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Prepared in cooperation with the Bureau of Land Management

Anderson Ranch Wetlands Hydrologic Characterization in Taos County, New Mexico

Yellow-headed blackbird and blue-winged teal at the Anderson Ranch wetlands, May 2016. Photograph by Fred Gebhardt, U.S. Geological Survey.

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Open-File Report 2019-1100

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U.S. Geological Survey

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U.S. Geological Survey, Reston, Virginia: 2019

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Contents

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Abstract

The Anderson Ranch property (study area), located in Taos County, north-central New Mexico, was transferred from Chevron Mining, Inc. (CMI) to the Bureau of Land Management (BLM) as part of a Natural Resource Damage Assessment and Restoration (NRDAR) court-ordered settlement. The study area supports freshwater emergent wetlands and freshwater ponds. The settlement states that CMI will provide the land and a monetary settlement to support the restoration of the wetlands on the property. To best manage the study area, the BLM requires an understanding of potential effects of climate variability and groundwater withdrawals on the wetland function. This study, completed by the U.S. Geological Survey in cooperation with the BLM, provides an initial hydrologic characterization of the study area, which included literature review, collection of groundwater-level and aqueous-chemistry data, completion of a vegetation survey, and preliminary data analysis. The data compiled, collected, and analyzed as part of this study indicate that the wetlands within the study area are groundwater fed and that the water maintaining the wetlands is modern. Surface-water levels in the pond and groundwater levels in the surrounding wetland fluctuate seasonally. The hydraulic gradient in the study area is from northeast to southwest. Evapotranspiration is a main driver of water demand within the study area.

Purpose and Scope

- The purpose of this study is to provide a hydrologic characterization of the Anderson Ranch wetlands that can be used to guide management strategies.

- This objective was met through literature review, data collection (groundwater-level data, aqueous-chemistry data, and a vegetation survey), and preliminary data analysis.

- The purpose of this Open-File Report is to communicate the results of the first phase of the study. This interim product can be used by BLM to determine the next steps of the study.

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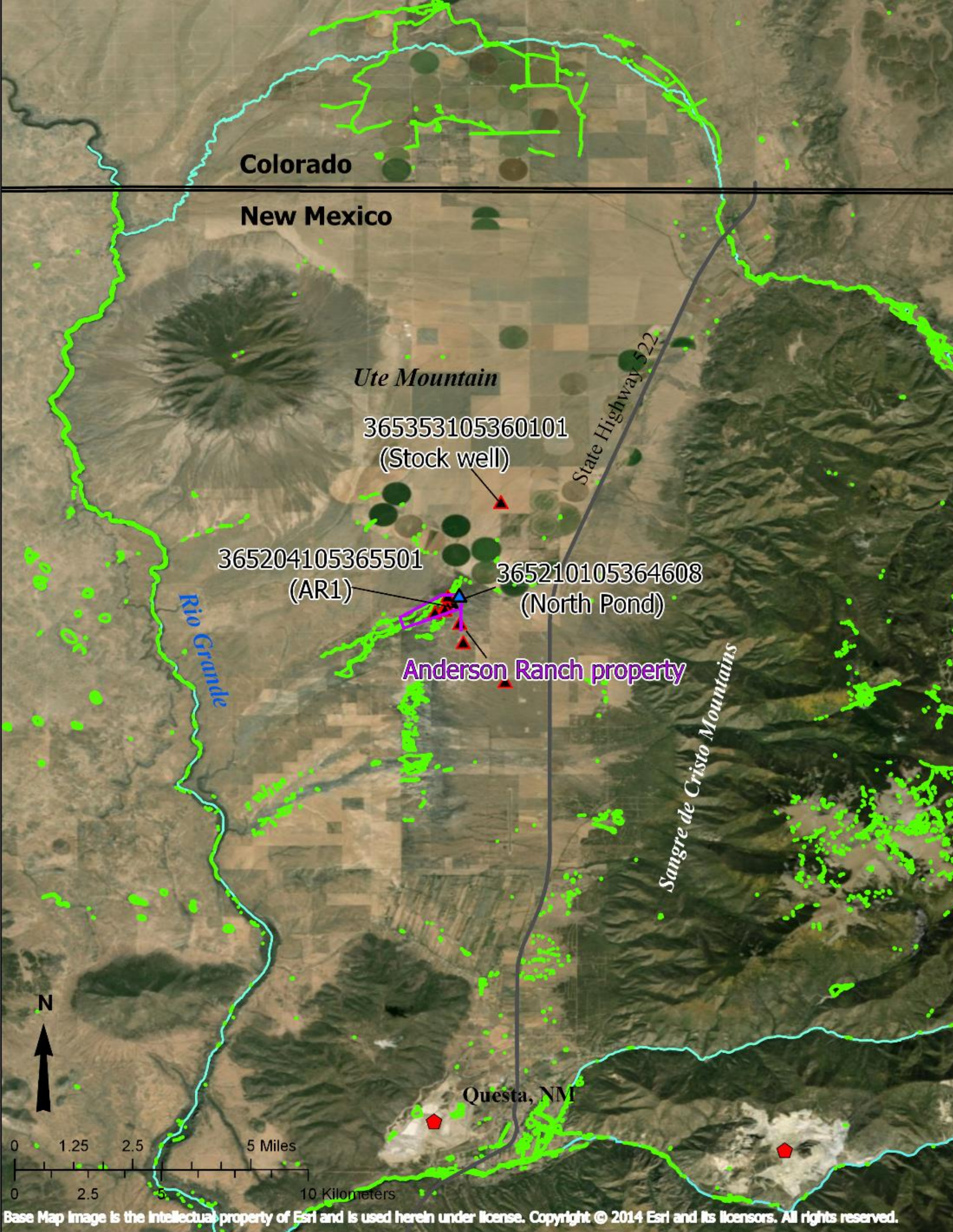
Long-Term Questions for BLM

- 50- to 100-year scenarios for the wetlands.

- Determining the value of investment in this property.

Study Area



The Anderson Ranch property is a 250-acre plot of land about 10 miles north of Questa, New Mexico.

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Anderson Ranch Property Background

Anderson Ranch property, from USGS archives for site number 365159105364801 (circa 1970s).

- 1955- 1964: Property was used for irrigation (NMOSE, 2019).
- 1964: Owner and operator of the Questa mine filed for a water right transfer (NMOSE, 2019).
- 2002-2017: Natural Resource Damage Assessment was conducted (DOI and others, 2018).
- 2018: Property was officially transferred to BLM (DOI and others, 2018).

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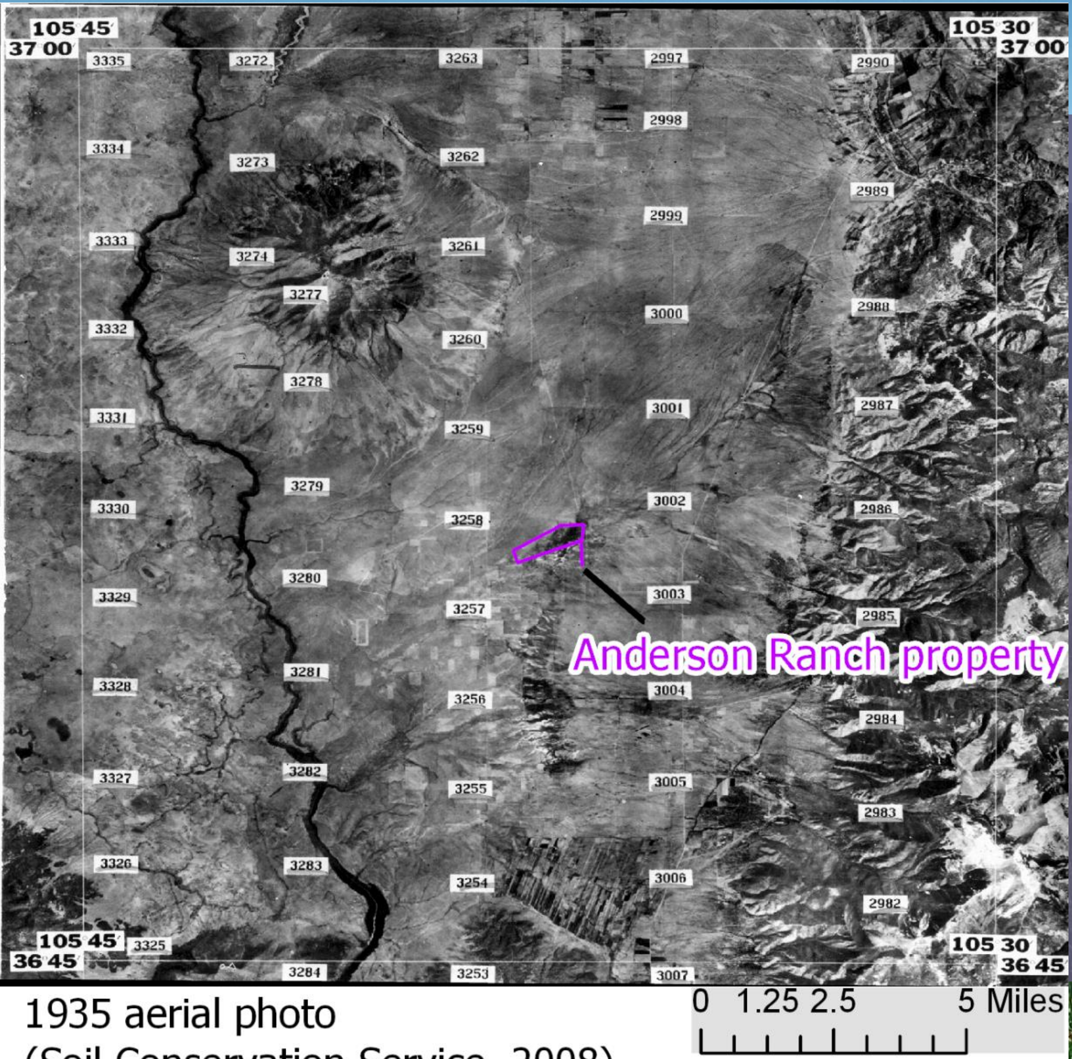
Past Indicators of Wetlands



1935 aerial photo
(Soil Conservation Service, 2008)

Historical imagery indicates that the Anderson Ranch wetlands have existed at least since 1935.

- Within the Anderson Ranch property, there is no volcanic outcropping at the land surface. The dark color from the 1935 image within the property boundary aligns with the National Wetlands Inventory (USFWS, 2010). Therefore, the darker color within and near the current wetlands extent is assumed to indicate the presence of wetlands in 1935.

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Wetlands in New Mexico

- Wetland landscapes are rare in New Mexico, and wetland habitat has shrunk in the last 200 years (Fretwell and others, 1996).
- Wetlands provide unique habitat for diverse ecosystems and many organisms, notably migratory waterfowl and wading birds (Fretwell and others, 1996; EPA, 2017).
- Wetlands serve important functions for watersheds, with potential for water-quality improvement and carbon storage (EPA, 2017).
- Connectivity between wetlands can affect resilience of wetlands and populations that depend on the wetlands for habitat (Uden and others, 2014).
- National Wetlands Inventory (USFWS, 2010) shows connectivity of freshwater-wetland features in the study area.

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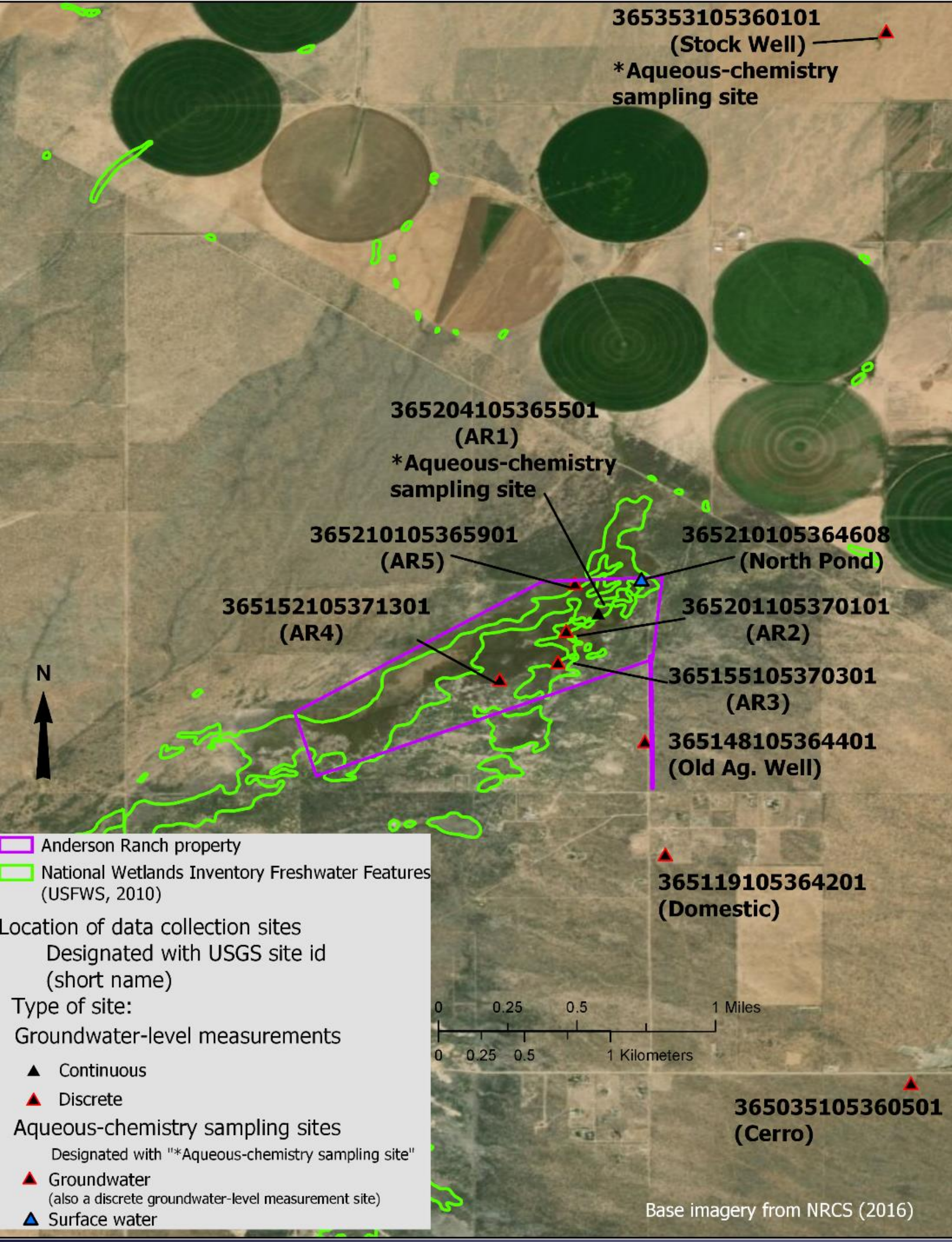


Study Approach

Hydrogeology

Examined hydrogeology based on literature review and elevation analysis.

Groundwater Levels

Assessed groundwater gradients and seasonal variability of groundwater levels.

Aqueous Chemistry

Assessed chemical composition of groundwater and surface water within and near the Anderson Ranch wetlands.

Vegetation Survey

Estimated coverage, frequency, and occurrence of plant species. Results of the vegetation survey will not be discussed in this report.

Preliminary Water Budget

Examined components of the water budget.

*All groundwater-level data and aqueous-chemistry data are available at USGS (2019). Aqueous-chemistry data are also summarized in the Appendix.

Literature Review

Winograd (1959)

Relevant findings from this study are summarized on the following slide.

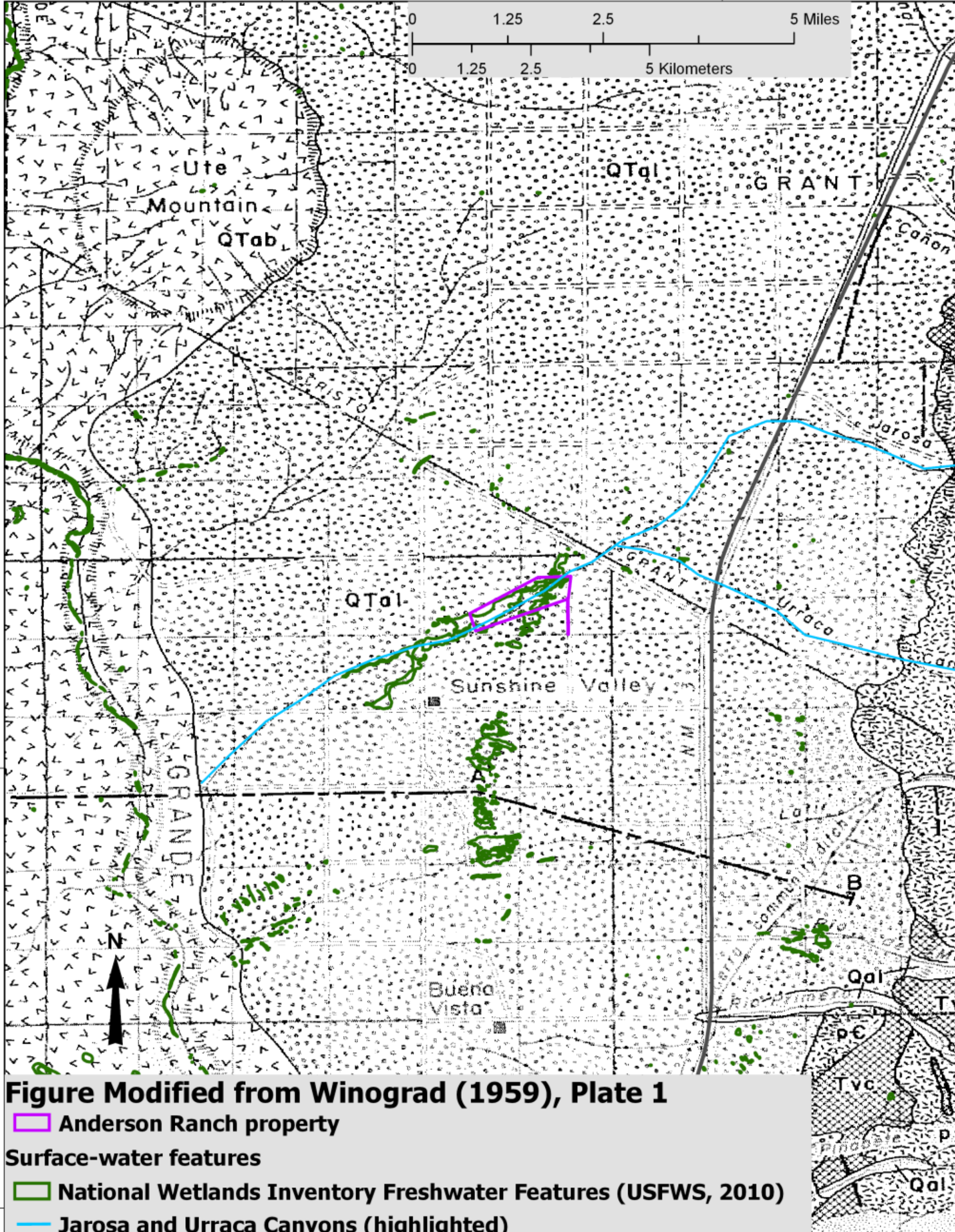


Figure Modified from Winograd (1959), Plate 1

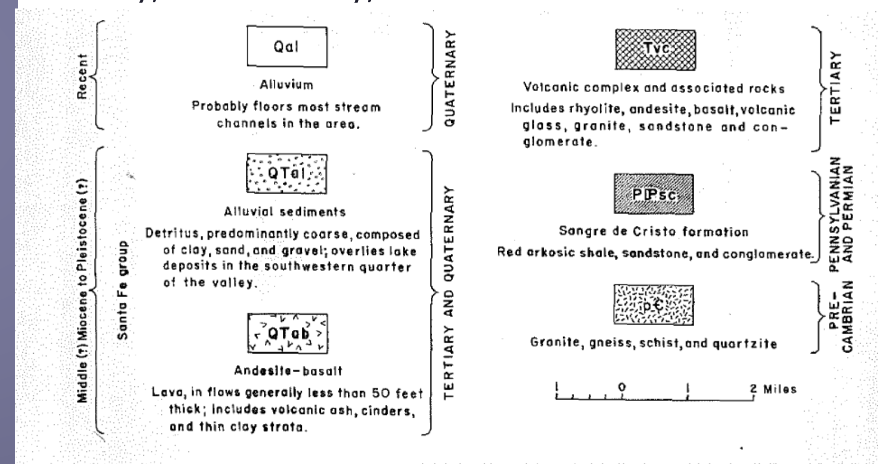
Anderson Ranch property

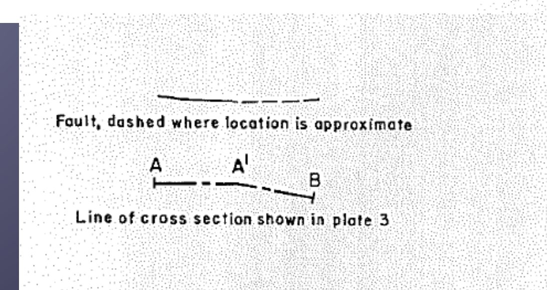
Surface-water features

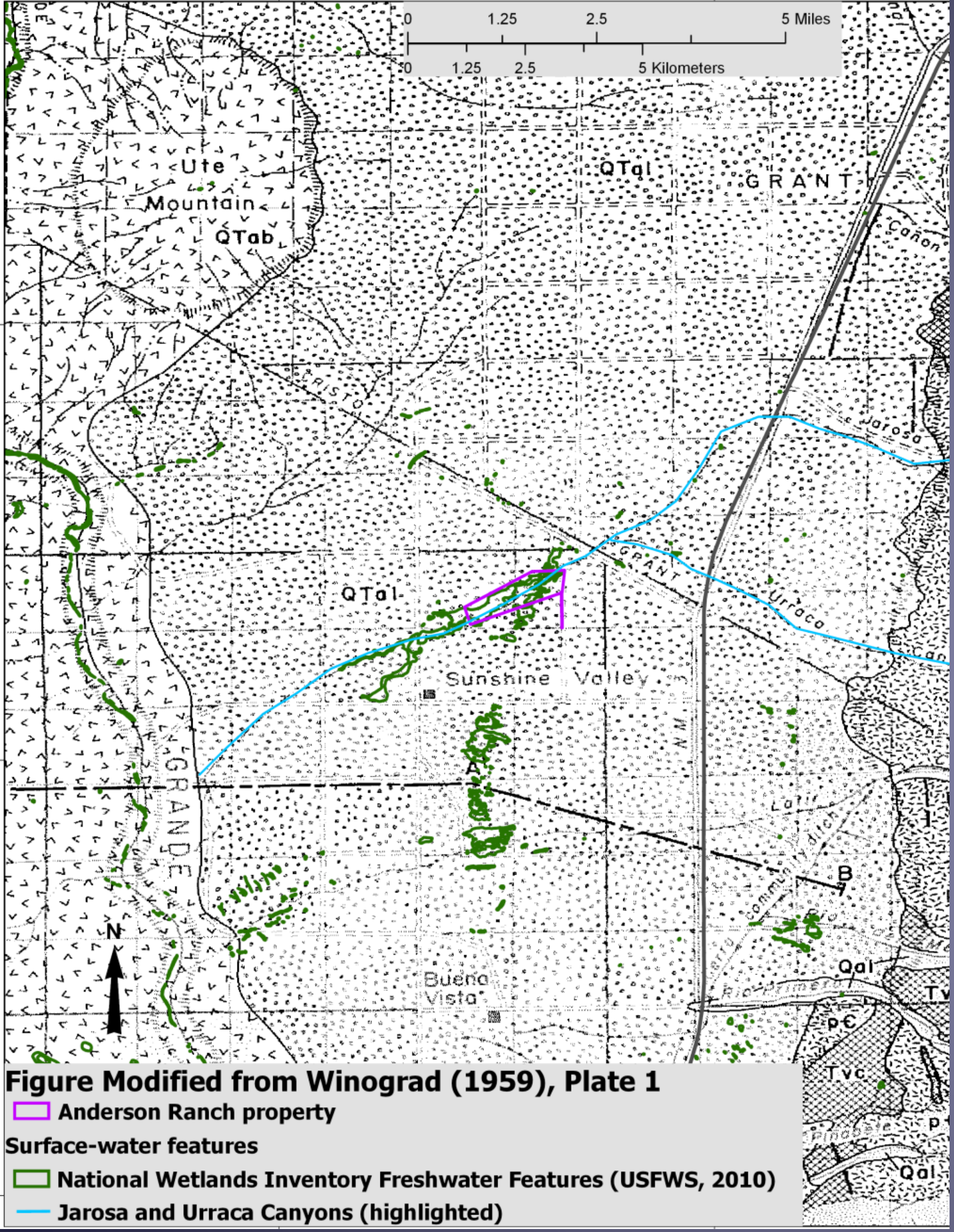
National Wetlands Inventory Freshwater Features (USFWS, 2010)

Jarosa and Urraca Canyons (highlighted)

Explanation from Winograd (1959) plate 1 – generalized geologic map of Sunshine Valley and vicinity, Taos County, N. Mex.





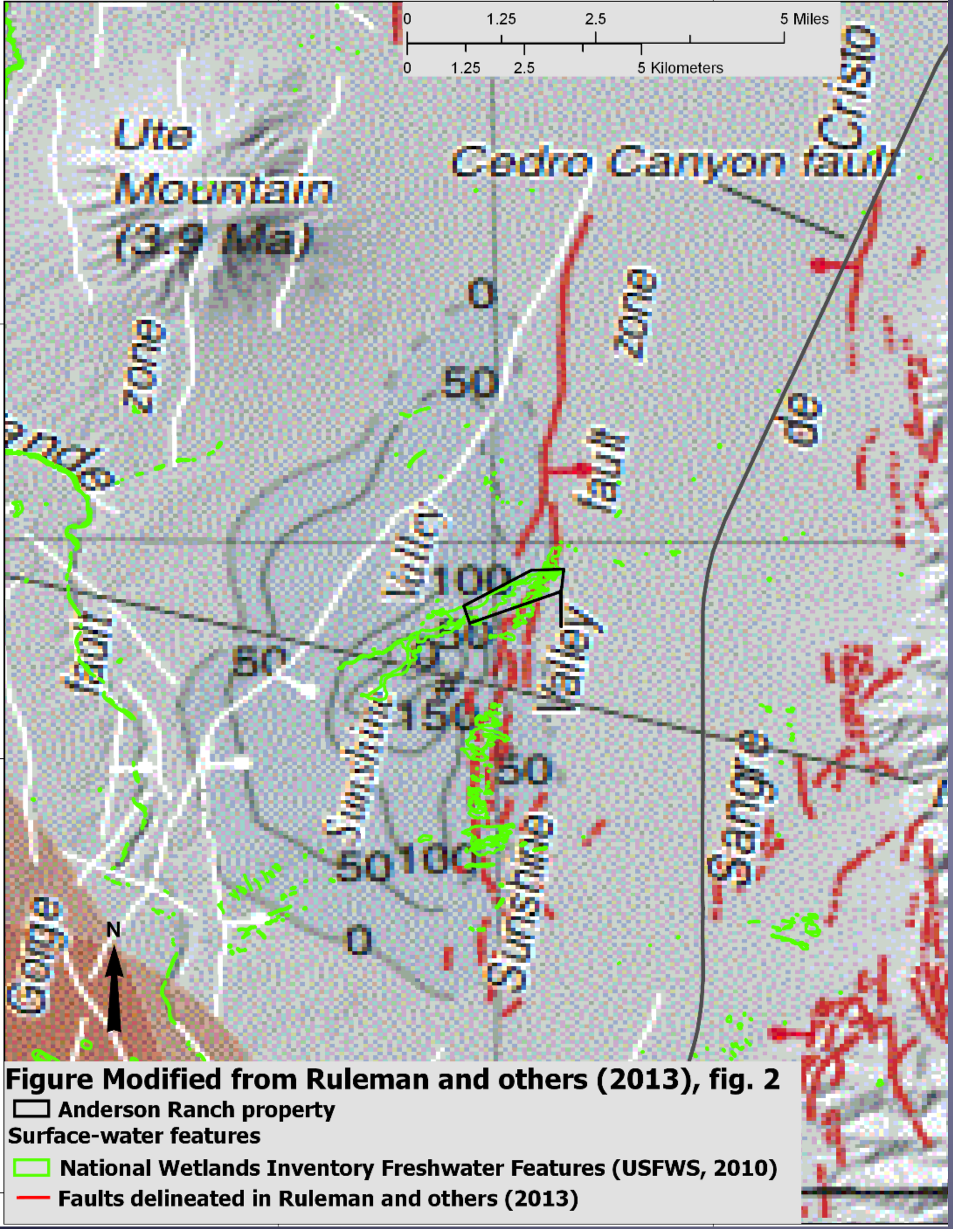


Literature Review

Winograd (1959)

Findings shown in this figure as well as within Winograd (1959):

- Sunshine Valley, the valley between the Sangre de Cristo Mountains on the east and the Rio Grande on the west, is a piedmont alluvial plain and contains alluvial sediments interbedded with lava as well as lacustrine sediments.
- Groundwater underlying the Sunshine Valley discharges to the Rio Grande.
- Groundwater is recharged from perennial streams, arroyo flood flows, direct infiltration, canals and irrigation infrastructure.
- Jarosa and Urraca Canyons (highlighted in blue) converge north of the Anderson Ranch wetlands.



Literature Review

Ruleman and others (2013)

Pliocene- to early Pleistocene-age “Lake Sunshine” is shown by contours defining the thickness of lacustrine and interstratified fan deposits, which range from 0 to 150 ft.

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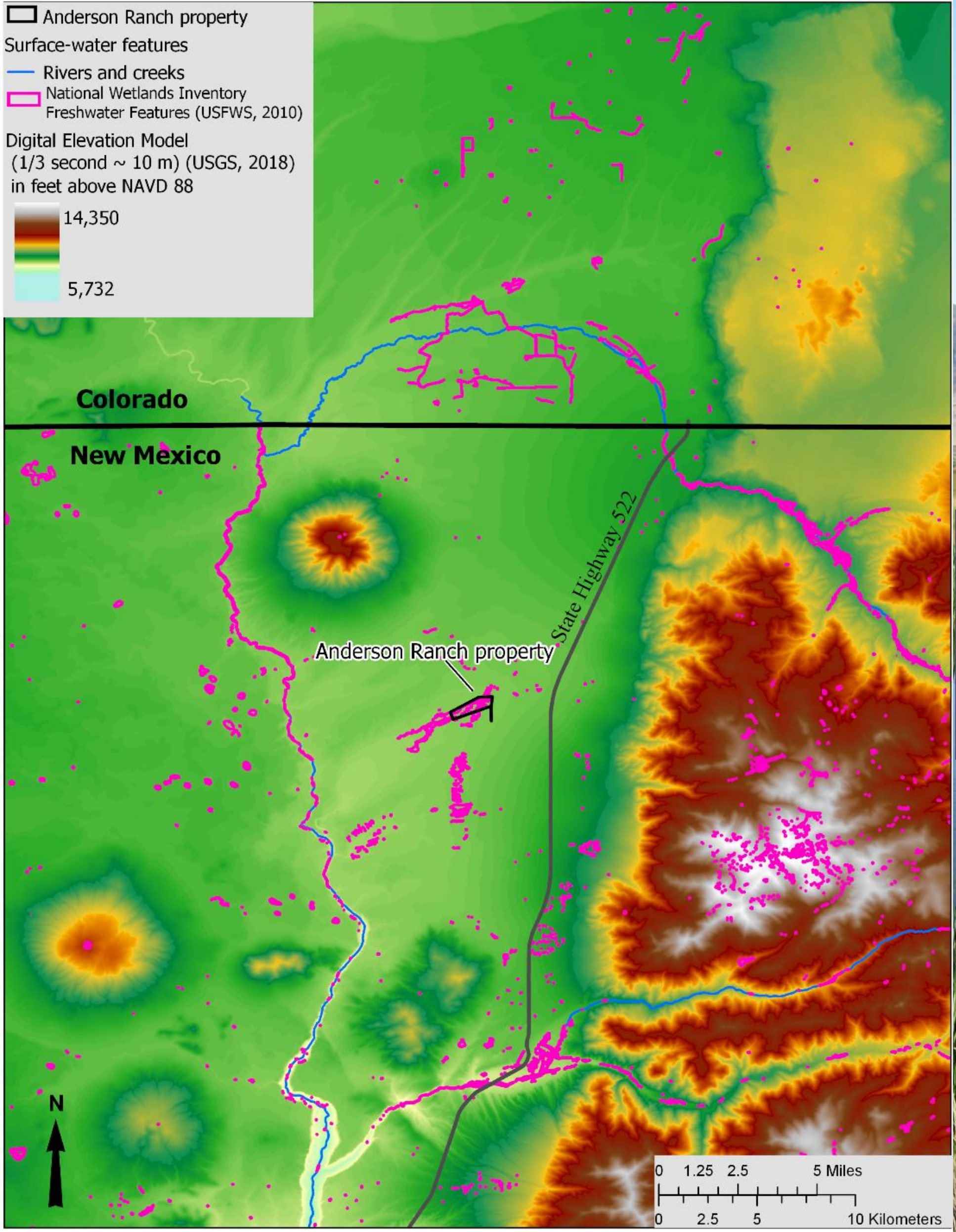
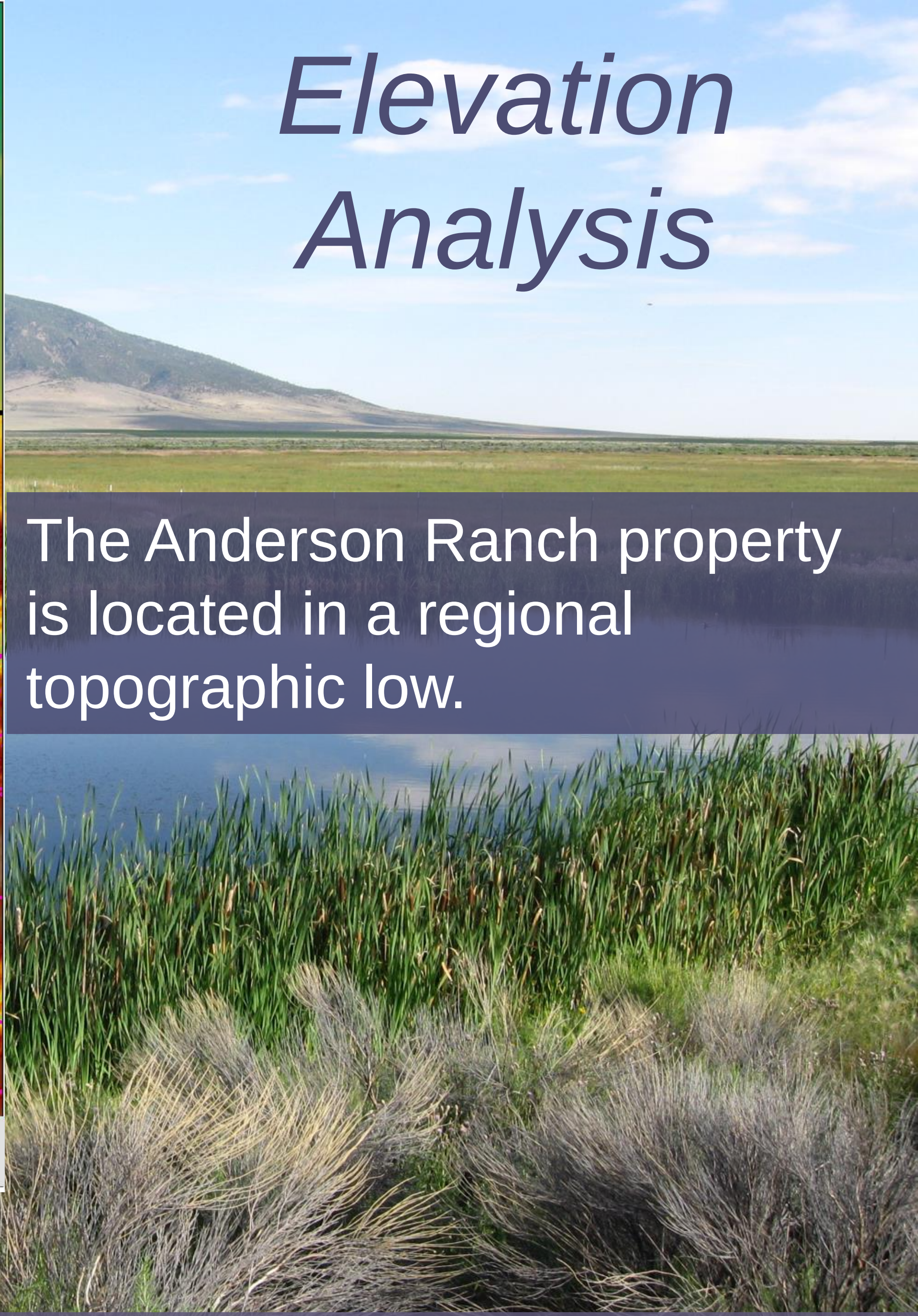


Elevation Analysis



The Anderson Ranch property is located in a regional topographic low.

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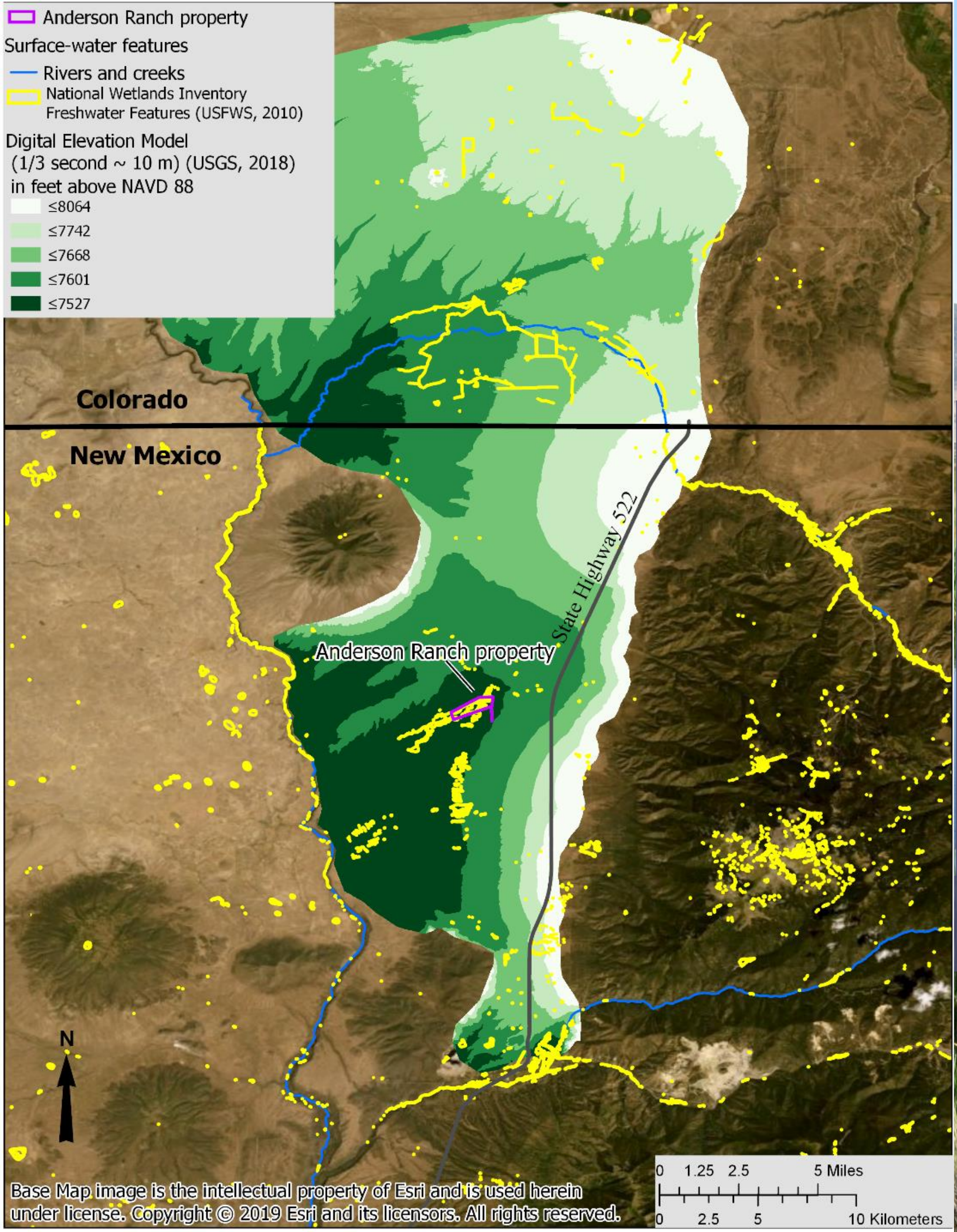


Elevation Analysis

Classifying lower elevations with smaller bins and natural jenks[1] illustrates that the Anderson Ranch property and the wetlands to the south are in a topographic low.

[1]*Natural jenks* is an option in ArcGIS that clusters data based on data distribution.

Groundwater-Level Data Collection Sites

Hydrologic Technician Fred Gebhardt installing a piezometer using a truck-mounted Geoprobe, August 2016. Photograph by Amy Galanter, USGS.

Groundwater-level measurement sites (locations of sites shown on slide 8)

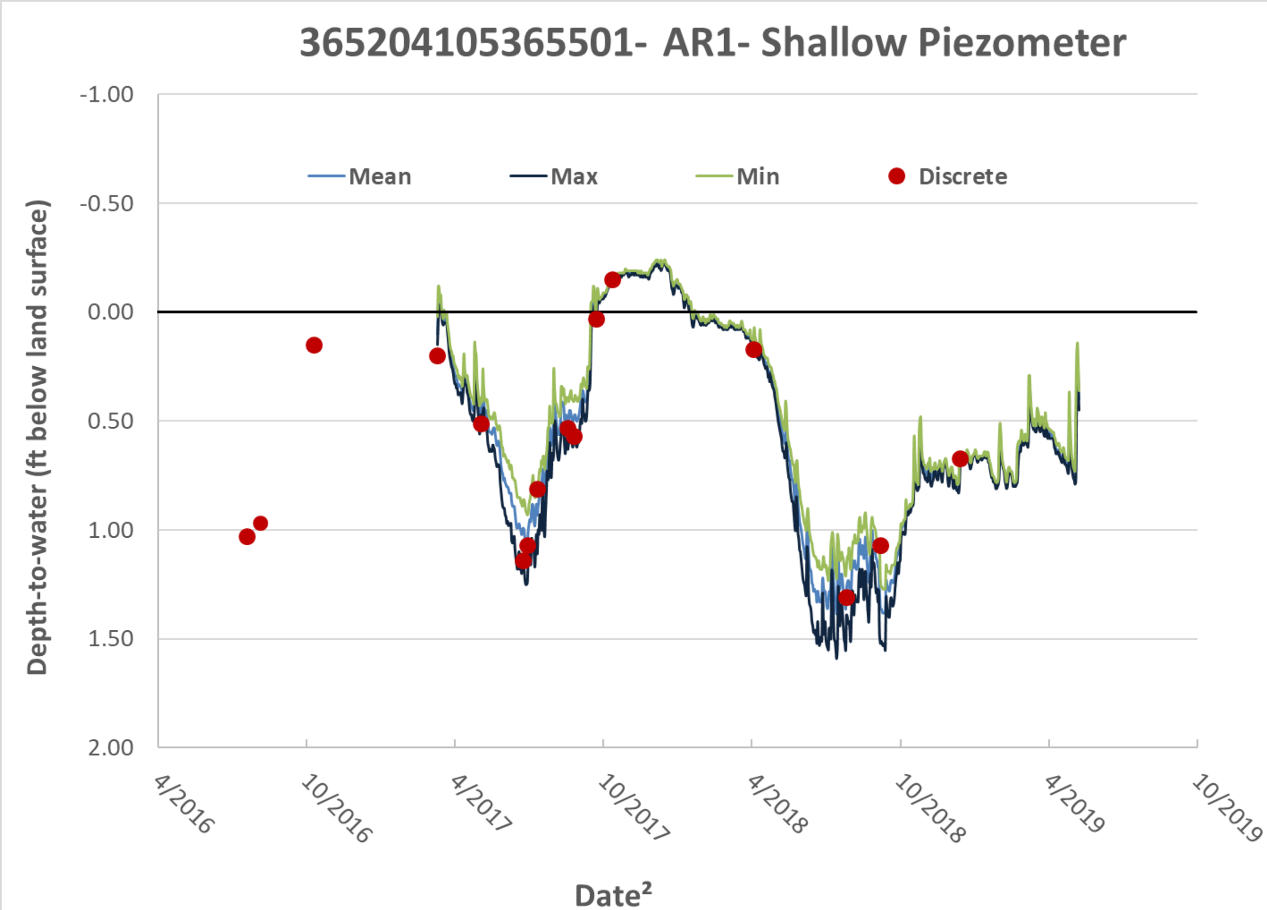
Well type	USGS site identifier	Short name	Screen depth, in feet below land surface	Total depth, in feet	Measurement frequency
Piezometer	365204105365501	AR1	22 - 27	27	continuous (15 min)
Piezometer	365201105370101	AR2	22 - 27	27	discrete (quarterly)
Piezometer	365155105370301	AR3	17.5 - 22.5	22.5	discrete (quarterly)
Piezometer	365152105371301	AR4	16.6 - 21.6	21.6	discrete (quarterly)
Piezometer	365210105365901	AR5	14.55 - 19.6	19.6	discrete (quarterly)
Monitoring well	365035105360501	Cerro	135 - 240 275 - 330 460- 470	500	discrete (quarterly)
Agricultural well (no longer in use)	365148105364401	Old Ag. Well	Unknown	187	discrete (quarterly)
Domestic well	365119105364201	Domestic	20-60	61	discrete (quarterly)
Stock well	365353105360101	Stock well	110-210	210	discrete (quarterly)

Geoprobe drilling refusals and driller’s logs for other wells in the area indicate that there is a potential clay layer around 20 feet below land surface.

USGS

Groundwater-Level Data

Groundwater-level Data Available at USGS (2019)



² Tick marks on the horizontal axis are for every 180 days to delineate a rough estimate of evapotranspiration and non-evapotranspiration seasons.

Interannual variation

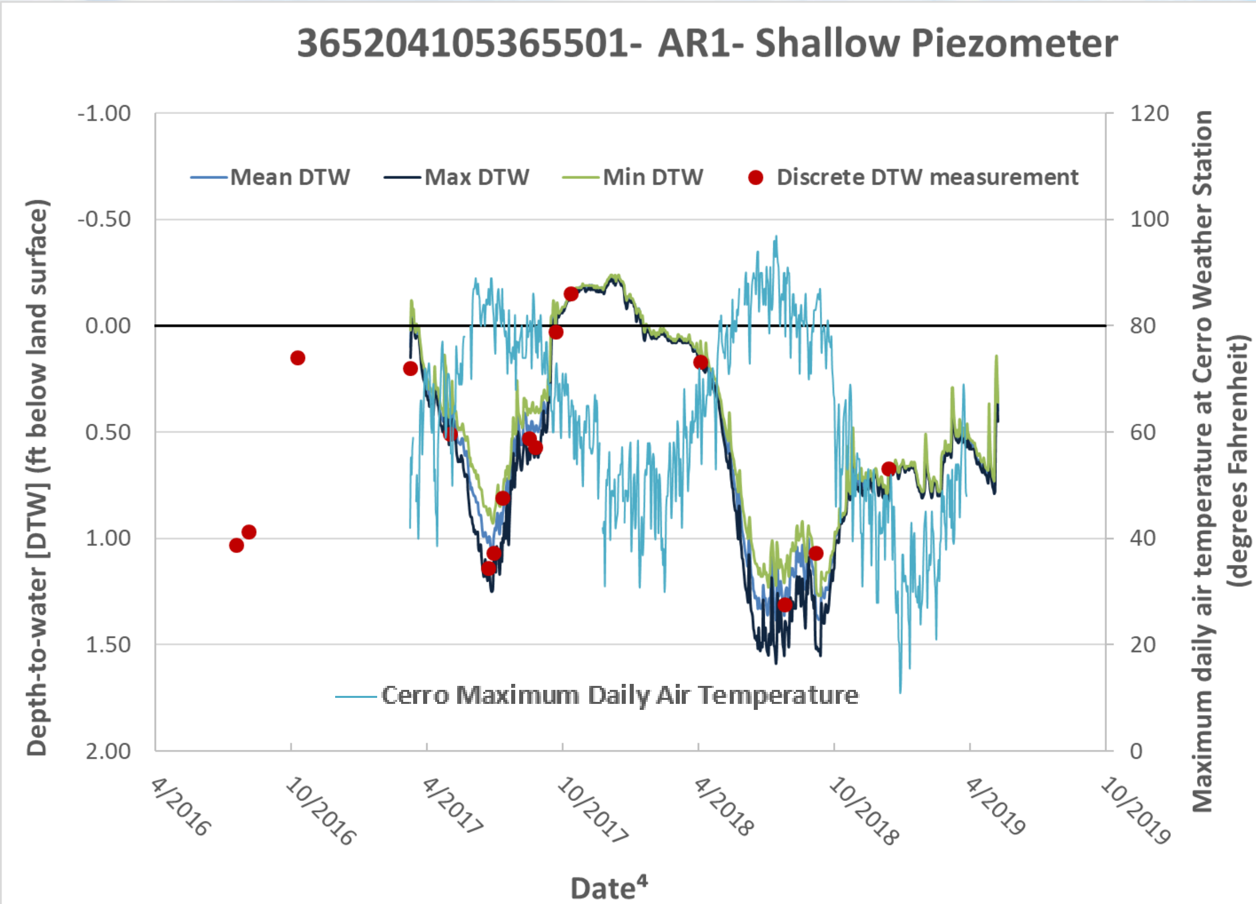
Groundwater levels were higher in 2017 than they were for the corresponding dates in 2018.

- Winter 2017 groundwater levels were above land surface[3]; this was not the case in winter 2018.
- Summer 2018 groundwater levels were lower than those of summer 2017. Summer 2018 groundwater levels remained lower for a longer duration than those of summer 2017.

[3]Note that the negative depth-to-water values are water pressure above land surface. Groundwater levels above land surface indicate that the upward pressure of the water within the piezometer causes the groundwater level within the piezometer casing to rise above the land surface. The piezometer casing allows the water to move above the land surface, and the upward pressure originates from below the ground.

Groundwater-Level and Temperature Data

(Groundwater-Level Data Available at USGS [2019])

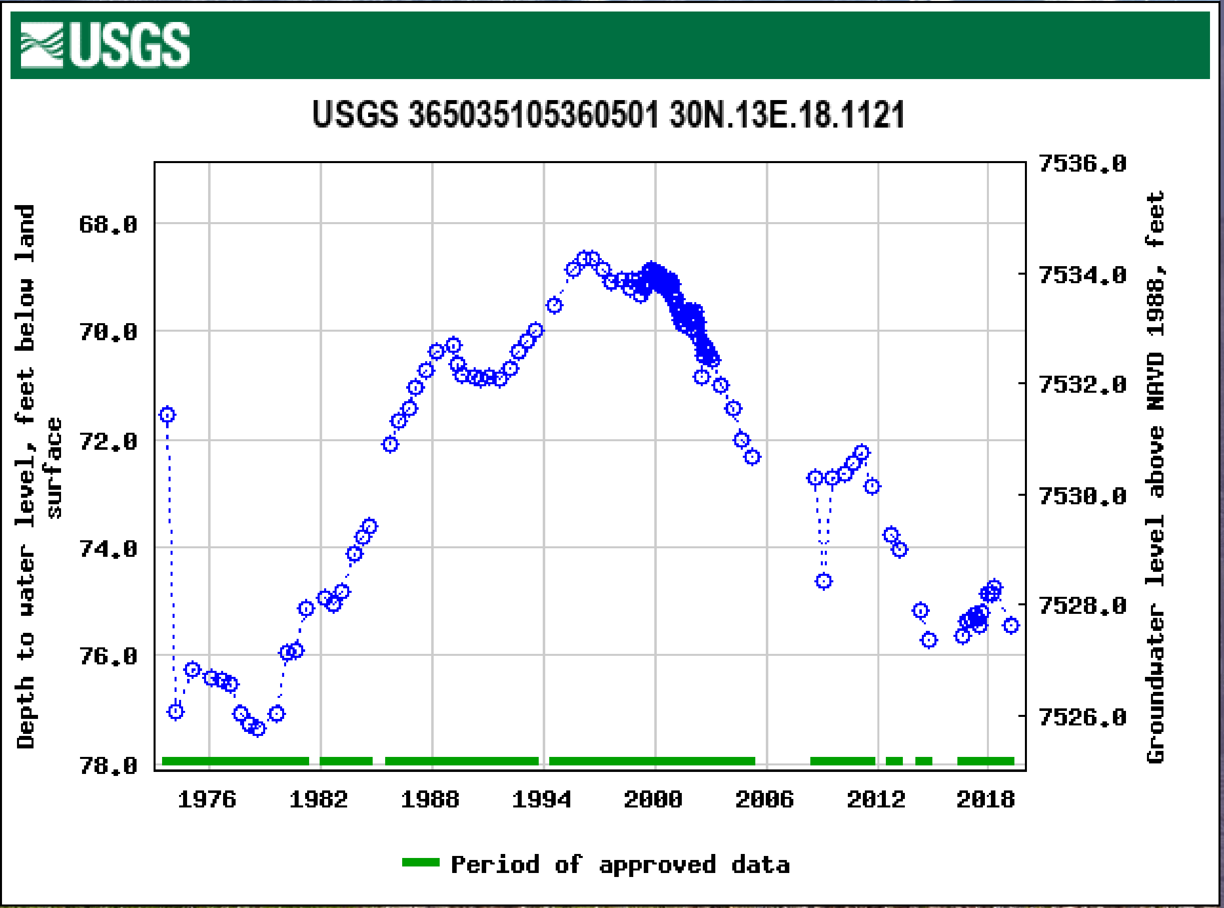


[4] Tick marks on the horizontal axis are for every 180 days to delineate a rough estimate of evapotranspiration and non-evapotranspiration seasons.

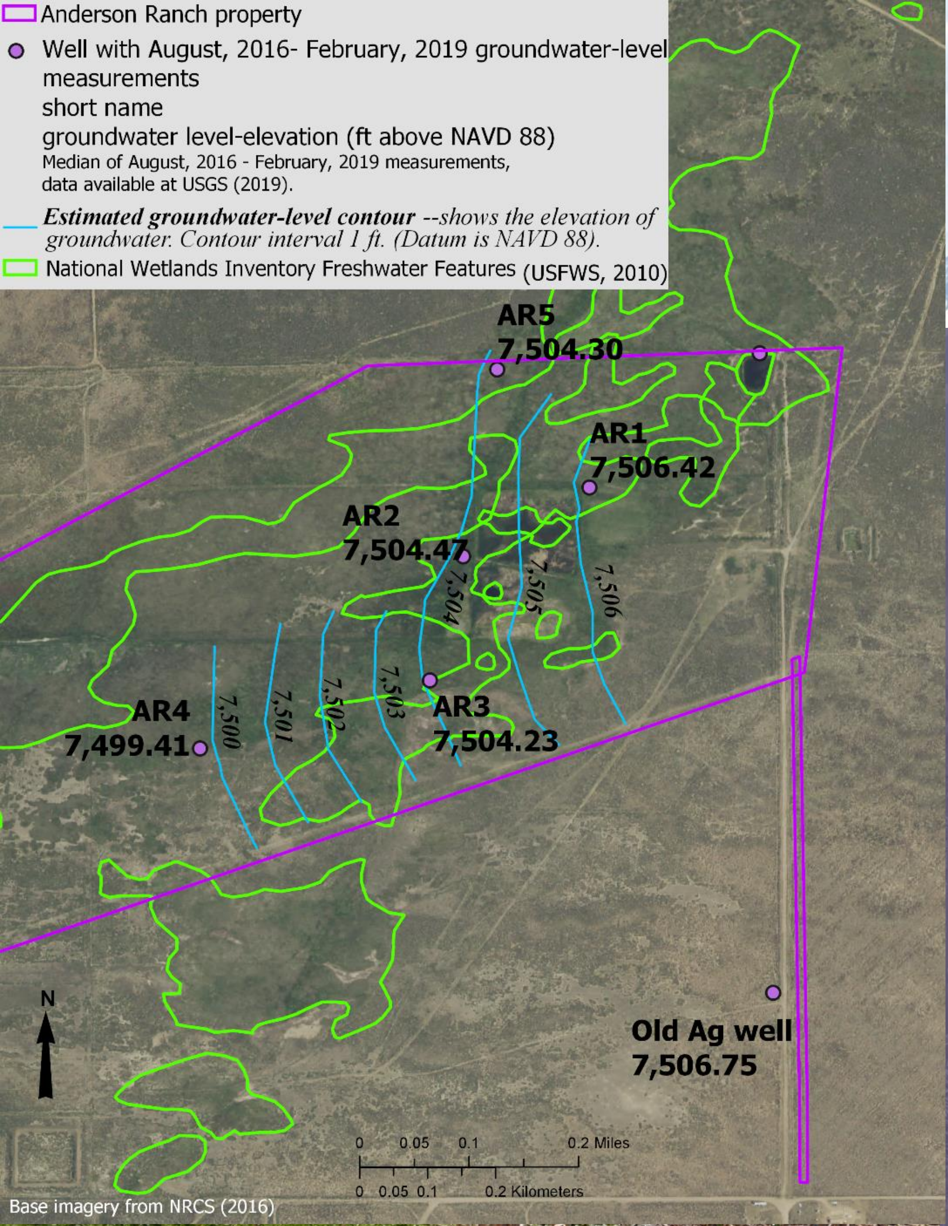
When compared with air temperature data from the nearby Cerro Weather Station (NOAA, 2019):

- Groundwater levels declined during warmer months and rose during cooler months.
- Daily groundwater levels fluctuated more during warmer months, as indicated by the difference between the maximum (max) and minimum (min) depth-to-water (DTW).
- Continued data collection and further time-series analysis could yield a better understanding of the seasonality of groundwater levels.

Groundwater-Level Data at Cerro Monitoring Well *(Groundwater-level data available at USGS [2019])*



- 46-year period of record at the Cerro monitoring well shows an upward trend in groundwater-levels during the 1980-2000 period and a downward trend in groundwater levels during 2000-2015 period.
- Precipitation and climate data analysis along with groundwater-level data analysis could yield information about correlations between precipitation, climate, and groundwater levels.



Groundwater-Level Elevations and Contours

- Hydraulic gradient within wetland area is about 20 feet per mile.
- Groundwater flows from northeast to southwest.
- Hydraulic gradient and groundwater flow direction did not change much with season.
- The old agricultural well outside of wetlands area has a similar groundwater-level elevation, despite a deeper well depth and greater distance from wetlands.

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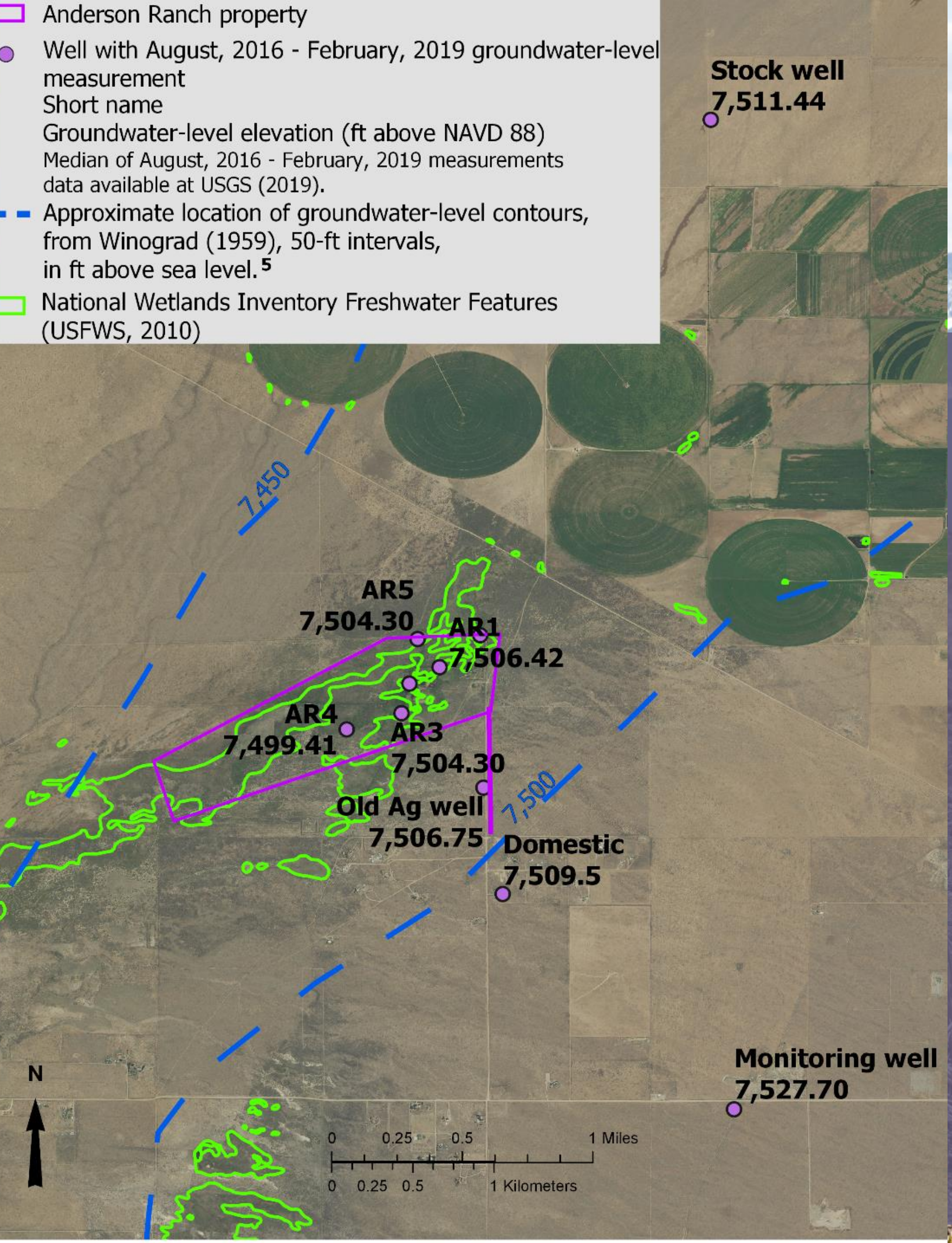

Groundwater-Level Elevations

- The Anderson Ranch property is located between the groundwater-level contours of 7,450 ft and 7,500 ft shown in plate 2 of Winograd (1959).
- Aug 2016 – Feb 2019 groundwater-level data show a similar groundwater-level elevation to Winograd (1959) contours.

[5]As described in Winograd (1959), groundwater-level contours are of the upper surface of the zone of saturation within alluvial sediments; semi-perched in part and artesian pressure surface in part. Assumed to be referenced to NGVD 29, which is likely less than 6 ft lower elevation than NAVD 88 (NOAA, 2017).

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Hydrologic Technician Kate Wilkins using a Van Dorn sampler to collect a water sample at the North Pond site, October 2016. Photograph by Robert Henrion, USGS.

Aqueous-Chemistry Sampling

(Aqueous-chemistry data available at USGS [2019] and in Appendix)

- Sites (locations shown on slides 4 and 8)

Surface water – North Pond
Piezometer – AR1
Stock Well

- Constituents

Field properties (temperature, specific conductance, dissolved oxygen, pH, turbidity, alkalinity), nutrients, major ions, trace elements, isotopes

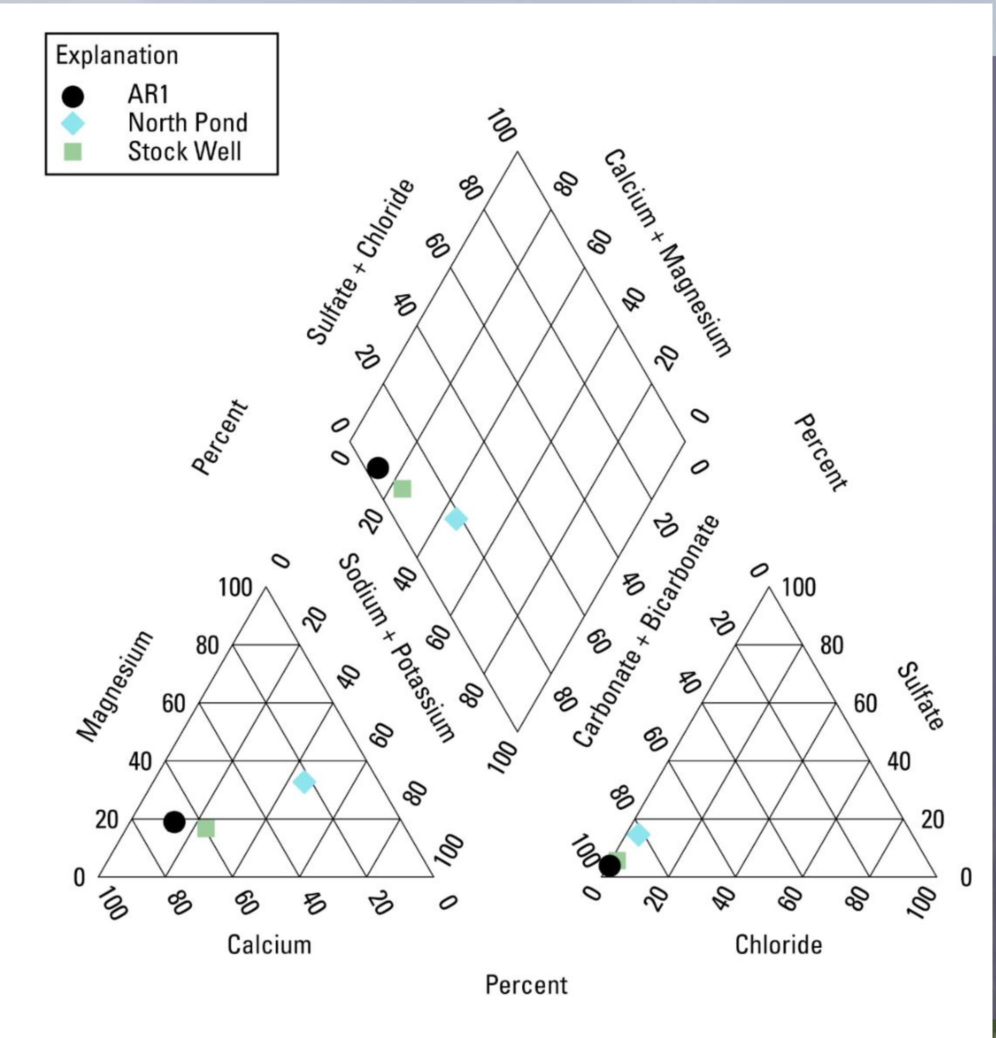
- Quality-control samples

Surface-water and groundwater blank, groundwater replicate

USGS

Aqueous Chemistry: Major Ions

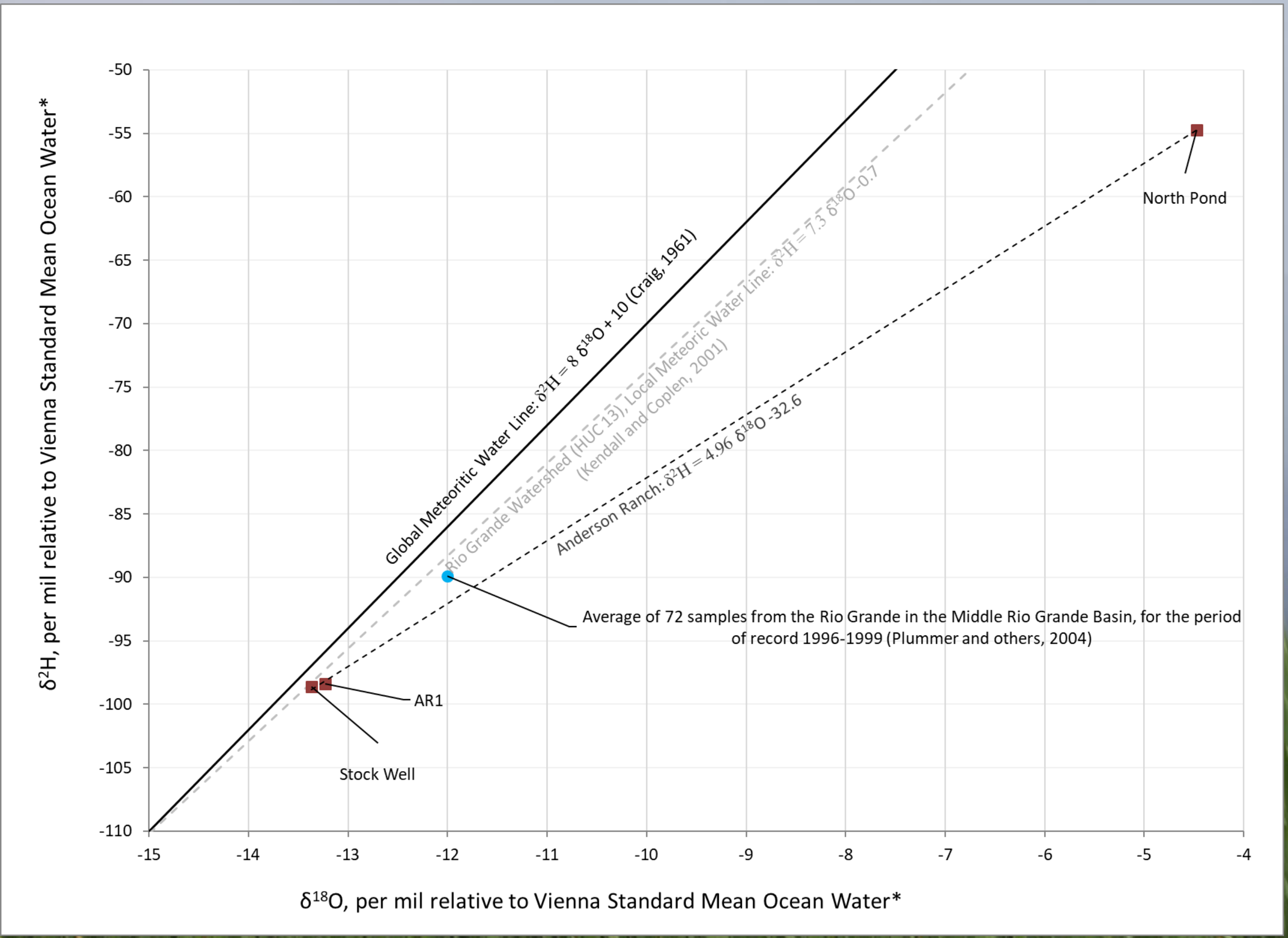
(Aqueous-chemistry data available at USGS [2019] and in Appendix)



- A piper diagram is a trilinear diagram useful for illustrating the hydrochemical facies of a water sample (Hem, 1985).
- Based on major ion composition, both groundwater samples are calcium-bicarbonate water type and the surface-water sample is a mixed-cation bicarbonate type.
- Possible explanations for water-type difference at the surface-water site:
  - An evaporative signal at the surface-water site.
  - Cation exchange occurring within clay layers (Hem, 1985).

Aqueous Chemistry: Stable Isotopes

(Aqueous-chemistry data available at USGS [2019] and in Appendix)



- The black dashed line connecting the Anderson Ranch sites is an estimated evaporative trend.
- The composition of the North Pond surface-water sample compared with the groundwater sample indicates evaporative fractionation.

*Please see the Appendix for an explanation of δ.

Aqueous Chemistry: Nitrate, Dissolved Solids, and Isotopes

(Aqueous-chemistry data available at USGS [2019] and in Appendix)

Parameter	North Pond	AR1	Stock Well
Nitrate as Nitrogen	< 0.040	3.39	1.34
δ* $^{15}N/^{14}N$ (per mil)	NA	5.61	5.13
δ* $^{18}O/^{16}O$, Nitrate water filtered (per mil) VSMOW[6]	NA	-2.25	-2.31
Dissolved solids dried at 180° Celsius (mg/L)	549	277	164
^{14}C percent modern carbon, normalized	NA	112.6	98.92
Tritium (pCi/L)	NA	19.3	12.7

Age-dating tracers ^{14}C and tritium indicate recent recharge to shallow and deeper groundwater systems.

*Please see the Appendix for an explanation of δ.
[6]Vienna Standard Mean Ocean Water
[7]2018 EPA drinking water standard, Maximum Contaminant Level (EPA, 2018).

- Nitrate levels at AR1 are higher than the surface-water sample and Stock Well nitrate levels, but still below the Federal drinking water standard of 10 mg/L.[7]
- Even low levels (greater than 2 mg/L) of nitrate as nitrogen have been found to affect aquatic organisms (Edwards and others, 2006; Edwards and Guillette, 2007).
- With further analysis, isotopes of nitrate could be used to identify the source of nitrogen at the wetlands.

Aqueous Chemistry Summary

(Aqueous-chemistry data available at USGS [2019] and in Appendix)

- Groundwater and surface-water samples showed similar ionic compositions and low dissolved solids.
  - Slightly higher dissolved solids and greater sodium and potassium concentrations in the surface-water sample indicates additional processes affecting the surface water.
- Radiocarbon and tritium activities measured in groundwater samples indicate that most of the groundwater is composed of recent recharge.
- Groundwater samples plotted on the Local Meteoric Water Line (Rio Grande Watershed [HUC 13]), and the stable isotope composition of the surface-water sample indicates evaporative fractionation.
- Nitrate levels were slightly elevated (greater than 2 mg/L) at AR1.

Vegetation Survey

USGS Botanist Joan Daniels and USGS Hydrologic Technician Alanna Jornigan identifying vegetation at the Anderson Ranch wetlands, August 2016. Photograph by Quan Dong, USGS.

To collect the baseline vegetation data of current characteristics and conditions of the wetland, a vegetation survey was conducted at the Anderson Ranch wetlands during August of 2016.

USGS

Vegetation Survey Classifications

Wetland indicator status, designation, and qualitative description are from Lichvar and others (2012). The wetland indicator status and designations were used to classify vegetation in the August 2016 survey.

Indicator status	Designation	Qualitative Description
Obligate (OBL)	Hydrophyte	Almost always occur in wetland.
Facultative Wetland (FACW)	Hydrophyte	Usually occur in wetland, but may occur in nonwetland.
Facultative (FAC)	Hydrophyte	Occur in wetland and nonwetland.
Facultative Upland (FACU)	Nonhydrophyte	Usually occur in non-wetland, but may occur in wetland.
Upland (UPL)	Nonhydrophyte	Almost never occur in wetland.

Vegetation survey methods were used to identify plant species and to determine wetland indicator status.

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Water Budget

$$\Delta S = P - ET + SW_{in} - R + GW_{in} - GW_{out}$$

ΔS = Change in storage

P = Precipitation

ET = Evapotranspiration

SW_{in} = Surface-water inflows

R = Runoff (surface-water outflows)

GW_{in} = Groundwater inflows

GW_{out} = Groundwater outflows

Where all units are volumes $[Length^3]$

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Assumptions Made in This Water Budget

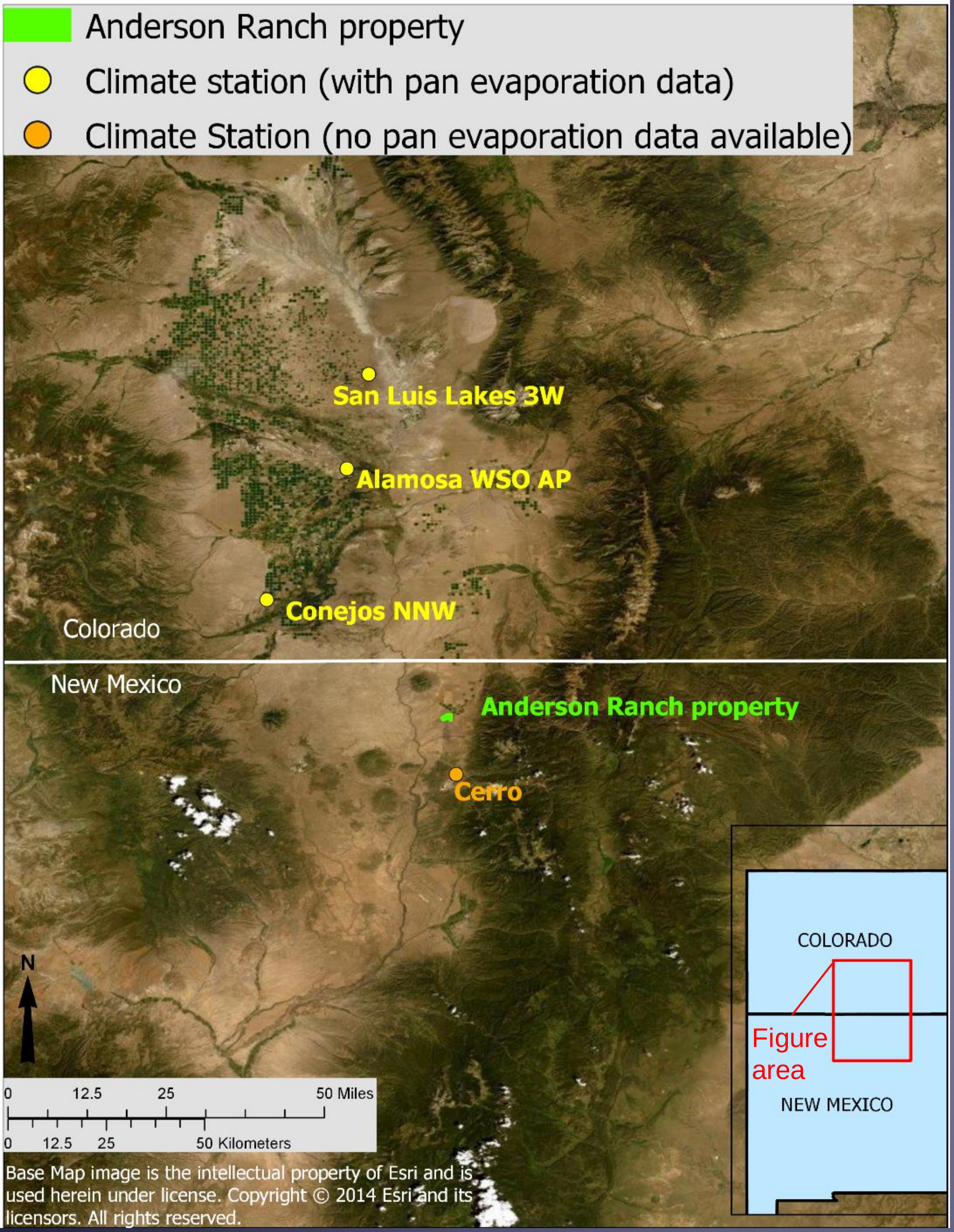
In order to estimate the Anderson Ranch wetland water budget in the absence of data for all components, several assumptions were made:

1. The SW_{in} and R terms were assumed to be zero because there had been no observed surface flows into or out of the wetlands.

2. The GW_{in} and GW_{out} terms were assumed to be equal because of a lack of subsurface-flow information, and therefore the difference was assumed to equal zero.

North Pond site, August 2016. Photograph by Amy Galanter, USGS.

USGS



Data for a Water Budget

Nearby climate stations provide precipitation and pan evaporation data (NOAA, 2019; WRCC, 2016).

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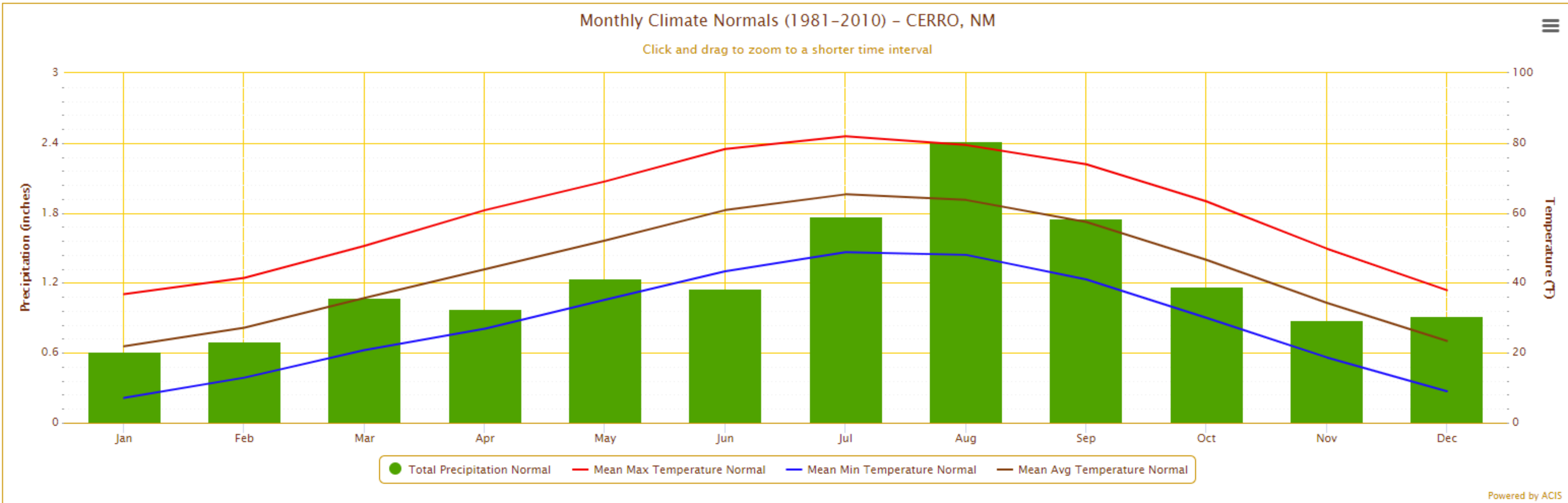
Precipitation

Station	Elevation (ft)	Period of record	Total Precipitation (inches)												
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ALAMOSA WSO AP (station 050130)	7533	1948-2019	0.29	0.27	0.43	0.54	0.64	0.52	1.09	1.18	0.85	0.65	0.38	0.35	7.13
CONEJOS 3 NNW (station 051816)	7907	1945-1960	0.41	0.24	0.24	0.63	0.82	0.62	1.55	1.57	0.58	0.8	0.25	0.21	7.44
SAN LUIS LAKES 3W (station 057433)	7536	1946-1955	0.14	0.12	0.12	0.40	0.76	0.45	1.16	1.32	0.66	0.55	0.14	0.09	5.42
CERRO (station 291630)	7650	1910 -2019	0.57	0.57	0.79	0.91	1.14	0.87	1.92	1.98	1.45	1.15	0.63	0.72	11.89



Total precipitation at Cerro, Alamosa WSO AP, Conejos 3NNW, and San Luis Lakes 3W climate stations and monthly climate normals at Cerro show that the greatest precipitation is during the monsoon season (July – September). Data from NOAA (2019).

Evapotranspiration (ET)

Data from WRCC (2016)

			Pan Evaporation (inches)												
Station	Elevation (ft)	Period of record	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ALAMOSA WSO AP	7533	1948-2005	--	--	--	7.06	9.01	10.08	9.16	7.81	6.4	4.39	--	--	53.91
CONEJOS 3 NNW	7907	1948-1960	--	--	--	6.3	7.14	7.67	7.41	6.87	7.19	5.74	--	--	48.32
SAN LUIS LAKES 3W	7536	1948-1955	--	--	4.5	6.07	8.51	9.88	8.49	7.77	6.57	4.53	--	--	56.32

- Pan evaporation is measured using an aboveground Class A evaporation pan and adjusted for precipitation inputs. Due to effects of radiation and heat exchanges between water in the pan and the side walls of the pan, pan evaporation is an overestimate of evaporation from ponded surface water or wet soil, and an adjustment using a multiplication factor of 0.70 or 0.80 is suggested (WRRC, 2016).

- Differences between pan evaporation and ET depend on many factors, including vegetation type. ET can be estimated by using the canopy crop coefficient (CCC) method, which uses the evaporative demand of a region and the plant-species-specific crop coefficient (Drexler and others, 2004).

- Further work to determine appropriate crop coefficients could yield estimates of ET at the Anderson Ranch wetlands.

Water Budget: Preliminary Conclusions

1. Based on evaporation estimates from pan evaporation rates at nearby climate stations, evaporative (and likely ET) demand exceeds precipitation inputs.

2. Climate variability could result in higher temperatures (Chavarria and Gutzler, 2018) and increased evaporative demand, creating a larger outward flux.

3. Drought conditions could result in decreased precipitation.

4. Increased groundwater pumping could result in decreases in subsurface inflows to the Anderson Ranch wetlands.

Information Required to Complete a Water Budget Analysis of the Anderson Ranch Wetlands

1. Subsurface inflows and outflows
   - Collect additional groundwater-level and surface-water-level data.
   - Build a groundwater/surface-water model to enable quantification of subsurface flows.
2. Historical and current extent of wetlands (for estimating the areal extent required for ET calculations)
   - Complete an analysis of historical wetland extent by using Landsat imagery.
   - Determine the current extent of wetlands by analyzing vegetation survey data and aerial imagery.
3. Crop coefficients for wetland vegetation
   - Use results of vegetation survey and complete a literature review to determine appropriate crop coefficients for ET calculation.

Conclusions

1. The Anderson Ranch wetlands are groundwater fed and may be the result of a regional topographic low and other geologic features.
2. The Anderson Ranch wetlands appear to be connected to other nearby wetlands.
3. Surface-water pond levels and groundwater levels at the Anderson Ranch wetlands fluctuate seasonally.
4. The hydraulic gradient in the Anderson Ranch wetlands area is from northeast to southwest.
5. The current groundwater-level elevation within the Anderson Ranch wetlands (about 7,500 ft) has not changed much since the 1950s (Winograd, 1959) as evidenced by groundwater-level contours.
6. Water maintaining the Anderson Ranch wetlands is modern and potentially vulnerable to climate variability. Deeper groundwater north of the wetlands (Stock Well) also has modern water.
7. Evapotranspiration is a main driver of the water budget at the Anderson Ranch wetlands.

USGS

Proposed Future Work

To better understand the source of water to the wetlands, the USGS proposes to:

- Continue data collection and upgrade equipment to allow for real-time data collection to provide data to cooperators and the public quickly and to prevent data loss due to equipment failures. Long-term data collection will allow for further trend analysis.
- Analyze temperature data at AR1.
- Analyze correlations between climate data and groundwater-level data.
- Conduct drone flights (NDVI,[8] infrared) to better characterize the extent of wetland vegetation and to examine groundwater-source locations.
- Analyze data from other sources, including precipitation and groundwater-level data from the NMBGMR,[9] as well as data from published reports and other agencies.
- Complete the water budget.

[8]Normalized difference vegetation index
[9]New Mexico Bureau of Geology & Mineral Resources

Proposed Future Work (cont.)

To better understand historical and future scenarios, the USGS proposes to:

- Analyze Landsat and historical imagery.
- Model climate change scenarios and analyze potential effects on the wetlands.
- Publish vegetation survey data and an interpretive report.

To support the creation of a watchable wildlife station, the USGS proposes to:

- Build interactive data collection infrastructure.
- Conduct outreach efforts.

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Appendix: Aqueous-chemistry data for North Pond, AR1, and Stock Well
*These data are also available at USGS (2019).

Abbreviations		Element Abbreviations	
NA	not applicable	C	Carbon
<	less than	H	Hydrogen
M	presence verified but not quantified	N	Nitrogen
E	estimated	O	Oxygen
		P	Phosphorus

Units	
Deg C	degrees Celsius
ft	feet
MDT	Mountain Daylight Time
mm/Hg	millimeters Mercury
mg/L	milligrams per liter
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NTRU	Nephelometric Turbidity Ratio Units
pCi/L	Picocuries per liter
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water
δ	delta, a measure of the ratio of stable isotopes within the sample. Delta is calculated from the ratio of the first stable isotope listed divided by the second stable isotope listed within the sample, divided by that same ratio within the standard, times 1,000. Below is an example equation for $\delta^{18}O$.
%	percent
‰	per mil

$$\left(\frac{\left(\frac{\delta^{18}O}{\delta^{16}O}\right)_{sample}}{\left(\frac{\delta^{18}O}{\delta^{16}O}\right)_{standard}} - 1 \right) x\ 1000\ ‰$$

Appendix (continued): Aqueous-chemistry data for North Pond, AR1, and Stock Well
*These data are also available at USGS (2019)

Constituent	365210105364608 North Pond	365204105365501 AR1	365353105360101 Stock Well
Site Information			
Local identifier	30N.12E.01.1422	30N.12E.01.1414	31N.13E.30.114 (Projected)
Latitude (Decimal degrees, NAD 83)	36.86958888	36.86783056	36.89818611
Longitude (Decimal degrees, NAD 83)	-105.6129889	-105.6153	-105.6002472
Well depth (ft below land surface)	NA	27	210
Screen depth (ft below land surface)	NA	22-27	110-210
Elevation (ft above NAVD 88)	7515	7506.98	7565
Field Properties			
Sample date	10/24/2016	10/25/2016	10/25/2016
Sample time (MDT)	14:00	10:00	14:00
Average depth to water [2016-2019] (ft below land surface)	NA	0.51	53.5
Temperature (deg C)	10.5	9.7	11.9
Barometric pressure (mm/Hg)	589	583	581
Specific conductance, at 25 deg C (µS/cm)	864	582	257
Dissolved Oxygen (mg/L)	10.3	5.2	7.6
Dissolved Oxygen (% of saturation)	120	60	92
pH, field (standard units)	8.3	7.5	7.6
Air temperature (deg C)	23.9	NA	NA
Turbidity (NTRU)	NA	1.6	6.3
Carbonate, inflection point titration (mg/L)	3.1	0.4	0.1
Bicarbonate, inflection point titration (mg/L)	369	335	126
Alkalinity (mg/L as Calcium Carbonate)	308	276	104

Appendix (continued): Aqueous-chemistry data for North Pond, AR1, and Stock Well
*These data are also available at USGS (2019).

Constituent	365210105364608 North Pond	365204105365501 AR1	365353105360101 Stock Well
Nutrients/Organics			
Total Nitrogen (mg/L)	< 1.0	3.5	< 1.4
Organic Nitrogen (mg/L)	< 0.97	< 0.07	< 0.07
Ammonia ($NH_3 + NH_4^+$) as N (mg/L)	< 0.01	< 0.01	< 0.01
Ammonia as NH_4^+(mg/L)	< 0.013	< 0.013	< 0.013
Ammonia + Organic Nitrogen as N (mg/L)	0.97	0.07	< 0.07
Nitrite as N (mg/L)	< 0.001	< 0.001	< 0.001
Nitrate as N (mg/L)	< 0.040	3.39	1.34
Nitrate + Nitrite as N (mg/L)	< 0.040	3.39	1.34
Orthophosphate (mg/L)	< 0.012	0.05	0.084
Orthophosphate as P (mg/L)	< 0.004	0.016	0.028
Phosphorus (mg/L)	< 0.02	0.05	0.02
Organic Carbon, unfiltered (mg/L)	13.9	9.8	< 0.7
Organic Carbon, filtered (mg/L)	12.4	0.95	0.44
Major Ions			
Calcium (mg/L)	44.6	87.0	31.7
Magnesium (mg/L)	39.9	14.9	5.39
Sodium (mg/L)	98.8	20.0	13.6
Sodium, fraction of cations (% in equivalents of major cations)	43	13	22
Potassium (mg/L)	8.67	2.27	1.58
Chloride (mg/L)	25.3	2.50	3.94
Sulfate (mg/L)	131	31.8	16.0
Iodide (mg/L)	0.009	0.001	0.001
Bromide (mg/L)	E 0.431	0.066	0.069
Fluoride (mg/L)	0.66	0.17	0.32

Appendix (cont.): Aqueous-chemistry data for sites North Pond, AR1, and Stock Well
*These data are also available at USGS (2019).

Constituent	365210105364608 North Pond	365204105365501 AR1	365353105360101 Stock Well
Trace Elements			
Silica as Silicon dioxide (mg/L)	5.84	23.4	22.9
Arsenic (µg/L)	1.1	0.57	0.21
Barium (µg/L)	77.8	146	56.5
Boron (µg/L)	83	8.0	11
Iron (µg/L)	9.5	7.7	13.0
Manganese (µg/L)	2.87	2.51	1.19
Strontium (µg/L)	404	474	224
Aluminum (µg/L)	6.9	< 3.0	< 3.0
Lithium (µg/L)	31.6	9.20	3.04
Isotopes			
$\delta^{13}C$ (‰) VPDB	NA	-15.08	-11.82
^{14}C (% modern carbon, normalized)	NA	112.6	98.92
^{14}C Counting error (% modern carbon)	NA	0.260	0.280
$\delta\ ^{2}H/^{1}H$ (‰) VSMOW	-54.70	-98.40	-98.60
$\delta\ ^{18}O/^{16}O$ (‰) VSMOW	-4.47	-13.23	-13.37
$\delta\ ^{15}N/^{14}N$ (‰)	NA	5.61	5.13
$\delta\ ^{18}O/^{16}O$, nitrate water filtered (‰)	NA	-2.25	-2.31
Tritium (pCi/L)	NA	19.3	12.7
Other			
pH, lab (standard units)	8.3	7.9	7.8
Carbon dioxide, unfiltered (mg/L)	2.7	18	5.4
Hardness, water, as calcium carbonate (mg/L)	276	279	NA
Hardness as bicarbonate (mg/L)	276	279	102
Dissolved solids dried (mg/L)	549	277	164
Dissolved solids sum (mg/L)	E 540	363	164