition methods:

A. disposition in a manner that does not constitute a hazard to fresh water, public health, safety or the environment; delivery to a permitted salt water disposal well or facility, secondary recovery or pressure maintenance injection facility, surface waste management facility or permanent pit permitted pursuant to 19.15.17 NMAC; or to a drill site for use in drilling fluid; or

B. use in accordance with a division-issued use permit or other division authorization.[1]"

Currently, most produced water is reinjected. The majority of injection wells used for disposal or enhanced recovery below any USDW are classified by the EPA as Class II wells, and they commonly are used for managing produced water in conventional oil and gas operations.[3]

Figure 6 shows 2013 injection volumes by well for New Mexico. They are not subdivided by type as to whether they are strictly disposal wells or are also used for pressure maintenance or EOR project, and in the available databases for the state well classification is not always accurate. However, a few wells have very large volumes of input; these are generally waste disposal wells. Permian Basin wells specified by the NM OCD as SWD (salt water disposal) are shown in Figure 7. Disposal wells could perhaps present the best opportunity to utilize water-gathering facilities that are already in place. There are many technological challenges to overcome before this might become a feasible water source; chief amongst these are wide variations in chemical constituents and water volumes.

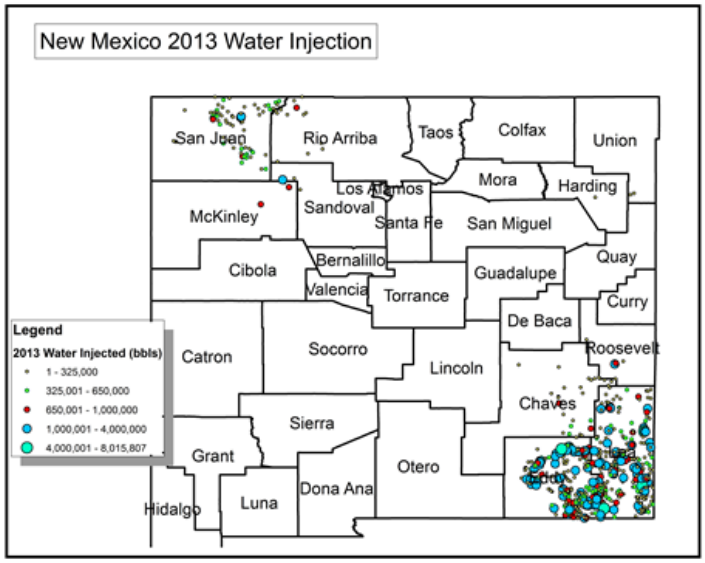

Figure 6. 2013 Water Injection wells in New Mexico.

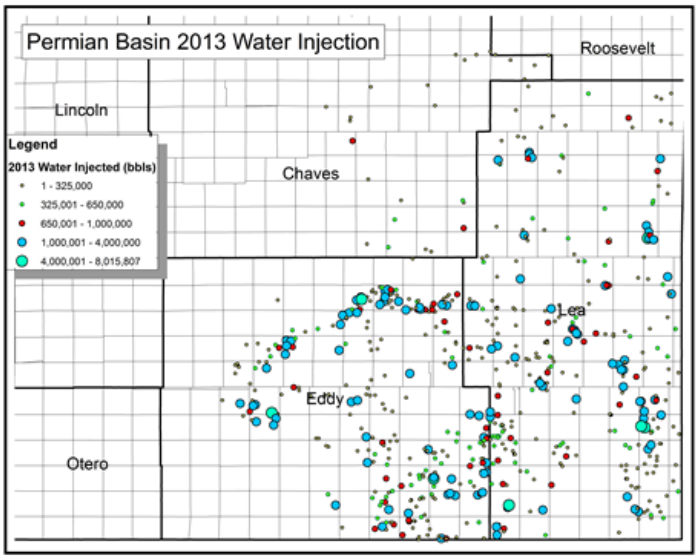

Figure 7. 2013 Permian Basin SWD wells showing locations and volumes.

Water Quality and the NM WAIDS Database and Website

The figures in the previous sections show only a very generalized view of produced water volumes that in theory could be available for some potential reuse. What cannot be observed from these figures is information about water quality–one of the most important considerations in any water treatment system. In 2001, the PRRC began assembling and maintaining a database on produced water quality in New Mexico. Much of

this work was funded under a U.S. DOE contract, and the process by which the NM WAIDS database was developed is described thoroughly in various reports submitted to the U.S. DOE[2,3]

For years, that database provided information for the NM WAIDS website which was hosted by the PRRC, and was also available via CD. The website had a number of purposes and features and included text and GIS-based access to both a produced water quality and groundwater quality database, interpretive maps, and a large section devoted to issues of corrosion and scale that had a variety of tools. The CD was published to make the data available without the need for an internet connection. Figures 8 and 9 are screen shots showing the old web entry page, and a cover of the CD. The CD came with ArcExplorer, a GIS program that allowed users to view the data via a map interface (Figure 10).

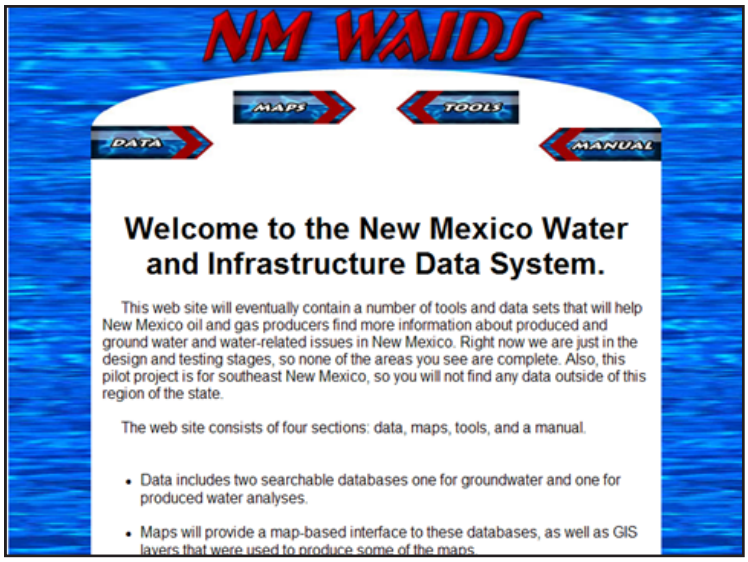

Figure 8. Screenshot of original NM WAIDS website.

Figure 9. NM WAIDs CD published by PRRC in support of the project.

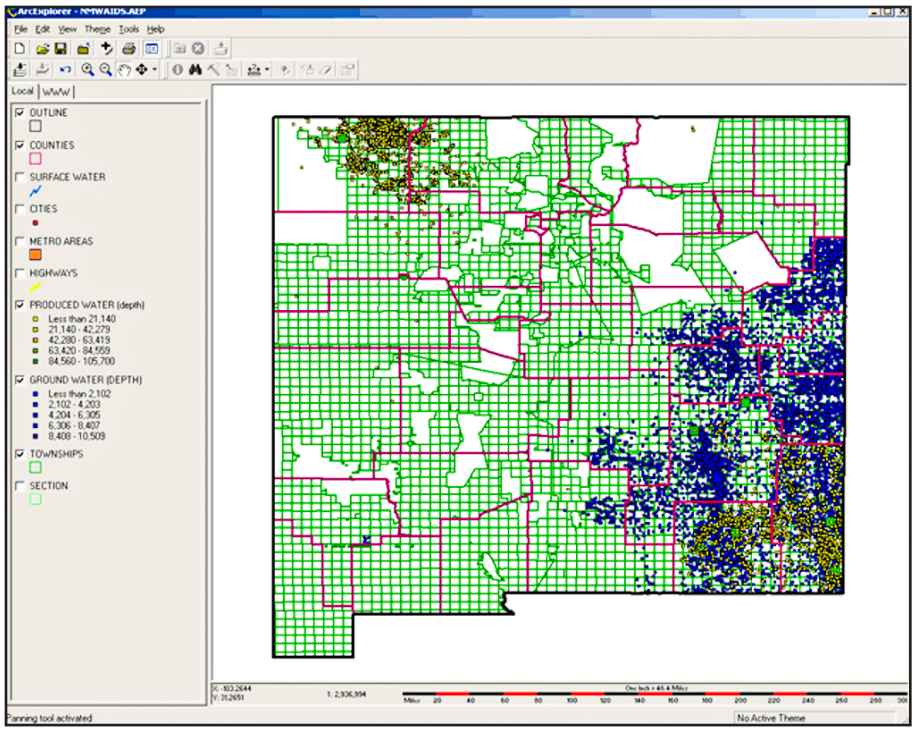

Figure 10. Opening image that was seen by users of the ArcExplorer project that was included in the CD. Data was also available in an online GIS mapping portal.

The NM WAIDS website, as a subsection of the entire Go-Tech website was taken offline in 2013 following identification of potential cyber security threats. Since that time significant time and effort has been expended to bring the entire Go-Tech website back online.

In addition to the water data, Go-Tech provides many types of data, including oil and gas production data, prices, historical well data, well activity, and an entire section devoted to accessing data from the NM State Land Office. When the rebuilding was executed, public and regulatory agency priorities dictated the order of attention, while finances constrained the speed. As a result, NM WAIDS was one of the lowest priority items on the list. However, as drought in the southwest has become an issue of major concern in recent years, so interest in the database was still high. Our WRRI funding enabled us to hire an additional graduate student whose main focus has been the recoding of the NM WAIDS portion of the Go-Tech website.

Progress on Website Conversion

The work entailed has been described briefly in progress reports submitted to WRRI and internal PRRC reports and presentations. Much of the work is technical and computer-terminology-intense, so will not be described in this paper. Work to date has focused on converting code from older development environments and programming languages (Microsoft Visual Studio and C#) to a newer development environment and language. Many scores of pages of code have been revised, rewritten, and properly documented to comply with strict security standards, and this work has been performed under the supervision of one of the leading providers of internet security solutions in the state. Currently the redesign is complete and revisions of pages and code are approximately 90% complete. We anticipate deployment of the entire Go-Tech website, including NM WAIDS in early 2015.

Future Goals

The NM WAIDS database and website are a valuable first step in obtaining data about produced water in New Mexico, but there is work that could greatly enhance the available data. High priority items include

identification of data gaps, identification of important data that may not be included in the current database, and then utilizing both public and private sources to begin to fill in those gaps.

The database is currently static and has not been modified since 2005. Figure 11 shows that there are several regions in the Permian Basin that have experience significant activity in the past four years alone. These include Bone Spring, Delaware Mountain Group, and Wolfcamp plays that have been reinvigorated by technology advances in hydraulic fracturing and horizontal drilling. There are other plays where activity could increase depending on economic incentive, such as the Mancos shale in the northwestern part of the state.

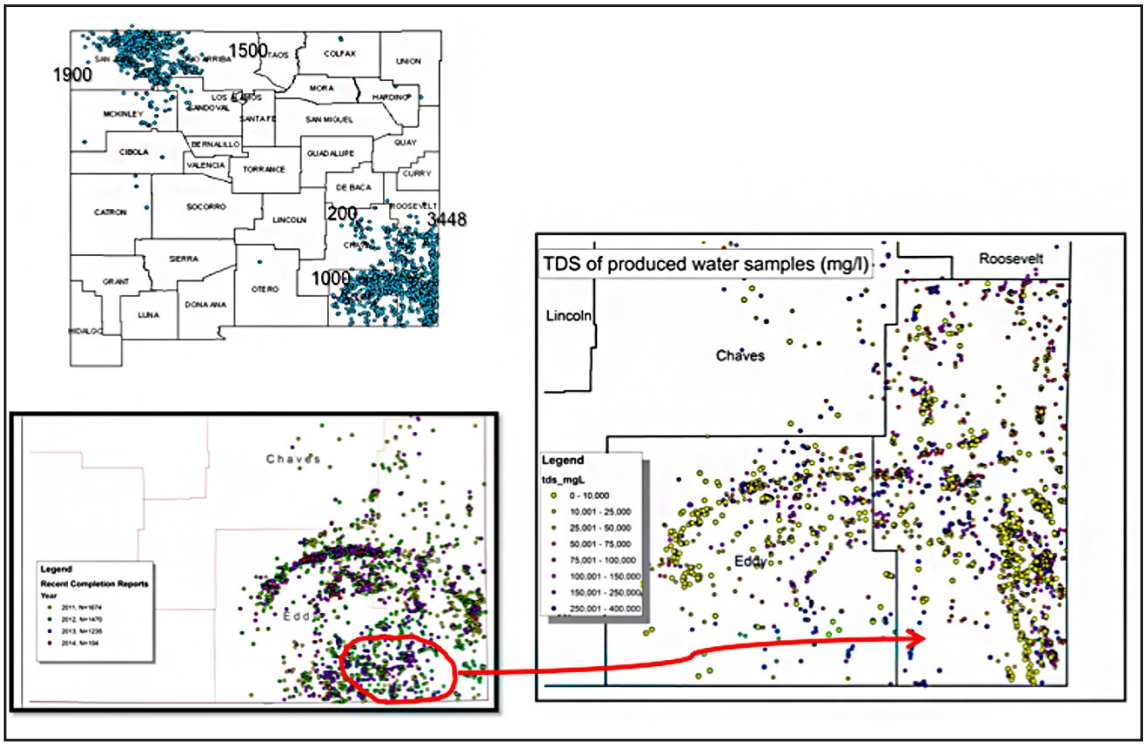

Figure 11. The NM WAIDS database currently has over 7000 data records. Upper left is number of records by county, while lower right is a detail of the southeast part of the state. The map on the lower left is well completions since 2011 in the southeast part of the state. Gaps in the data corresponding mostly to areas of current oil activity are easily seen.

The NM WAIDS database contains data from many vintages and sources, so data is of variable quality it is likely that important parameters not collected in the original data set. One data item that may be highly useful is water temperature data. Many of the techniques that have been developed for water treatment are energy intensive and any benefit that could be obtained from use of warmer water should be utilized. Other useful parameters that could be incorporated into the database could be information regarding water use in the oilfield, chiefly water used in drilling and hydraulic fracturing. Some of this data is available via the voluntary FracFocus reporting system, and other information is found in online images and forms, but the data is scattered and databases are not optimized for the purposes of understanding water budgets – how much of the water is reused, where is it obtained, and what is the final amount disposed?

Finally, once these data gaps have been identified, data sources must be found. Some is available in public sources and requires harvesting and manipulation to fit the needs of the current project, while others must be obtained from operators and other sources and often requires transcription from hard-copy files. As funding becomes available, each of these new goals will be addressed.

References

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