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Middle Rio Grande Surface and Well Water Quality and the Health Implications to Humans

Juan Carlos Peña-Philippides

Middle Rio Grande Surface and Well Water Quality and the Health Implications to Humans

By

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The Degree of

Master of Water Resources

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I. Committee Approval

The following committee approves the Water Resources Professional Project report of Juan Carlos Peña-Philippides titled **Middle Rio Grande Surface and Ground Water Quality and the Health Implication to Humans** in fulfillment of a master's degree:

Dr. Floyd Frost (Chair) Date:

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Dr. Mark Stone Date:

II. Acknowledgments

I would like to thank:

- My committee: Dr. Kristine Tollestrup, Dr. Floyd Frost, Dr. Bruce Thomson, and Dr. Mark Stone for their patient guidance as I wrote my professional project and for their valuable knowledge and time;
- The entire Water Resources Department faculty at UNM for their support;
- Mrs. Miriam L. Walmsley, a classmate and collaborator, for providing me with historical well water quality data from the Middle Rio Grande;
- My family for their support of my ideas and beliefs while I was pursuing my master’s degree and for their understanding during the times I was absent so I could attend classes and field trips;
- The late faculty member and mentor Dr. Cliff Crawford for cultivating in many the passion of working for the benefit of nature and for understanding the evolution of The Middle Rio Grande and its ecosystems and how this work reflects the city we live in;
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- My parents for the sacrifice and support they provided long ago to ensure that I received the best education and to make me the critical-thinking person I am, who questions every aspect of life.

III. Abstract

This professional project reviews the water quality along The Middle Rio Grande in New Mexico from the Cochiti Dam to the town of Bernalillo to San Acacia. This project focuses on the quality of the surface and well water and its implications to human health.

The State of New Mexico Environment Department provided historical data of the well water quality in Albuquerque and the surrounding area. This project focuses on the analysis of chemical and microbiological testing in the areas of the North Valley, South Valley and Albuquerque Acres.

The Bosque Ecosystem Monitoring Program (BMEP) provided historical data that identifies surface and well water quality using a chemical and biological panel of testing.

The issue of well water in a state such as New Mexico is a major concern. For households served by private wells, wastewater treatment and disposal are usually done by septic and leaching systems. Sewage discharge from households that are close to one another could create a cluster of disease.

IV. Introduction

Parts of Albuquerque are considered semirural and rural communities (mainly the areas of the South Valley, North Valley, parts of the newly populated Westside and Albuquerque Acres). In these areas it was not cost effective to develop the proper infrastructure to provide clean water. This report summarizes the surface and ground water testing available and addresses the identification of the possible point sources of contamination for surface and ground water.

As described by Harter (2003) naturally occurring chemical and biological contaminants in surface and ground water are natural. However, human activity may be the most important factor for increasing point source pollution in the surface and ground water through increasing rates of percolation via leaching pipelines, septic tanks and non-point source pollution and by human deposition wastes from industrial, agricultural and other human activities (Harter, 2003)

The Environmental Protection Agency (EPA, 2003) reported that 15% of the United States population sources their only available water out of ground wells and springs. This report describes the implications of well housekeeping and how human impact can be negative to the water table (EPA, 2003).

As described by the Utton Center (2015), in New Mexico there are 160,000 domestic wells, and Albuquerque and Rio Rancho share 12% of the total domestic wells west of the Sandia Mountains. As described by Thomson (2000), the percolation of septic tanks and leaching systems might have a significant impact on the contamination of their own water tables.

The take home ideas are how, through non-point and point source pollution and through the lack of knowledge in a non-proactive population, over time the quality of groundwater can be depleted and can pose health concerns to certain populations in the semirural and rural

Albuquerque area. Protecting ground water resources is a major concern to make water last for generations to come and to promote a healthy environment in a sustainable way.

Many people from Albuquerque's South Valley and some from Albuquerque's North Valley live on a fixed income. They are unable financially to make changes to their onsite water treatment septic systems and leaching systems. This lack of maintenance promotes generation after generation of contamination of their own water table and creates a cluster of public health concerns. As described by Frost (1996), it could be hard to determine the levels of contamination and the risk factors associated with E. coli and total coliforms in the ground water table used for drinking. Healthy individuals might develop tolerance after long-term exposure.

The prevention of water borne diseases is of major importance to sustain a healthy population. One of the major causes of disease is the presence of fecal coliforms in water. The middle Rio Grande is a source of outbreak of waterborne diseases. The community uses the Rio Grande for boating, swimming and fishing, which increases the likelihood of encountering a waterborne illness, especially in the spring and summer.

As described by Tollestrup (2014), the risk of enteric parasite transmission is a concern that is associated with failing onsite water treatment systems. Population growth is inevitable, and with it the demand for clean water is an important factor to prevent waterborne illness (Tollestrup, 2014).

Giardia, cryptosporidium, Escherichia coli, fecal coliform and total coliform are examples of bacterium present in water that can impact the health of the community.

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VI. Methods

1. The Middle Rio Grande Basin

The Rio Grande is one of the most important rivers in the southwest United States and northern Mexico. The Rio Grande is 1,896 miles (3,051 km) long. It begins in the San Juan Mountains near Creede in southern Colorado and flows from north to south through the entire state of New Mexico, north of Texas and ends in the Gulf of Mexico. It is considered the fourth or fifth most important river in the southwest US.

Figure 1. Map of the Rio Grande. Source: Wikipedia (4)

The Middle Rio Grande is one of the most important water resources in the central part of New Mexico. In 1925, dams were created to either store or divert water for the central part of New Mexico. The dams include EL Vado, Cochiti and Elephant Butte to serve as water reservoirs, and Angostura, Isleta and Santa Acacia are diversion dams. The water is managed by the Middle Rio Grande Conservancy District established in 1925 to irrigate up to 89,652 acres (36,281 ha), including 30,000 acres (12,000 ha) of Native American land and water rights land.

2. Drinking Water and Waste Water in The Middle Rio Grande

The water supply for residents near the middle Rio Grande comes from two sources: surface water and ground water. These water sources are linked through the hydrologic cycle and are interconnected.

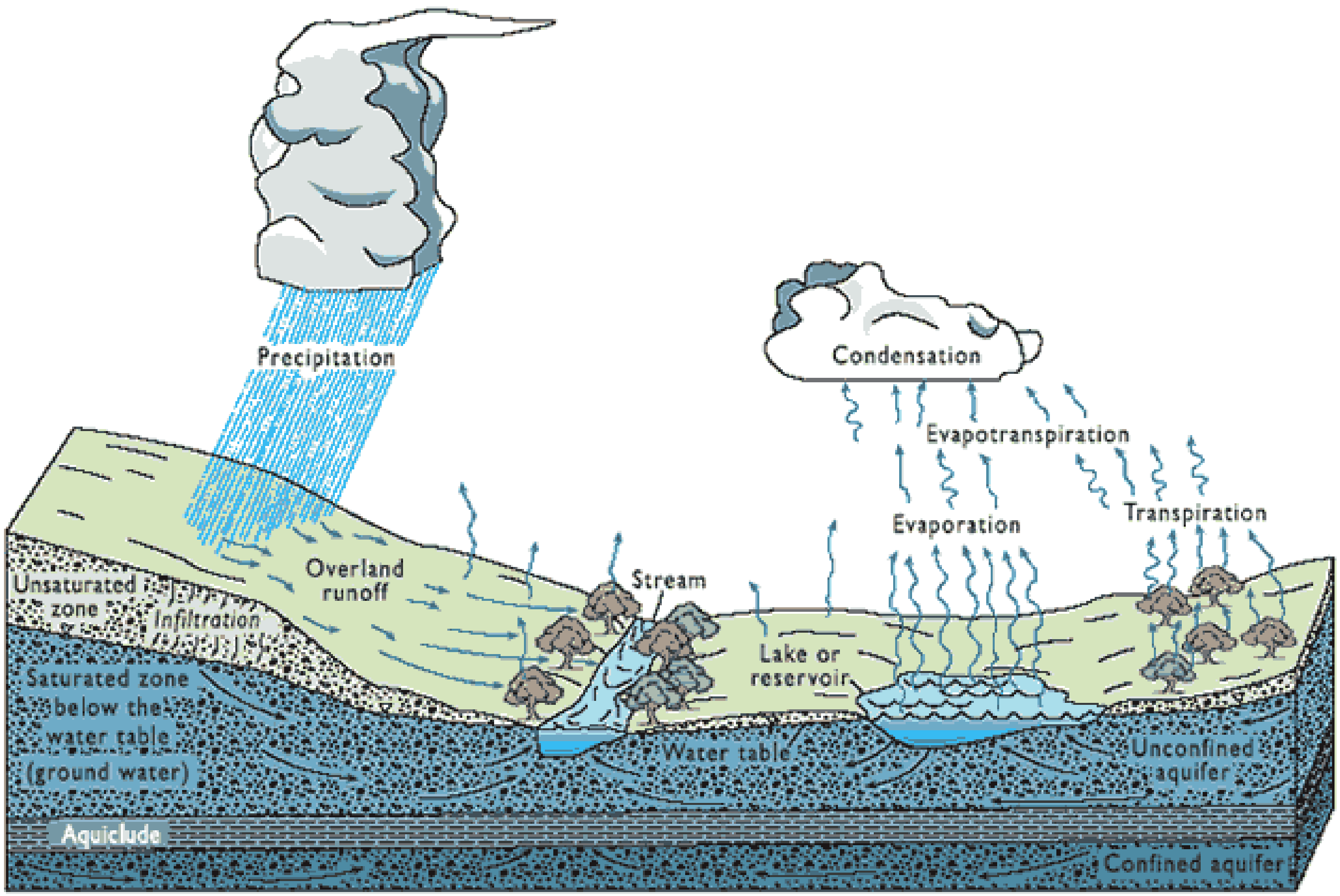

Figure 2. Source: New Mexico Bureau of Geology and Minerals Resources

The water waste management depends on the size and location of the population and its proximity to a large city uses a centralize water system. Nearly all residents of urban areas in this region are served by public water supply systems. The Middle Rio Grande Valley is composed of populations living in urban, suburban, rural and semirural conditions. Within the urban Albuquerque area there is a large number of people in the North Valley, South Valley and North

Albuquerque Acres living with decentralized water systems due to the distance from the urban center and a lack of infrastructure.

3. Centralized Versus Decentralized Water Systems

A centralized wastewater system is a system that provides the distribution of potable water to its residents. It is managed by a single treatment area that serves a large community. A centralized water distribution system is cost effective for reducing contaminants. For example, it uses chemical and biological to reduce water borne diseases and exposure to naturally occurring minerals that might have health effects on the population. The Albuquerque water treatment center is a publicly owned system as defined in the 40 CFR 122.2 (EPA, February 2003). The system uses costly city-wide infrastructure to supply water to all houses within the metro and some suburban areas. Also, it provides a sewage system from all households to the wastewater treatment center. The center treats the water to reuse for watering public land or to release into the Rio Grande. A centralized water treatment center is, in a way, environmentally friendly and more cost effective in highly-populated metropolitan areas.

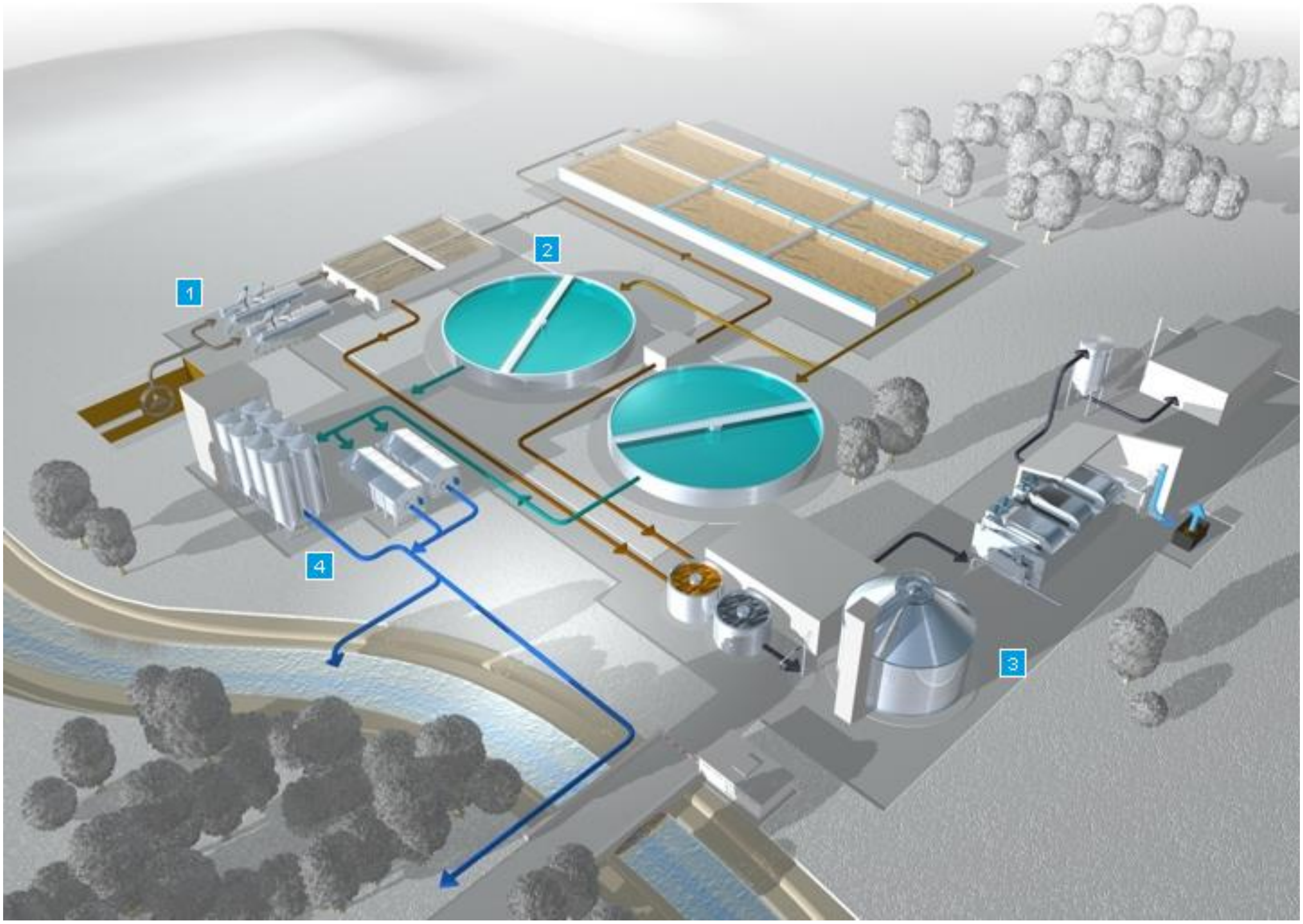

Figure 3. Huber Technology of a Centralized Waste Water System, 2017

In rural areas, on-site wastewater treatment and disposal systems are often used in lieu of wastewater collection and centralized treatment. These systems are typically used in small communities for small groups of residences or a single home, using a well to provide the water to a residence for basic use. The wastewater is usually processed using a septic system with a leaching system.

The Middle Rio Grande has water distribution disadvantages due to the suburban and semi-rural community structure, which lacks the infrastructure and resources to provide basic clean water to its residents.

Advantages of a Decentralized Water System

Decentralized water systems provide the following advantages:

- They are a feasible alternative when centralized systems are not available due to technical, economic or governmental reasons.
- They are relatively inexpensive and provide a variety of cost effective alternatives for people to choose from.
- They provide independence from a centralized water system.
- They can provide water faster than centralized drinking water treatment systems and can dispose of water faster than centralized waste water systems.

In addition, there is a reduced risk of contamination or poor maintenance and operation in smaller networks.

Disadvantages of a Decentralized Water System

The disadvantages of decentralized water systems are:

- They require self-responsibility from the households or communities.

- These types of technologies may be difficult to monitor, operate and maintain correctly.
- Each household needs to be knowledgeable of the system they use.
- Some systems are extremely expensive for a household or a small community.
- The systems requires biyearly or yearly testing.
- The systems require skills and knowledge most people are not familiar with.
- If not well maintained or monitored, the system may have negative health effects on the household or community.

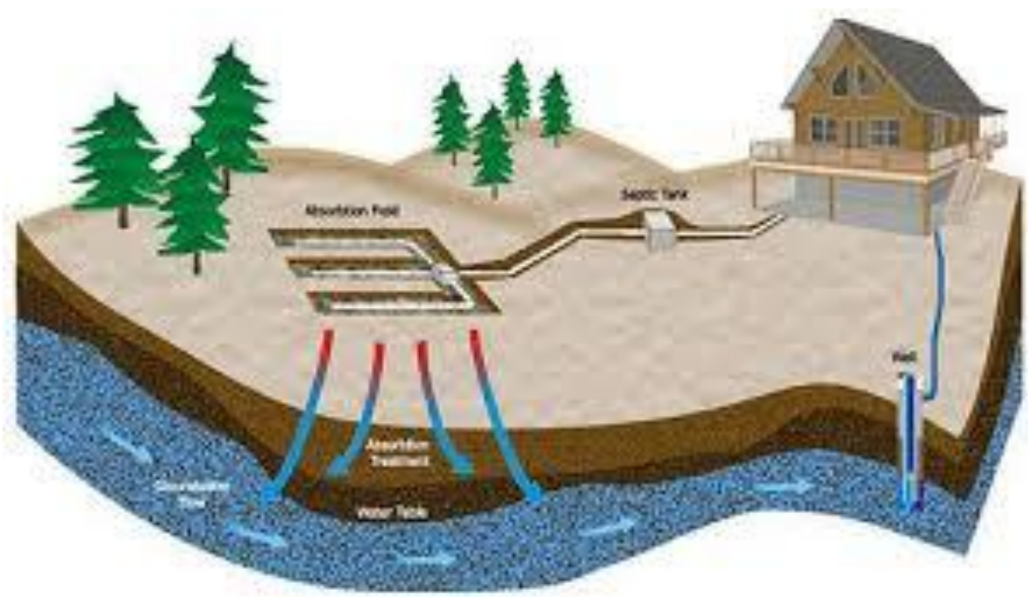

Figure 4. Pennington County, South Dakota Model of a Decentralized Water Treatment System

4. Bosque Ecosystem Monitoring Program (BEMP)

BEMP is the Bosque Ecosystem Monitoring Program established by Dr. Cliff Crawford at the University of New Mexico department of Biology. This program uses a science-based school youth program to connect the youngsters from 15 middle schools to study and understand the

Middle Rio Grande ecosystem, surface and ground water quality and its importance to the ecological system. BEMP is cosponsored by the Bosque School, and many other middle schools participate in the program's hands-on learning. BEMP was established in 1996, and with its 21 years of environmental enrichment covers 174 miles of the Bosque and 32 environmental sites from Ohkay Owingeh Pueblo (6-7 miles north of Española, NM) to Sandia Pueblo (north of the Town of Bernalillo) and south to Lemitar, NM (which is 6 miles north of Socorro, NM). (Please see Figure 5 for a map of the BEMP sites.) The students from these schools are mentored by teachers, BEMP staff and UNM students. They collect and analyze data to understand the biomass of the river and the Bosque, to understand the quality of surface and ground water chemistry testing and analysis, testing water and air temperature precipitation, wood debris from fallen trees and vegetation population distribution along the Middle Rio Grande. As an undergraduate, and later as a graduate student, I was fortunate to participate in the Bosque internship with BEMP, and my focus was the surface and ground water quality chemistry along the Middle Rio Grande.

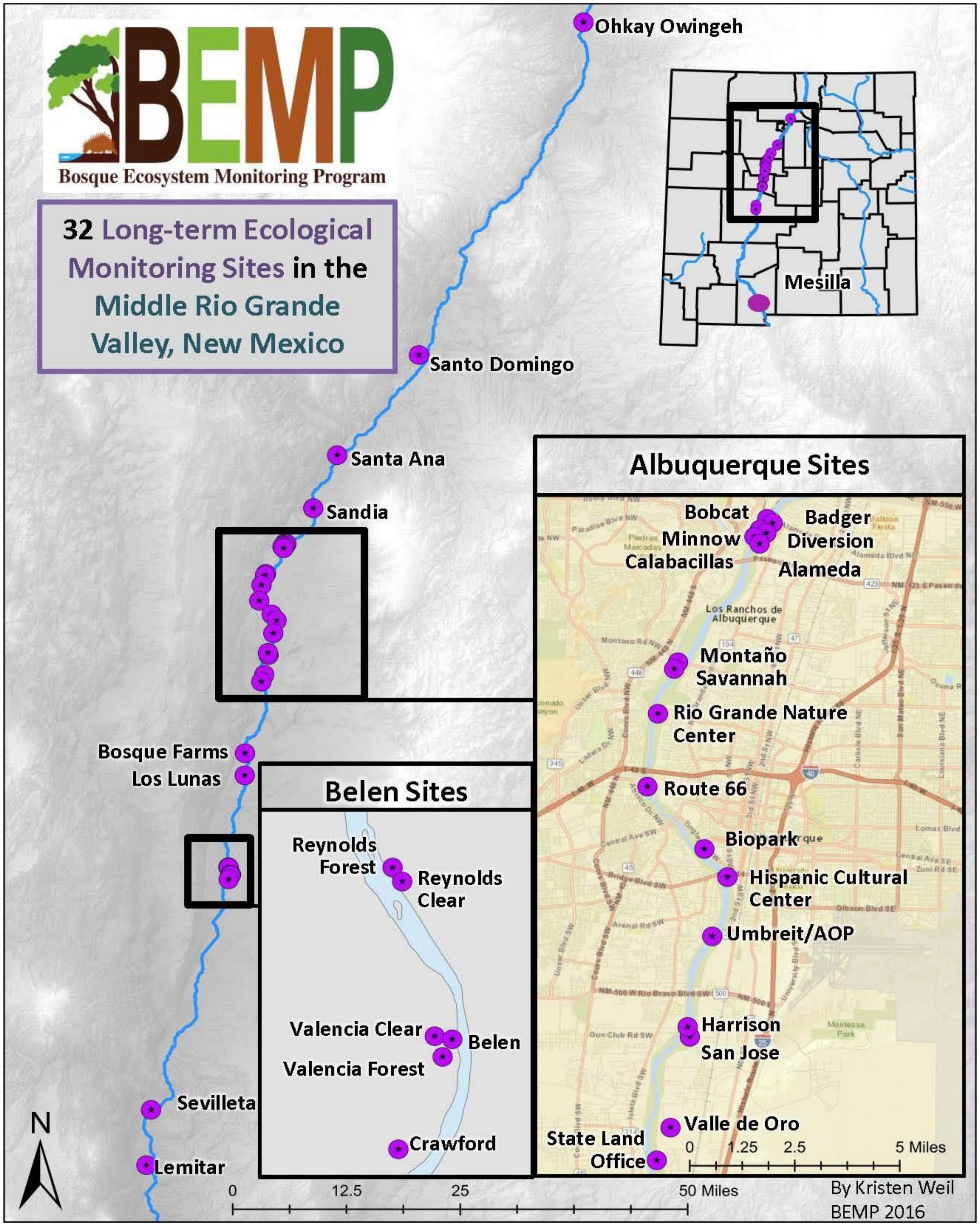

Figure 5. Map of 32 BEMP sites along the Rio Grande. Source: BEMP Report 2016

Table 1 provides a summary of BEMP sites, including establishment date, monitoring group, the geographical location of the site, and a brief description of vegetation or site history.

Site Name	Date Established	Monitored by	Grade (s)	County	GPS Coordinates (NAVD 88 decimal degrees)	Site Description
Alameda	Apr 1997	Bosque School	6	Bernalillo	35.1880506, -106.646919	olive understory; one of the most native (90%) sections of the bosque throughout ALbuquerque; oldest BEMP site
Albuquerque Overbank Project	established in 1998, BEMP took over in March 2014	La Academia de Esperanza HS	9-12	Bernalillo	35.04546, -106.6657	mature cottonwoods along east side of site, west side was lowered and experiences overbank flooding during high flows, lots of young cottonwoods and willows
Badger	Dec 2004 wells; Jul 2006 rest of site	Rio Rancho Cyber Academy	6	Bernalillo	35.19556856, -106.6416219	cottonwood-dominated bosque with elm sub-canopy; most wells have automated groundwater recording device as part of a collaboration between the US Army Corps of Engineers Urban Flood Demonstration and the University of New Mexico.
Belen	Feb 1998	Rio Grande Elementary	2	Valencia	34.6484315, -106.7377022	15 year-old cottonwoods, willows and Russian olives; experiences overbank flooding with high surface flow
BioPark	Feb 2007	Albuquerque Institute of Math and Science	7	Bernalillo	35.06688861, -106.7202778	medium sized cottonwoods over elm and Russian olive sub-canopy; wetland to the west of site, pond to the northwest of site
Bobcat	Dec 2004 wells; Aug 2006 rest of site	La Cueva	10 - 12	Bernalillo	35.19705633, -106.6439494	cottonwood-dominated bosque with a couple Gooding's willows; C well has automated groundwater recording device as part of a collaboration between the US Army Corps of Engineers Urban Flood Demonstration and the University of New Mexico.
Bosque Farms	Feb 2012	UNM interns	.	Valencia	34.848851, -106.714722	first site immediately south of Albuquerque; cottonwood-dominated bosque with some native grasses and willows on the east side, closer to the river
Calabacillas	Jan 2003	Volcano Vista HS	9-12	Bernalillo	35.19056822, -106.6491626	mature cottonwood-dominated bosque with little to no understory
Crawford	Sep 2008	UNM interns	.	Valencia	34.6375111, -106.7434661	strongly hydrologically connected, seep floods occuring at higher flows; northern section: cottonwoods in low-lying areas with saltcedar and kochia in higher areas, lots of cocklebur; southern section: yerba mansa, rushes and sedges, CFRP site
Diverson	Nov 2002	Bosque School	6	Bernalillo	35.191958, -106.6441893	sparse, pole-planted cottonwoods, few elm; very open and sandy site; DWDD located directly north of site;
Harrison	Spring 2003	Highland HS	9 - 12	Bernalillo	35.01505603, -106.6736953	located on a sand bar; covered with young cottonwoods, lots of willows, some seepwillow and some Russian olives; floods when river is high
Hispanic Cultural Center	fall 2001 started, finished Apr 2002	School on Wheels	10 - 12	Bernalillo	35.06881267, -106.6580575	cottonwood-dominated bosque with light understory of elm, Russian olive and Gooding's willows; tall wheatgrass getting denser each year
Lemitar	Sep 2002	Parkview Elementary	3	Socorro	34.16703188, -106.8899486	north of Socorro Nature Area; site outside the levee; xeric site; open landscape with a sparse cover of grasses, forbs, broom dalea, sand sage, and four-wing saltbush; handful of stunted cottonwoods and clumps of saltcedar
Los Lunas	Oct 1997	Los Lunas High School	9-12	Valencia	34.81236936, -106.7144580	large, older cottonwood overstory with mostly native understory of willow, New Mexico olive, wild currant, some Russian olive and saltcedar; yerba mansa covers much of the ground; experiencing more and more large branches falling; seep flood through a trough that runs through the center of the site

Site Name	Date Established	Monitored by	Grade (s)	County	GPS Coordinates (NAVD 88 decimal degrees)	Site Description
Mesilla	Jun 2011	John Paul Taylor	5	Doña Ana	32.248328, -106.821014	primarily kochia with sparse wood chip piles and some native forbs
Minnow	Dec 2002	Bandelier Elementary	5	Bernalillo	35.1931509, 106.646915	cottonwood-dominated bosque with a couple Gooding's willows, otherwise little understory; wells have automated groundwater recording devices as part of a collaboration between the USACE Urban Flood Demonstration and UNM.
Montaño	May 2004	Bosque School	6	Bernalillo	35.14528819, -106.6803699	contains a few cottonwoods; northern section covered in kochia and tumbleweed; middle of site thick with tree of heaven
Ohkay Owingeh	Mar 2002	OOCS	4-5	Rio Arriba	36.0618, -106.0761	located by an extensive constructed wetland; periodically flooded by rising wetland water and a correspondingly rising adjacent water table; few large cottonwoods,history of few large fires, mostly native shrubs, vines, forbs and grasses
Reynolds Cleared	Spring 2004	Infinity High School	9-12	Valencia	34.65966431, -106.7421328	fairly open site with young cottonwood canopy of pole plantings, with kochia and tumbleweed and also NM olive planted by river
Reynolds Forest	Spring 2004	School of Dreams Academy	9-12	Valencia	34.66054583, -106.7429525	cottonwood overstory with a saltcedar and Russian olive understory; yerba mansa patches in northern section of site, wild currant interspersed; site continues to experience cottonwood dieback leading to the high woody debris load (prior to clearing in Feb 2012) - post 2013 clearing: kochia understory with thick woodchips from exotic clearing
Rio Grande Nature Center	Jun 1997	Wilson MS	6	Bernalillo	35.12675286, -106.6884322	numerous thin cottonwoods with some Russian olive understory; lots of clover; very open site
Route 66	Sep 2004	Jefferson MS	6-8	Bernalillo	35.1006408, -106.6914783	natural seep or trough in the center of the site that is thickly vegetated with willows with some elm and Russian olive; cottonwoods line the trough; east and west sides of the trough cleared by Albuquerque Open Space every few years and are vegetated by kochia and tumbleweed
Sandia	Feb 2016	Mountian View ES	3	Bernalillo	35.255, -106.5907	high intensity burn (2012) site with many dead standing and down cottonwoods (few living), revegetated with seepwillow and native grasses; some sunflowers, silverleaf nightshade, and occassional Russian olive.
San Jose	Dec 2015	NACA	12	Bernalillo	35.012375, -106.6727833	site installed in USACE constructed willow swale. High flow channel runs through the center of the swale and innundates around 2,500 cfs. Mature cottonwoods on west side of site
Santa Ana	Jul 1999	Bernalillio MS	7	Bernalillo	35.34284, -106.5458	Dying cottonwood gallery forest with understory of kochia
Santo Domingo (Kewa)	Jan 2008	Santo Domingo Nat Res Dept	.	Sandoval	35.50989, -106.3896	sparse cottonwood overstory with scattered juniper, New Mexico olive and willow understory; lots of grasses; horse activity at site
Savannah	Mar 2000	Bosque School	6	Bernalillo	35.14285294, -106.6819814	grasses and forbs with pockets of overstory cottonwood stretching above an understory of Russian olive and saltcedar
Sevilleta	Spring 2003	Cottonwood Valley Charter School	4	Socorro	34.25834233, -106.8831845	southern boundary of Sevilleta NWR upstream of San Acacia Diversion Dam; dense woody vegetation of mostly Russian olive and saltcedar mixed with smaller cottonwoods and a patchy understory of coyote willow; site has high groundwater salinity and soils contain heavy clay; occasional saltgrass dominated swards occur among trees

Site Name	Date Established	Monitored by	Grade (s)	County	GPS Coordinates (NAVD 88 decimal degrees)	Site Description
State Land Office	June, 2014	The International School	3-4	Bernalillo	34.96785, -106.6856	moderately dense mature cottonwood overstory with two large channels dug through site intended for stormwater runoff drainage to the river; some trenches with permentant standing water supporting coyote willow stands. Much of site outside of ditches covered with tumbleweed and kochia
Valencia Cleared	Spring 2003	Belen HS	9-12	Valencia	34.64863444, -106.7391728	few cottonwoods, Gooding's willows, Russian olives with large patches of wolfberry and ground cover of yerba masa
Valencia Forest	Spring 2003	Belen Family Schools	3-6	Valencia	34.64716225, -106.738482	was uncleared and dominated by cottonwood, Russian olive, saltcedar with a saltgrass meadow at the south end of the site; after fire and clearings, now almost entirely covered by kochia and tumbleweed with small patches of yerba mansa and saltgrass
Valle de Oro	January 2014	South Valley Academy	9-12	Bernalillo	34.97895, -106.6801	site was installed ouside of levee system on a fallow farm field. No trees or shrubs, primarily various forb ground cover

Table No. 1. Descriptive BEMP Sites from BEMP Report, 2016.

5. BEMP Monitoring Data

The Bosque Ecosystem Monitoring Program (BEMP) collects a tremendous amount of data to understand The Middle Rio Grande basin. On a weekly and monthly basis, BEMP monitors the ground and surface water from the 32 sites to understand the health, changes and quality of the Bosque's ground and surface water.

BEMP's surface water monitoring collects the following data:

- Total Dissolve Solids TDS
- Conductivity
- Temperature
- pH

- Dissolved Oxygen DO
- Surface Water Flow
- E. Coli
- Total Coliforms
- Turbidity
- Nitrates
- Nitrites
- Sulfates
- Calcium
- Magnesium
- Potassium
- Sodium
- Chloride
- Bromide
- Phosphates

BEMP’s ground water monitoring collects the following data:

- Dissolved Oxygen DO
- Turbidity
- Conductivity
- Ground Water Depth
- Temperature
- pH

- Ammonia
- Sulfate
- Phosphate
- Bromide
- Chloride
- Nitrates

BEMP data collection from 2005 to 2015 was analyzed to help understand the quality of the ground and surface water along the Middle Rio Grande. A basic form was used to collect data. (See Table 2.)

Bosque Ecosystem Monitoring Program: **Monthly Monitoring**

Site Name:____________________ Collection Date: ____________________

Data Collected by:____

Comments:

Groundwater Monitoring		
Well	Depth from top of well to water table	Comments
North		
East		
Center		
South		
West		
Nearby Ditch		

Precipitation Monitoring				
Gauge	Net amount of precipitation (less oil)		Amount of oil added	Comments
Canopy	(mm)	(inches)		
Open	(mm)	(inches)		

Litterfall Collection		
Tub	Collected?	Comments (note if tubs were moved, turned over, etc.)
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		

White copy (original) to be turned in to: Kim Eichhorst, UNM, Department of Biology, Albuquerque, NM 87131
Yellow copy to be turned in to Site Representative
Pink copy to be retained in collector's files

Data entry: file:________________ entry by: ____________ date:__________

Table 2. Form used to summarize the Weekly or Monthly Monitoring that BEMP performs at the 32 sites.

BOSQUE ECOSYSTEM MONITORING PROGRAM

Groundwater Quality Monitoring Directions

Site:		Date:		Data Collectors:		
Time:				Barometric Pressure:		
Well:	W = depth to water (cm):			T = total well depth (cm):		T-W (cm):
Gallons purged	Air temp (C)	Turbidity (NTU)	DO (mg/L)	DO (% sat)	Conductivity (uS/cm)	pH
Obtain a water sample? Correct label on vial for sample?			Temp (C)		Temp (C)	Temp (C)

Site:		Date:		Data Collectors:		
Time:				Barometric Pressure:		
Well:	W = depth to water (cm):			T = total well depth (cm):		T-W (cm):
Gallons purged	Air temp (C)	Turbidity (NTU)	DO (mg/L)	DO (% sat)	Conductivity (uS/cm)	pH
Obtain a water sample? Correct label on vial for sample?			Temp (C)		Temp (C)	Temp (C)

Site:		Date:		Data Collectors:		
Time:				Barometric Pressure:		
Well:	W = depth to water (cm):			T = total well depth (cm):		T-W (cm):
Gallons purged	Air temp (C)	Turbidity (NTU)	DO (mg/L)	DO (% sat)	Conductivity (uS/cm)	pH
Obtain a water sample? Correct label on vial for sample?			Temp (C)		Temp (C)	Temp (C)

Site:		Date:		Data Collectors:		
Time:				Barometric Pressure:		
Well:	W = depth to water (cm):			T = total well depth (cm):		T-W (cm):
Gallons purged	Air temp (C)	Turbidity (NTU)	DO (mg/L)	DO (% sat)	Conductivity (uS/cm)	pH
Obtain a water sample? Correct label on vial for sample?			Temp (C)		Temp (C)	Temp (C)

Table 3. Sample of the Form used to describe the Various Analyses Performed to the Samples Obtained from the Monitoring Wells

River or Ditch Water Quality Sampling

AMAFCA/BEMP Storm Water Education Program
In-situ Water Quality Parameter Values and Environmental Observations

In-situ Water Quality Parameters (Units)	Sample Location	Sample Location	Sample Location	Sample Location
	BEMP SHIRK	BEMP SAVANNAH	BEMP BADGER	BEMP 550
lat/long				
Date (dd-mmm-yyyy)				
Time of site arrival (24 - hour clock)				
Time sample taken (24 - hour clock)				
Dissolved Oxygen (mg/L)				
Dissolved Oxygen (%)				
D.O. Water Temp (ºC)				
pH (SU)				
pH Water Temp (°C)				
Specific Conductance (µS/cm or mS/cm)				
Conductivity (µS/cm or mS/cm)				
Conductivity Water Temp (°C)				
Turbidity (NTU)				
Water Appearance				
Air Temp (°C)				
General Weather Conditions				
Upstream Waterfowl (#)				
Unusual Odors				
Watershed or In-stream Activities				
Specific Sample Information				
Missing Parameters				
MRGCDWater Sample(s) Taken?				
	pH 1:	pH 1:	pH 1:	pH 1:
	pH 2:	pH 2:	pH 2:	pH 2:
	pH 3:	pH 3:	pH 3:	pH 3:
Ice Bath Temperatures (°C)	notes	notes	notes	notes
Minimum:				
Maximum:				

Data collected by: Entered by: Verified by:

Table 4. Sample of Form used to describe the Various Analyses Performed to the Samples Obtained from Monitoring Ditches and Areas of the River

BOSQUE ECOSYSTEM MONITORING PROGRAM

River or Ditch Water Quality Sampling

Bosque Ecosystem Monitoring Program: **River Monitoring**

Collection Date: ____________ Collected By: ____________

Photo log	Comments
Station ID	
Upstream	
Downstream	
Left bank (E)	
Right bank (W)	
Additional	(high flow, disturbance, algal growth…)
Photo log	Comments
Station ID	
Upstream	
Downstream	
Left bank (E)	
Right bank (W)	
Additional	(high flow, disturbance, algal growth…)
Photo log	Comments
Station ID	
Upstream	
Downstream	
Left bank (E)	
Right bank (W)	
Additional	(high flow, disturbance, algal growth…)
Photo log	Comments
Station ID	
Upstream	
Downstream	
Left bank (E)	
Right bank (W)	
Additional	(high flow, disturbance, algal growth…)

Table 5. Form used to describe the Various Analyses Performed on the Samples Obtained from Monitoring Ditches and Areas of the River.

6. Bosque Ecosystem Monitoring Program (BEMP) Water Quality: Ground Water

Raw data from the BMEP were obtained to perform the historical analyses. The data showed an increase in bromide only at Sevilleta. Ammonia levels seemed to be increasing gradually from north to south and phosphate levels were gradually increasing from Alameda to Sevilleta. The overall level of nitrates was about 0.25-0.5 mg/L from Alameda to Belen with a twofold increase in Sevilleta. These levels of nitrates, phosphates and ammonia may indicate the use of fertilizers in the area and the ability of those fertilizers to travel to the water table, probably by evapotranspiration and water table recharge. The conductivity was a relative constant overall but increased in Sevilleta by fivefold. Turbidity in the ground water showed levels from 5-30 NTU, which is important to note. These are shallow monitoring wells with a depth of 15 meters, about 50 feet. Throughout the monitoring area, pH levels were normal. Dissolved oxygen (DO) showed anoxic levels, below 2 mg/L, indicating poor water quality to promote life. Although salinity was not tested, it can be hypothesized that levels of salinity might be high in the ground water. Using an average with the standard error, there might have been an increase to above 4 mg/L. Normal DO levels should be 4-8 mg/L. Conductivity in the ground water tested high at the southern part of the Middle Rio Grande, which correlates with the high levels of salts, such as bromide, sulfates, nitrates and chloride.

The next 13 figures (Fig. 6-a to Fig. 6-m) present the statistical analyses developed from the raw data for studying the ground water. These figures show the historical ground water quality from 2005-2015 as collected by the BEMP.

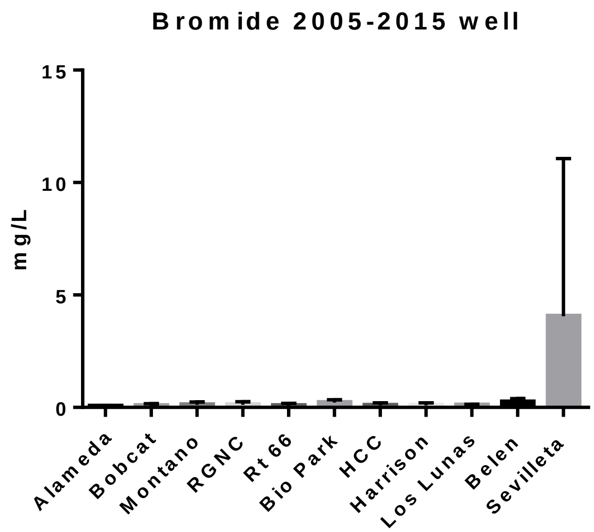

Figure 6-a. BEMP Bromide Well Levels, Middle Rio Grande

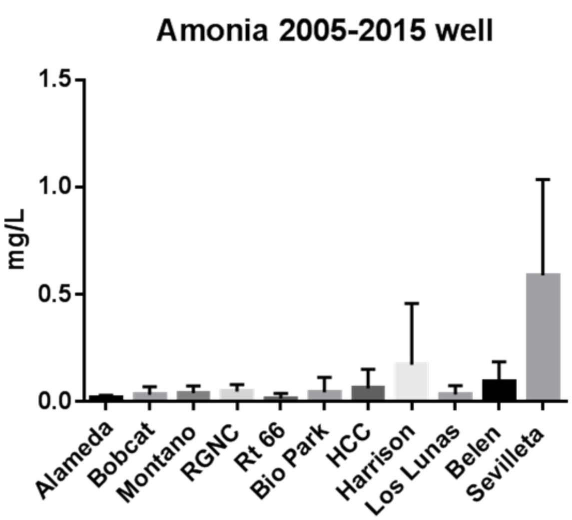

Figure 6-b. BEMP Ammonia Well Levels, Middle Rio Grande

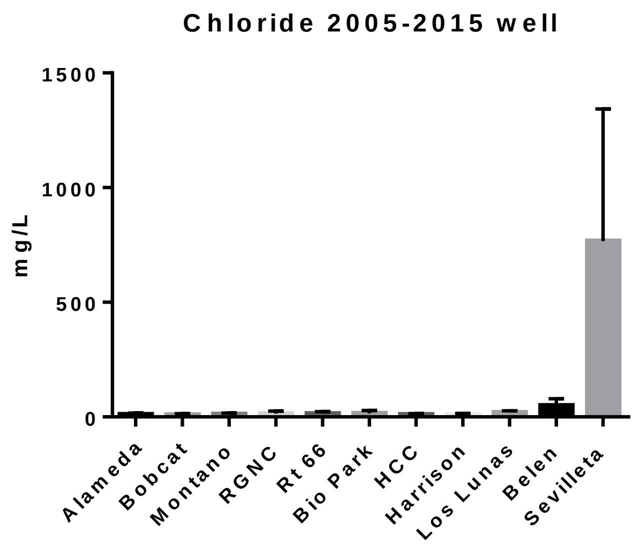

Figure 6-c. BEMP Chloride Well Levels, Middle Rio Grande

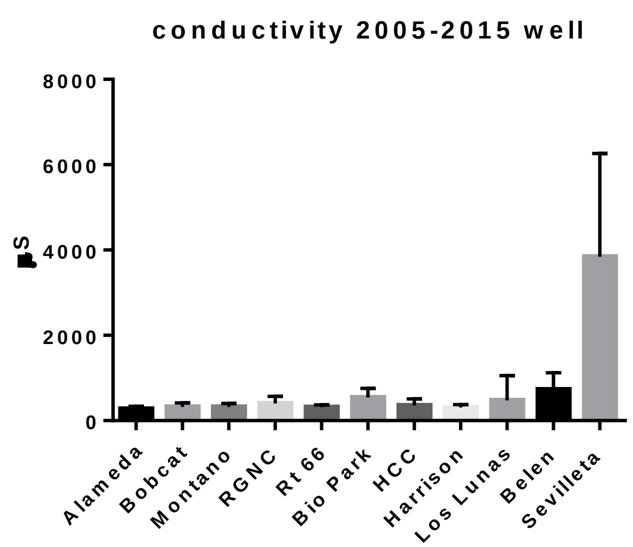

Figure 6-d. BEMP Conductivity Well Levels, Middle Rio Grande

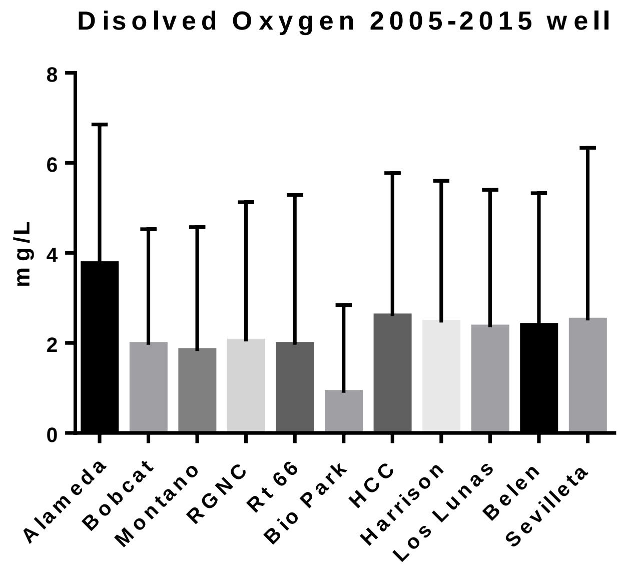

Figure 6-e. BEMP Well Dissolved Oxygen Levels, Middle Rio Grande

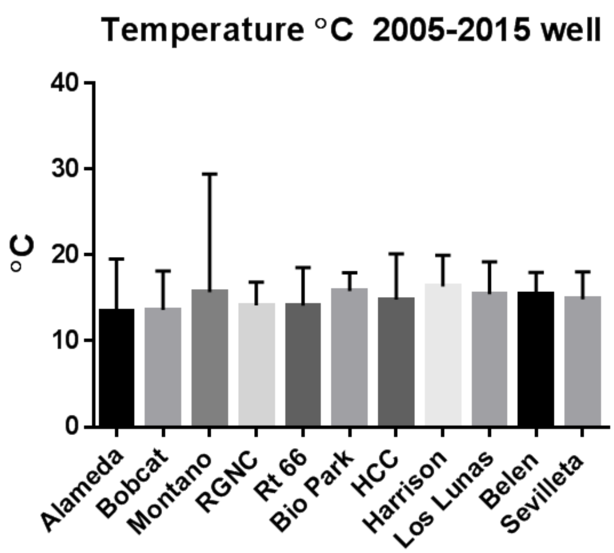

Figure 6-f. BEMP Temperature Well Levels, Middle Rio Grand**e**

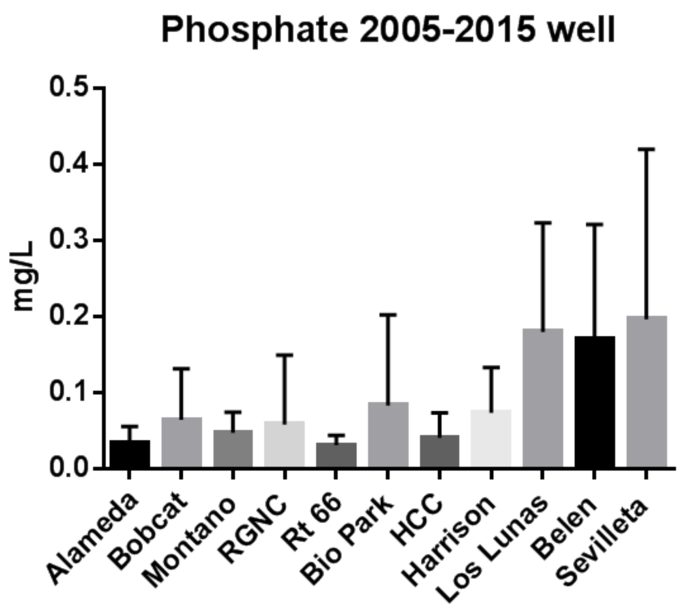

Figure 6-g. BEMP Phosphate Well Levels, Middle Rio Grande

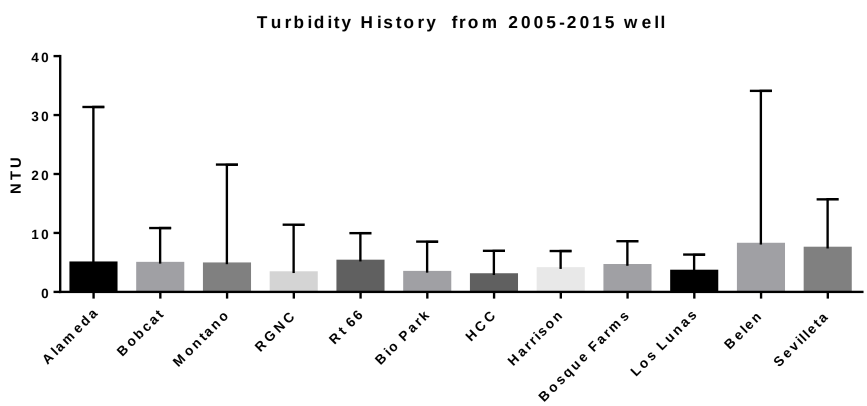

Figure 6-h. BEMP Turbidity Well Levels, Middle Rio Grande

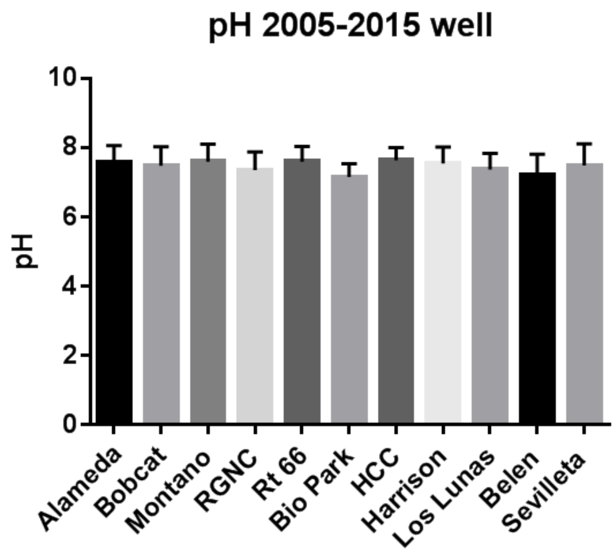

Figure 6-i. BEMP pH Well Levels, Middle Rio Grande

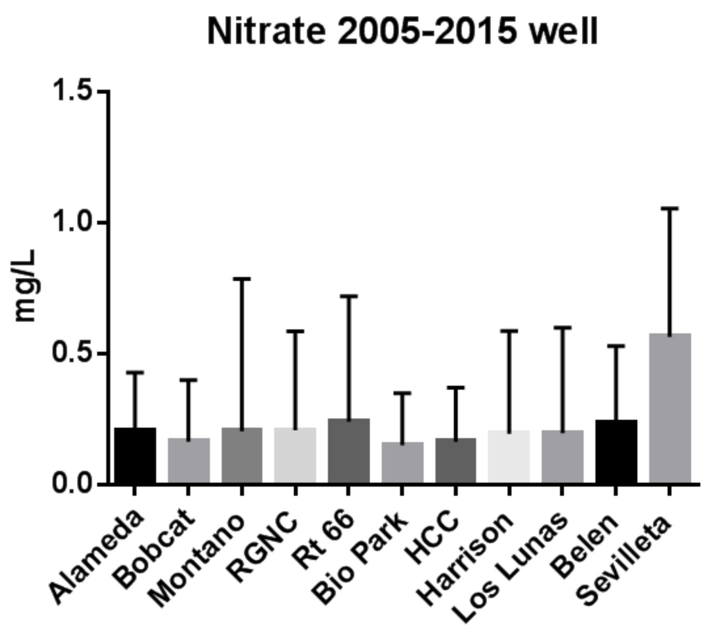

Figure 6-j. BEMP Nitrate Well Levels, Middle Rio Grande

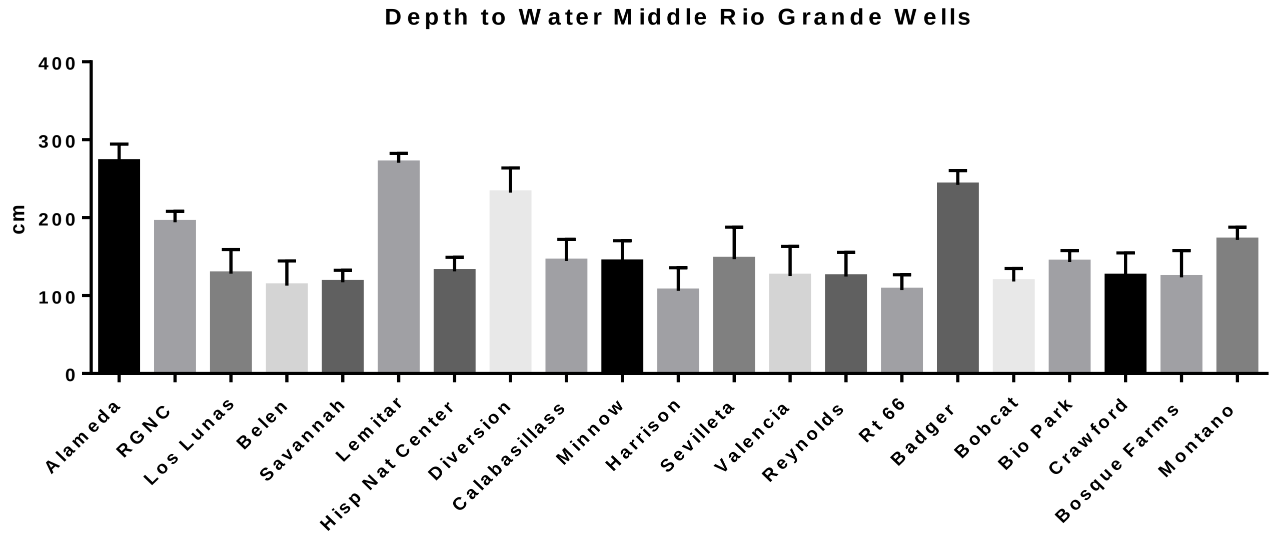

Figure 6-k. BEMP Depth to Water Well Levels, Middle Rio Grande

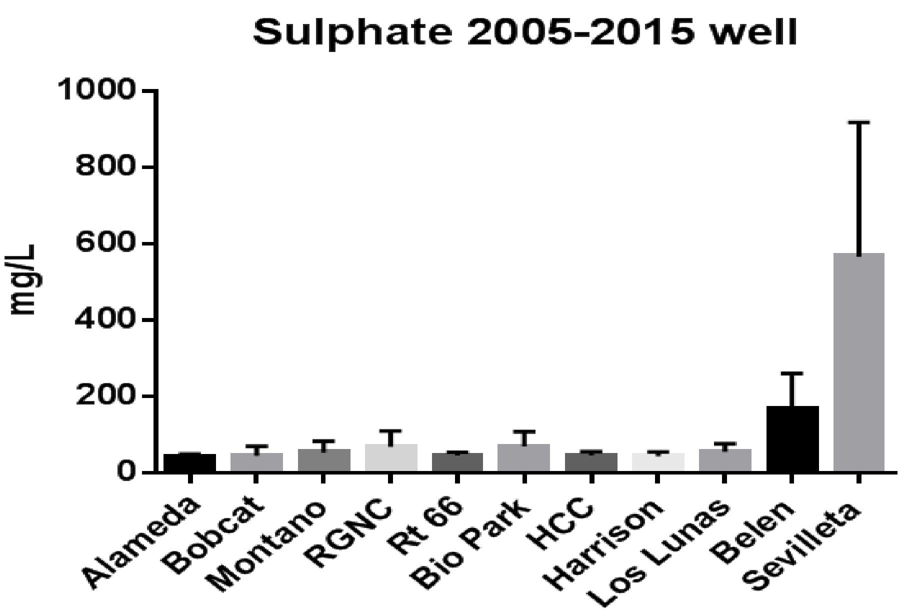

Figure 6-l. BEMP Sulphate Well Levels, Middle Rio Grande

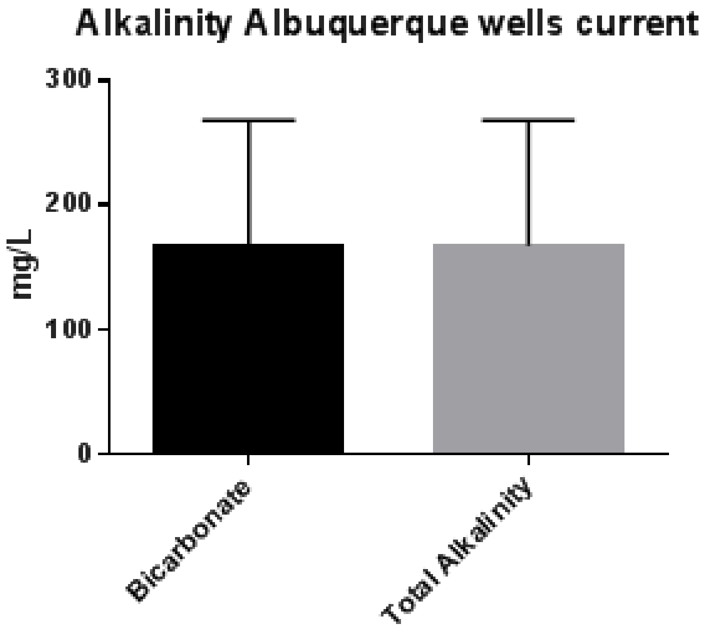

Figure 6-m. BEMP Alkalinity Well Levels, Middle Rio Grande

7. Bosque Ecosystem Monitoring Program (BEMP) Water Quality: Surface Water

Surface water was obtained from various monitoring points of sampling along the Middle Rio Grande from Alameda to Sevilleta. Various data analyses were performed to examine the surface water quality over a period of 15 years. The raw data were obtained from the BEMP to perform the historical analyses. The data were compiled from year-round monitoring for over 15 years. The data show that there was an increase in turbidity, especially during the rainy seasons, with about 1000 NTU with an average flow of 1000 cfs in all testing areas. Dissolved oxygen was in a normal range (from 6-9 mg/L), demonstrating a high water quality and fresh enough to promote life growth. Conductivity shows incrementally due to the presence of sulfates, calcium, magnesium and sodium in the surface water. This also indicates a heavy runoff from agricultural fields to the surface water. Total dissolved solids (TDS) were high, even during the dry seasons. These high deposits in the water may indicate high levels of turbidity. Specific conductivity ranged from 280-380 µS/cm to a high of 900 µS/cm. This indicating an increase in runoff from upstream agricultural activity, including phosphate, nitrates, magnesium, potassium, sodium, calcium, nitrates, chlorine and sodium.

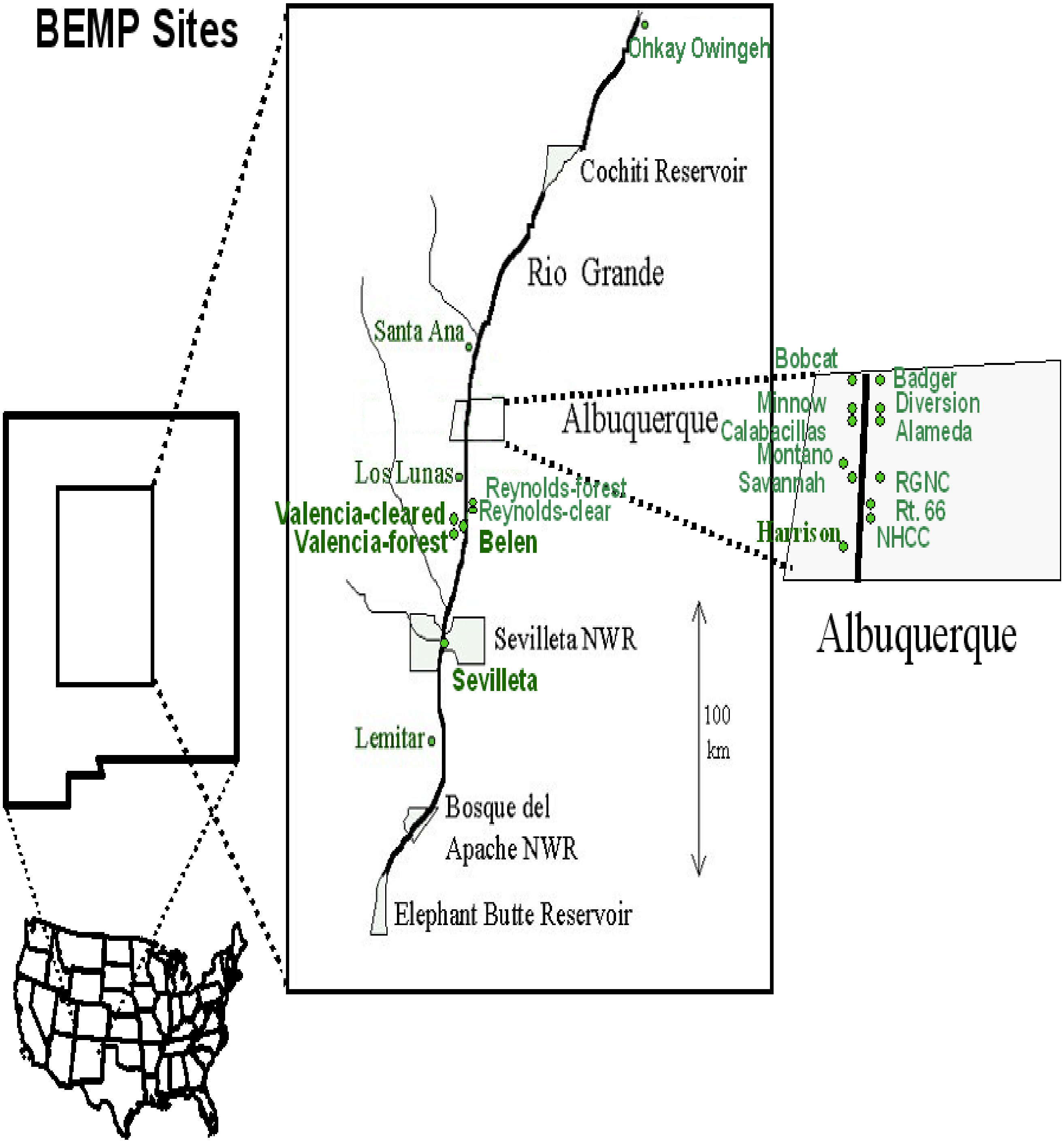

Figure 7. BEMP Map of Site Distribution, Albuquerque, BEMP Report 2004-2005

Figures 8-a through 8-h present the BEMP historical ground water quality data from 2005-2015.

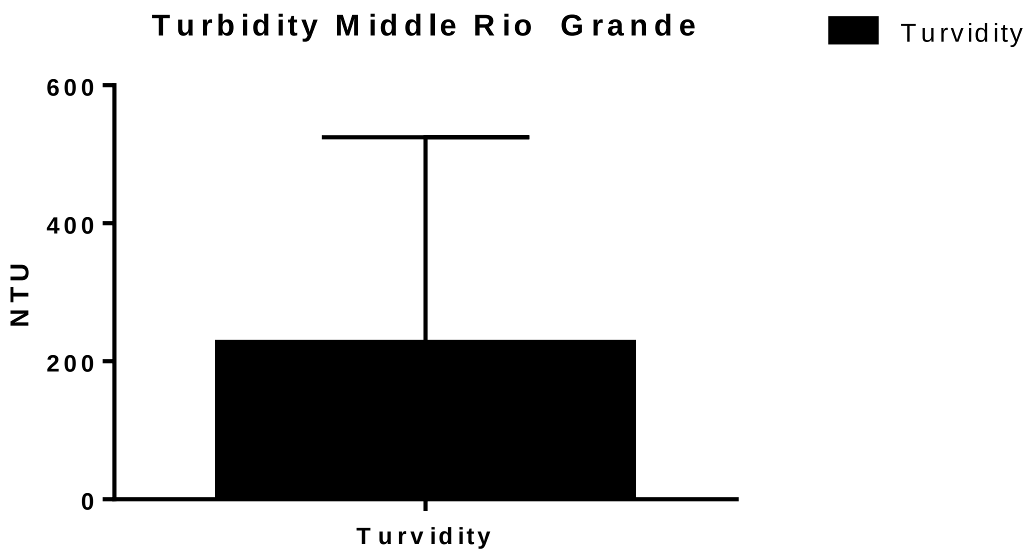

Figure 8-a. BEMP Turbidity Surface Levels, Middle Rio Grande

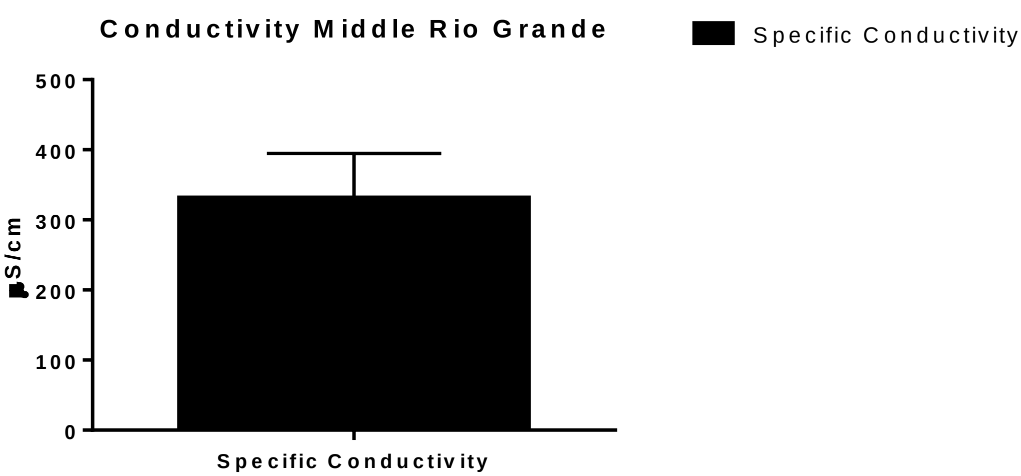

Figure 8-b. BEMP Conductivity Levels, Middle Rio Grande

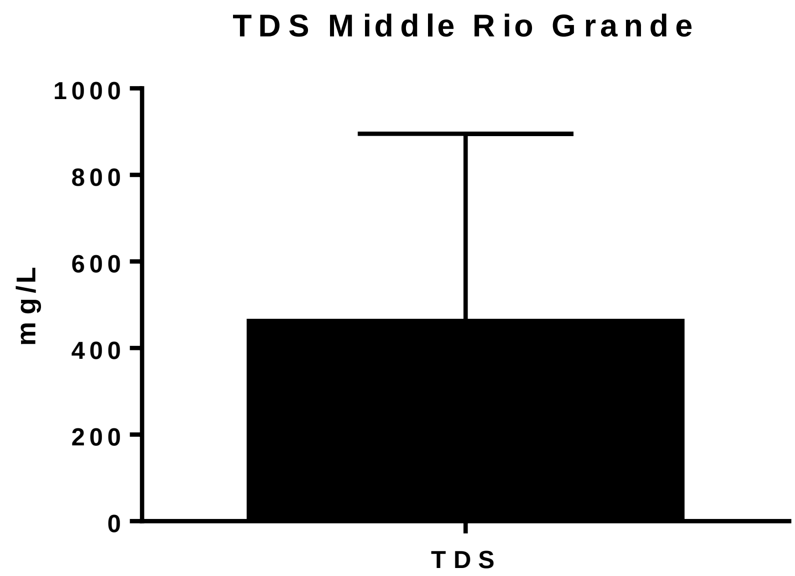

Figure 8-c. BEMP Total Dissolved Solids Surface Levels, Middle Rio Grande

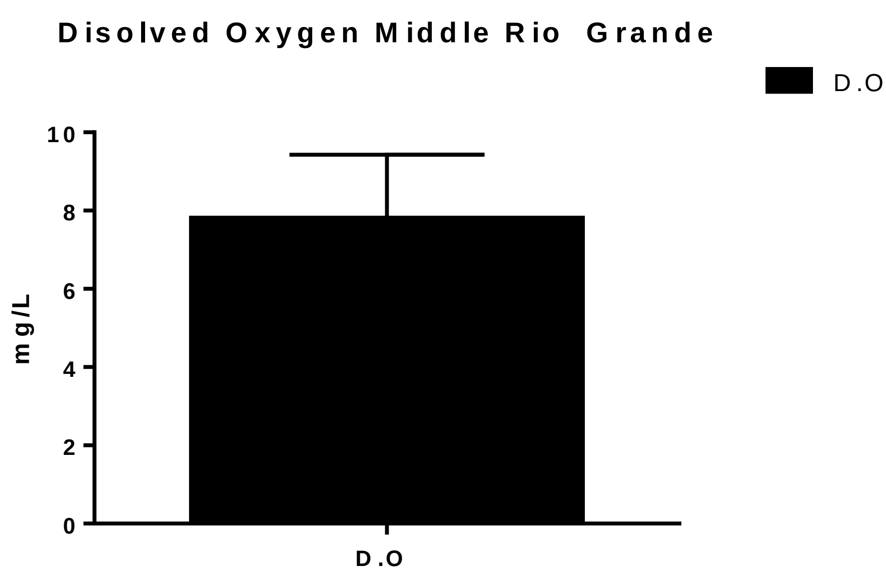

Figure 8-d. BEMP Dissolved Oxygen Surface Levels, Middle Rio Grande

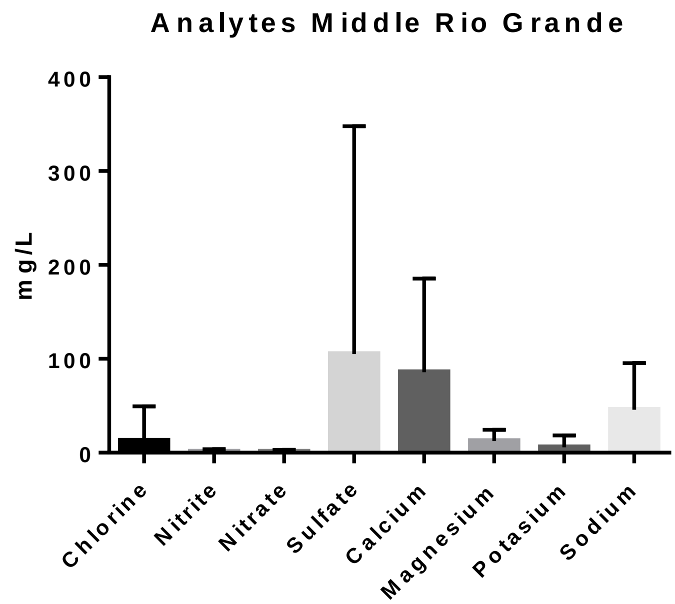

Figure 8-e. BEMP Analytes Surface Levels, Middle Rio Grande

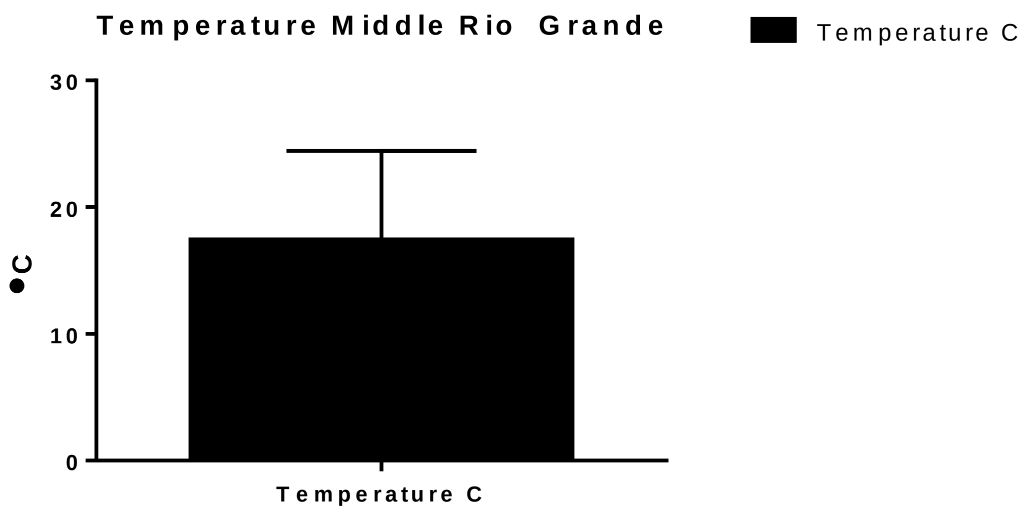

Figure 8-f. BEMP Temperature Surface Levels, Middle Rio Grande

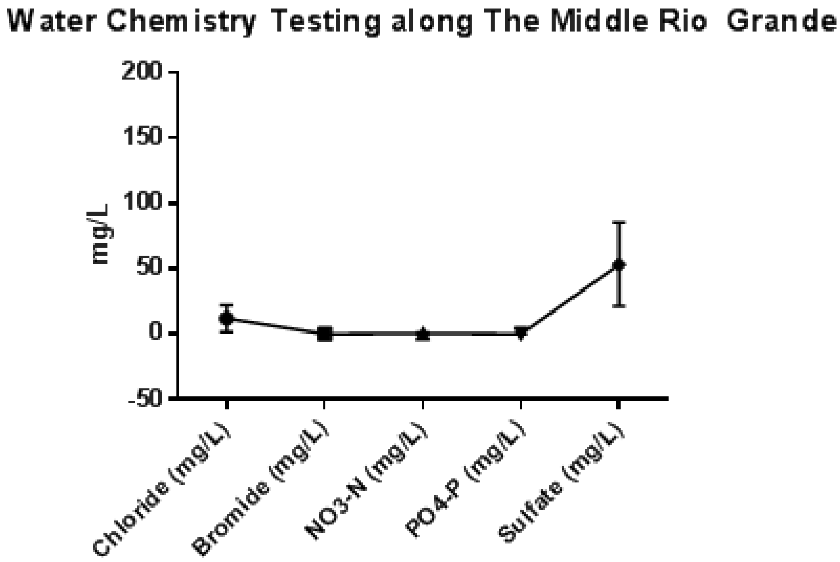

Figure 8-g. BEMP Water Chemistry Surface Levels, Middle Rio Grande

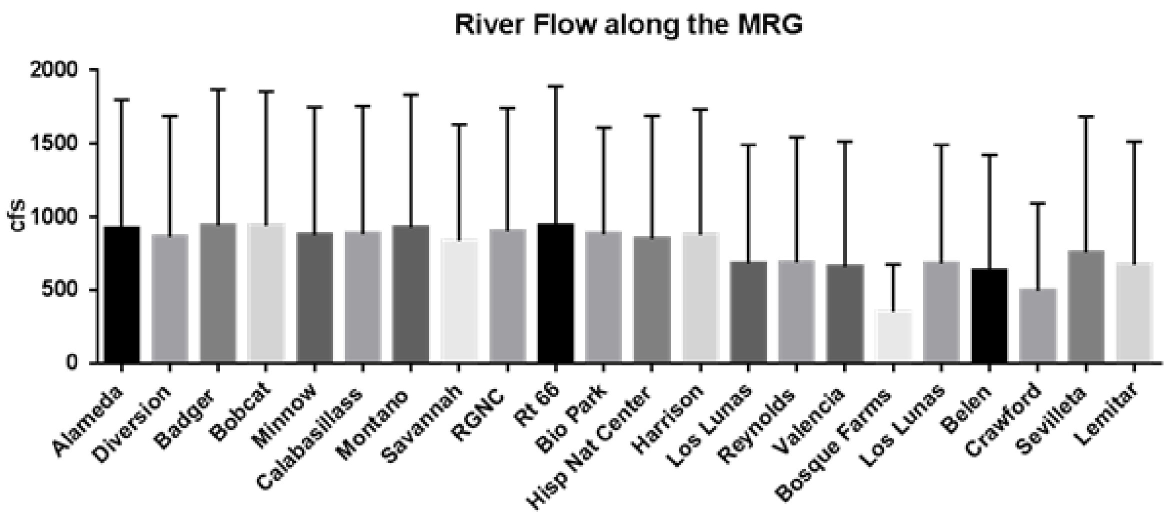

Figure 8-h. BEMP River Flow Surface Levels, Middle Rio Grande

8. Albuquerque Historical Ground Water Quality

While working on this professional paper, I was lucky to meet one of my classmates, Ms. Miriam L Walmsley. At the time, she was working at the New Mexico Water Epidemiology Program. With her help and approval from the New Mexico Environmental Department, USGIS, and the Albuquerque Bernalillo Water Authority I was able to review and use historic and current data on ground water testing throughout the state of New Mexico. I analyzed this data for this project to present the ground water quality of the Middle Rio Grande. I was able to use a series of ground water quality data from the state of New Mexico, but because the data covered the entire state of New Mexico, I chose to focus on the ground water quality in Bernalillo County, and I compared these data sets to the Middle Rio Grande BEMP data sets to see if there were any similarities. Testing included: pH, conductivity, temperature, nitrates, sulfates, iron, fluoride, arsenic, magnesium, uranium and chloride as well as E. coli and total coliforms.

Water quality testing was positive for E. coli and total coliforms in private domestic wells. Data sheets describe these isolates cases among the Albuquerque zip codes 87107, 87105, 87120 and 87122. The distribution of these zip codes includes the North Valley, South Valley, West Side and North Albuquerque Acres. The percentage of the wells tested for total coliforms and E. coli was 30%, which is high and worrisome from the public health standpoint. All of the wells that tested positive were wells dug between 2010-2014 and were not shallow wells. The New Mexico Office of the State Engineer maintains minimum requirements for drilling a well for water. There are guidelines for where a house is located in relationship to the septic tank and the drain field, the leaching line and the sewer. These minimal requirements may have an impact on the health of the community using ground water as a source of water. In small clusters, households can be responsible for water table contamination through percolation increasing point source contamination in the Albuquerque water table. The zip codes below represent the areas within Albuquerque where private wells have tested positive for E. coli and total coliforms.

87112
87005
87154
87107
87107
87008
87105
87105

87008
87059
87059
87047
87122
87120
87059
87121
87120
87120
87047

Figure 9. Albuquerque Map by Zip Code, City of Albuquerque Website

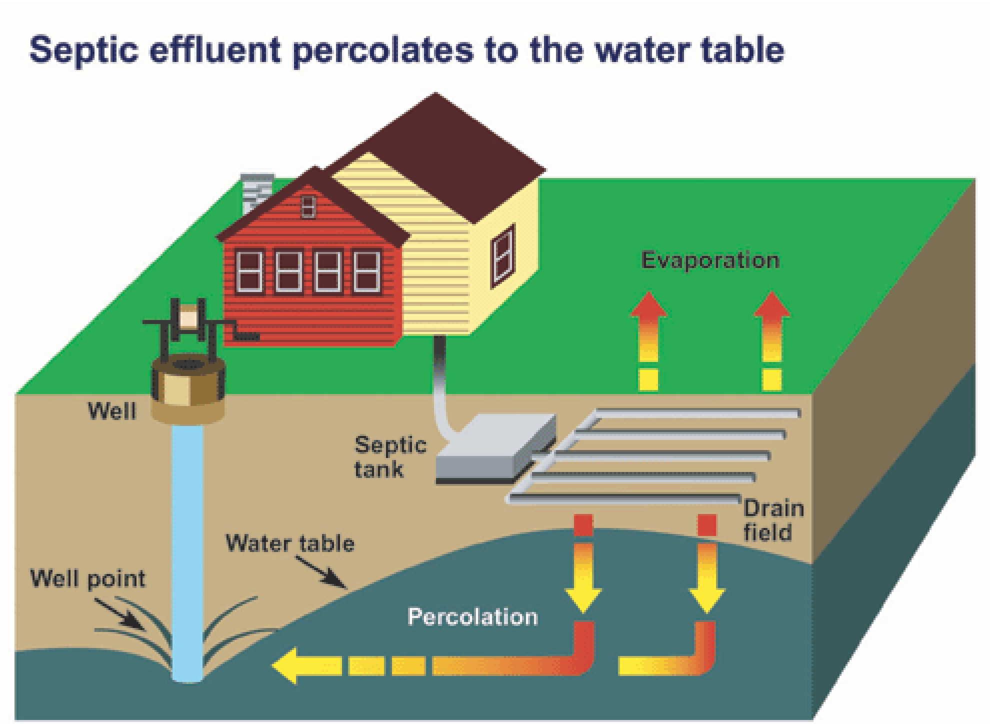

Figure 10.   Water Table Contamination Model

Figures 11-a to 11-e describe the ground water quality of private wells in the Albuquerque area along the Middle Rio Grande, including the North Valley, South Valley, Albuquerque Westside (parallel to the Middle Rio Grande) and North Albuquerque Acres. The ground water had a pH range from 6 to 9; ground water temperature had a range of 9.8 degrees Celsius to 35 degrees Celsius. The ground water had an increase in conductivity to 4000 uS/cm. These wells were reaching the 1000 feet (or 300 meters) range with a depth to water of 0-200 feet (or 0-60 meters). The water panel test only showed increases in nitrates and sulfates with a range of Sulfates at a maximum of 550 mg/L and nitrates at a low of 25 mg/L. The ground water seemed to be free of arsenic, fluoride, iron, manganese, uranium and chlorine.

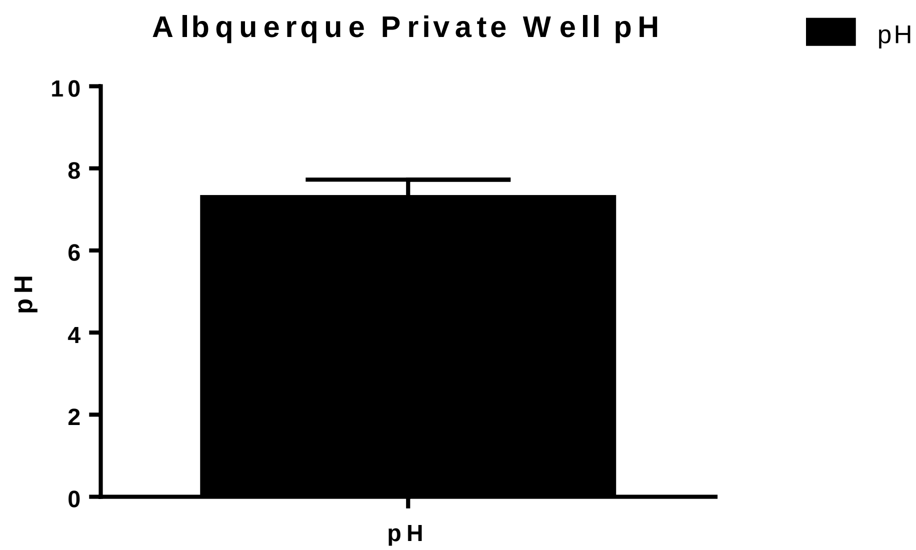

Figure 11-a. Albuquerque Private Well pH Level

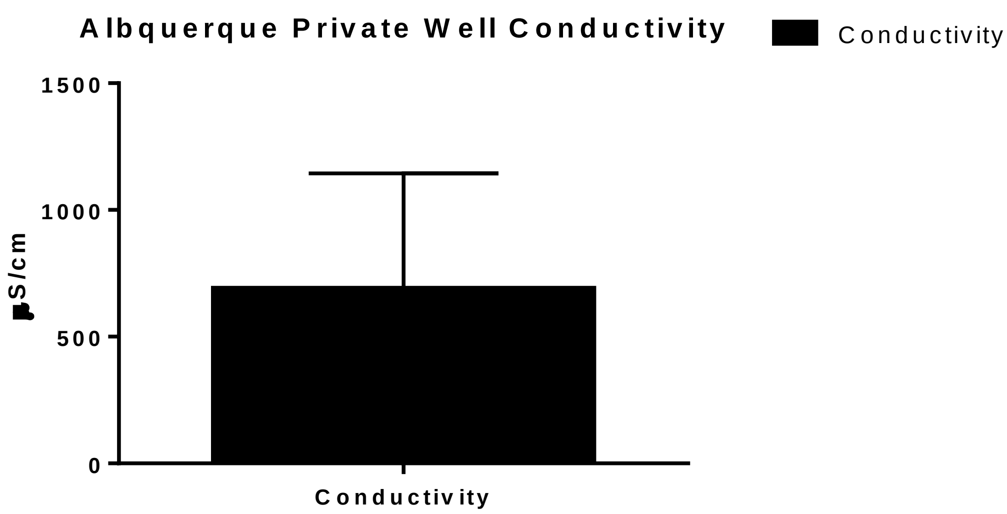

Figure 11-b. Albuquerque Private Well Conductivity Level

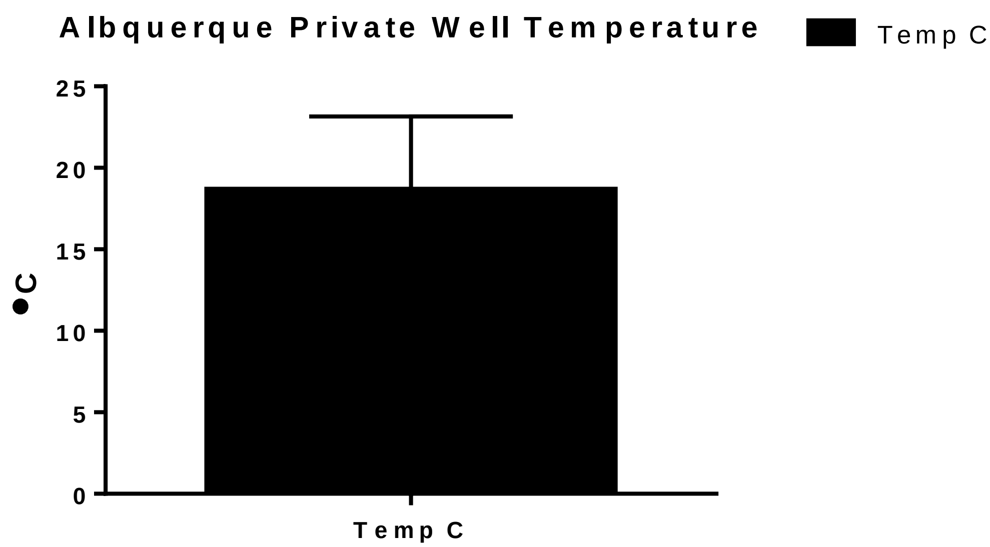

Figure 11-c. Albuquerque Private Well Temperature Levels

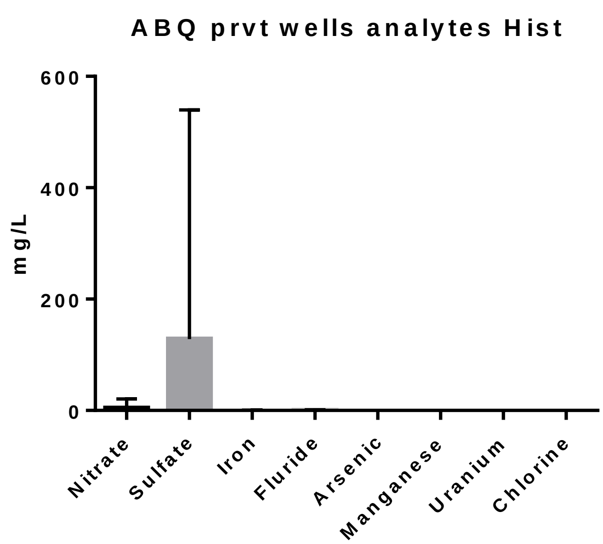

Figure 11-d. Albuquerque Private Well Analytes Level

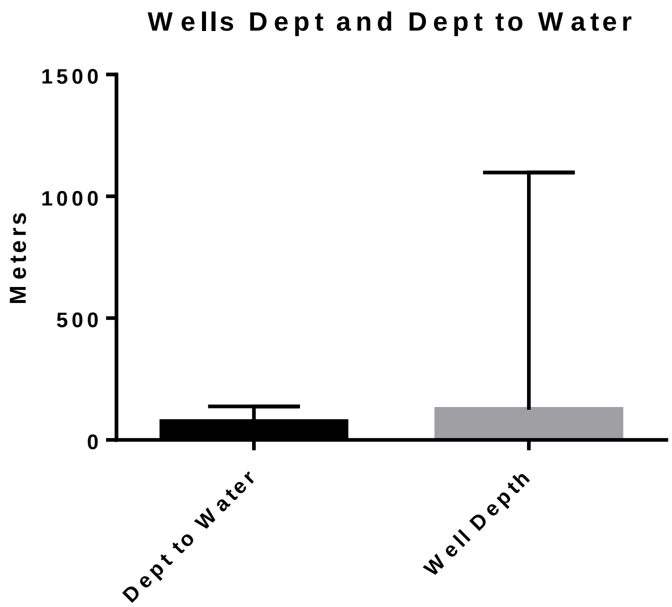

Figure 11-e. Albuquerque Private Well Depth to Water and Well Depth Level

9. E. Coli and Total Coliforms in Water and Water Borne Diseases in the Middle Rio Grande

Clean water is a key factor for the sustainability of a city and for maintaining a healthy environment for its residents. The Clean Water Act (CWA) is a primary federal law in the United States that administrates and governs water quality and pollution. The idea is to maintain water quality free from chemical and biological pollutants, to improve the treatment of water to sustain the population, and to provide wastewater treatment that is environmentally friendly and prevents any point or non-point source pollution.

The federal statues in the Clean Water Act regulate environmental laws. The Clean Water Act is managed by the United States Environmental Protection Agency (EPA) in conjunction with individual state governments which codify the Clean Water Act regulations at 40 C.F.R. Subchapters D, N, and O (Parts 100-140, 401-471, and 501-503) (EPA, 1987)(7).

Samples tested by the Bosque Environmental Monitoring Program (BEMP) have shown the presence of E. coli and total coliforms in the Middle Rio Grande, especially in the spring and summer. The feces of animals and also humans can be delivered to the river by non-point source pollution. Water can be polluted by the naturally occurring presence of animal and human feces in the skirts of the rivers or creeks and washed into the streams by rainfall. Also, ground water can be contaminated by percolation of septic systems and leaching systems in a rural, semi-rural or even in a semi urban environment where housing is too close together and lots are small. Neighbors with a minimum of a half an acre can form a cluster of infection by percolation of a septic system, contaminating the water table.

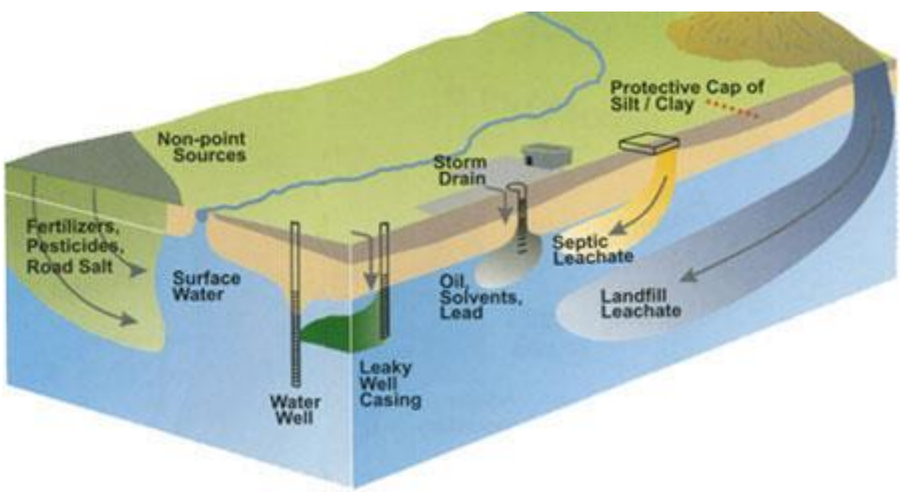

Figure 12. Idaho Geology Contamination of Ground Water Model

10. Giardiasis

Giardiasis is a waterborne disease caused by a parasite named Giardia Lamblia typically present in water contaminated by feces. It is also called beaver fever. Intestinal giardiasis may show an increase in diarrhea, an increase of intestinal gas, greasy floating stools, abdominal cramps and nausea. Individuals infected with giardiasis tend to lose weight and become severally dehydrated. The symptoms can begin a week or two after contracting the parasite. This illness is treatable after diagnosed but can reoccur with repeated exposure or if the immune system is compromised.

The parasite lives in the intestinal tract of the infected animal or person and can remain for long periods of time. It can also spread from person to person. Giardiasis can be acquired by drinking contaminated water or swimming in a contaminated stream. In New Mexico, giardiasis does not impact the majority of the population. However, it does impact the infant population and also may cause a negative impact in adult populations that are immune-compromised and the elderly.

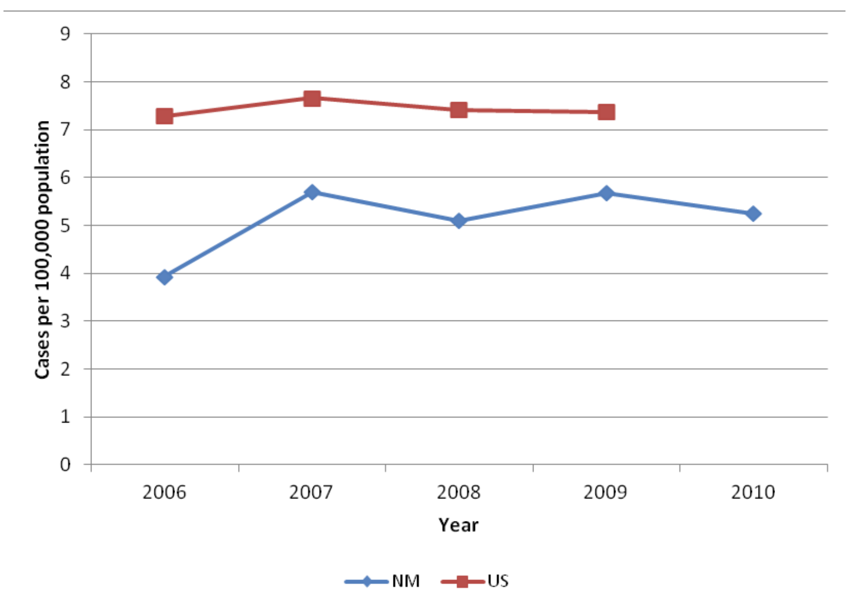

Figure 13. Incidence of Giardiasis, New Mexico and the United States, 2010*

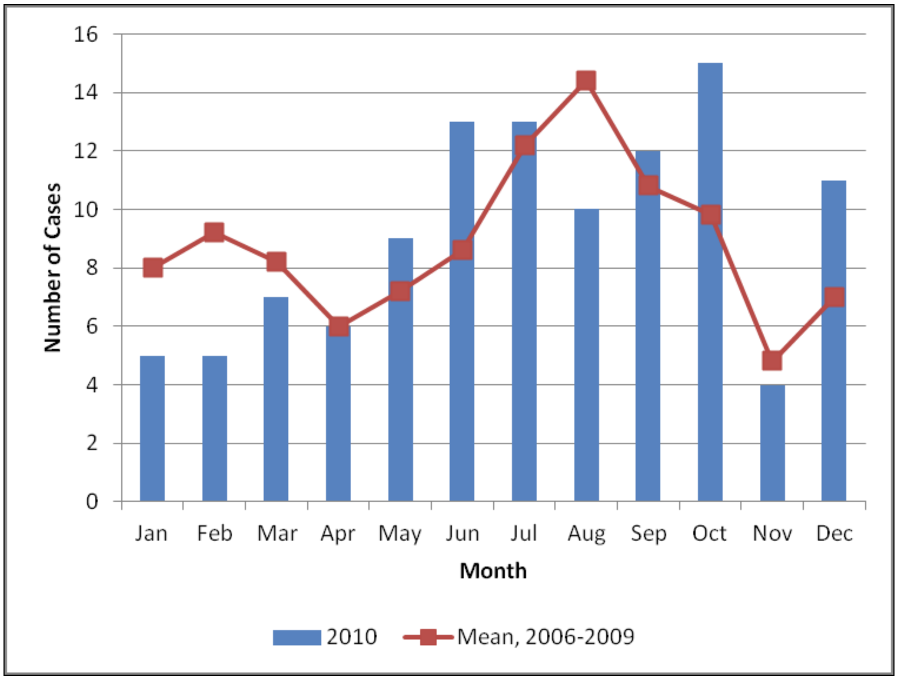

Figure 14. Incidence of Giardiasis by Month, New Mexico, 2010

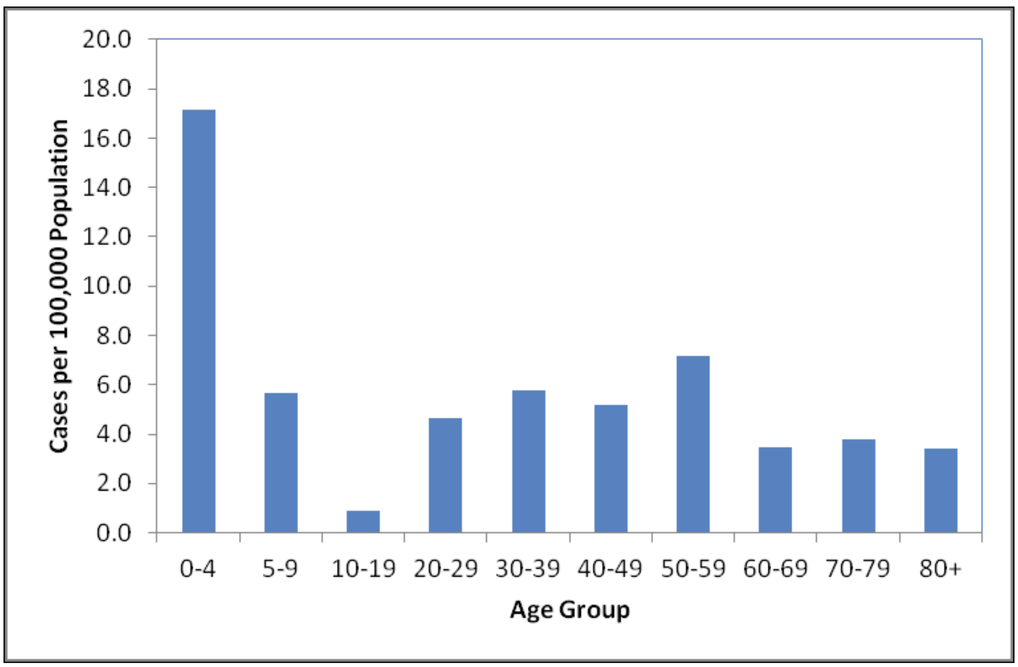

Figure 15. Incidence of Giardiasis by Age Group, New Mexico, 2010

11. Shiga Toxin-Producing E. coli (STEC) Infection

Escherichia coli or E. coli is a large family of gram positive bacteria that is generally considered to be harmless and is frequently used as an indication of contamination from mammalian waste, including that from humans. Shiga toxin-producing E. coli or STEC causes disease by producing the Shiga toxin. One strain that is pathogenic is E. coli O157:H7. The disease occurs three to four days after exposure and may create bloody diarrhea and severe abdominal pain. As described by Allen (2000), 5%-10% of the population affected by STEC can develop a life threatening condition known as HUS: hemolytic uremic syndrome. Hemolytic uremic syndrome leads to kidney failure in children, the elderly and immune compromised individuals. In New Mexico, recreational water in streams and lakes can be an epicenter point of infection and outbreak, especially in the spring and summer.

In 2010, there were 47 cases of STEC in New Mexico according to the New Mexico Department of Health annual report of 2012. However, this is only the number of reported cases. There are many unreported cases, and the number might be larger. The average number of cases in New Mexico is higher than the average number of cases in the US overall.

Tollestrup, Frost, Kunde, Yates and Jackson (2014) report that there is a potential association with failing onsite water treatment and contamination of a water table by cryptosporidium, a small enteric pathogen that affects the gastrointestinal tract.

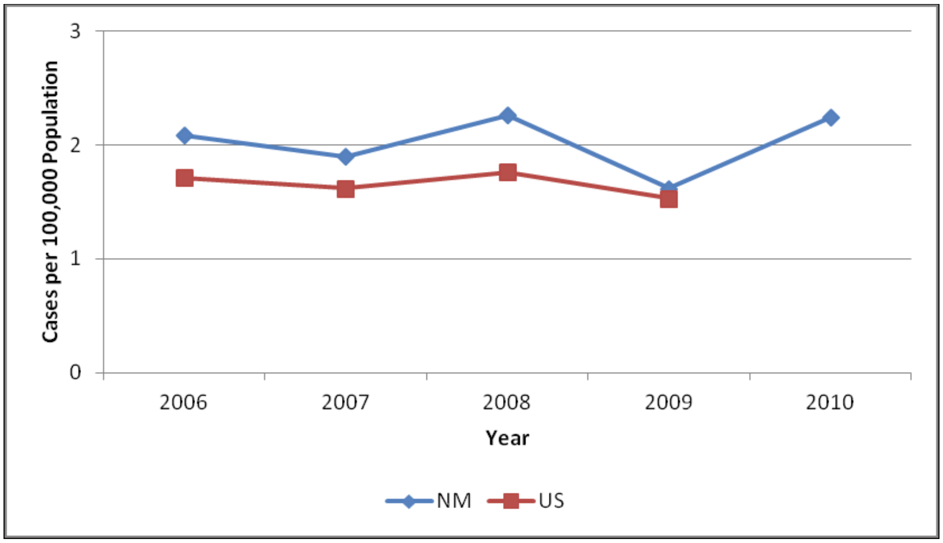

Figure 16. Incidence of STEC by Year, New Mexico and United States, 2006- 2010

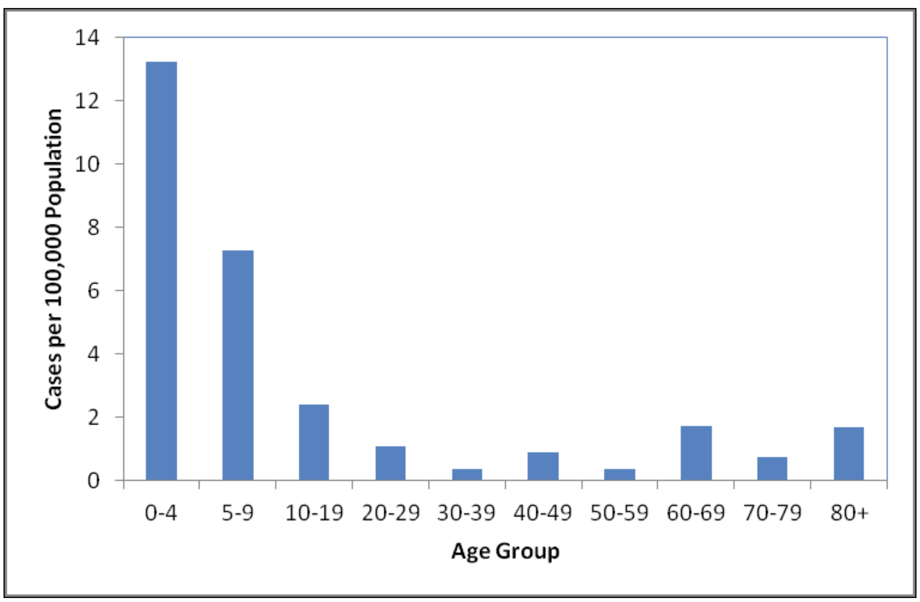

Figure 17. Incidence of STEC by Age Group, New Mexico, 2010

The Bosque Ecosystem Monitoring Program BEMP has monitored the Middle Rio Grande to understand the levels of contaminants in the past years. Measurements from November 2014 showed elevated concentrations of E. coli in the spring and summer with levels of E. coli in water of 10,000 MPN/100 ml and total coliforms of 90,000 MPN/ 100 ml at its highest level. Figure 18 shows a presence of total coliforms and E. coli in the surface water along the Middle Rio Grande in November 2014.

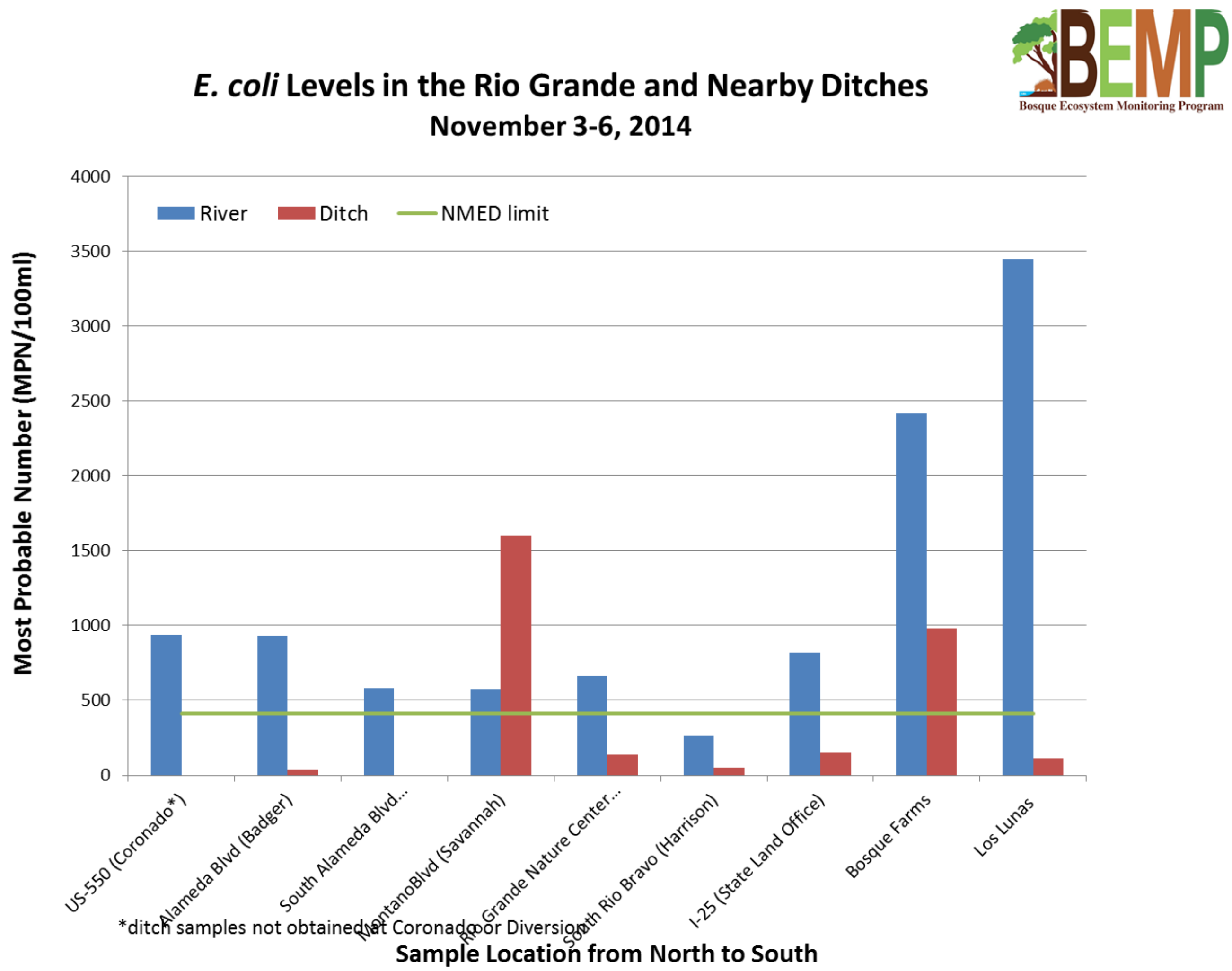

Figure 18. E.coli Levels during November 2014, BEMP Data Set 2015

X. Conclusions

Water analysis records of Middle Rio Grande surface water, BEMP ground water wells in the Middle Rio Grande area, and ground water from Albuquerque private wells provided a good account of the overall water quality in central New Mexico over a period of 15 years.

These samples of Middle Rio Grande surface water at various collection points showed an increase in turbidity within 1000 NTUs. The samples also showed levels of conductivity of 280-380 µS/cm to 900 µS/cm and a normal level of dissolved oxygen 6-9 mg/L, indicating good water quality for life growth. Also, the samples showed an increase in sulfates, calcium and magnesium, indicating heavy runoff from agricultural irrigation into the surface water. Total dissolved solids were present in the surface water throughout the years reviewed.

Public health concerns in the Middle Rio Grande surface water include the presence of total coliforms, E. coli, and giardia, especially during the hot spring and summer months when the community tends to use the surface water for recreation. These are indicators that could jeopardize human health.

The BEMP monitoring of ground water wells at designated sites indicated a flowing increase of bromide and ammonia and an increase of nitrates at the Sevilleta site. Levels of nitrates 0.25-0.5 mg/L might indicate an increase of fertilizers used to aid agricultural activities. However, an increase of agricultural fertilizer to the point increase on evapotranspiration may have brought nitrates and ammonia to the ground water recharge. Turbidity in the ground water that was monitored had a fivefold increase: 5-30 NTU. The BEMP monitoring wells showed a normal pH, but anoxic levels of oxygen with DO levels of 4-8 mg/L. Conductivity in the ground water tested high, mainly because of the increase in bromide, chloride, nitrates and sulfates. There was no testing being done in the ground water monitoring wells for E. coli, total coliforms and giardia, which is a worrisome from the public health perspective.

Historical and current analyses of Albuquerque ground water were provided by the New Mexico State Department of Health, covering an area in Albuquerque ground water that is parallel to the Middle Rio Grande, including the North Valley, South Valley, West Side and Albuquerque Acres where some residents still use ground water to source water for their household use. The following testing was performed in these wells: pH, conductivity, temperature, nitrates, sulfates, iron, fluoride, arsenic, magnesium, uranium and chloride. Also, E. coli and total coliforms were tested from newly dug wells between 2010-2014.

Water tested positive for E. coli and total coliforms in private wells used for household usage, including drinking water. Data sheets describe these isolates cases among the Albuquerque zip codes 87107, 87105, 87120, and 87122. The distribution of these zip codes are North Valley, South Valley, West Side and North Albuquerque Acres. The percentage of the wells tested for total coliforms and E. coli is 30%, which is high and worrisome from a public health standpoint. All of the wells that tested positive were wells dug over the period of 2010-2014 and were not shallow wells. The New Mexico Office of the State Engineer has no minimum lot requirements to drill a water well. However, as described in Table 6, there are minimum distance requirements for drilling wells and establishing onsite water systems and leaching systems. The distribution of the house in relationship to the septic tank and drain field with leaching line and sewer are described in table 6. These minimal requirements may have an impact on the health of the community using ground water as a water source. In small clusters, many households can be responsible for water table contamination through percolation that increases the point source contamination of the Albuquerque water table.

The ground water had a pH range of 6 to 9 and temperatures between 9.8 to 35 degrees Celsius. The ground water had an increase in conductivity to 4000 μS/cm. These wells were reaching the 1000 feet (or 300 meters) range with a depth to water of 0-200 feet (or 0-60 meters). The water panel test only showed increases in nitrates and sulfates with a range of sulfates to a maximum of 50 mg/L and a low in nitrates of 2.5 mg/L. The ground water seems to be free of arsenic, fluoride, iron, manganese, uranium and chlorine.

Table 1. Minimum Setback Distances for Individual and Multiple Household Wells

Minimum setback distance for an individual well	*To*
50 Feet	Wells of different ownership
25 Feet	Watertight Sewer Lines or Drain Lines
10 Feet	Property Lines
100 Feet	Vitrified Clay or Concrete Sewers
50 Feet	Watertight Septic Tanks, On-site Treatment Units, or Wastewater Pump Basins
100 Feet	Individual wastewater system disposal fields
150 Feet	Seepage pits
200 Feet	Community wastewater system disposal fields
100 Feet	Rivers, streams, irrigation canals and drains (lined or unlined), ponds, or other surface waters
25 Feet	Arroyos and small man-made ditches for irrigation purposes that infrequently carry water
100 Feet	Animal holding areas including corrals, stables, pens
100 Feet	Any underground storage tank
500 Feet	Any known ground water contaminant plume

Table 6. Set Standards from the Well Office of the State Engineering, 2005

VIII. Recommendations

Water is an important factor to maintain and grow a healthy community. This report focuses on the quality of the surface and ground water along the Middle Rio Grande and the ground water in the Albuquerque area. Albuquerque has some semi-rural households that are under pressure to use private wells as their only source of water. These areas include the North Valley, the South Valley, the Westside and North Albuquerque Acres.

The following recommendations are based on water quality data gathered from the Middle Rio Grande area. However, these recommendations can be expanded to all users of ground water well systems.

The following recommendations are made to help improve water quality for a healthy community:

- Public Awareness: Communities using private ground water and septic systems should be notified of the intention of water testing for their own health benefit and the quality of their water source by the city of Albuquerque. New Mexico State Labs has a water chemistry laboratory that can provide testing at a lower cost.
- Public Education: The communities using private wells and septic systems need education about how ground water is recharged and how to test their water and evaluate the conditions of their water source. At the same time, the community needs to be educated about how wells and septic/leaching systems work and how behavior can impact the water table.
- Planning: The community, through town/public meetings, should develop measures for substantiality reform which would evaluate the water quality, prepare design options to

implement a water management system, train communities and individuals, and evaluate future options of water resources for the community. Results of water quality testing should be recorded and reported, and future plans for using ground water should be made with the communities' participation.

- Financial Considerations: Installing a new septic tank and leaching system and perforating a new or deeper well are highly expensive for individual families. However, creating a community well and septic system by integrating several families might create a more cost effective solution.
- Drinking Water Solutions: Ultra violet water treatment is recommended to control bacteria and protozoa that may be present in drinking water. However, this method will not filter salts or heavy chemicals. For wells with high concentrations of salts or other contaminants it may be desirable to use a point-of-use water treatment system such as a water softener or reverse osmosis system.
- Ground Water Testing: It is recommended that ground water testing be conducted every six months and that septic systems should be monitored once a year. These could be mandatory evaluations to prevent any further water table contamination, as well as leaching system.
- GIS Mapping: Bernalillo County should continue GIS mapping of households that use ground well water for consumption and the state should establish periodic monitoring to prevent any unwanted exposure.
- Correlation of Testing Results: BEMP and Albuquerque ground water could have a parallel study where similar testing can be performed to establish a better correlation of the ground water quality.

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