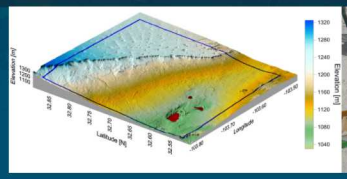
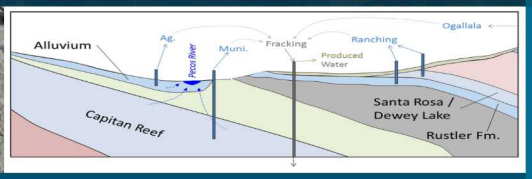
SAND2019-6771C

Assessing Risk to Water Resources from Oil and Gas Activities in the San Juan Basin





Animas and San Juan Watersheds Conference
June 19-20, 2019

PRESENTED BY

Thomas Lowry, Sandia National Laboratories

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The Project Team

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Patricia Johnson – Sandia National Laboratories

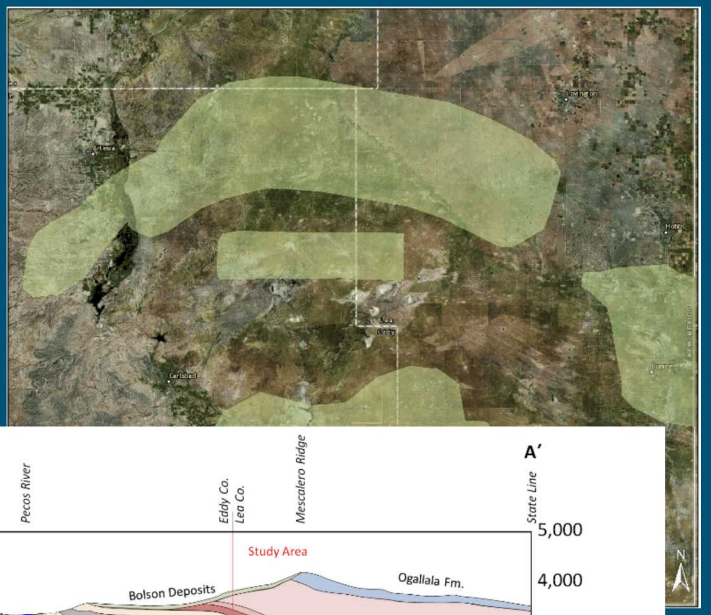
Dale Bowman – Sandia National Laboratories

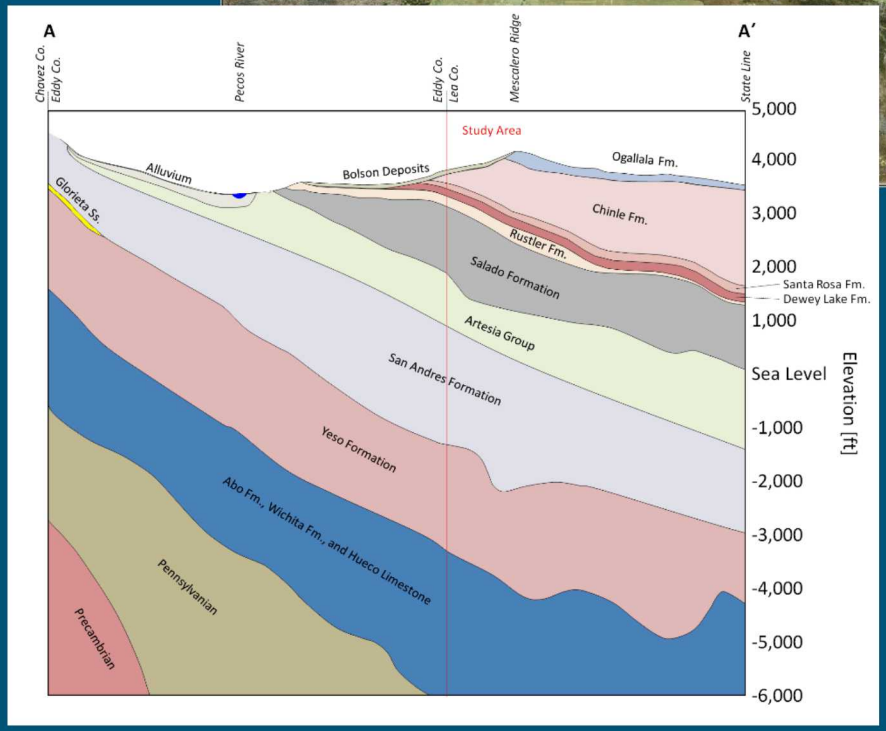
Whitney Thomas – BLM Farmington

Dave Herrell – BLM Santa Fe

Introduction

- Motivation
- Reasonable Foreseeable Development
- Water Resource Studies
  - Dewey Lake / Santa Rosa
  - Permian Basin
- San Juan Basin
  - Groundwork
  - Issues
  - Schedule
  - Shameless call for input





Motivation

With the increase in drilling activity and hydraulic fracturing in particular, there is need to insure the regions ability to meet increasing water demands in a manner that is sustainable while also avoiding unintended, localized impacts.

Approach

Use a multi-disciplinary approach to identify and rank potential cumulative impacts of future water demands. Of key importance is understanding the current state of the groundwater system (quality and quantity).

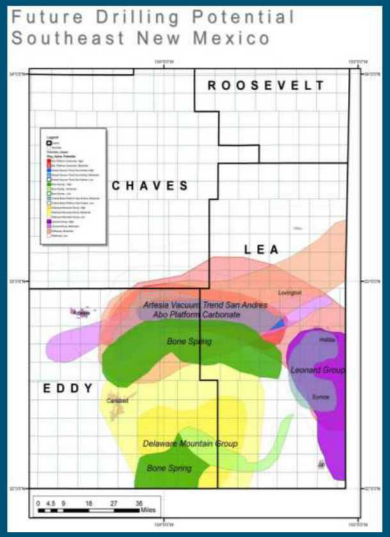
1. Data collection
2. Field verification
3. Field testing and monitoring
4. Modeling??

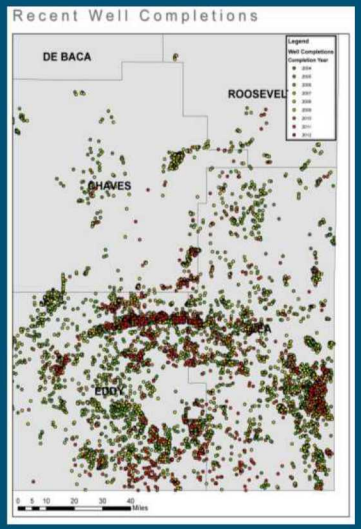
Reasonable Foreseeable Development (RFD)

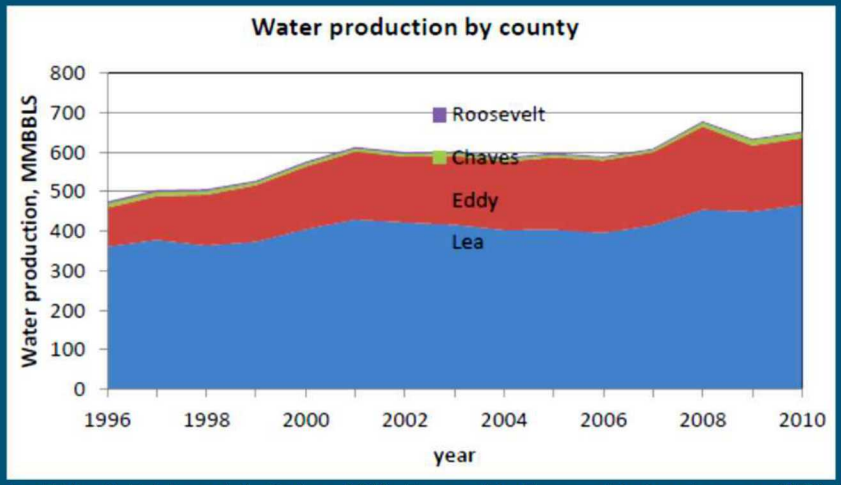
Study by Engler et al. (2012, 2013, 2014) to estimate the development of hydrocarbon production in southeast NM (Chaves, Eddy, Lea, and Roosevelt counties) over the next 20 years

Identified the major oil (16) and gas (10) plays and categorized them into potential areas of 'low', 'moderate', 'high', or 'very high'

Oil production ~800 wells / yr, gas production decreasing, water demand increasing (7.3 AF/well ave.)

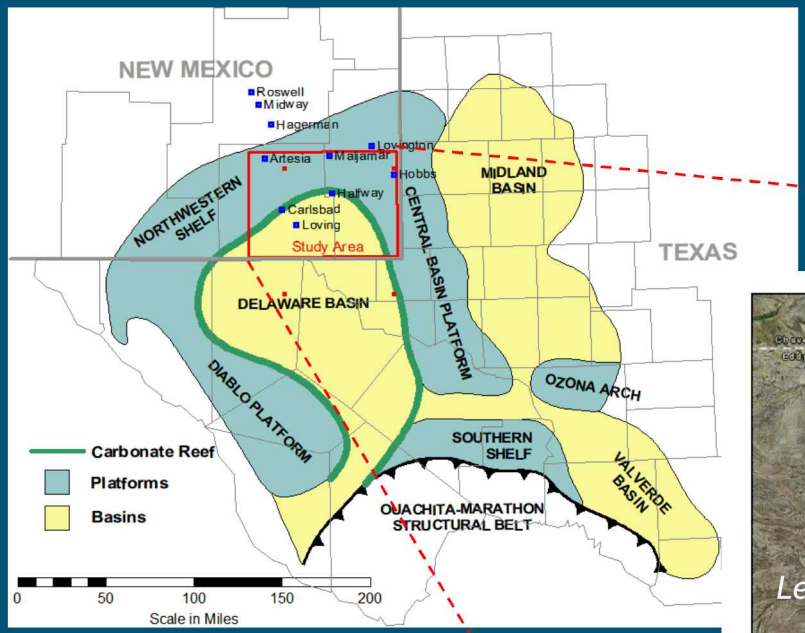


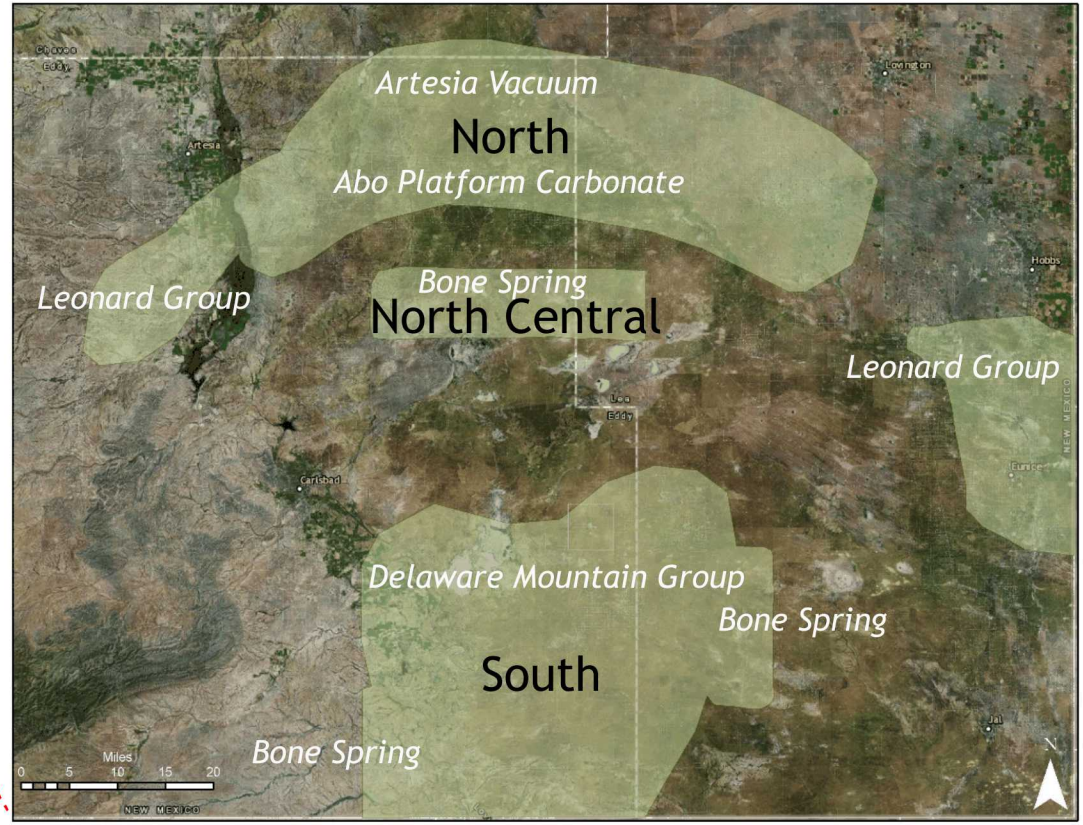




Engler T.W., R. Balch, and M. Cather, 2012, *Reasonable Foreseeable Development (RFD) Scenario for the B.L.M New Mexico Pecos District*, Final Report submitted to Jim Stovall, Project Manager Carlsbad Field Office, 55p

PA's and Study Area





Data Collection, Verification, Testing

Inventory of the water users and water sources: Areas of high and very high potential

Identify past studies and/or tests that may pertain to conditions at each site.

Verify the data

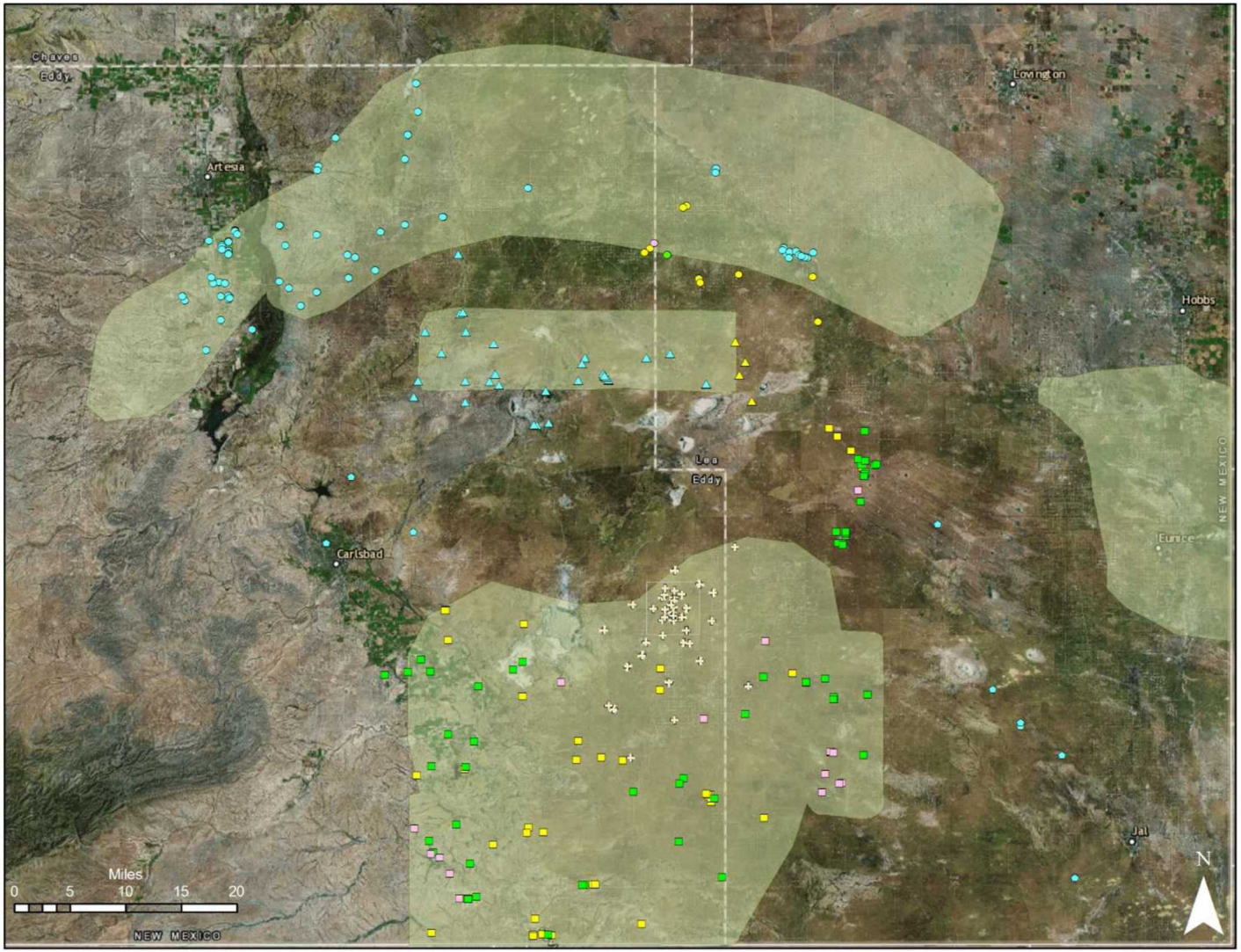
- Contact and work with each water user to access their well(s)

Field Testing and Sampling

- Measured and Verified: GPS coordinates, surface elevation, well diameter, distance to top of casing depth to water, total depth
- Sampled: Cations/anions, pH, conductivity, trace metals

Established current baseline from which future changes can be compared to and provide hydrogeologic parameters to the model.

Data Collection, Verification, Testing



Working with Private Well Owners

Figure 42 Wallen Fed. No. 9 East

Dear XXXXXXX, May 24, 2016

On behalf of the Bureau of Land Management (BLM), Sandia National Laboratories (Sandia) is conducting a study to assess the sustainability of water resources in Eddy, Lea, and Chavez Counties. The demand for water is increasing proportionally with the recent increase in hydraulic fracturing and the BLM would like to better understand the sustainability of these practices on federal land given the limitations on water in our arid region.

As part of this study Sandia will be collecting field data on water wells in your area that includes depth to water, overall depth, water quality, and the primary purpose of the well. This information will be compiled into a database and utilized to develop a model that can predict impacts on the regional water supply in correlation with changes in oil and gas production.

You are receiving this letter because one or more wells on your property have been identified as candidates for field data collection. We are asking landowners to participate in our study by granting Sandia access to their wells for the purposes of gathering the various measurements. In return for allowing access, participating landowners will receive a comprehensive report documenting the current status and state of each of their wells. To preserve your anonymity the information will be assigned a generic identification number that will be used in documents released to the public.

The value of this study is greatly dependent on the quality and quantity of information gathered in the field so we hope you will support us as we attempt to find a balance between development and preserving our water resources.

By signing this letter, the Landowner agrees to allow Sandia access to their well(s) for the purposes of measuring water level and total well depth and to collect water samples that will be analyzed for general geochemistry and metals profiling. A copy of the water quality report and the water level data will be supplied to the landowner.

Figure 38 Windmill No. 2 West

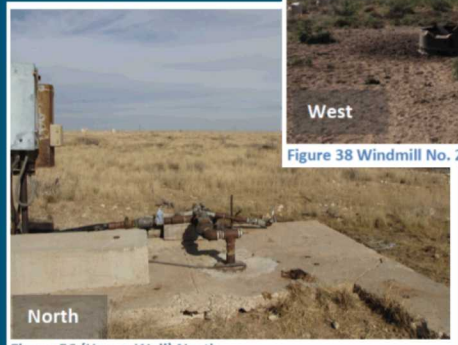


Figure 56 (House Well) North

Sandia National Laboratories

Results of Well Survey and Water Quality Analysis
BLM Dewey Lake Study
XXXXXXX Geographic Area Wells
Lea County, New Mexico

dual report is tiered from a former
ıcted by Sandia National Laboratories
was an effort to assist the Bureau of
nagement (BLM)
sing ground water
ı BLM, State and
ıds, targeting the
ːe and Santa Rosa
aring formations
model boundary
the agency. The
tent of that work
was to better define the
Dewey Lake and Santa Rosa
aquifers to aid the BLM with
on-going and
gas permitting
informing
environmental
to *BLM Lea*
Study for the
Santa Rosa Fo
Report - SANI
more informa
study).

Before field
conducted,
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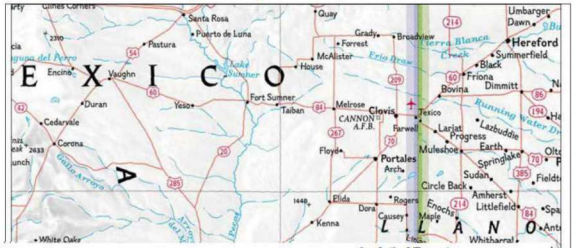
geographic area names were selected based on the landowner or grazing permittee's name. This specific report is confined to the



Analytical Report
Lab Order 1412226
Date Reported: 12/19/2014

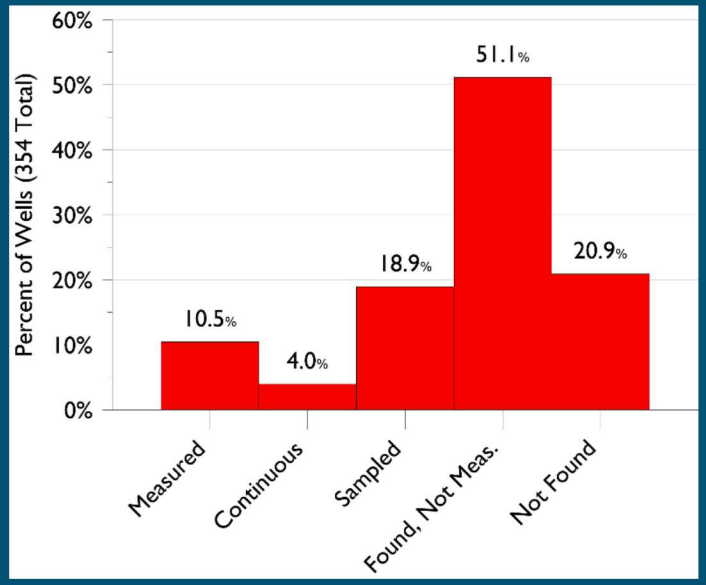
Hall Environmental Analysis Laboratory, Inc.

CLIENT: Sandia National Labs — **Client Sample ID:** CP-1330-20141202
Project: BLM-DL — **Collection Date:** 12/2/2014 9:50:00 AM
Lab ID: 1412226-001 — **Matrix:** AQUEOUS — **Received Date:** 12/4/2014 9:00:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 300.0: ANIONS						Analyst:	lgp
Fluoride	1.4	0.10		mg/L	1	12/4/2014 7:17:21 PM	R22950
Chloride	32	10		mg/L	20	12/4/2014 7:29:46 PM	R22950
Bromide	0.18	0.10		mg/L	1	12/4/2014 7:17:21 PM	R22950
Phosphorus, Orthophosphate (As P	ND	0.50	H	mg/L	1	12/4/2014 7:17:21 PM	R22950
Sulfate	190	10		mg/L	20	12/4/2014 7:29:46 PM	R22950
Nitrate+Nitrite as N	ND	1.0		mg/L	5	12/4/2014 10:11:08 PM	R22950
EPA METHOD 6010B: DISSOLVED METALS						Analyst:	ELS
Calcium	8.0	1.0		mg/L	1	12/9/2014 9:26:37 AM	R23012
Magnesium	4.9	1.0		mg/L	1	12/9/2014 9:26:37 AM	R23012
Potassium	1.6	1.0		mg/L	1	12/9/2014 9:26:37 AM	R23012
Sodium	210	5.0		mg/L	5	12/9/2014 9:28:34 AM	R23012
SM2510B: SPECIFIC CONDUCTANCE						Analyst:	JRR
Conductivity	1000	0.010		µmhos/cm	1	12/5/2014 9:49:06 AM	R22984
SM4500-H+B: PH						Analyst:	JRR
pH	8.43	1.68	H	pH units	1	12/5/2014 9:49:06 AM	R22984
SM2320B: ALKALINITY						Analyst:	JRR
Bicarbonate (As CaCO3)	240	20		mg/L CaCO3	1	12/5/2014 9:49:06 AM	R22984
Carbonate (As CaCO3)	4.9	2.0		mg/L CaCO3	1	12/5/2014 9:49:06 AM	R22984
Total Alkalinity (as CaCO3)	240	20		mg/L CaCO3	1	12/5/2014 9:49:06 AM	R22984
SM2540C MOD: TOTAL DISSOLVED SOLIDS						Analyst:	KS
Total Dissolved Solids	636	20.0	*	mg/L	1	12/7/2014 4:12:00 PM	16683

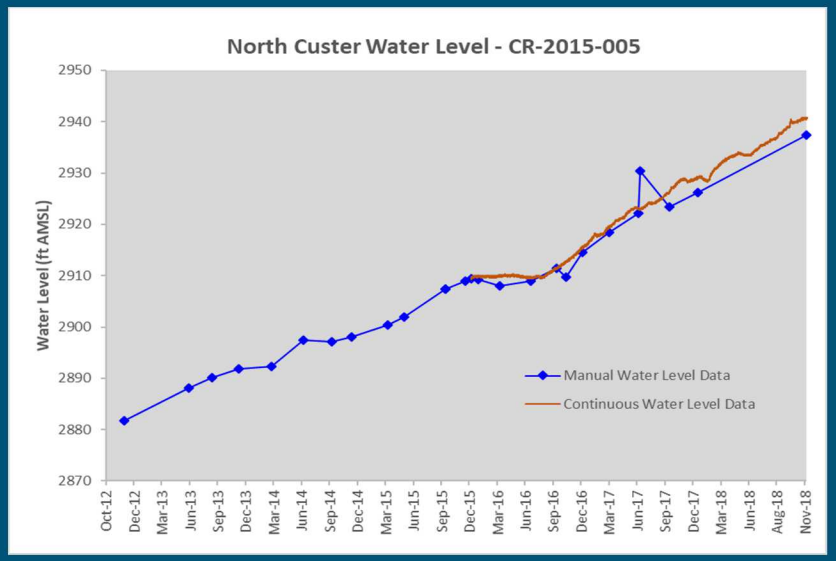
Data Collection, Verification, Testing

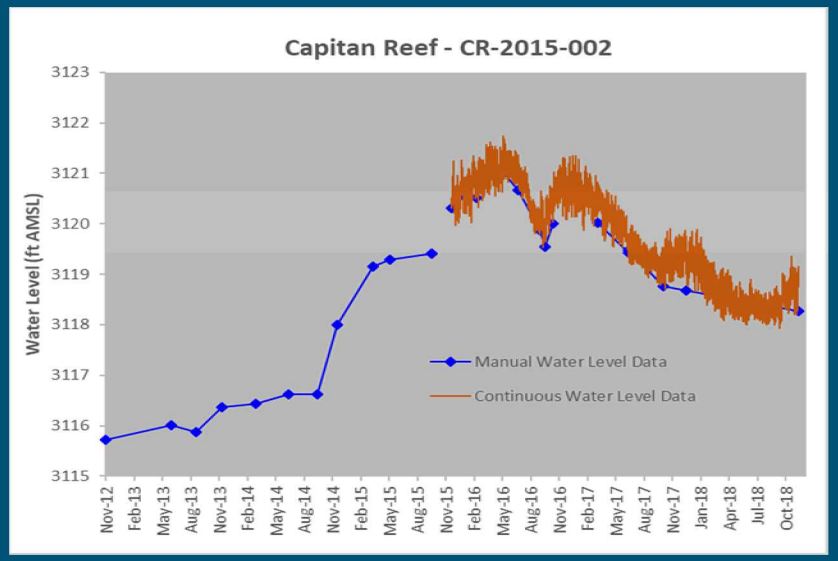
	North	N Central	South	Capitan	Total
Total	127	60	158	9	354
Measured	7	10	16	4	37
Continuous	3	2	5	4	14
Sampled	19	11	30	7	67
Found, Not Measurable	70	24	86	1	181
Not Found	28	17	29	0	74

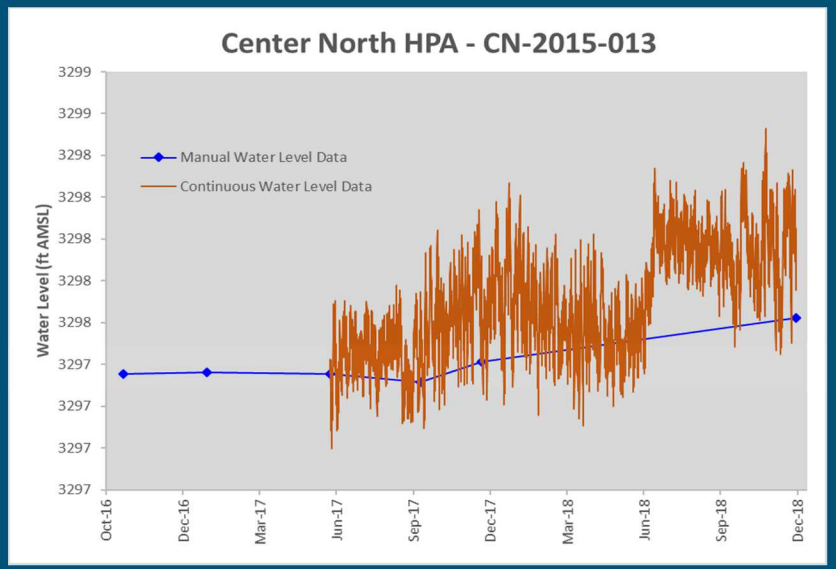


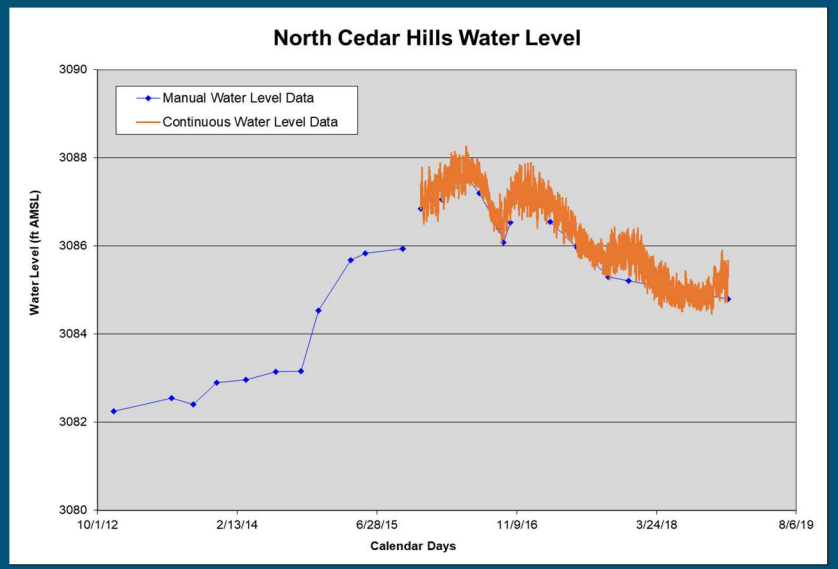
Most of the wells (72%) were either not found or not measurable

Continuous Measurements









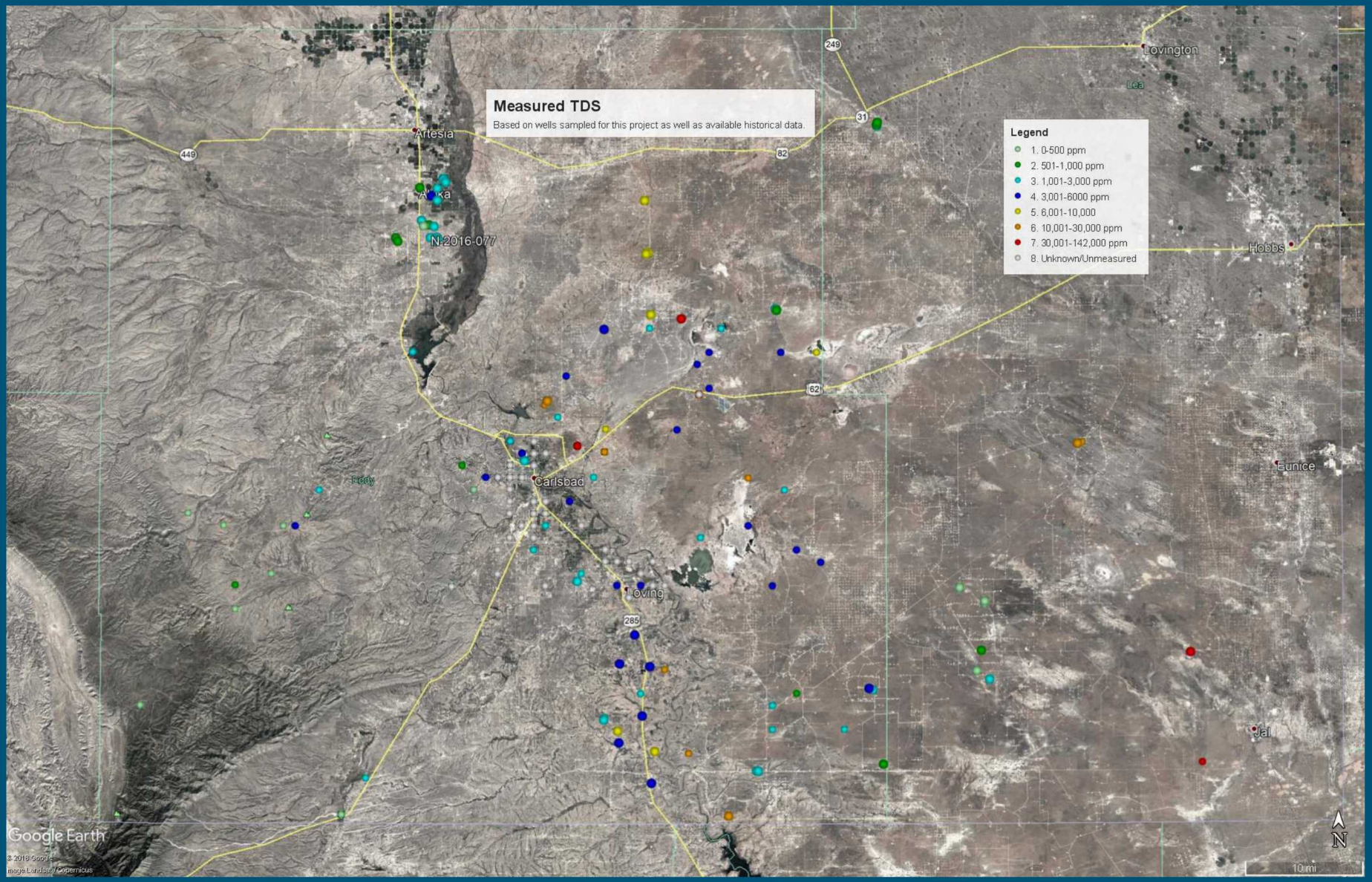
Water Chemistry

- Water samples on ~27% of wells identified/accessed
- Looked at cation/anion balance and other water quality indicators

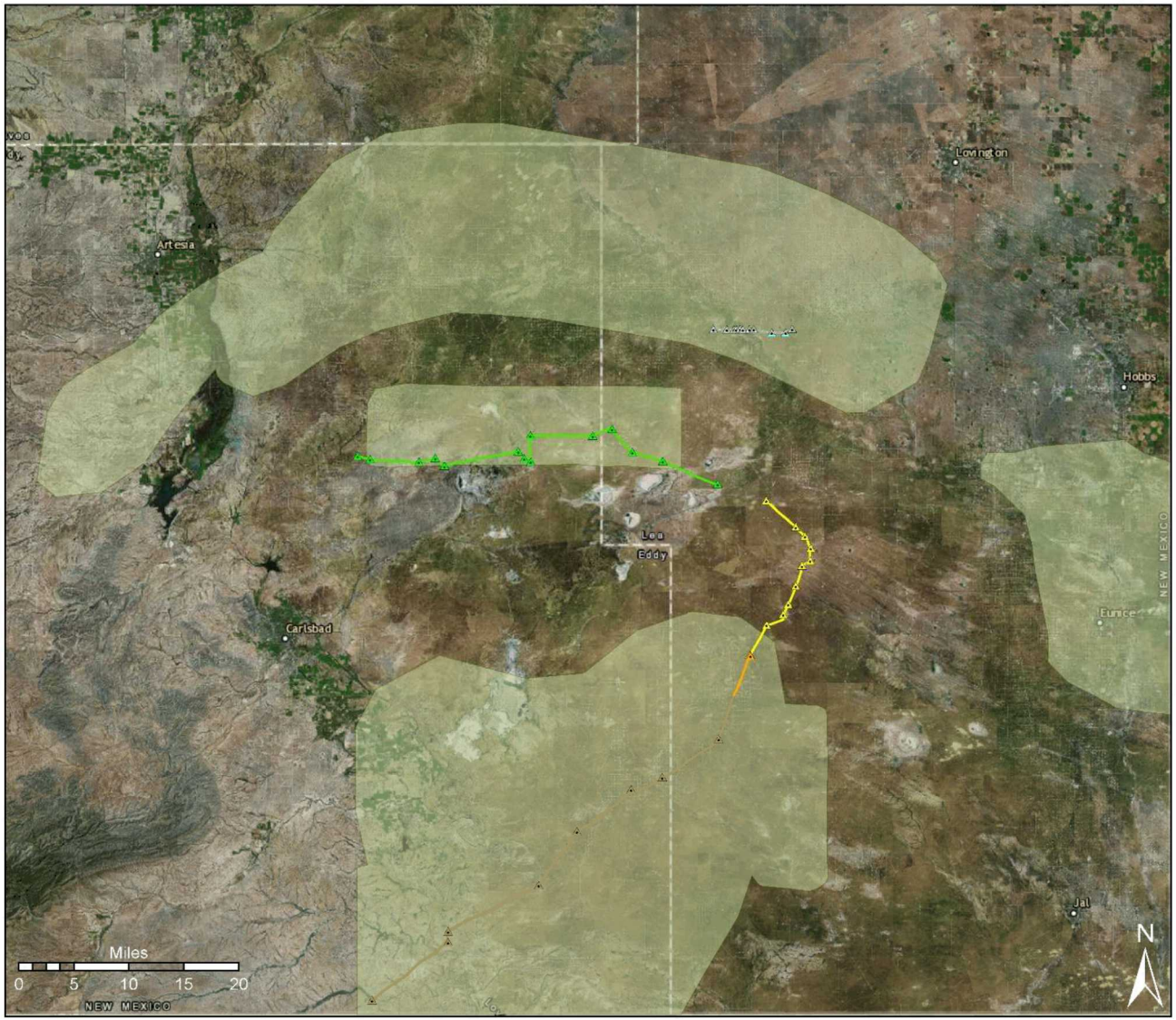
pH	Magnesium (Mg_2^+)	Sulfate (SO_4^{2-})
Specific Conductance	Sodium (Na^+)	Fluoride (F^-)
Total Dissolved Solids (TDS)	Potassium (K^+)	Nitrate (NO_3^-)
Calcium (Ca_2^+)	Bicarbonate (HCO_3^-)	Nitrite (NO_2^-)
Chloride ($^{Cl-}$)	Carbonate (CO_3^-)	

- Some wells also sampled for 17 trace metals

Water Chemistry



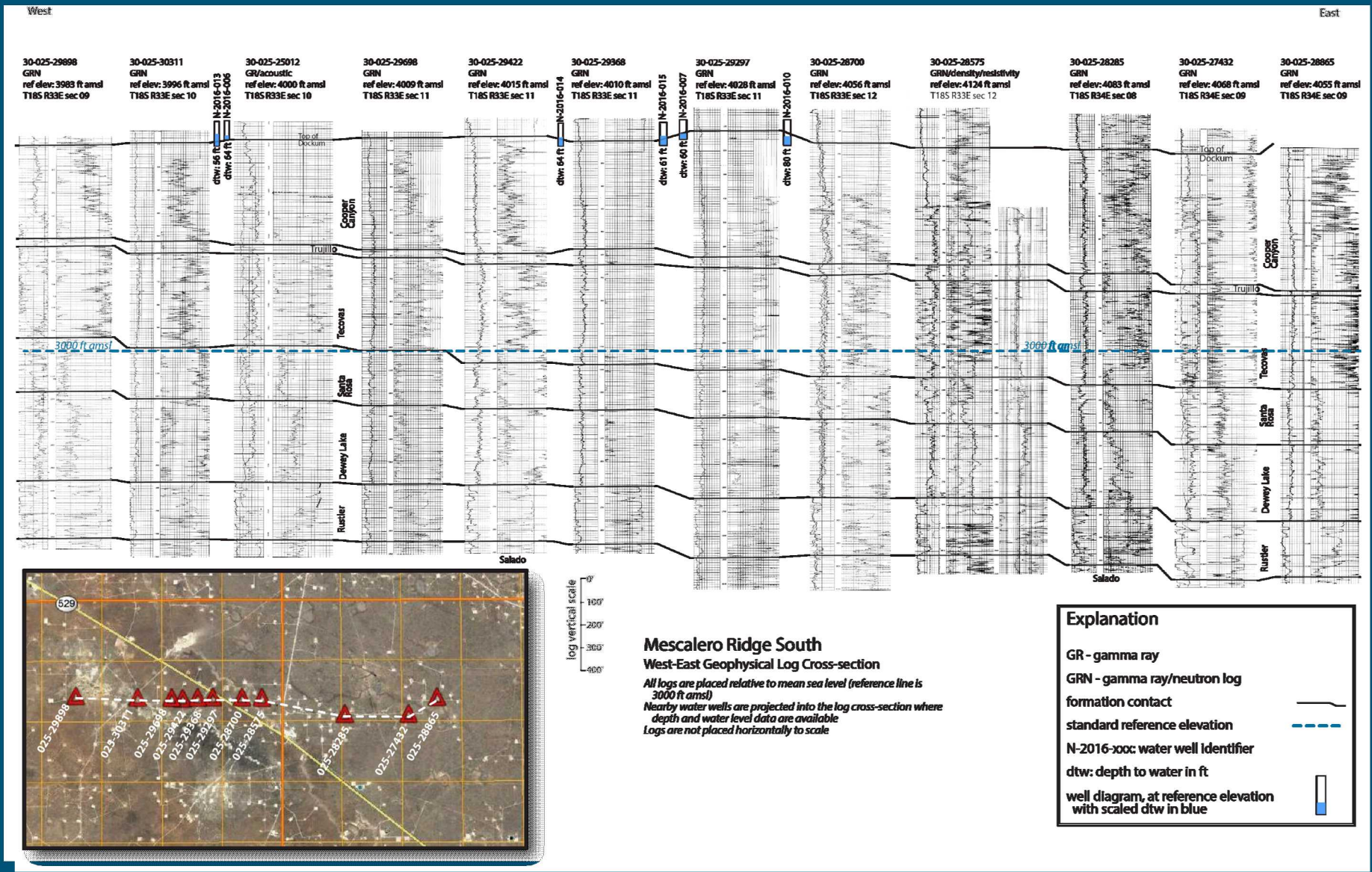
Cross-Sections



Cross-Section Locations

- South Area X-Section
- North-Central Area (N-S) X-Section
- Mescalero Ridge South X-Section
- North-Central Area (W-E) X-Section
- BLM High Potential Areas

North HPA - Mescalero Ridge W to E



Mescalero Ridge South

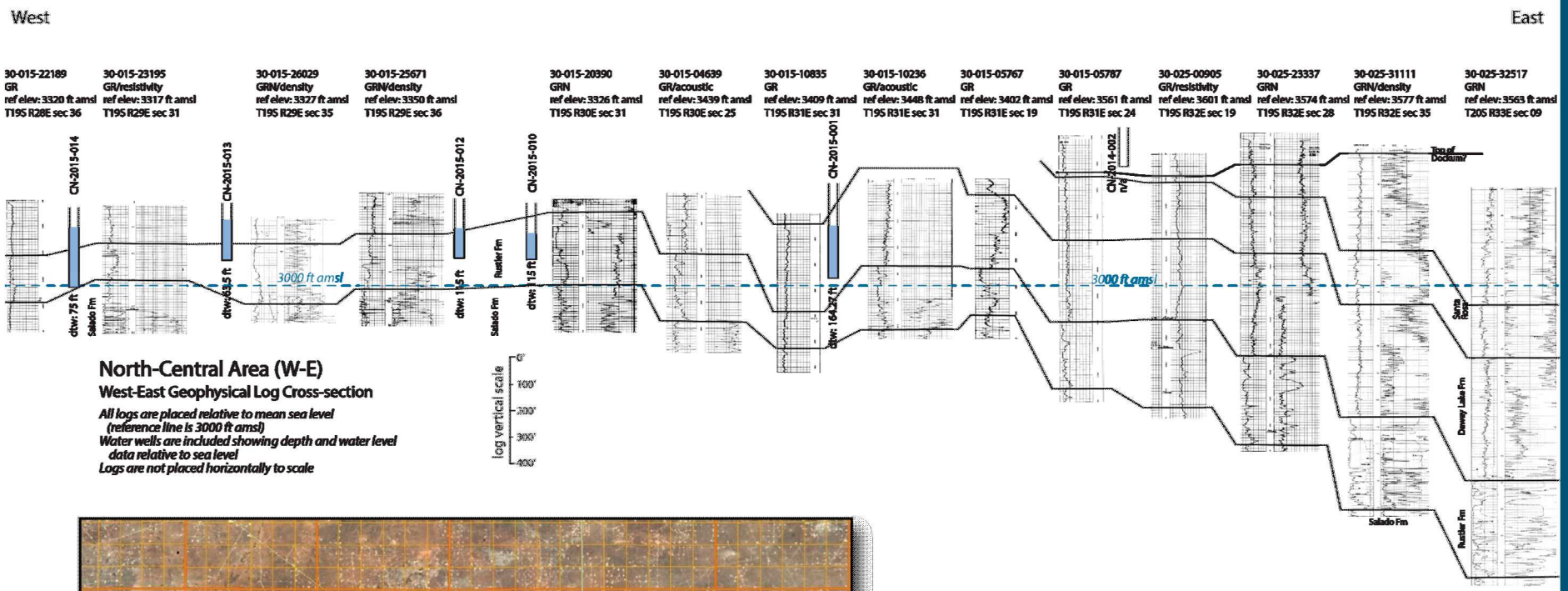
West-East Geophysical Log Cross-section

All logs are placed relative to mean sea level (reference line is 3000 ft amsl)
Nearby water wells are projected into the log cross-section where depth and water level data are available
Logs are not placed horizontally to scale

Explanation

- GR - gamma ray
- GRN - gamma ray/neutron log
- formation contact
- standard reference elevation
- N-2016-xxx: water well identifier
- dtw: depth to water in ft
- well diagram, at reference elevation with scaled dtw in blue

North-Central HPA - W to E



North-Central Area (W-E)

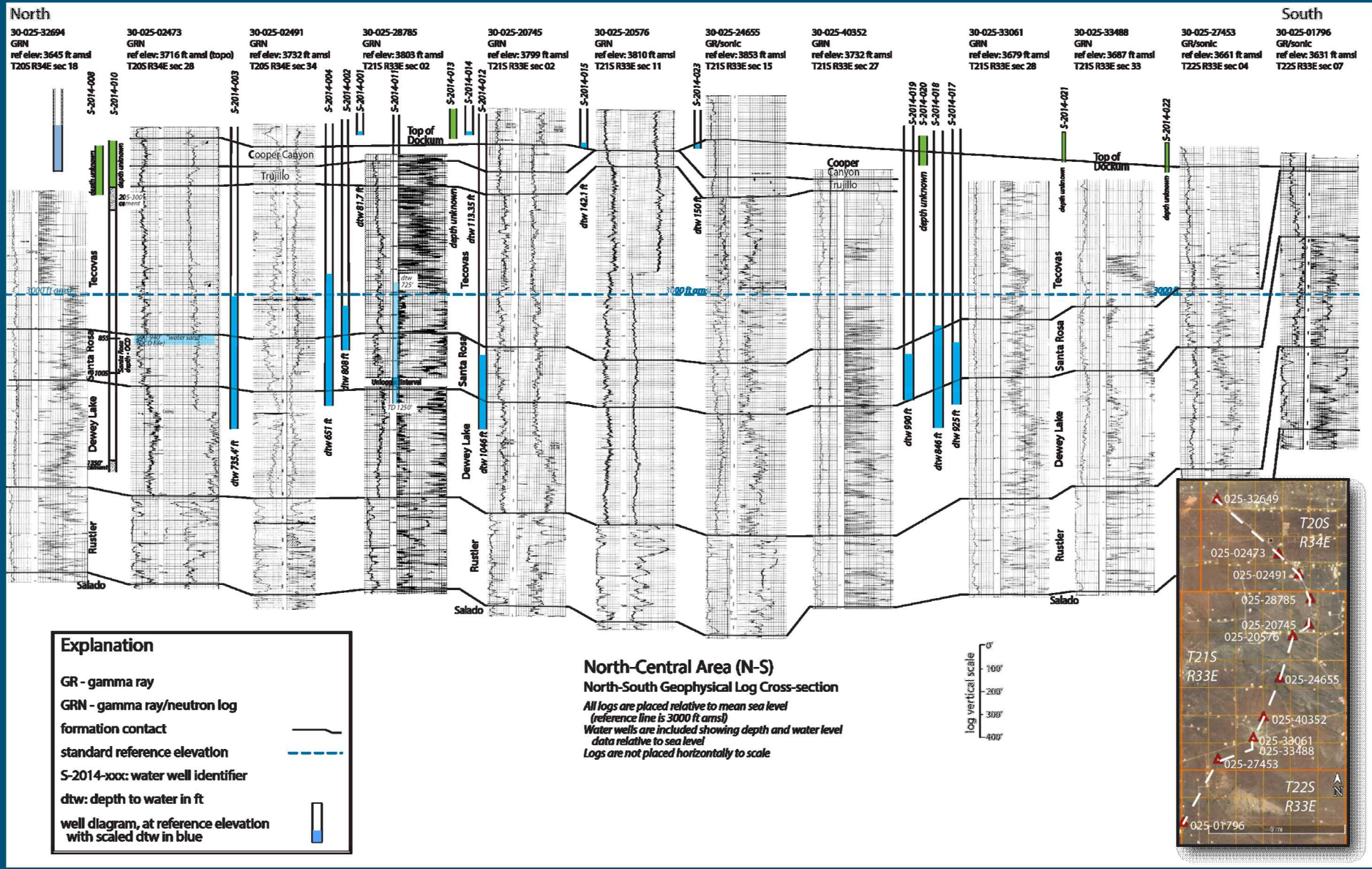
West-East Geophysical Log Cross-section

All logs are placed relative to mean sea level (reference line is 3000 ft amsl)
Water wells are included showing depth and water level data relative to sea level
Logs are not placed horizontally to scale

Explanation

- GR - gamma ray
- GRN - gamma ray/neutron log
- formation contact
- standard reference elevation
- CN-201x-xxx: water well identifier
- dtw: depth to water in ft
- well diagram, at reference elevation with scaled dtw in blue

North-Central HPA - N to S



Explanation

- GR - gamma ray
- GRN - gamma ray/neutron log
- formation contact
- standard reference elevation
- S-2014-xxx: water well identifier
- dtw: depth to water in ft
- well diagram, at reference elevation with scaled dtw in blue

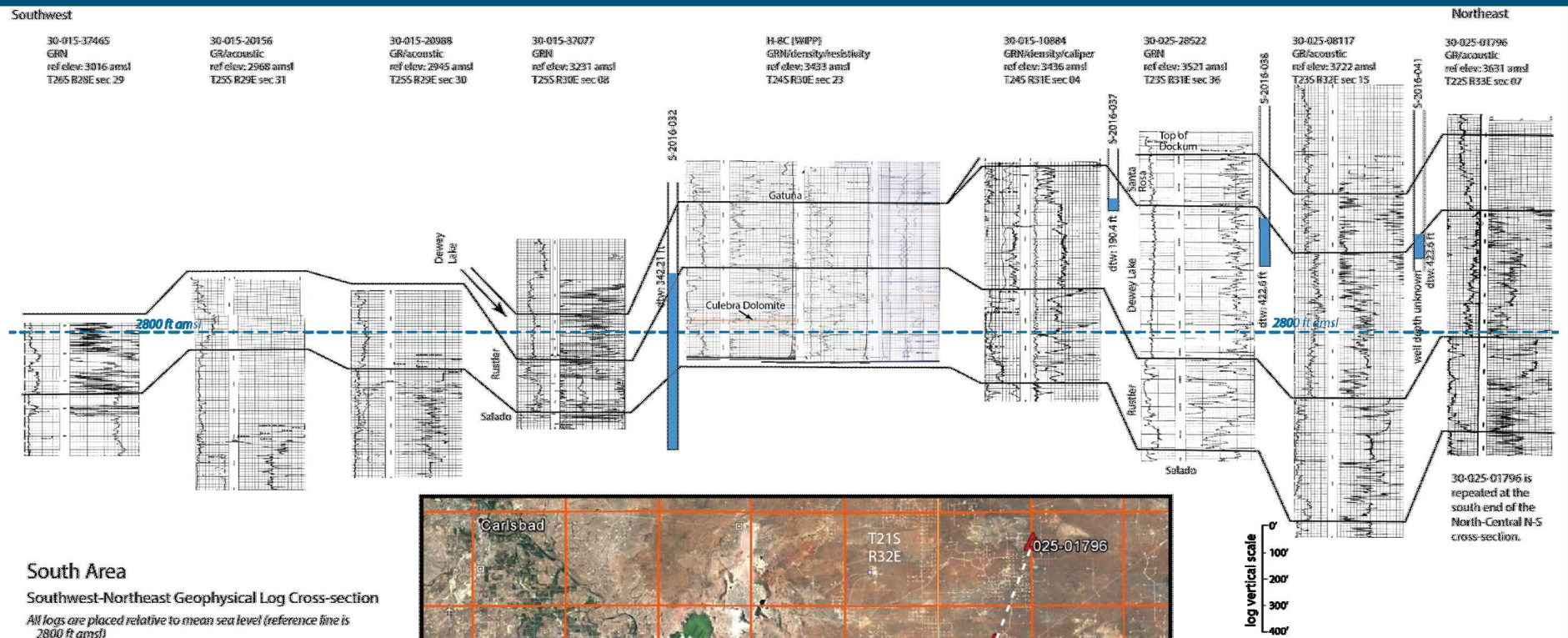
North-Central Area (N-S)

North-South Geophysical Log Cross-section

All logs are placed relative to mean sea level (reference line is 3000 ft amsl)
Water wells are included showing depth and water level data relative to sea level
Logs are not placed horizontally to scale

log vertical scale: 0', 100', 200', 300', 400'

South HPA – SW to NE



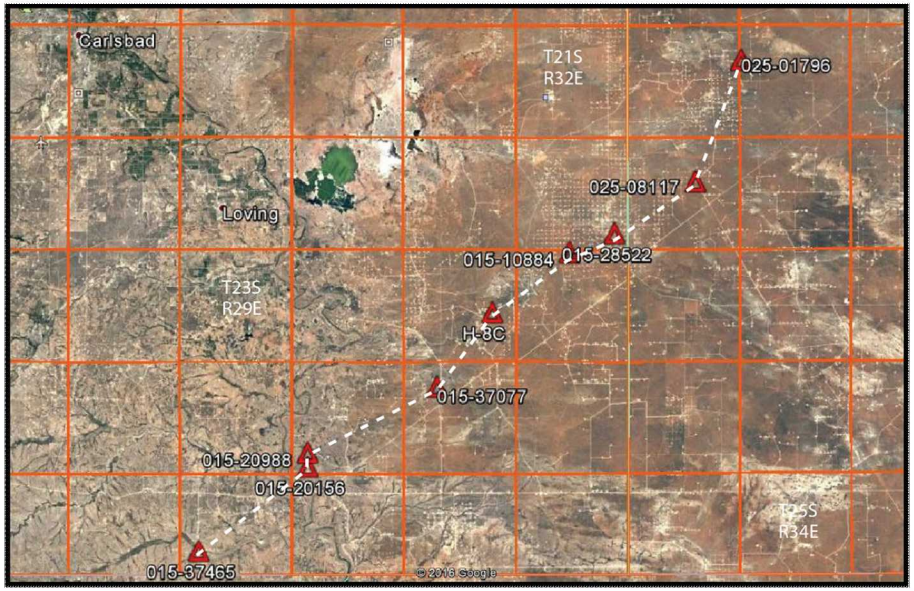
South Area

Southwest-Northeast Geophysical Log Cross-section

All logs are placed relative to mean sea level (reference line is 2800 ft amsl)

Water wells are not included due to lack of depth and water level data along trend

Logs are not placed horizontally to scale



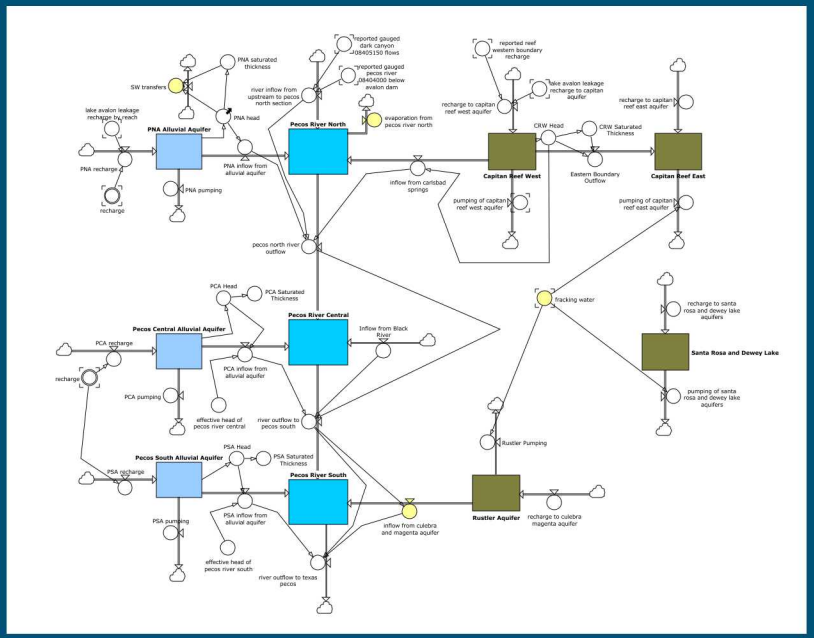
Explanation

- GR - gamma ray
- GRN - gamma ray/neutron log
- formation contact
- standard reference elevation
- S-2016-xxx: water well identifier
- dtw: depth to water in ft
- well diagram, at reference elevation with scaled dtw in blue

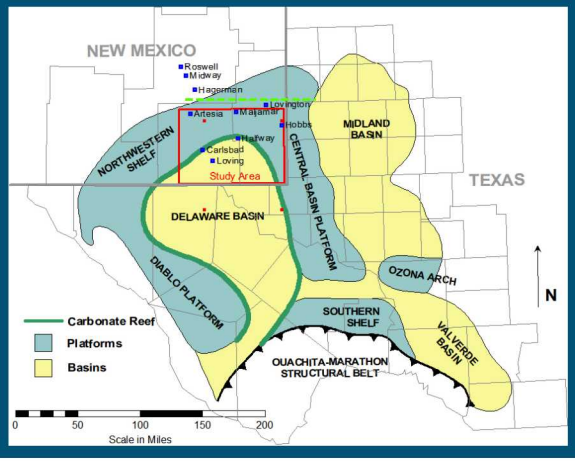
Modeling

System Dynamics Modeling – Develop a system dynamics (SD) simulation tool to simulate water availability over a range of different future scenarios as identified in the RFD.

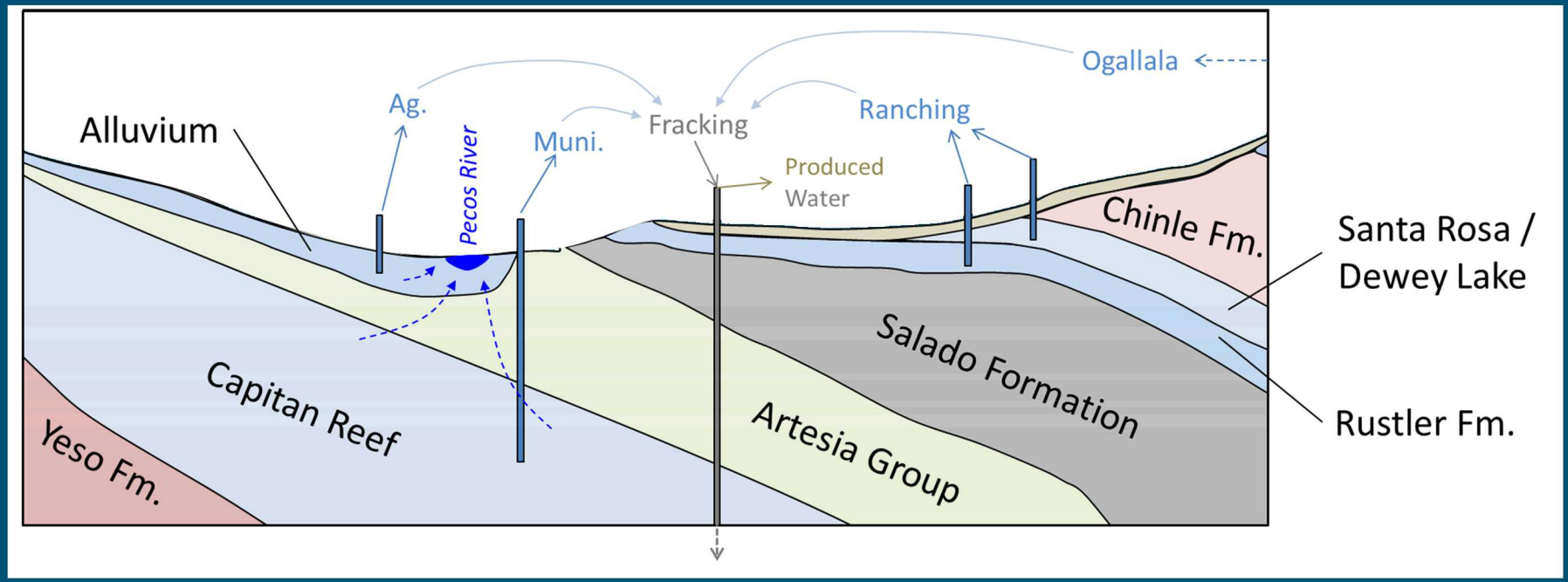
- Table-top player
- Simulate the increase in drilling activity and water demand relative to each formation and water source to identify the areas/users/formations that are most vulnerable and to estimate the risk to water quantity and quality.
- Provide decision makers with a tool to assess localized, cumulative impacts.



Conceptual Model

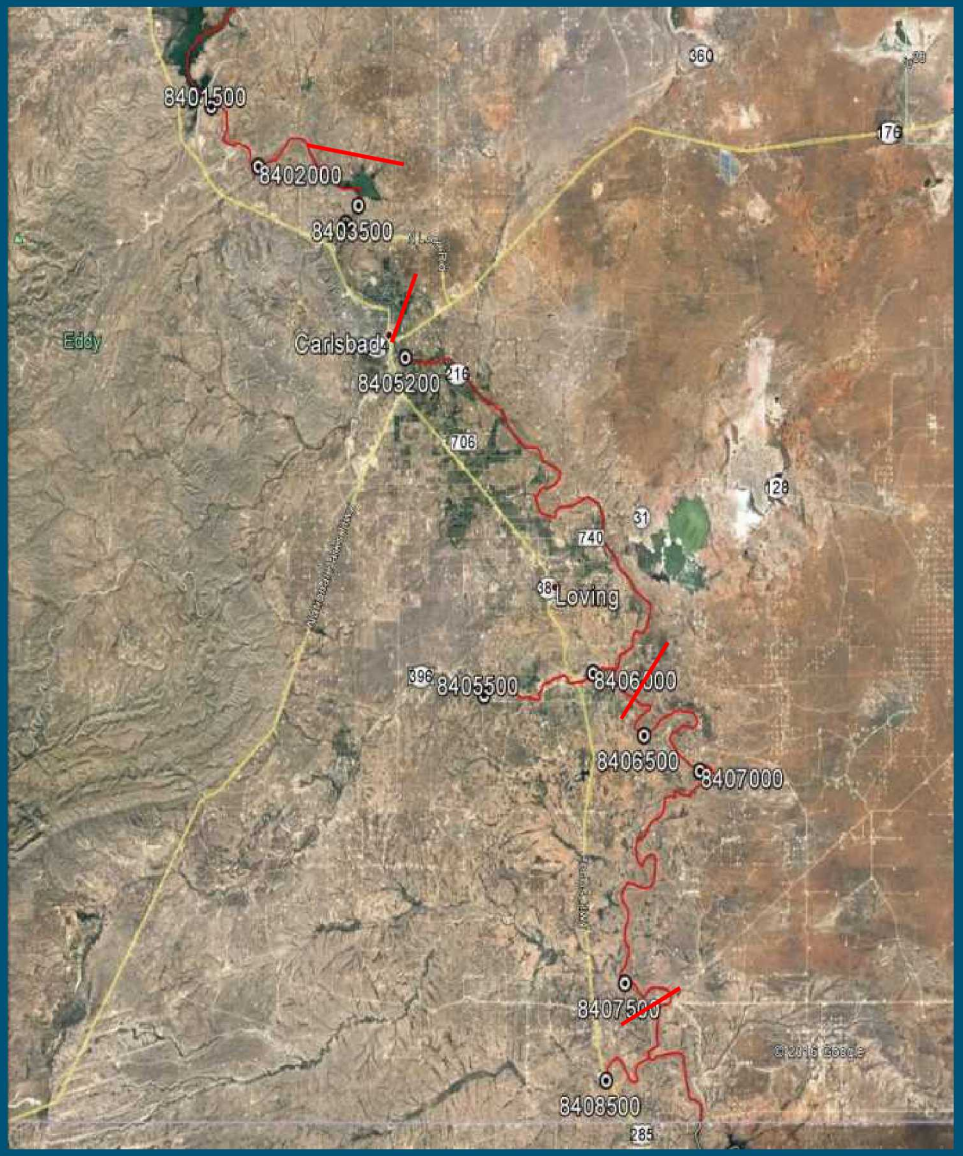


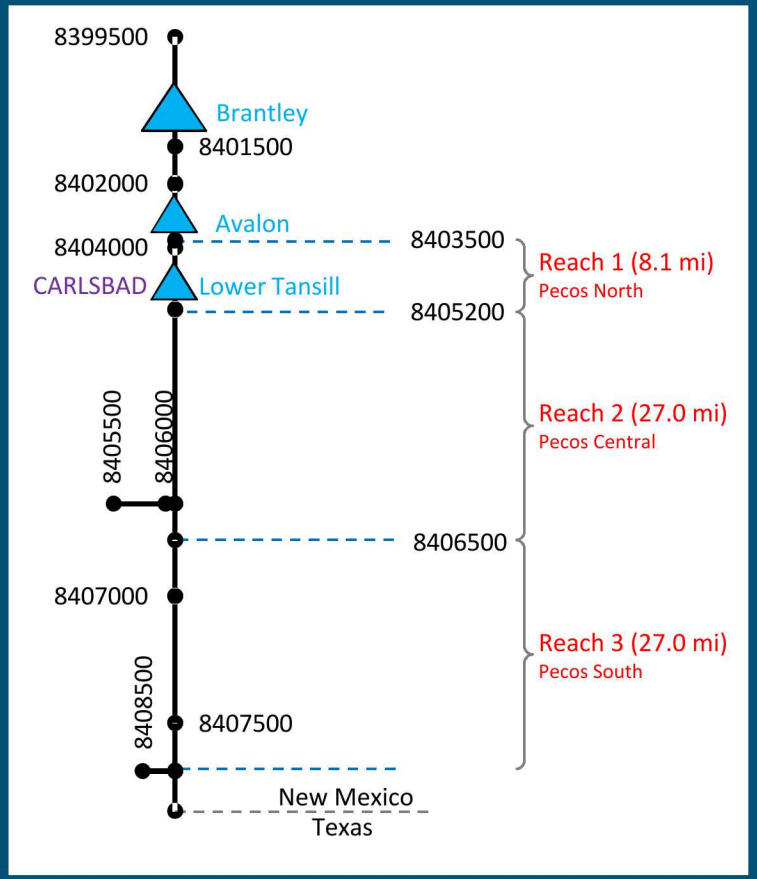
Reproduced from Summers, 1972



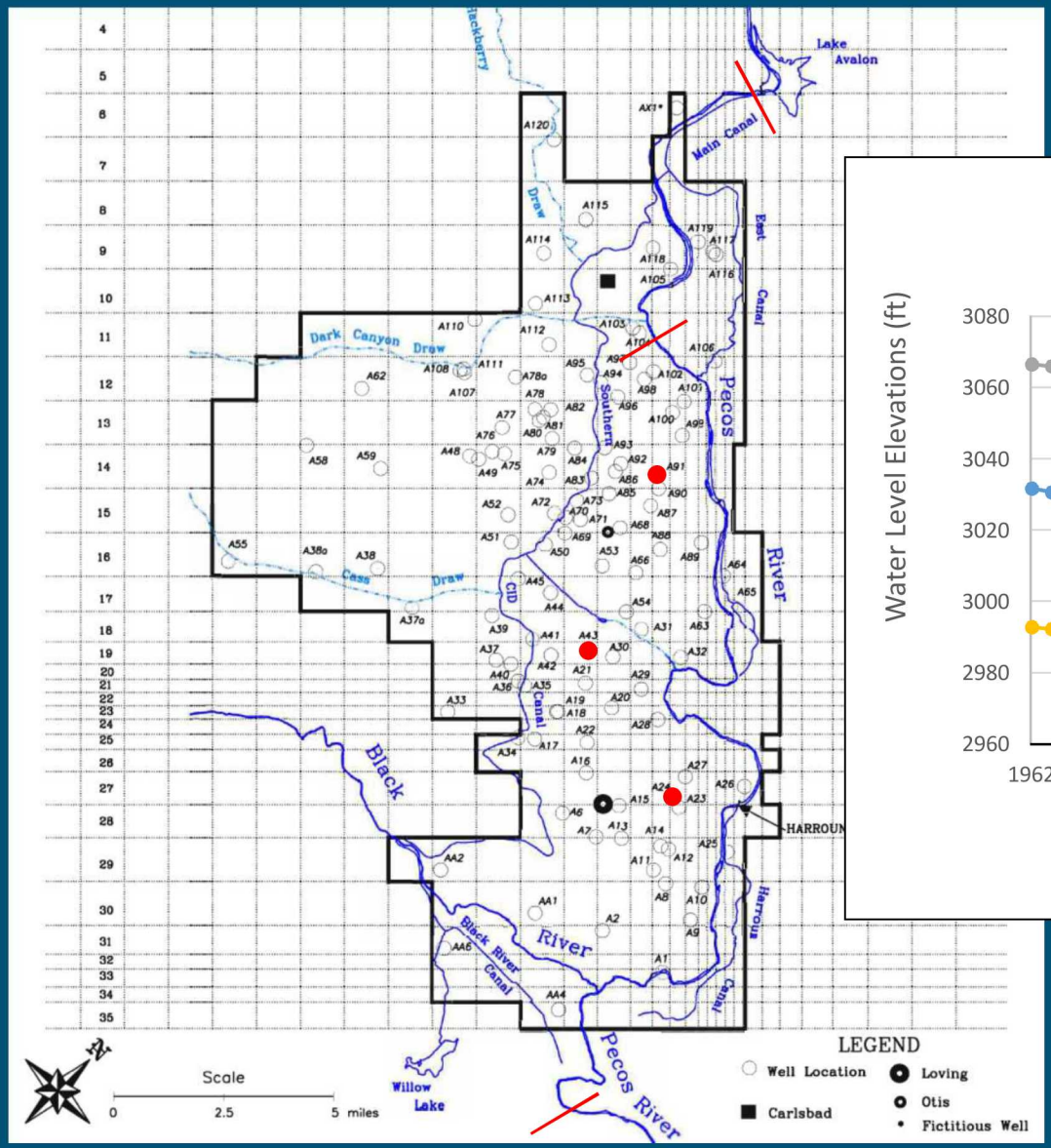
Summers, W.K., 1972, Geology and regional hydrology of the Pecos river basin, New Mexico, Open File Report #37, New Mexico Water Resources Institute, New Mexico State University, Las Cruces, New Mexico, 393 p.

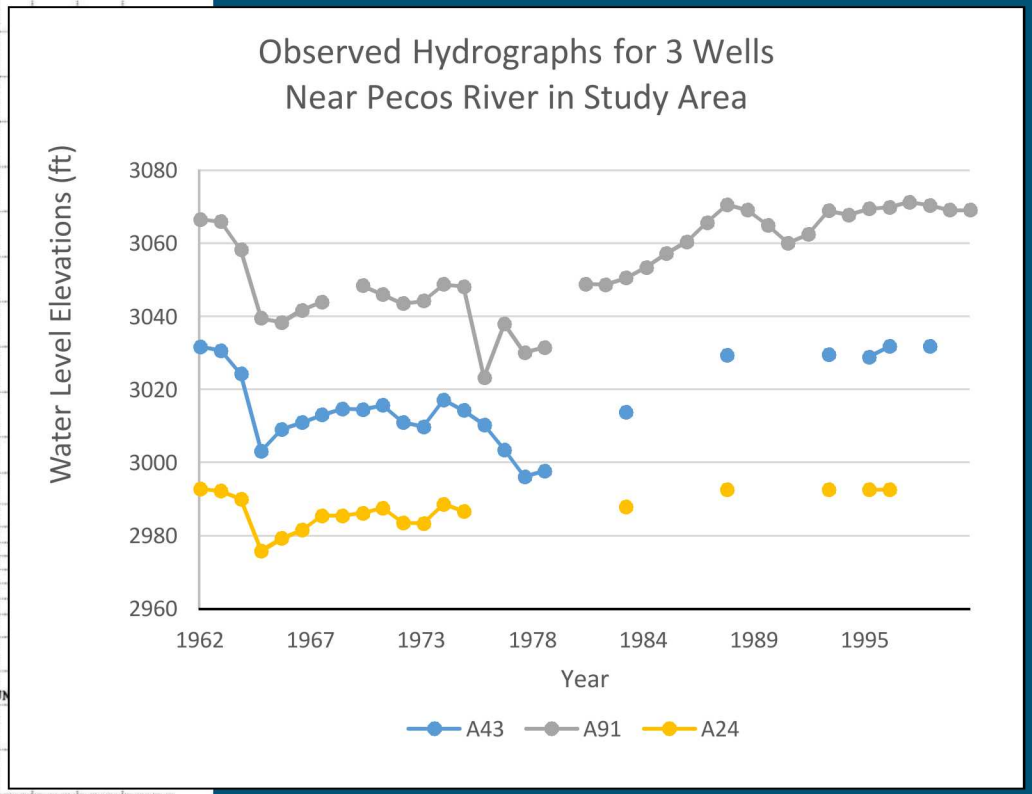
Conceptual Model





Numerical Model

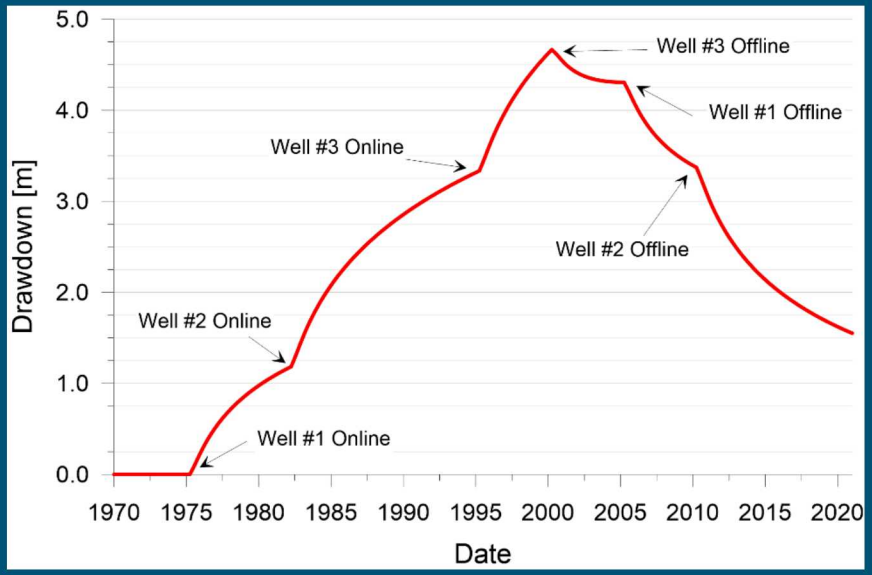


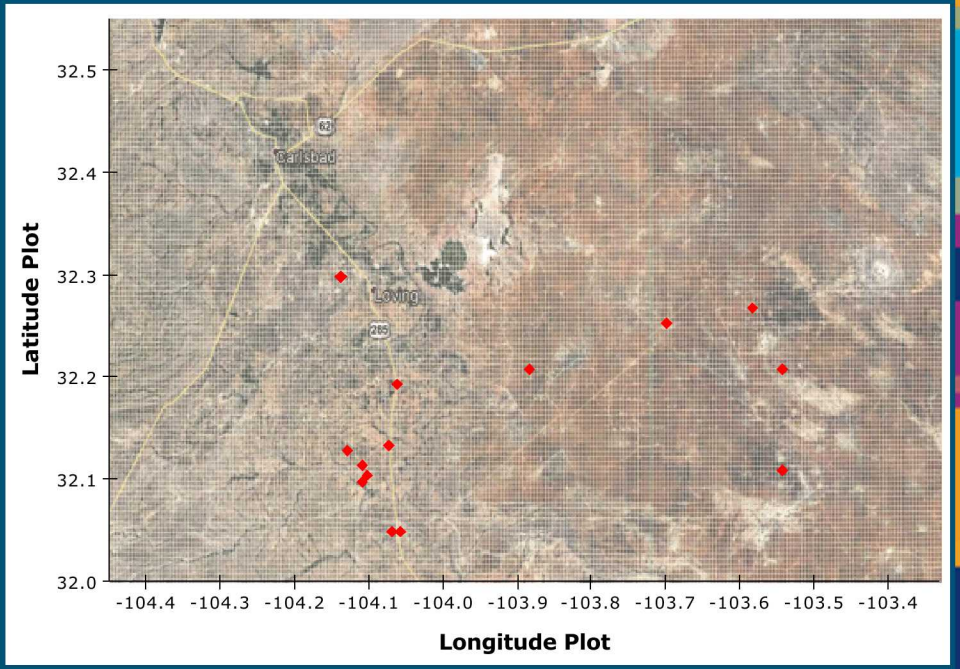


Localized Impacts

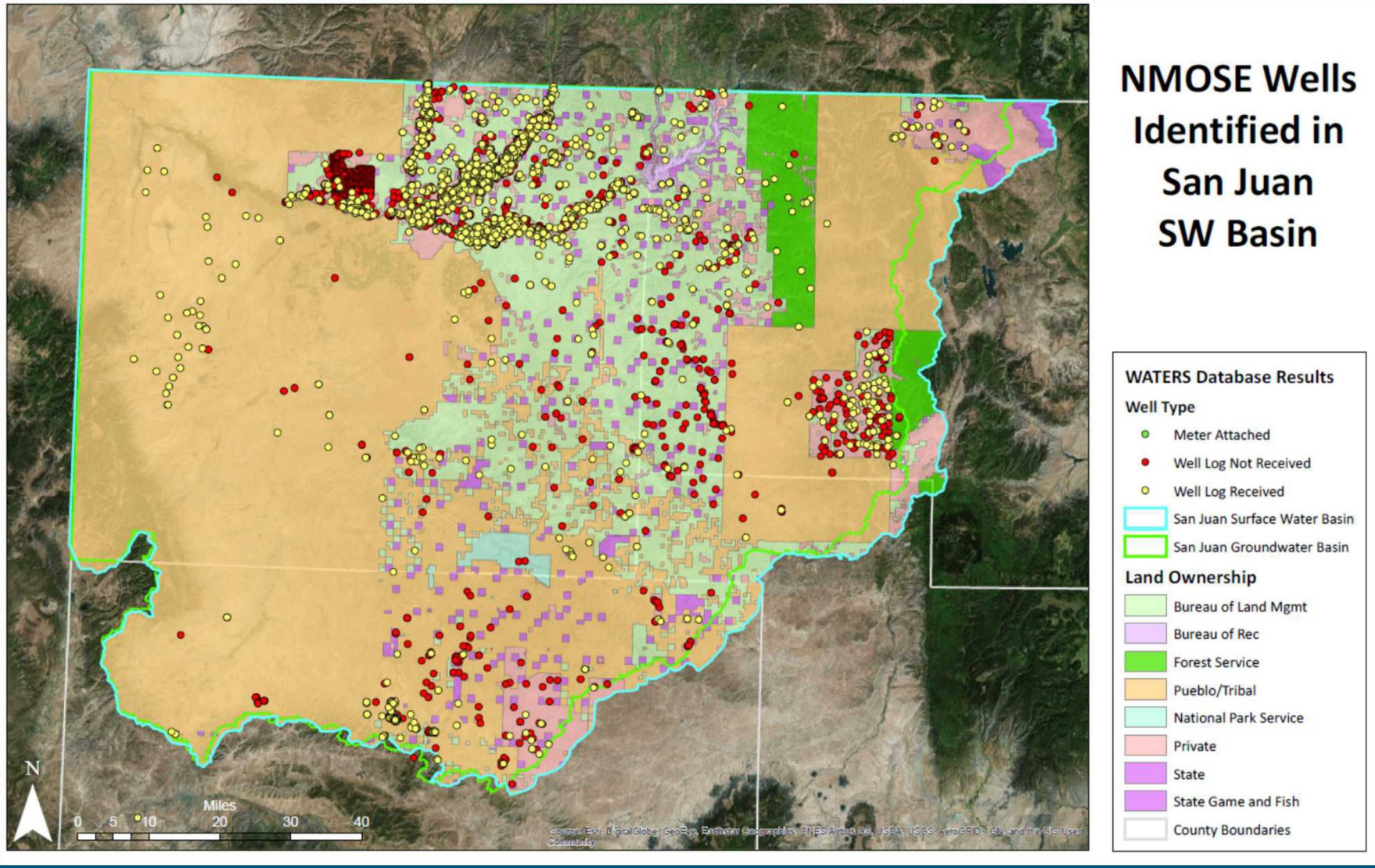
Domain split into 1/200th degree grid (~360 m)

Mean aquifer dynamics, T, S, pumping rate



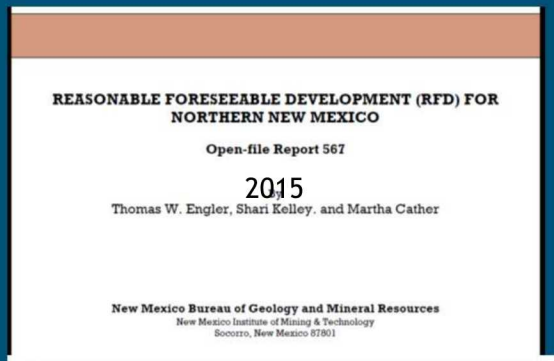


San Juan Basin



Past Work

Oil Potential Map

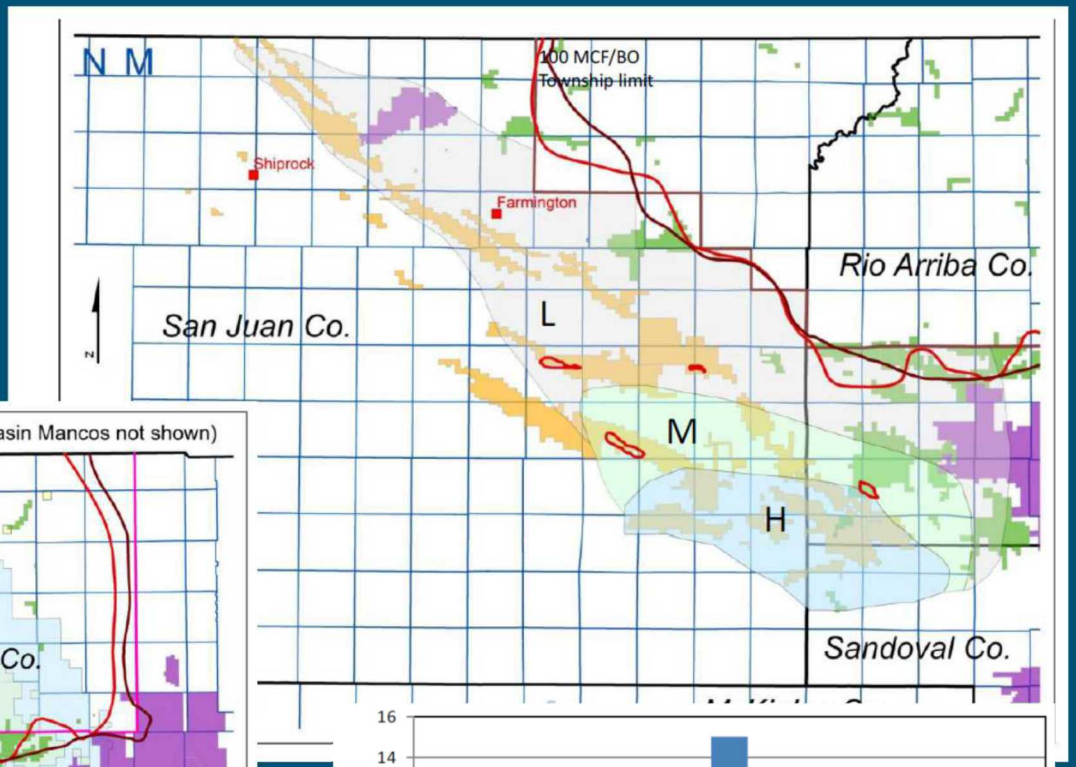

REASONABLE FORESEEABLE DEVELOPMENT (RFD) FOR NORTHERN NEW MEXICO

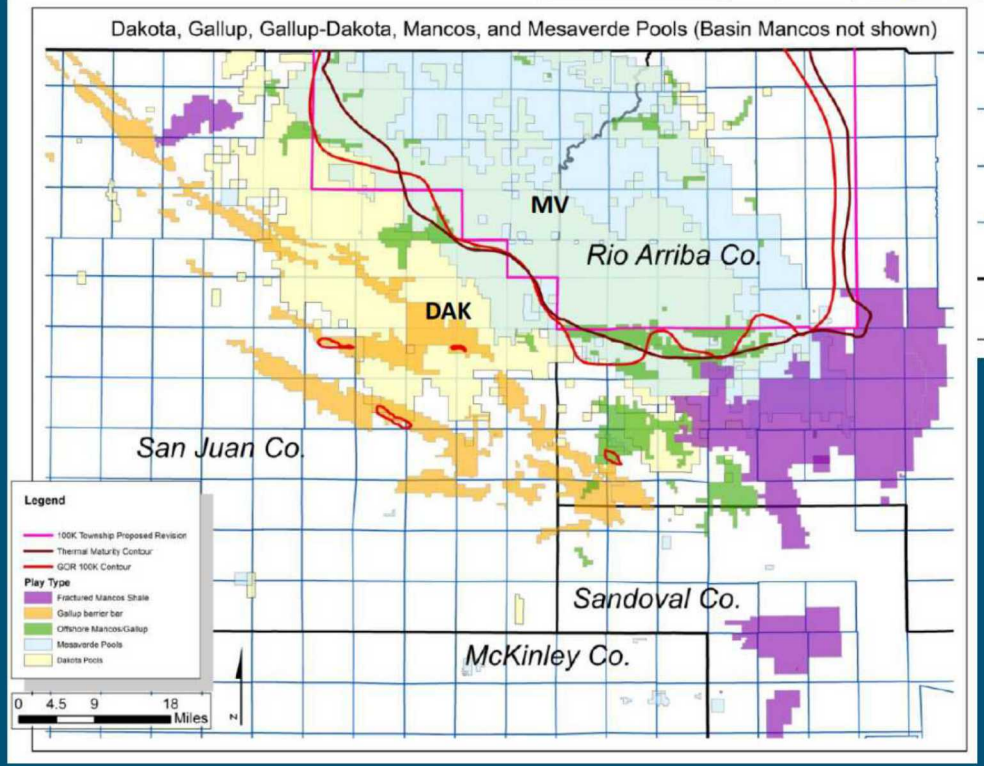
Open-file Report 567

2015

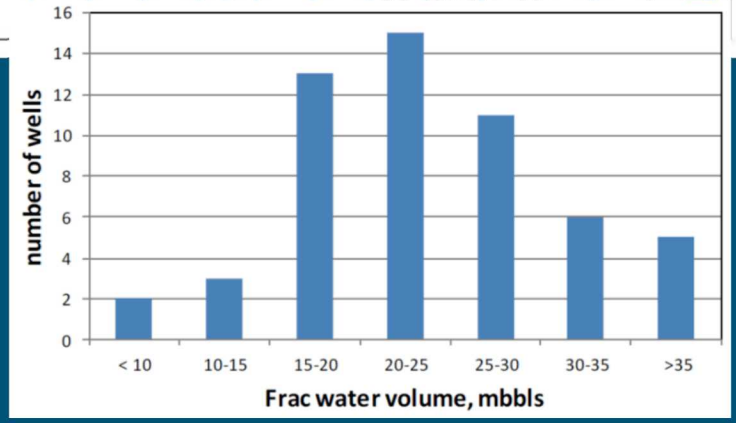
Thomas W. Engler, Shari Kelley, and Martha Cather

New Mexico Bureau of Geology and Mineral Resources
New Mexico Institute of Mining & Technology
Socorro, New Mexico 87801





Mancos Gas Potential



Water Use Distribution (3.13 AF/well ave.)

Past Work

HYDROLOGIC ASSESSMENT OF OIL AND GAS RESOURCE DEVELOPMENT OF THE MANCOS SHALE IN THE SAN JUAN BASIN, NEW MEXICO

Open-file Report 566

By
Shari Kelley, Thomas Engler, Martha Cather, Cathryn Pokorny, Cheng-Heng Yang, Ethan Mamer, Gretchen Hoffman, Joe Wilch, Peggy Johnson, and Kate Zeigler

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November 2014

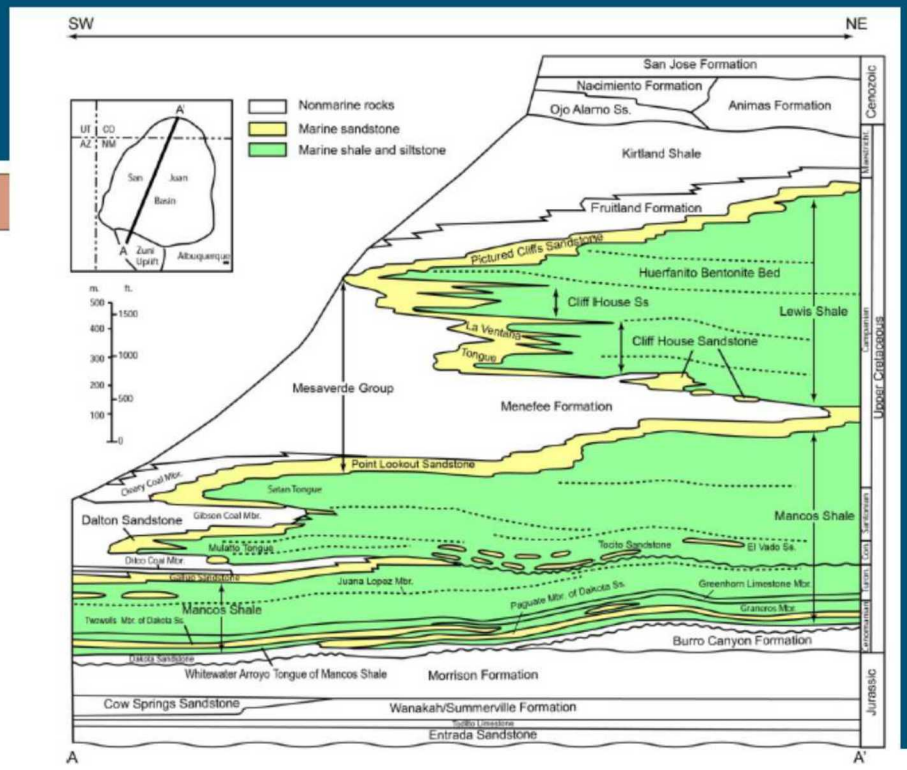
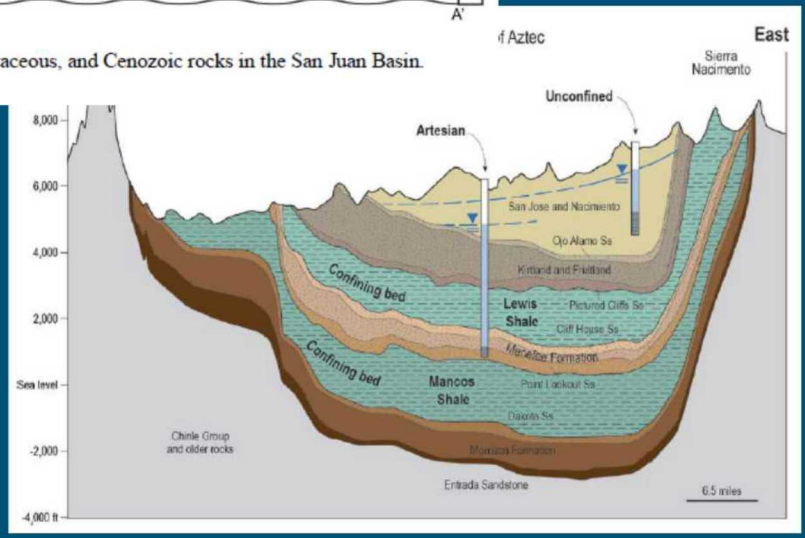


Figure 3—Stratigraphy of the Jurassic, Cretaceous, and Cenozoic rocks in the San Juan Basin. Modified from Molenaar (1977, 1989).



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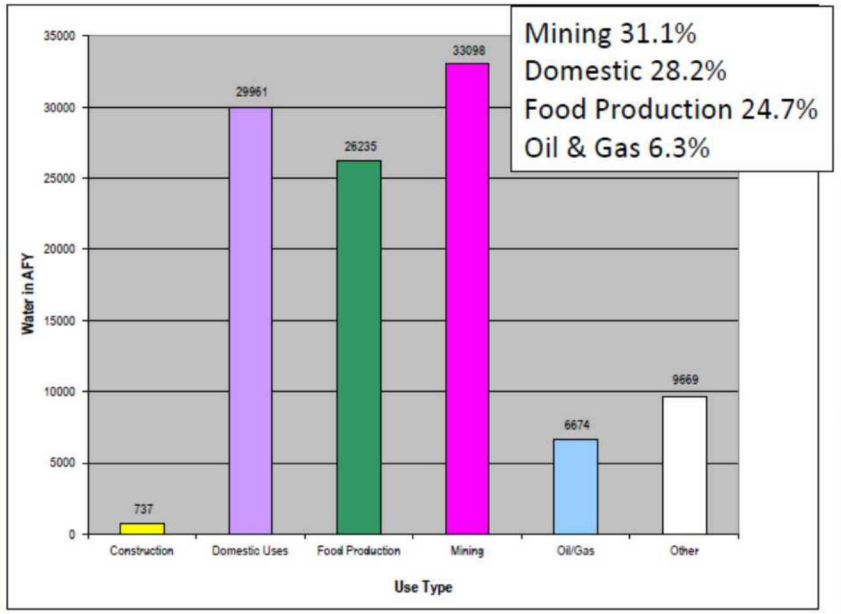
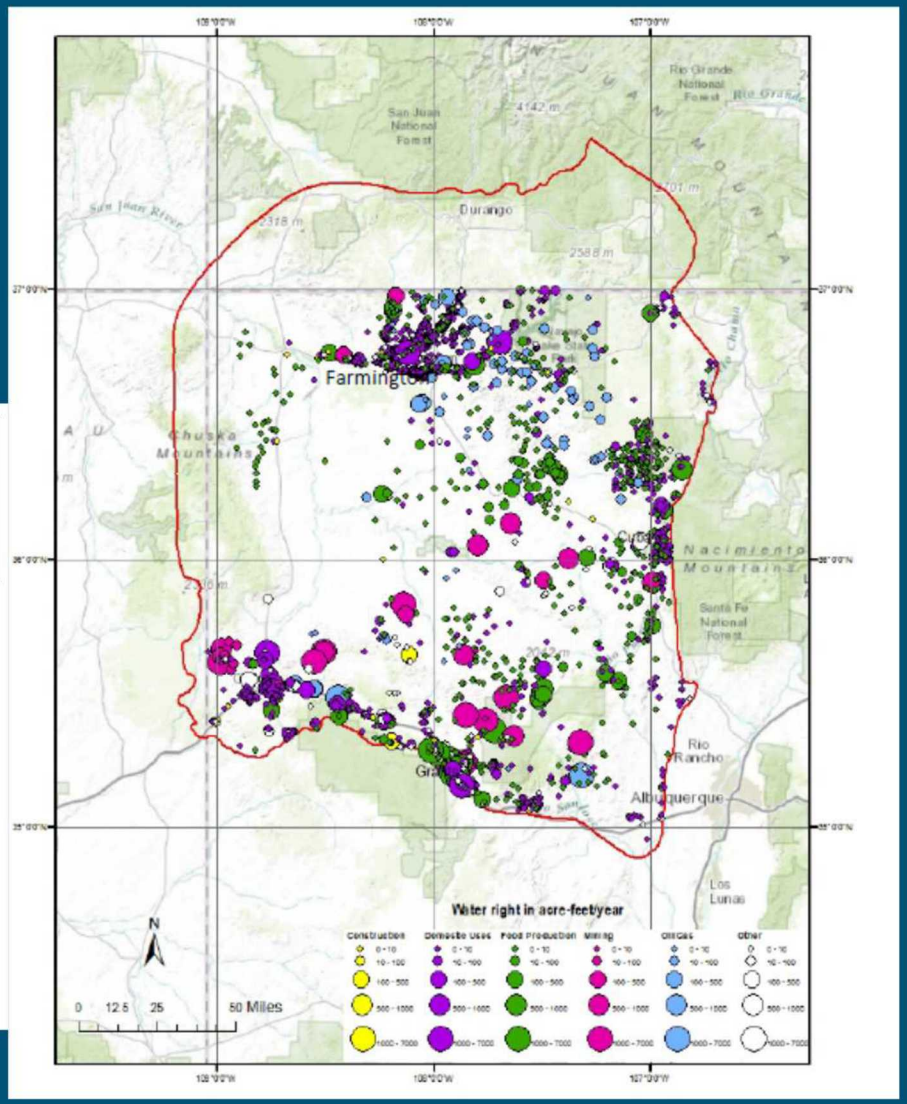


GW Water Right Usage

Spatial Distribution of GW Water Rights



Questions for This Project

Field Work

- Where, what, how often?

Modeling

- Systems model? (Decision support?)
- Basin-scale flow model?
- Other?

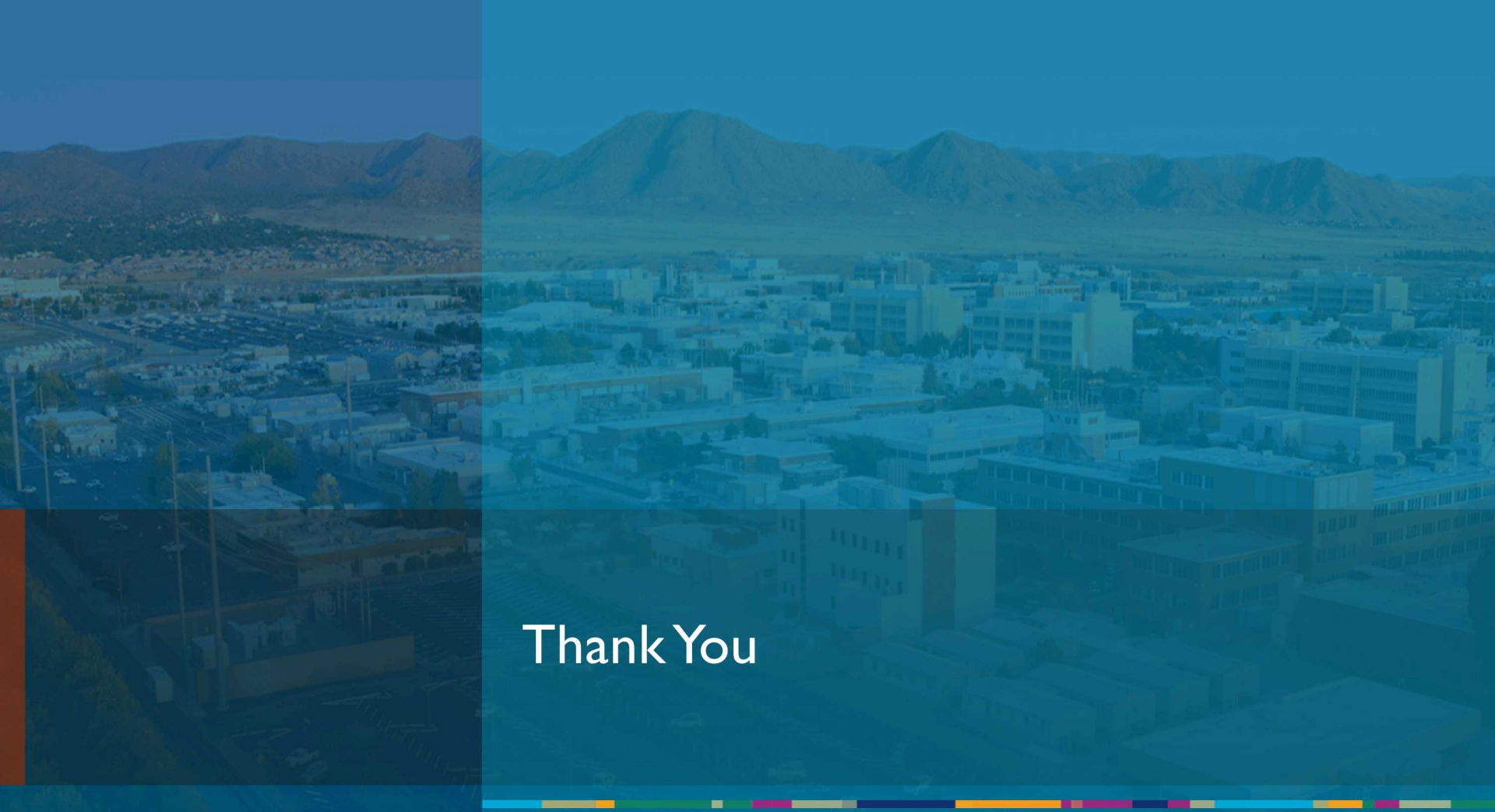
Monitoring

- Periodic vs continuous
- Locations
- Who manages it?

Data Repository

How to not be redundant? Collaboration with other agencies (USGS, OSE, etc.)

Benefits to BLM / Farmington Office / Nation



Thank You