1. **Title:** Identification of Salinity Sources in the Northern Segment of the Brazos River Alluvium Aquifer
2. **Project Type:** Research
3. **Focus Categories:** Water Quality (WQL), Hydrogeochemistry (HYDGEO), Groundwater (GW),
4. **Research Category:** Water Quality
5. **Keywords:** Salinity, alluvium, aquifer, Brazos River
6. **Start Date:** 3/1/2018
7. **End Date:** 2/28/2019
8. **Principal Investigator:**

Erin Noonan, GIT
Baylor University Department of Geosciences
Master of Science in Geology Candidate
Degree Starting Year: August 2017
Expected Graduation: May 2019
Erin_Noonan1@baylor.edu

9. **Congressional District:** Texas Congressional District-017

10. **Abstract**

The Brazos River Alluvium Aquifer is a minor aquifer in Texas, (George and Petrossian, 2011). Variability in salinity can be seen throughout the aquifer, although the source of this variability is unclear. Salinization can degrade the water quality of the aquifer and ultimately impact its ability to be used as a source drinking water or for irrigation. The objective of this study is to identify sources of salinity in the northern segment of the Brazos River Alluvium aquifer, including Bosque, Hill, McLennan, and Falls Counties. Potential sources of salinity to be investigated include irrigation, an influx of water from the Brazos River, and brine contamination from historic oil and gas fields. The Brazos River Authority (BRA) and Southern Trinity Groundwater Conservation District (GCD) are aware of the variability of salinity in the Brazos River Alluvium aquifer, and are interested in a study to identify the sources of salinity. Identifying sources of salinity in the Brazos River Alluvium aquifer could help improve management practices of both the river and the aquifer, and help limit future increases in salinity. This in turn will help preserve this valuable resource for use by future generations.

The first goal of this research project is to identify areas of elevated salinity in the northern segment of the Brazos River Alluvium aquifer, and evaluate the horizontal and vertical distribution of salinity within the aquifer. In April, water samples will be collected from 26 wells throughout the study area and analyzed for common cations and anions, including a measure of salinity. Fourteen wells will be resampled in August after irrigation has ended, to see if salinity has increased. Salinity measurements will be plotted using ArcGIS, and areas of elevated salinity will be compared to the locations of potential sources of salinity. The vertical distribution of salinity in the aquifer will be assessed by measuring conductivity at different depths in wells.

The second goal of this research project is to investigate how changes in salinity vary with precipitation, groundwater levels, and river discharge. Two conductivity data loggers will be placed in wells for approximately one year, to measure changes in salinity with time. The data will be compared to changes in groundwater level, river discharge, and precipitation, to determine possible controls on salinity.

The third goal of this research project is to use isotopic and ionic analysis to help identify the sources of salinity within the aquifer. Water samples will be collected from precipitation, the river, and 8 wells, and analyzed for ratios of hydrogen and oxygen isotopes. Each source of water (i.e. groundwater, precipitation, irrigation return flow, river water, brine) should have a distinct isotopic and ionic signature which can be compared to samples from areas of elevated salinity, to possibly identify sources of salinity within the aquifer. Bivariate plots of oxygen versus hydrogen isotopes and piper trilinear diagrams will be used to help identify the sources of salinity in the Brazos River Alluvium aquifer.

A comprehensive report will be produced containing an evaluation of irrigation, the Brazos River, and historic oil and gas fields as potential sources of salinity in the northern segment of the Brazos River Alluvium aquifer. A current water quality dataset will be developed as well as maps showing the horizontal and vertical distribution of salinity within the aquifer. The report from this study can then be used by the BRA and local GCDs to improve management of both the river and the aquifer, to prevent further degradation of this important resource. Presentations will be made at the BRA and GCDs focusing on sharing new knowledge about the Brazos River Alluvium aquifer with land owners, board members, and water managers. Presentations will also be made at national and regional meetings.

Attachment A –BUDGET BREAKDOWN

Cost Category	Federal	Non-Federal	Total
1. Salaries and Wages	$	$	$
- Principal Investigator(s)	0	5,830	5,830
- Graduate Student(s)	0	0	0
- Undergraduate Student(s)	0	0	0
- Others	0	0	0
Total Salaries and Wages			
2. Fringe Benefits			
- Principal Investigator(s)	0	0	0
- Graduate Student(s)	0	0	0
- Undergraduate Student(s)	0	0	0
- Others	0	0	0
Total Fringe Benefits			
3. Tuition			
- Graduate Student(s)	0	0	0
- Undergraduate Student(s)	0	0	0
Total Tuition			
4. Supplies	1,750	0	1,750
5. Equipment	0	0	0
6. Services or Consultants	2,500	0	2,500
7. Travel	750	0	750
8. Other direct costs	0	0	0
9. Total direct costs	5,000	5,830	10,830
10a. Indirect costs on federal share	XXXXXXXX XXXXXXXX	0	0
10b. Indirect costs on non-federal share	XXXXXXXX XXXXXXXX	4,170	4,170
11. Total estimated costs	$5,000	$10,000	$15,000
Total Costs at Campus of the University on which the Institute or Center is located.	$0	$0	$0
Total Costs at other University Campus Name of University:	$5,000	$10,000	$15,000

Attachment B – BUDGET JUSTIFICATION

Salaries and Wages for PIs. Provide personnel, title/position, estimated hours and the rate of compensation proposed for each individual.
Erin Noonan, GIT. Master of Science in Geology Candidate. Baylor University is providing a compensation of $5,830 during the study period as much of Erin Noonan's time will be spent working on this research project.
Salaries and Wages for Graduate Students. Provide personnel, title/position, estimated hours and the rate of compensation proposed for each individual. (Other forms of compensation paid as or in lieu of wages to students performing necessary work are allowable provided that the other payments are reasonable compensation for the work performed and are conditioned explicitly upon the performance of necessary work. Also, note that tuition has its own category below and that health insurance, if provided, is to be included under fringe benefits.)
None
Salaries and Wages for Undergraduate Students. Provide personnel, title/position, estimated hours and the rate of compensation proposed for each individual. (Other forms of compensation paid as or in lieu of wages to students performing necessary work are allowable provided that the other payments are reasonable compensation for the work performed and are conditioned explicitly upon the performance of necessary work. Also, note that tuition has its own category below and that health insurance, if provided, is to be included under fringe benefits.)
None
Salaries and Wages for Others. Provide personnel, title/position, estimated hours and the rate of compensation proposed for each individual.
None
Fringe Benefits for PIs. Provide the overall fringe benefit rate applicable to each category of employee proposed in the project. . Note: include health insurance here, if applicable.
None
Fringe Benefits for Graduate Students. Provide the overall fringe benefit rate applicable to each category of employee proposed in the project. Note: include health insurance here, if applicable.
None
Fringe Benefits for Undergraduate Students. Provide the overall fringe benefit rate applicable to each category of employee proposed in the project. Note: include health insurance here, if applicable
None
Fringe Benefits for Others. Provide the overall fringe benefit rate applicable to each category of employee proposed in the project.. Note: include health insurance here, if applicable.
None
Tuition for Graduate Students.
None
Tuition for Undergraduate Students
None
Supplies. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies. Provide a breakdown of the supplies in each category.
Two HOBO Fresh Water Conductivity Data Loggers will be purchased for $595 each ($595 x 2 = $1,190). Sample bottles for the isotopic and ionic analysis will cost approximately $3 per bottle ($3 x 52 = $156). Chemical standards and other consumables for sampling are allotted an amount of $404. The total cost of supplies is $1,750.
Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items. A detailed breakdown is required.
None
Services or Consultants. Identify the specific tasks for which these services, consultants, or subcontracts would be used. Provide a detailed breakdown of the services or consultants to include personnel, time, salary, supplies, travel, etc.
The ionic analysis will cost $50 per sample ($50 x 42 = $2,100) and includes the cost of the technician and any consumables used. Isotopic analysis will cost $40 per sample ($40 x 10 = $400) and includes the cost of the technician, hydrogen and oxygen isotopes and other consumables used in the analysis. Total cost of analysis is $2,500.
Travel. Provide purpose and estimated costs for all travel. A breakdown should be provided to include location, number of personnel, number of days, per diem rate, lodging rate, mileage and mileage rate, airfare (whatever is applicable).
Four trips of approximately 50 miles each will be taken in both the spring and late summer to collect water samples, totaling about 400 miles. Baylor University's rate is $0.535 per mile ($0.535 x 400 = $214). In March of 2018, a trip will be made to present research for the project at the South Central Geological Society of American Conference in Little Rock, Arkansas. A department vehicle will be used for the trip and $80 is budgeted for lodging and $48 is budgeted for meals. In December of 2018, a trip will be made to present research for the project at the National Ground Water Association Conference in Las Vegas, Nevada. For the conference, $240 is budgeted for a round-trip flight, $120 is budgeted for lodging, and $48 is budgeted for meals. Total cost of travel is $750.
Other Direct Costs. Itemize costs not included elsewhere, including publication costs. Costs for services and consultants should be included and justified under "Services or Consultants (above). Please provide a breakdown for costs listed under this category.
None
Indirect Costs. Provide negotiated indirect ("Facilities and Administration") cost rate.
Total indirect cost at Baylor University is 38.5% of total direct cost. The total indirect cost is $4,170 for this study.

Identification of Salinity Sources in the Northern Segment of the Brazos River Alluvium Aquifer

Introduction: The Brazos River Alluvium aquifer is an official minor aquifer in the state of Texas, (George and Petrossian, 2011). Previous studies by Cronin and Wilson (1967), O'Rourke, and Chowdhury et. al. (2010), have shown that variability in salinity can be seen in wells throughout the Brazos River Alluvium aquifer. However, the source of this variability is unclear. Salinization can impair water quality and eventually render the aquifer unfit for use as irrigation or drinking water. A better understanding of sources of salinity in the Brazos River Alluvium aquifer is needed to help limit future degradation of water quality.

Objectives: The objective of this study is to identify the sources of salinity in the northern segment of the Brazos River Alluvium aquifer, including Bosque, Hill, McLennan, and Falls Counties. *The primary hypothesis for the source of salinity in the aquifer is irrigation.* Farmland near the Brazos River Alluvium aquifer is irrigated with either groundwater from the aquifer or with water from the Brazos River. Irrigation could be the source of salinity, as evapotranspiration of applied irrigation water results in an increase of salinity in irrigation return flow, (Goff et. al. 1998). Since the water table of the aquifer is quite shallow, some of the irrigation return flow likely recharges the aquifer, possibly resulting in the elevated salinity seen in some areas of the aquifer. *A second hypothesized source of salinity is an influx of water from the Brazos River into the aquifer.* If the salinity of the river is higher than that of the aquifer, groundwater-surface water interactions between the Brazos River Alluvium aquifer and Brazos River could increase the salinity of the aquifer. *The third hypothesized source of salinity is contamination from unplugged wells or brine spills related to historic oil and gas fields in or near the study area.* For the purpose of this study, salinity is defined as equivalent to total dissolved solids (TDS).

Statement of Regional or State Water Problem: In the past few decades, Texas' increase in population has put a strain on its water resources. Salinization and other degradation of water resources could inhibit the ability to provide enough water for the entire population. The Brazos River Authority (BRA) and Southern Trinity Groundwater Conservation District (GCD) are aware of the variability of salinity in the aquifer, and are interested in a study involving identification of sources of salinity in the aquifer. Preliminary analysis of data from the Texas Water Development Board (TWDB) Groundwater Database shows that a significant number of wells in the Brazos River Alluvium aquifer have a TDS greater than 500 mg/L, which is the Environmental Protection Agency's (EPA) secondary standard for drinking water. If the salinity of the aquifer were to increase, the aquifer would no longer be a viable source of drinking water or irrigation water. The use of high TDS water for irrigation can result in a build of up salts in the soil, which can decrease crop productivity. Identifying sources of salinity in the Brazos River Alluvium aquifer could help improve management practices of both the river and the aquifer, and help limit future increases in salinity. This in turn, will help ensure that future generations will be able to use the aquifer as a source of water for both irrigation and human consumption.

Methods: *The first goal of this research project is to identify areas of elevated salinity in the northern segment of the Brazos River Alluvium aquifer, and evaluate the horizontal and vertical distribution of salinity within the aquifer.* Almost all water quality data from the TWDB in the northern portion of the Brazos River Alluvium aquifer was obtained decades ago. This

demonstrates the need for a current water quality dataset. In April of 2018, water samples will be collected from approximately 26 wells distributed throughout the study area, in a time period not to exceed one week. The northern segment of the aquifer is thought to be compartmentalized due to bedrock and river boundaries. This means that bedrock and the Brazos River divide the aquifer into different compartments, that communicate little with each other, (J. Jarvis, personal communication, fall 2017). Therefore, 3-5 samples will be collected in approximately 8 of the 15 compartments, as nearly half of the compartments are too small to reasonably collect 3 samples from. Water samples will be analyzed in-house at Baylor's Center for Reservoir and Aquatic Systems Research (CRASR), for sodium, potassium, calcium, magnesium, chloride, sulfate, carbonate, and nitrate, including a measure of salinity. Bicarbonate will be titrated in the field. This will help establish the variability of salinity within the aquifer and will produce a baseline, before irrigation occurs during late spring and summer. During August, at least 14 of the wells near farmland will be resampled after irrigation has ended, to see if salinity has increased. Baylor University has a working relationship with the Southern Trinity GCD, and by working with the Middle Trinity GCD, Prairielands GCD, Southern Trinity GCD, and Falls' County Government, access to wells should be obtained. Due to well placement and land access, sample distribution in the northern segment might not be as uniform as desired, but should not be a significant problem.

Salinity measurements will be plotted using ArcGIS and then kriged, to identify the spatial distribution of salinity in the aquifer. Wang and Shenggao (2011), have shown that using kriging to create maps of the spatial distribution of heavy metals in soils can help identify the source of contamination. This method could also be applicable to identifying sources of salinity within the aquifer. The hotspot analysis tool will also be implemented to correlate groups of elevated salinity measurements. These "hotspots" will be compared to the locations of irrigated farmland, the Brazos River, and historic oil and gas fields, to see if any correlation exists.

To measure the vertical distribution of salinity within the aquifer, conductivity meters will be used in wells, to measure the conductivity at different depths within the aquifer. Approximately 5 wells will be tested in the spring of 2018. These measurements will be converted to salinity and then plotted against well depth, to analyze the vertical distribution of salinity within the aquifer. This will help determine if there is any salinity stratification in the aquifer. Salinity found in the upper portion of the aquifer and in a close proximity to farmland is likely due to irrigation.

The second goal of this research project is to investigate how changes in salinity vary with precipitation, groundwater levels, and river discharge. Two HOBO Fresh Water Conductivity Data Loggers will be placed in selected wells for approximately one year, to investigate changes in salinity with time. Data loggers will be checked periodically, and the data will be downloaded at a set time interval. Changes in salinity with time will be compared to changes in precipitation, groundwater level, and river discharge, to see if any relationship exists. Groundwater data will be gathered from the Southern Trinity GCD, river discharge data will be gathered from the BRA, and precipitation data will be gathered from the National Oceanic and Atmospheric Administration. This comparison will help determine the controls on salinity and possibly help quantify the extent of mixing between the aquifer and river.

The third goal of this research project is to use isotopic and ionic analysis to help identify the sources of salinity within the aquifer. Areas of elevated salinity are likely formed due to the

mixing of different sources of water, so these areas should have a different isotopic and ionic signature than the rest of the aquifer. One water sample will be collected from the Brazos River and another from precipitation in the study area, and will be analyzed for hydrogen and oxygen isotopes. Eight water samples will be collected from wells during the spring, and will also be analyzed for hydrogen and oxygen isotopes. The samples will be analyzed in-house, using the Department of Geosciences' mass spectrometer. The end member waters will also be analyzed for common ions and salinity at CRASR. Each source of water (i.e. groundwater, precipitation, irrigation return flow, river water, brine) should have a distinct isotopic and ionic signature which can be compared to samples from areas of elevated salinity, to possibly identify sources of salinity within the aquifer. Mehta et. al. 2000 showed that bivariate plots of oxygen versus hydrogen isotopes and piper trilinear diagrams could be used to help identify the source of salinity in the Ogallala Aquifer. The isotopic and ionic chemistry for end member waters and all samples will be plotted on bivariate plots and piper trilinear diagrams (respectively), to help identify the sources of salinity in the Brazos River Alluvium aquifer. Samples from oil field brine will not be able to be obtained. However, previous studies that detail the chemistry of various brines near the study area, will be used for comparison. Mass balance calculations will also be performed to determine the degree of mixing between the different sources of water, and could help quantify the groundwater-surface water interactions between the aquifer and river.

Samples will not be collected directly after large precipitation events, as recent precipitation could alter the isotopic or ionic signature of areas of elevated salinity, making it difficult to identify the source of salinity in the aquifer. The bivariate plots and piper diagrams may produce a non-unique solution; therefore, isotopic and ionic analysis may not be able to definitively identify the source of salinity. However, they should be able to at least eliminate a few potential sources of salinity. When used in combination with information on the spatial and vertical distribution of salinity in the aquifer, and controls on salinity, the sources of salinity in the Brazos River Alluvium aquifer should be able to be identified.

Facilities: The Baylor University Science Building (BSB) is a state-of-the-art building that houses numerous science departments. The Department of Geosciences is located on the 4th floor of BSB. The building has many analytical labs, computing labs, and various research centers which support the research of Baylor's faculty, graduate, and undergraduate students. The 4th floor of the BSB is home to a hydrogeology lab which contains a lab-style work space. The 5,200 square foot Carlile Geology Research Building located next to BSB, contains another large hydrogeology lab utilized for field preparation, core description, experiments, analysis, and equipment storage. Baylor University owns hand-held field probes for temperature, electrical conductivity, and pH, as well as the equipment to titrate bicarbonate in the field. The Center for Reservoir and Aquatic Systems Research has the ability to analyze common cations and anions as well as nutrients, while the Geoscience Department has a mass spectrometer to analyze hydrogen and oxygen isotopes. In addition, the university has a dedicated GIS Laboratory with dual-screen work stations and maintains a license for ArcGIS, a geospatial tool used for map making and analysis of spatial data.

Related Research: The Brazos River Alluvium aquifer is classified as a minor aquifer by the TWDB, (George et. al. 2011). The aquifer spans from Bosque to Fort Bend County, Texas and is dominantly used for irrigation, (Shah et. al., 2007). It is an alluvium aquifer that exhibits a fining upward sequence of gravel, sand, silt, and clay, but is very heterogeneous, (Cronin and Wilson,

1967). Epps (1973) documented four terraces adjacent to the alluvium, some of which are likely connected to the alluvium. The alluvium is underlain by Cretaceous bedrock that acts as a boundary to flow, (Munster and Mathewson, 1996). The aquifer is under water table conditions, primarily recharges by precipitation, and discharges at the Brazos River, (Cronin and Wilson, 1967). Waters and Nordt (1995), found that the sand and gravel deposits of the Brazos River Alluvium aquifer are Pleistocene in age, and formed due to the lateral accretion of the Brazos River. The Brazos River Alluvium aquifer is one of the most susceptible aquifers to contamination in the state of Texas as shown using the DRASTIC method, (Harlan, 1990). In addition, Pinkus (1987) determined the outer limit of which river level affects the aquifer, is about 2,200 feet from the river.

A study by Cronin and Wilson (1967), identified an area of elevated salinity near the Falls-Robertson county line. They postulated that an influx of water from the Brazos River or contamination from oil fields were not likely the source of salinity in the aquifer. *This study shows that variability in water chemistry and areas of elevated salinity levels date as far back as 1962.* A map in a study by O'Rourke shows that in 1999, multiple areas in Falls County had salinities ranging from 1,000-3,000 mg/L. *This study confirms Cronin and Wilson's findings as it shows that in 1999, areas in Falls County still exhibited elevated salinity levels.* A study completed by Chowdhury et. al. (2010), documented areas of elevated salinity in Falls, Robertson, Brazos, and Burleson counties. They posed that irrigation could play a role in salinity, but was not likely. They also documented that the Brazos River was not the source of salinity, but that evapotranspiration could be a potential source of salinity in the aquifer, (Chowdhury et. al. 2010). *All three studies (over the span of decades) documented an area of elevated salinity in Falls, County. However, no study was able to definitively identify the source of salinity and identifying the source of salinity was not the primary focus of any of the three studies.*

Goff et. al (1998) have shown that irrigation of farmland near an alluvial aquifer in the Arkansas River Basin in Colorado, resulted in an increase of salinity in the aquifer, due to recharge from irrigation return flow. Salinity in the irrigation return flow increased due to evapotranspiration. In addition, a land use map from the Groundwater Availability Model (GAM) shows that significant amounts of corn are grown in Falls County, (Ewing, John E., 2016). There are approximately 8,311 irrigated acres in the study area, and the average irrigation rate is about 14 in/yr. Irrigation return flow is about 24-35% of applied irrigation water for flood irrigation, and 13-15% of applied irrigation water for sprinkler systems or drip irrigation, (Ewing et. al., 2016). *These studies show that a significant amount of irrigation return flow likely recharges the aquifer, and that irrigation is a viable potential source of salinity in the Brazos River Alluvium aquifer.*

Training Potential: This project will help fund the thesis research of a Master of Science in Geology candidate.

Results and Benefits: A comprehensive report (thesis) will be produced containing an evaluation of irrigation, the Brazos River, and historic oil and gas fields as potential sources of salinity in the northern segment of the Brazos River Alluvium aquifer. An updated water quality dataset for the northern segment of the Brazos River Alluvium aquifer will be produced. Maps will also be developed to show the horizontal and vertical distribution of salinity within the aquifer. The

controls on salinity will also be determined and some analysis of groundwater-surface water interactions will likely be included. This document will provide a much needed current overview of the northern segment of the Brazos River Alluvium aquifer and can then be used as a tool for future water planning and management decisions, by organizations such as the BRA and local GCDs in the study area. By identifying the sources of salinity in the northern segment of the Brazos River Alluvium aquifer, water mangers may be able to improve management of both the Brazos River Alluvium aquifer and Brazos River, to prevent further degradation of this important resource. Presentations will be made periodically at the local board meetings for the BRA and local GCDs that will focus on sharing new knowledge about the Brazos River Alluvium aquifer with land owners, board members, and water managers. Presentations will also be made at national and regional meetings to disseminate findings to academia and industry. Salinization of aquifers is a problem in many arid and semi-arid regions, so new techniques may be developed for identifying sources of salinity, that could be applicable to other aquifers.

Table 1: Detailed timeline for March 1, 2018 through March, 2019.

Detailed Timeline													
Task	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Literature review													
Collect data on salinity, precipitation, groundwater level, and river discharge													
Collect water samples													
Analysis of water samples													
Collect data on vertical distribution of salinity in aquifer													
Develop maps and graphs of horizontal and vertical salinity distribution													
Correlate salinity data to precipitation, groundwater level, and river discharge													
Retrieve data loggers													
Analyze potential sources of salinity													
Write and edit thesis													
Thesis defense													
Progress reports to local agencies													
Final Report to TWRI													

References

Chowdhury, Ali H, Osting, Tim, Furnans, Jordan, and Ray Mathews. 2010. Groundwater-Surface Water Interactions in the Brazos River Basin: Evidence from Lake Connection History and Chemical and Isotopic Compositions. Texas Water Development Board Report 275: 36-44.

Cronin, James G. and Clyde A. Wilson. 1967. Ground Water in the Flood-Plain Alluvium of the Brazos River, Whitney Dam to Vicinity of Richmond, Texas. Texas Water Development Board Report 41: 1-78.

Environmental Protection Agency. Secondary Drinking Water Standards: Guidance for Nuisance Chemicals. Accessed November 22, 2017.

Epps, Lawrence Ward. A Geologic History of the Brazos River. 1973. Baylor Geological Studies 24: 1-44.

Ewing, John E. 2016. Final Numerical Model Report for the Brazos River Alluvium Aquifer Groundwater Availability Model. Texas Water Development Board 1-357.

Ewing, John E., Harding Jevon, J., and Toya L. Jones. 2016. Final Conceptual Model Report for the Brazos River Alluvium Aquifer Groundwater Availability Model. Texas Water Development Board 1-514.

George, Peter G., and Rima Petrossian. 2011. Aquifers of Texas. Texas Water Development Board Report 380: 22-170.

Goff, Karin, Lewis Michael E., Person, Mark A., and Leonard F. Konikow. 1998. Simulated Effects of Irrigation on Salinity in the Arkansas River Valley in Colorado. *Ground Water* 36.1: 76-86.

Harlan, Scott K. 1990. Hydrogeologic Assessment of the Brazos River Alluvial Aquifer Waco to Marlin, Texas. A Theses Submitted to the Faculty of Baylor University in Partial Fulfillment of the Requirements for the Degree of Master of Science 1-124.

Mehta, Sunil, Fryar, Alan E., and Jay L. Banner. 2000. Controls on the regional-scale salinization of the Ogallala aquifer, Southern High Plains, Texas, USA. *Applied Geochemistry* 15: 849-864.

Munster, Clyde, Mathewson, Christopher, and Christine Wrobleski.1996. The Texas A&M University Brazos River Hydrogeologic Field Site. *Environmental & Engineering Geoscience* 2.4: 517-530.

O'Rourke, David. Conjunctive Use of the Brazos River Alluvium Aquifer, HDR Engineering Incorporated Chapter 4: 61-80.

Pinkus, Joel R. 1987. Hydrogeologic Assessment of Three Solid Waste Disposal Sites in the Brazos River Alluvial Deposits. A Theses Submitted to the Faculty of Baylor University in Partial Fulfillment of the Requirements for the Degree of Master of Science 1-157.

Shah, Sachin D., Houston, Natalie A., and Christopher L. Brown. 2007. Hydrogeologic Characterization of the Brazos River Alluvium Aquifer Bosque County to Fort Bend County, Texas. U.S. Geological Survey, Scientific Investigations Map 2989, 5 sheets.

Texas Water Development Board. Texas Water Development Board Groundwater Database Well Water Quality Report (Sample Year: All, Aquifer: Brazos River Alluvium Aquifer, County: All Available Selected, Water Quality Parameter: Total Dissolved Solids). Accessed November 22, 2017.

Wang, Hongyan, and Shenggao Lu. 2011. Spatial distribution, source identification and affecting factors of heavy metals contamination in urban-suburban soils of Lishui city, China. *Environmental Earth Science* 64: 1921-1929.

Waters, Michael R., and Lee C. Nordt. 1995. Late Quaternary Floodplain History of the Brazos River in East-Central Texas. *Quaternary Research* 43: 311-319.

Erin Noonan
Erin_Noonan1@baylor.edu

Baylor University
One Bear Place 97354, Waco, TX 76798
Master of Science in Geology
Expected Graduation: May 2019

Angelo State University
2601 W. Avenue N, San Angelo, TX 76909
Bachelor of Science in Geoscience
Minor in Mathematics
Graduated May 13, 2017

CERTIFICATIONS

- Texas Board of Professional Geoscientists certified Geoscientist in Training, GIT-238
- MOAS certified in 2010 expert Microsoft Office Word and in 2010 core Microsoft Office Word, Excel, Access, and PowerPoint

WORK EXPERIENCE

Baylor University Department of Geosciences
Graduate Teaching Assistant for Earth Science Lab: Fall 2017

- Responsible for teaching two sections of Earth Science Lab

Angelo State University Department of Physics and Geosciences
Teaching Assistant for Field Methods in Geology Lab: Spring 2017

- Assisted in teaching techniques necessary for successful field navigation and mapping of geologic units
- Assisted on class trip to the Indio Mountains

Teaching Assistant for Mineralogy and Petrology Lab: Fall 2016

- Assisted in teaching various techniques to identify igneous and metamorphic rocks and minerals, in hand sample and thin section
- Prepared for lab by setting up microscopes, thin sections, and hand samples

Terracon Engineering Consultants and Scientists
6911 Blanco Road, San Antonio, TX 78216
Summer Intern in the Soils Lab: May 18, 2015-July 31, 2015

- Performed Atterberg Limits for the Materials Department
- Performed daily lab maintenance and assisted in running proctors and gradations
- Assisted in the GEO and Concrete Labs

Angelo State University Robert G. Carr and Nona K. Carr Scholarship Foundation
ASU Station #11007, San Angelo, TX 76909-1107
Student Assistant: September 2014-October 2015

- Assisted in filing, drafting documents, and proofing spreadsheets

RESEARCH EXPERIENCE

Angelo State University Undergraduate Faculty Mentored Research

Undergraduate Researcher: Spring 2016 - spring 2017

- Drafted a proposal, obtained funding, and completed a project involving the remediation of brine contaminated soils using halophytes
- Presented posters over research project at a national and regional conference

PUBLICATIONS AND PRESENTATIONS

- **Erin Noonan**, Mason Houser, Michael Foust, Kye Burris, James W. Ward, and Cody Scott, Soil Chemistry Analysis of Brine Contaminated Soils in West Texas, USA. Poster presentation at the 2017 Annual Meeting of the Southwest Section of the American Association of Petroleum Geologists in Midland, Texas.
- Dillon Bagnall, **Erin Noonan**, Mason Houser, William Bond, Michael Foust, Maigan Dunlap, James W. Ward, Kye Burris, and Cody Scott, Restoration of Brine Water Impacted Soils Using Halophytes in West Texas. Poster presentation at the 2016 Geological Society of America Conference in Denver, Colorado.
- **Erin Noonan**, Maigan Dunlap, Steve Shaw, James W. Ward, Stop 4: Edith Springs (Also Known as Dripping Springs), Coke County, Texas, *Eastern Shelf Permian Sandstones and Cretaceous Carbonates: Surface Exposures and Subsurface Applications*. Field trip guidebook for the 2016 Annual Meeting of the Southwest Section of the American Association of Petroleum Geologists, April 9, 2016. Also served as leader for this field trip stop.

SKILLS

- Proficient using the program ArcGIS
- Proficient using Microsoft Office Excel, Word, PowerPoint, and Access

AWARDS

- Graduated Summa Cum Laude from Angelo State University, spring 2017
- Angelo State University Presidential Award Nominee, spring 2017
- Angelo State University Dean's List, fall 2014-spring 2017
- Member of the Theta Gamma Chapter of the Sigma Gamma Epsilon Geology Honor Society, spring 2016-present
- Member of the Phi Kappa Phi National Honor Society, spring 2016-present
- Member of the Texas Alpha Iota Chapter of the Alpha Chi National Honor Society, fall 2015-present
- Recipient of Angelo State University's Outstanding Senior Geoscience Student Award, 2017
- Recipient of Angelo State University's Outstanding Junior Geoscience Student Award, 2016
- Recipient of Angelo State University's Outstanding Sophomore Geoscience Student Award, 2015
- Recipient of Angelo State University's Field Camp Scholarship, 2016
- Recipient of the Betty Mills Geoscience Scholarship, 2015 & 2016
- Recipient of Angelo State University's Carr Excellence Scholarship, 2014-2017