NM WRRI Student Research Grant Final Report

Student Researcher: Elizabeth Brock (New Mexico State University)

Faculty Advisor: Dr. Wiebke Boeing (Department of Fish, Wildlife and Conservation Ecology)

Project title: Impacts of Water Discharge and Flow Variations of the Rio Grande on Macroinvertebrate Abundance and Community Composition

Research problem:

Human disturbances such as dams regulate the Rio Grande River and mostly manage water for agricultural irrigation and flood control. Studies have predicted that reservoir dams may negatively influence aquatic food-chain structures. Investigating taxa communities such as benthic macroinvertebrates provide knowledge of the surrounding ecosystem health after these large water management infrastructures.

Objectives:

My main objective is to evaluate how macroinvertebrate communities along the Rio Grande respond to human disturbances. My specific aims are to (1) evaluate flow regime and water quality parameters along the Rio Grande, and (2) observe macroinvertebrate abundance, species diversity, size, and categorize feeding groups above and below diversion dams and reservoirs during four months in 2024.

Methodology:

Study area

My study was conducted along the Rio Chama and Rio Grande rivers. The Rio Chama and the Rio Grande River merge channels on the Ohkay Owingeh pueblo reservation. Ancient civilizations have depended on these southwestern streams for centuries, or even millennia. I selected six sites: Three reservoirs and three diversion dams (Fig. 1, Table 1). Specific sites from north to south included the Abiquiu Reservoir, Cochiti Reservoir, Angostura Diversion Dam, Isleta Diversion Dam, San Acacia Diversion Dam, Caballo Reservoir. For my last sampling, I was denied access to Angostura Diversion Dam and replaced it with Leasburg Diversion Dam. Selecting another diversion dam site allowed me to maintain similarities in habitat and infrastructure type.
I visited each site four times in 2024 (January, March, May, and July) and collected data described below. I have competed all field work. I am still in the process of isolating, identifying, and measuring invertebrate specimens before being able to conduct final statistical analyses.

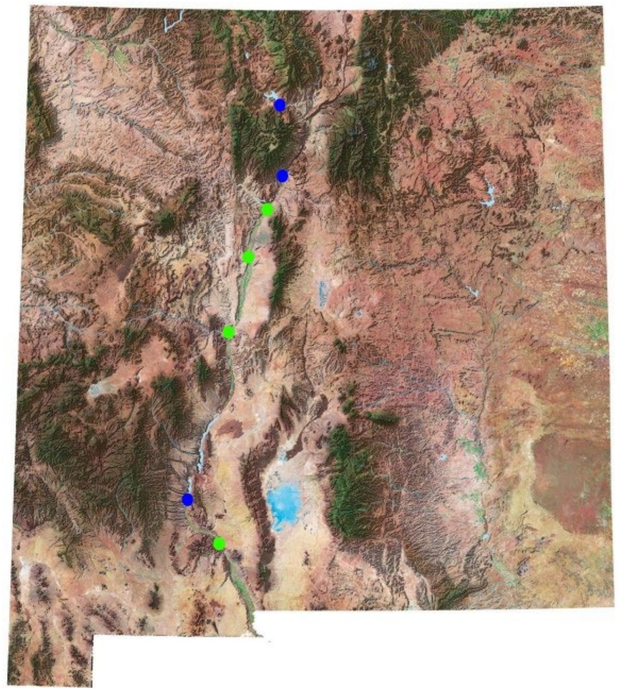

Figure 1. A satellite image of New Mexico and labeled are seven study sites; three Reservoir dams (blue dots) and four Diversion dams (green dots).

Table 1: Reservoirs and Diversion Dams from north to south and their abbreviations.

Site	Reservoir/Diversion Dam	Abbreviation
Abiquiu	Reservoir	AB-R
Cochiti	Reservoir	CO-R
Angostura	Diversion Dam	ANG-DD
Isleta	Diversion Dam	ISL-DD
San Acacia	Diversion Dam	SA-DD
Caballo	Reservoir	CAB-R
Leasburg	Diversion Dam	LEAS-DD

Hydrological Data and Water Chemistry

Water chemistry and hydrology data were measured both in the field and laboratory. I took physical parameters of each of my sites including depth (meters) and velocity (m/s), using a Flowprobe (Xylem). I also measured standard water quality parameters such as Secchi Depth (cm) using a turbidity tube as well as dissolved oxygen (DO, mg/L), temperature (WT, ˚C), pH, and conductivity (Cond, µS/m) using a Hach Hydrolab for each sites (Fig. 2). Furthermore, I collected a water sample from each site, stored it in a cooler with ice, and sent them to a water quality lab for total nitrogen (TN) analyses. Nitrate (NO_3) and Ammonia (NH_3) testing was done in the field using DR900 Hach Multiparameter Portable Colorimeter. Furthermore, I obtained quantitative streamflow data such as water discharge measurements and height throughout my Rio Grande sites through the United States Geological Survey (USGS), which operates several stream gauges that measure continuous seasonal and annual data in the flow regime from Abiquiu to Leasburg Diversion Dam.

Figure 2. Elizabeth Brock and Undergraduate Pauline Mae Sanchez used Hydro Lab and Hatch HQ40d to measure water chemistry and Nitrate/Ammonia.

Habitat Identification

Macroinvertebrate communities are influenced by the substrate that can range from bedrock to large boulders, gravel, cobble, sand or silt (Merritt and Cummins, 1996), all of which are found in the Rio Grande River channel. The substrate of each of the accessible sites varied. To determine the composition of substrate, I used a meter square to depict the percentage of sand versus stone ratio (Fig. 3), while also recording habitat observations such as categorizing stone size, woody debris, vegetation, and algae.

Figure 3. Use of the square meter to identify habitat type at each sampling site

Aquatic Macroinvertebrate Samples

I sampled each dam site before (control site), and at two sites after (directly after and about 1,000 m downstream) of the reservoir or diversion dam with a 12’x12’ Surber sampler with a D-frame net (500 µm mesh size). Macroinvertebrates were collected and preserved in 75-90% ethanol (Fig. 4). Jars were returned to the lab and identified to family taxonomic and maturity level (larvae, nymph or adult) (Merritt and Cummins, 1996). Specimens were also counted and measured (mm) from each site.

Figure 4. March collection of Macroinvertebrate at San Acacia Diversion Dam.

Data Analysis

I used visual techniques such as line graphs to illustrate physical and water quality trends amongst all measured sites going north to south and compare reservoir and diversion dam structures. Column graphs were created as an observation tool to evaluate the substrate for each study site.

I used the Shannon-Wiener Index for current data to measure biodiversity that accounts for species richness and evenness and took averages across sites and months.

Additional data analyses will occur after I have completed sorting, counting, and identifying the macroinvertebrates from the July samples.

Current Results and Discussion:

Flow Regime

In general, I found higher velocities during the May sampling (Fig. 5). This increase could be explained by an increase in temperature from spring to summer and associated spring runoff (Passell et al., 2024). The USGS streamflow gauges (data not shown) also recorded lower water discharge during the months of March and July (USGS.gov, 2024). I was unable to collect data for water velocities in January due to ice on the river, especially in the northern sampling sites.

Water management facilities such as the Bureau of Reclamation, Army Corps of Engineers and Middle Rio Grande Conservancy District release water from reservoirs due to water allocations downstream. These water releases correspond with discharge peaks. However, it was impossible to receive notifications about release times due to lack of interest in communicating with non-government personnel and short-term decision making on release times amongst the different agencies.

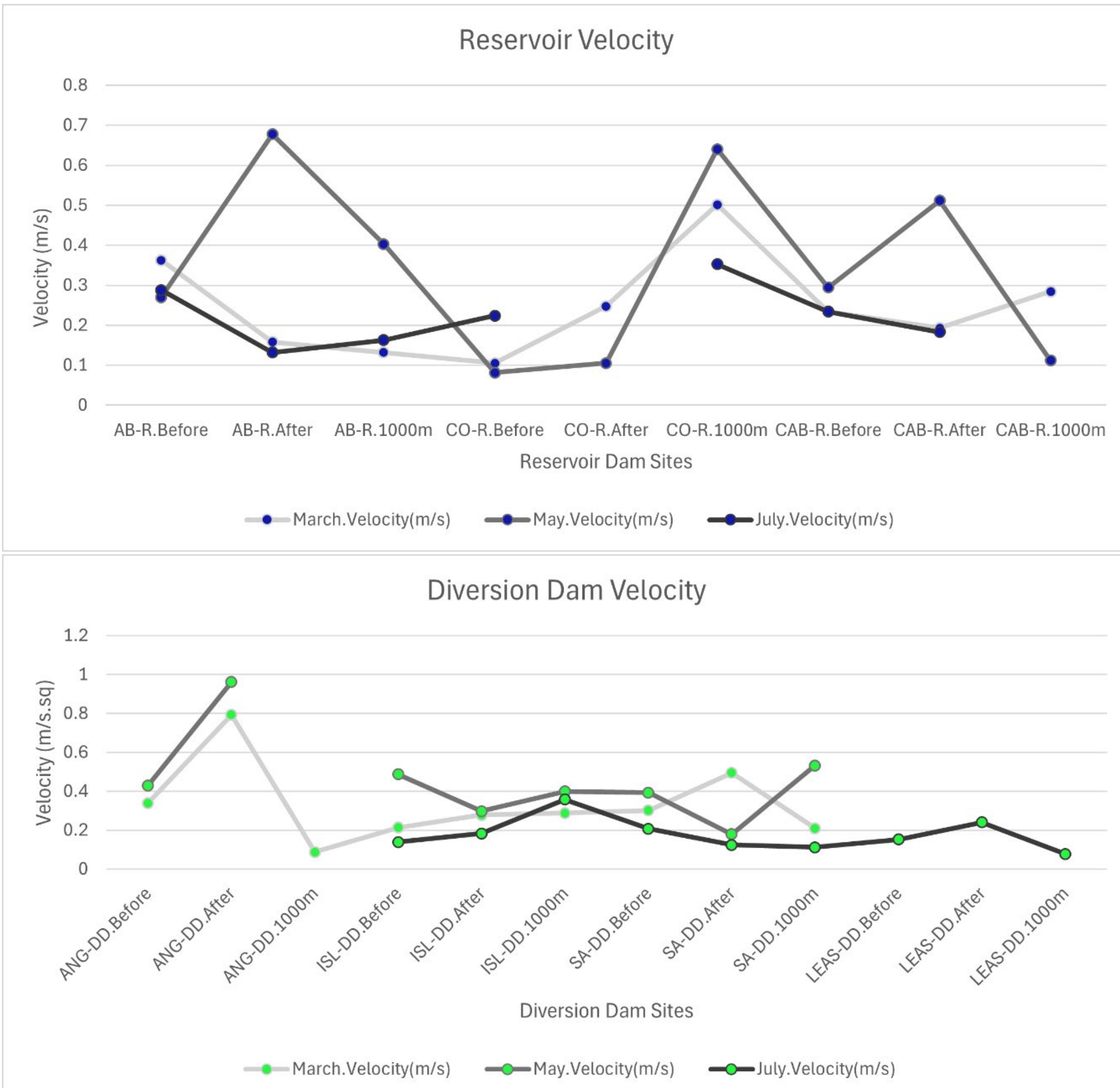

Figure 5. Comparison of average velocity (m/s) for Reservoirs and Diversion Dams for each measured sampling period (March, May, and July)

Mortensen et al. (2024) classified the Rio Grande River reaches into three seasonal sections: Base flow (1 October – 31 March), spring runoff (1 April – 30 June), and summer low flow (1 July – 30 September). By obtaining discharge measurements from USGS, they found that spring runoff caused moderate to high flow rates due to increased water discharge. Thus, an increase in flood pulse increases velocity (Molles et al., 1998). During peak runoff periods an ecosystem is more vulnerable to habitat degradation (Keulegan, 1938).

Water quality

My current water quality data show a slow but persistent increase in conductivity and salinity from Abiquiu to Leasburg for all sample periods (Fig.6).

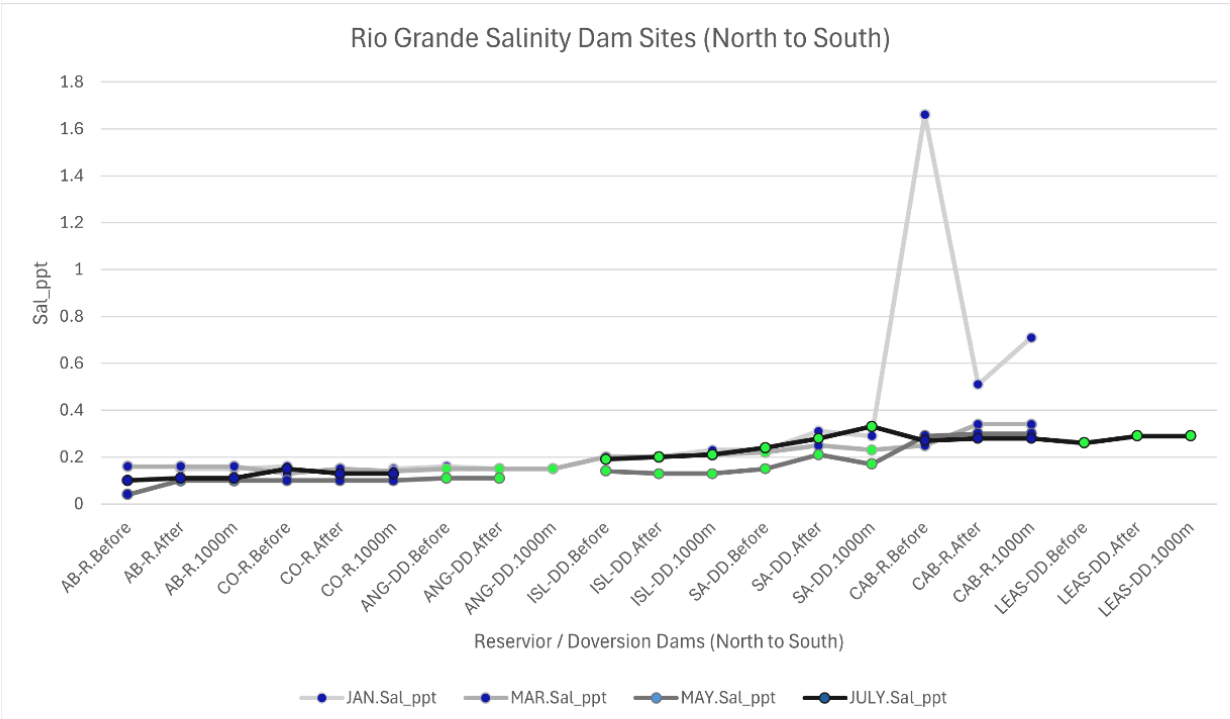

Figure 6. Salinity measurements for every sampling site and for each period (January, March, May, and July)

Nutrient levels

There is an increasing trend in Total Nitrogen (TN) from northern to southern reservoirs and diversion dams, while nitrate (NO_3), and ammonia (NH_3) can vary depending on location (Fig. 7). In river ecosystems, nutrient cycling plays a crucial role in aquatic habitats (Sun et al., 2024). Total nitrogen, nitrate, and ammonia fluctuations can be influenced by seasonal discharge variation, which may influence macroinvertebrate functional diversity and cause shifts in their species compositions. Studies found that increases in nitrate and ammonia could be linked to overall decreases in macroinvertebrate abundance and an increase in tolerant species (Benítez-Mora & Camargo, 2014; Kullasoot et al., 2017; Sun, 2024)

Figure 7. Total nitrogen, nitrate, and ammonia before and after reservoirs and diversion dams

Rio Grande Substrate

Since macroinvertebrates are greatly influenced by habitat type, I evaluated the difference in habitat structure at my sites. After dams, I generally observed an increase in bedrock and large boulders compared to the “before dam” sites (Fig. 8).

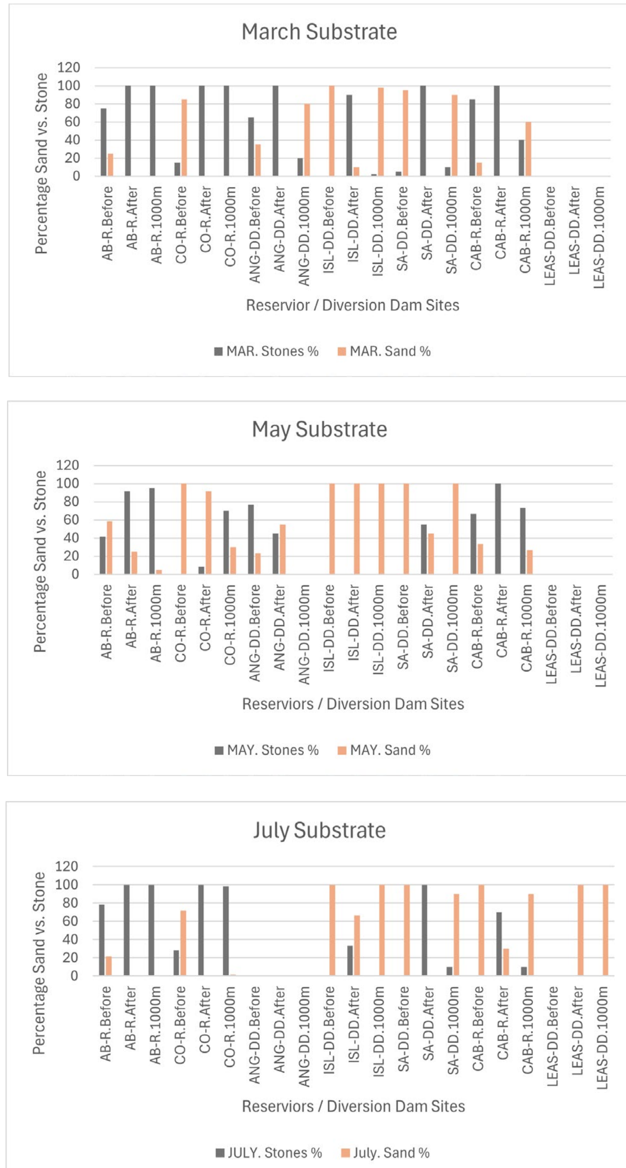

Figure 8. Cluster column graph illustrates my field observations of substrates at each Dam site

Observations such as sand vs. stone within my habits are vital to keep in mind when determining flow impacts on macroinvertebrate species. A study done is western Himalayas showed that rivers with fine sandy substrata have low macroinvertebrate species richness due to the shifting of the sand, which provides poor habitat and low quantities of organic matter (Tachamo Shah et al., 2020). Certain aquatic insects in arid rivers often have morphological adaptations to sand or silt. Species belonging to families such as Beastisidea and Leptophyphidea, have protected gill plates to keep sand from clogging respiratory surfaces (Merritt and Cummins,1996). Some studies have also indicated that gravel and sand provide the better habitat for macroinvertebrates (Tupinambás et al., 2013)

Macroinvertebrate Community Composition

To better understand the health of aquatic ecosystems surrounding dams, I compared species diversity (Shannon-Wiener Index) of macroinvertebrate communities before, directly after, and 1000 m downstream from reservoirs and diversion dams (Fig. 9). In total, 27 families for January, March, and May sampling have been identified, while July samples are still being processed.

Species diversity is highest before Reservoir Dams and lowest directly after the dams. Diversion Dams do not appear to have the same negative effect than Reservoir Dams on macroinvertebrate diversity (Fig. 9).

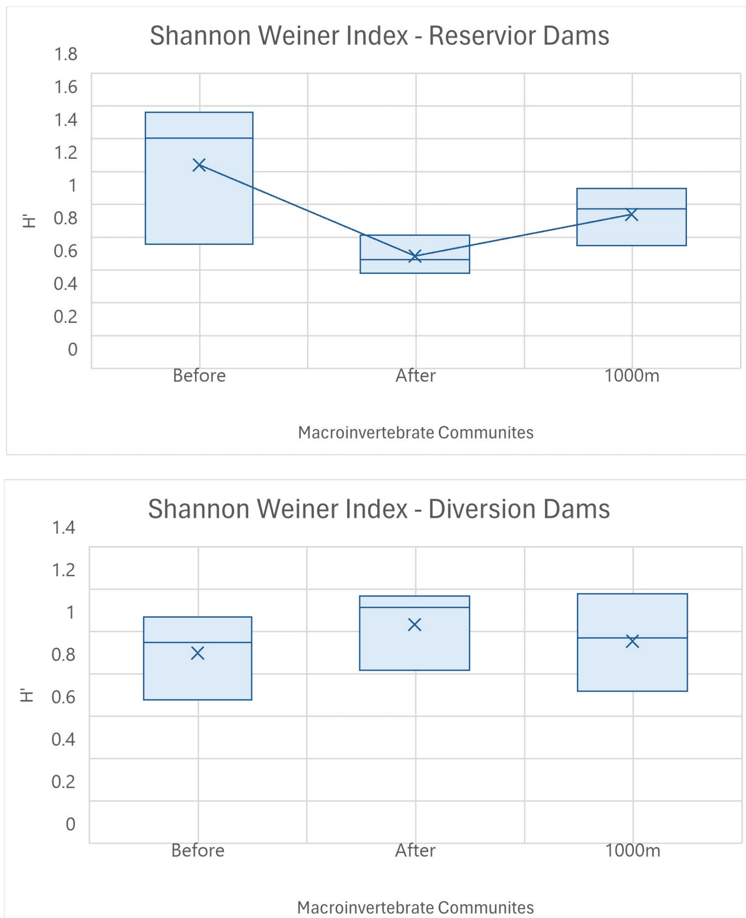

Figure 9. Shows the Shannon-Wiener Index (*H'*) averages for sampled periods comparison amongst Reservoirs vs. Diversion Dams

Reservoir dams retain organic and inorganic particles and disrupt natural flow regime (Tupinambás et al.,2013). Disturbances due to water flow variabilities are greatest below a dam, which makes it difficult for many macroinvertebrate species to adapt to that habitat (Tupinambás et al., 2013). Abiquiu and Cochiti Reservoir generate hydroelectric energy, and their operations often lead to an abrupt increase in water discharge, flow velocities, and bed shear stress directly after their dams (Tonolla et al., 2022). This likely causes dislodgement of macroinvertebrates and avoidance of this habitat by macroinvertebrate species that are more sensitive to this kind of disturbance (Tonolla et al., 2022). Some studies suggest the impoundment effect on macroinvertebrates could be a combination of abiotic changes that downstream reservoirs experience (Krajenbrink et al. 2019). As of now, I have not been able to identify clear impacts of diversion dams on macroinvertebrates, which might be explained by a smaller disturbance scale and differences in their functioning (Krajenbrink et al. 2019; Tonolla et al.,2022).

Physical-chemical factors can determine the make-up of invertebrate communities depending on tolerance level of individual invertebrate species (Merritt and Cummins, 1996). Studies have found that damming does disrupt physicochemical quality downstream of a river stretch, thus favoring macroinvertebrates that are morphologically adapted to the hydrological conditions downstream of these structures (Benítez-Mora & Camargo, 2014; Tonolla et al., 2022; Tupinambás et al., 2013).

Variable water discharge and thus flow regimes is an interplay of many environmental and biological factors (e.g., water quality, substrate, taxa characteristics) and likely causes a complex ecological response that further contributes to shaping macroinvertebrate communities. More advanced statistical analyses will occur after completion of July macroinvertebrate sorting, identifying, counting, and measuring.

Beneficiaries:

A diverse range of stakeholders, including scientists, water resource managers, policymakers, farmers, educational institutions, local communities, wildlife conservation organizations, and the recreation industry, can benefit from this research by gaining insights into the complex interactions between human activities, dam infrastructure, and freshwater ecosystems. The study's outcomes can inform decision-making processes and contribute to the sustainable management of water resources in the Rio Grande River.

By the knowledge gained from my study, Pueblo communities along the Rio Grande and communities with Reservoir or Diversion Dam structures within their reservations will enhance their ability to protect lands and waters, while ensuring their resources will continue to be sustainable through a stewardship lens.

Grant Funds:

<u>Money spent</u>

Undergraduate Research Assistant:	$ 513.21
Fringe:	$ 2.36
Registration WRRI Conference:	$ 50.00

Surber Sampler:	$ 460.61
Flowmeter:	$ 1,367.00
DR860 Hatch Colorimeter:	$ 2,375.00
Hatch NH4/NO3 Reagents:	$ 89.49
Travel reimbursement (January Trip) Brock:	$ 1,070.00
NMSU MAR. Truck mileage:	$ 613.08
NMSU JAN. Truck mileage:	$ 709.80
Total:	$ -309.23

Salary for Ms Brock and a second undergraduate research assistant came from Dr. Boeing's USDA NIFA HSI grant "ENHANCEMENT".

NM WRRI money was spent on salary for undergraduate research assistants for helping collect field samples for each trip, mileage, and field equipment. Any missing funds will be covered by Dr. Boeing's grants.

Presentations:

Brock, E.A., W.J. Boeing. 2023 Research Proposal: Impacts of Water Discharge and Flow Variations of the Rio Grande on Macroinvertebrate Abundance and Community Composition. 68th Annuel New Mexico Water Conference, Albuquerque, NM, USA

Brock, E.A., J.H. Thorp, C.F. Frazier, Karlin, A.T., J.D. Buchanan, K.E. McCluney, W.J. Boeing. 2023 Influence of Ambient Conditions Among Branchiopod Community Composition. Chihuahuan Desert Conference, El Paso, TX, USA

Student and Faculty Assistants:

Committee Members: Drs Fitsum Abadi Gebreselassie, Theresa M. Laverty, A.G. "Sam" Fernald, Wiebke Boeing

Undergraduate Assistants: Pauline Mae Sanchez, Jayden Garcia, Anna White, Juan Montenegro

Graduate Assistant: Maggy Walrath

Degree completion and future career plans:

I will graduate with my MSc from the Water Science and Management Program in 2025. After graduation, I plan to work for a water management facility for my tribe (Isleta Pueblo) or a local facility close to the surrounding pueblos. I would also like to continue to do research with the focus of acknowledging indigenous knowledge in the world of STEM. I would also like to be more involved with advocacy towards pushing indigenous perceptions of nature into my future research and possibly policy.

From January 2023 to Spring 2024, I completed 25 credits within the Water Science and Management Program at NMSU. In spring 2024, I took 6 Thesis Credits and a 3-credit Watershed Methods and Management course. Next semester, Fall2024, I plan to take Statistical Hydrology or Spatial Analysis and Modeling courses. I would also like to take a Geographic Information System course as one of my elective credits before Graduation.

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