2019 NM WRRI Student Water Research Grant Final Report

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2. Project title: Rainfall-Runoff Relationships in the Arroyo de los Pinos, Socorro New Mexico

3. Description of research problem and research objectives.

In semi-arid climates, sediment influx to large rivers such as the Rio Grande from small ephemeral streams is challenging to quantify. Small ephemeral streams are not studied as often as perennial streams because of their erratic nature and the fact that they are usually located in hard to access, remote deserts where flash floods are common. The Arroyo de los Pinos is currently one of very few study sites collecting data on water discharge, bedload transport, suspended sediment, and other relevant measurements during flash floods in dryland environments. This study site is located close to the confluence of the arroyo and the Rio Grande, yet data on the contributing watershed are lacking. Gaining a clearer picture of stream connectivity and rainfall-runoff relationships in this channel will be useful for quantifying flow generation as well as aquifer recharge and transmission loss through the stream bed. These processes affect flow conditions, and thus sediment transport.

4. Description of methodology employed.

Eighteen Hobo pressure transducers (Onset Corporation) and five tipping bucket rain gauges collected runoff and rainfall data in the Pinos watershed over the past monsoon season. The pressure transducers collect stage hydrographs during rare flooding events, which can be convert to discharge hydrographs using surveyed channel geometry and the Manning equation. Six runoff events were recorded by the array of equipment in the Pinos watershed during 2019.

The runoff ratio is the ratio of the volume of water that was generated as runoff divided by the total volume of rain that fell on a catchment. Because the tipping bucket rain gauge measurements are point measurements, the Theissen polygon method was used to estimate the spatial distribution of rain that fell on each subbasin. This was done by drawing perpendicular lines half-way between each rain gauge and its neighboring gauges and extending these lines out until they reached the entire arroyo's boundary, thereby creating separate polygons around each gauge. The percent of each subbasin that fell within each Theissen polygon was calculated and used to estimate a weighted rainfall average for each subbasin. For each flow event, the volume of rain was compared to the volume of runoff.

The lag time was calculated by comparing every pressure transducer that recorded flow to all rain gauges that recorded precipitation for a specific storm.

5. Description of results; include findings, conclusions, and recommendations for further research.

Six runoff events were recorded by the equipment in the Pinos watershed during late 2018 and 2019. I will present results from only one event that occurred on 10/2/2018.

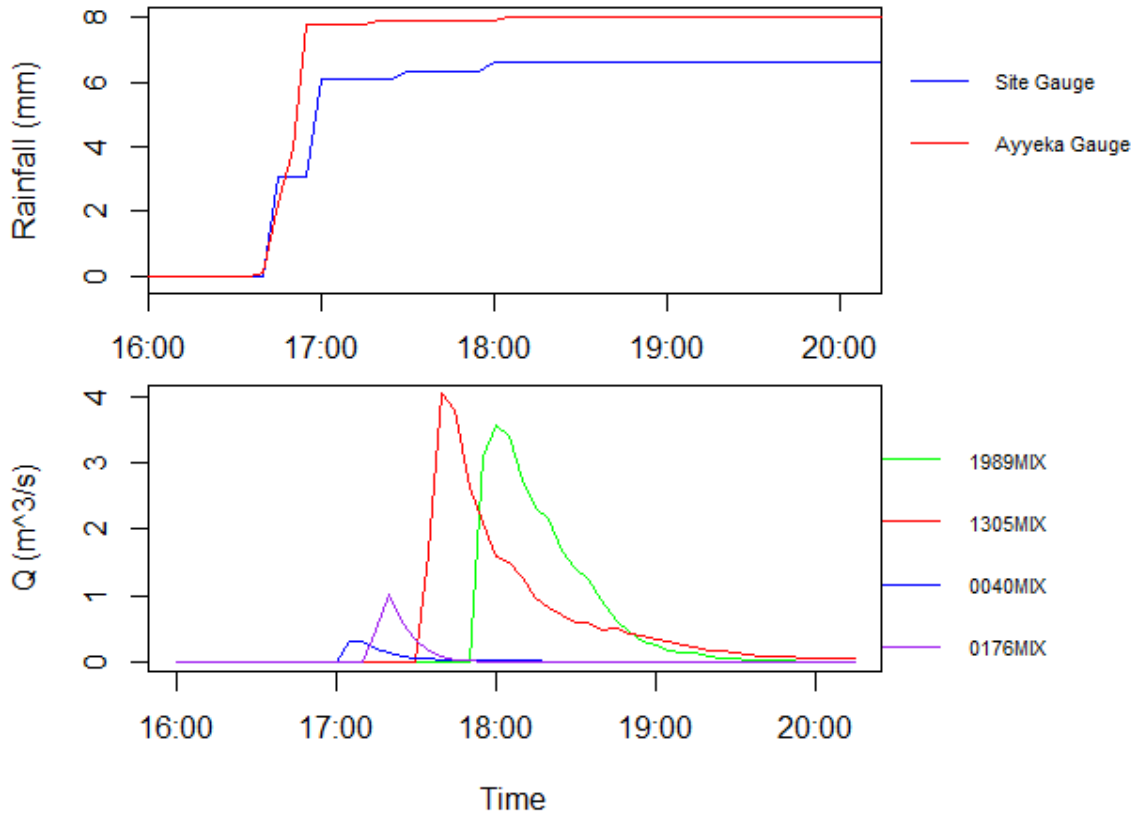

Figure 1: Rainfall Hyetograph and Discharge Hydrograph for flow event on 10/2/2018

Event Date	1989MIX	1305MIX	0040MIX	0176MIX
10/2/2018	0.00569%	0.000916%	0.015%	0.00705%

Figure 2: Runoff Ratios for flow event on 10/2/2018

Pressure Transducer	Lag from Site Gauge (hours)	Lag from Ayyeka Gauge (hours)
1989MIX	1hr 15mins	1hr 25mins
1305MIX	55mins	1hr 5mins
0040MIX	25mins	35mins
0176MIX	35mins	45mins

Figure 3: Lag Times for flow event on 10/2/2018

In the arroyo de los Pinos, rainfall intensity and duration, lithology, and antecedent soil moisture conditions are primary controls on whether runoff is generated for a given storm. For a majority of the runoff events analyzed in this thesis, storms moved west to east across the watershed. Runoff was not generated until the storm cell had moved past the lower third of the basin that was dominated by alluvial cover. Watershed 0043PEN produced runoff for four out of the six runoff events looked at, and it has one of the smallest drainage areas, and is very homogeneous in lithology (dominated by Pennsylvanian aged Madera Group). The lowest rainfall intensity that generated runoff over the study period was 4.58 mm over 40 minutes (or 6.87 mm/hr).

Drainage area is the main control on lag time within the Arroyo de los Pinos watershed. This makes sense because it takes more time for runoff to be generated at the outlet of a large basin because the flood water must travel a further distance. The position and areal extent of flood generating storm cells is also an important factor that influences lag time. If the storm centroid is close to the outlet it will take less time for flow to reach the outlet than if the centroid had been near the basin's headwaters.

Drainage basin area is the main control on runoff ratio within the Arroyo de los Pinos watershed. The sub basins associated with pressure transducers 0043PEN and 0040MIX had the greatest runoff ratios overall. This makes sense because it takes longer for runoff to make its way to the outlet of larger basins, and longer flow paths allow for more infiltration. 0043PEN overall had a slightly greater runoff ratio compared to 0040MIX, suggesting that lithology is a secondary control on runoff ratio.

In order to further illuminate the driving mechanisms that control flash flooding in deserts, more data is needed. To really understand the processes at work, rainfall and runoff data should continue to be collected for several more years. This is important because climate is one of the main controls on runoff generation, and storm recurrence intervals in the Pinos watershed are not yet well understood. I believe this study would benefit from a higher density rain gauge network. The spatial variation of rainfall in the Pinos watershed is the least well understood factor I analyzed, and so gaining a better understanding of how rainfall varies in space (and time) would help support the runoff generation analysis.

6. Provide a paragraph on who will benefit from your research results. Include any water agency that could use your results.

This project was funded by the US Bureau of Reclamation in an effort to better understand the sediment flux from arroyos into main stem rivers like the Rio Grande. Other agencies that manage dams, reservoirs, and mainstream channels, such as the Army Corps of Engineers, will also benefit from a better understanding of flow and sediment generating mechanisms in ephemeral channels like the Arroyo de los Pinos.

7. Describe how you have spent your grant funds. Also provide your budget balance and how you will use any remaining funds. If you anticipate any funds remaining after May 15, 2019, please contact Carolina Mijares immediately. (575-646-7991; mijares@nmsu.edu)

Items	Amount spent
7 Hobo Pressure Transducer	$500 each x 7 = $3,500
Undergraduate field assistant	$323 ($10 per hour x 30 hours; plus fringe)
Travel (gas) to field site	$40
Total spent	$3,863

Remaining funds: Travel (gas) $137

8. List presentations you have made related to the project.

There are several past and upcoming presentations related to the Pinos:

1. AGU Fall Conference; December 8-15th, 2019
2. NM WRRI 64th New Mexico Water Conference; November 7-8th, 2019
3. Graduate Seminar presentation; April 6th, 2020
4. (Upcoming) Thesis Defense; May 2020

9. List publications or reports, if any, that you are preparing. Remember to acknowledge the NM WRRI funding in any presentation or report that you prepare.

I am preparing my Master's thesis on the data I have collected in the Pinos watershed.

10. List any other students or faculty members who have assisted you with your project.

Dr. Johnathan Laronne from Ben-Gurion University of the Negev has been instrumental in conceiving and providing technical expertise as my co-advisor. Kyle Stark (PhD student) and Sharllyn Pimentel (MSc student) are both working on different aspects of the Pinos project and have helped tremendously with equipment installation and data collection.

11. Provide special recognition awards or notable achievements as a result of the research including any publicity such as newspaper articles, or similar.

NA

12. Provide information on degree completion and future career plans. Funding for student grants comes from the New Mexico Legislature and legislators are interested in whether recipients of these grants go on to complete academic degrees and work in a water-related field in New Mexico or elsewhere.

I plan to finish my master's this May. Over the past six months I have worked part time at the Army Corps of Engineers, in the Hydrology and Hydraulics division in Albuquerque. I plan on transitioning to full time employment at the Army Corps once I graduate.