IS THERE A CORRELATION BETWEEN STORM ORIGINATION AND MAXIMUM SATURATION EVENTS IN THE WALNUT GULCH EXPERIMENTAL WATERSHED?

Wolfgang Knudson (*wolfknud@email.arizona.edu*),
Master's Candidate, *College of Civil Engineering, University of Arizona*

1. Introduction

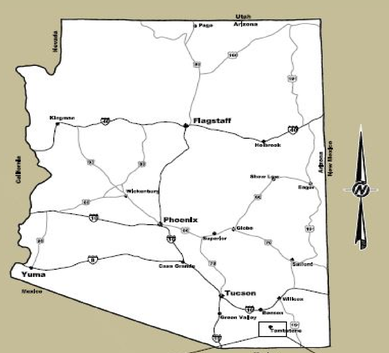
Very little of either summer or winter precipitation reaches the aquifer in Arizona. Horton's equation suggests that infiltration capacity exponentially declines during the early phase of a storm and then tends towards a constant value after a couple of hours for the remainder of the event. When the rainfall intensity is less than the infiltration capacity, all of the water reaching the ground can infiltrate. But if the rainfall intensity exceeds the infiltration capacity, the potential recharge is lost from the aquifer by either surface runoff or evapotranspiration. Maximum saturation events are those that occur over a longer duration with lower intensities which allow the soils to reach their infiltration capacity, and thus maximizing the amount of water that reaches the aquifer.

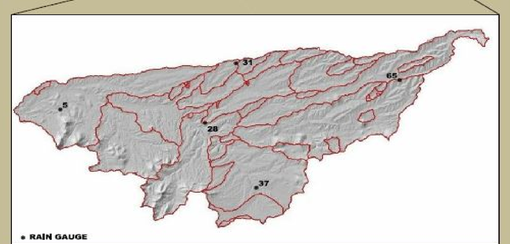
2. Objective

The objective of this study was to 1) Analyze the originations of summer and winter storms in the Walnut Gulch Experimental Watershed (WGEW) and 2) Compare multiple consecutive wet-day rainfall events with similar precipitation depths to determine which seasonal storms have the longer duration and lower rainfall intensity, and thus are likely to contribute the greatest amount of infiltration to the aquifer.

3. Study Site

Located in Southeast Arizona, the 150 sq. km experimental watershed was established in the early 1950's by the USDA to conduct hydrologic and erosion research.



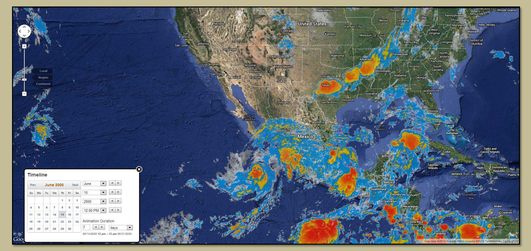


WGEW contains 119 rain gauges. Due to the extensive data available, 5 spatially representative gauges were chosen for their geographic location.

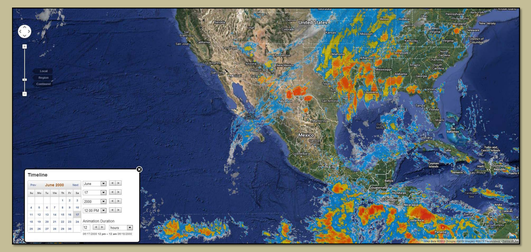
RAIN GAUGE COORDINATES				
	UTM			
Gauge ID	East (m)	North (m)	Elevation (m)	Elevation (ftamsl)
5	582649	3510770	1269	4163
28	590624	3509990	1369	4491
31	592402	3513702	1413	4636
37	593303	3506068	1401	4596
65	601253	3512633	1550	5085

4. Storm Origination

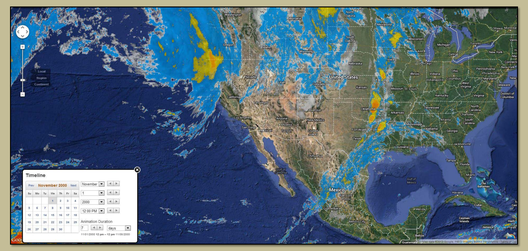
A typical summer storm originates in the Gulf Region.



These summer storms migrate to the north at a fast pace.



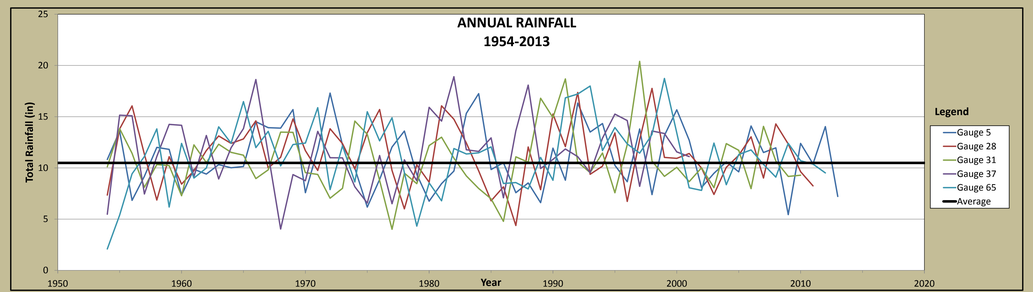
A typical winter storm originates in the Pacific Ocean.



These winter storms move to the east and south at a slower rate.

5. Precipitation Data

Active rain gauge precipitation values were averaged to obtain daily values presented in the Storm Analysis below.



6. Storm Analysis

Between July 1954 and August 2013, 4,052 wets days were recorded for the 5 rain gauges analyzed in the watershed.

Of those events, over 81% (3,276 days) occurred within 2 or more (2+) consecutive days. Of those 2+ days, 21% occurred during the winter storms (November through March), 70% during the summer storms (June through September), and 9% occurred during one of the months not mentioned above.

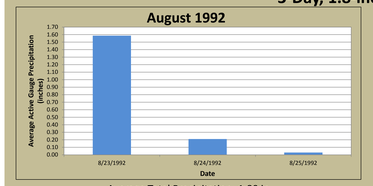
Of the winter storms analyzed, 90% originated from the Pacific Ocean, 95% of the summer storms originated from the Gulf region and the other storm category originated from the Pacific Ocean and Gulf region 40% and 60% respectively.

Eight (8) storm events (4 summer and 4 winter) of similar interval and total cumulative precipitation were compared by the average and maximum storm duration and rainfall intensities to determine which seasonal events produce the maximum saturation potential.

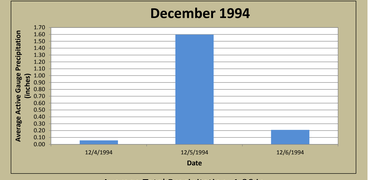
Consecutive Rainfall	Total Number of Occurrences within Listed Average Precipitation Value					
Days	0-1 inch	1-2 inches	2-3 inches	3-4 inches	4-5 inches	5-6 inches
2	450	20	5	0	0	0
3	193	26	2	0	0	0
4	77	24	2	1	0	0
5	41	24	3	0	0	0
6	16	19	3	1	0	0
7	10	12	1	0	0	0
8	5	8	1	2	0	1
9	2	5	6	0	0	0
10	1	3	1	1	0	0
11	0	1	2	0	0	0
12	0	2	0	1	1	0
13	0	1	1	0	0	0
14	1	0	2	0	0	0
15	0	0	1	0	0	0
16	0	0	1	0	0	0
19	0	1	0	0	0	0

7. Storm Comparisons

3-Day, 1.8-inch Storm Events

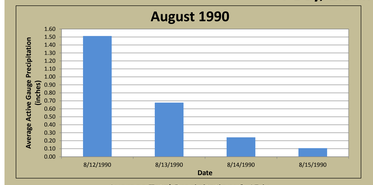


Average Total Precipitation: 1.80 in
Average Storm Duration: 141 min Maximum Storm Duration: 504 min
Average Intensity: 0.12 in/hr Maximum Intensity: 0.36 in/hr

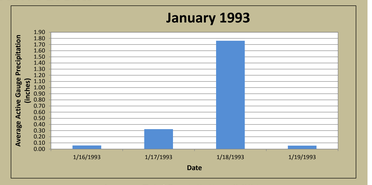


Average Total Precipitation: 1.86 in
Average Storm Duration: 810 min Maximum Storm Duration: 1547 min
Average Intensity: 0.08 in/hr Maximum Intensity: 0.38 in/hr

4-Day, 2.3-inch Storm Events

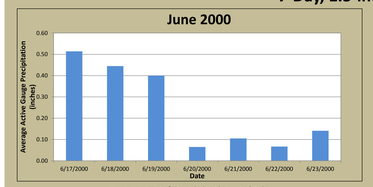


Average Total Precipitation: 2.45 in
Average Storm Duration: 131 min Maximum Storm Duration: 398 min
Average Intensity: 0.19 in/hr Maximum Intensity: 0.96 in/hr

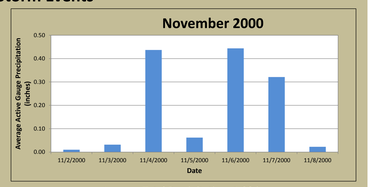


Average Total Precipitation: 2.20 in
Average Storm Duration: 284 min Maximum Storm Duration: 988 min
Average Intensity: 0.06 in/hr Maximum Intensity: 0.19 in/hr

7-Day, 1.3-inch Storm Events

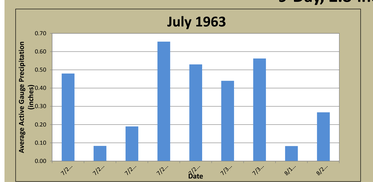


Average Total Precipitation: 1.31 in
Average Storm Duration: 30 min Maximum Storm Duration: 192 min
Average Intensity: 0.50 in/hr Maximum Intensity: 2.30 in/hr

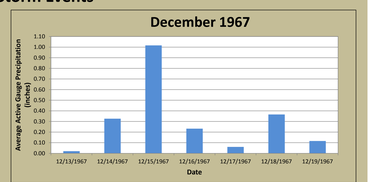


Average Total Precipitation: 1.29 in
Average Storm Duration: 96 min Maximum Storm Duration: 376 min
Average Intensity: 0.19 in/hr Maximum Intensity: 0.60 in/hr

9-Day, 2.8-inch Storm Events



Average Total Precipitation: 2.80 in
Average Storm Duration: 115 min Maximum Storm Duration: 343 min
Average Intensity: 0.34 in/hr Maximum Intensity: 1.80 in/hr



Average Total Precipitation: 2.92 in
Average Storm Duration: 510 min Maximum Storm Duration: 2020 min
Average Intensity: 0.04 in/hr Maximum Intensity: 0.12 in/hr

8. Results

Of the 8 storms compared, all 4 originating from the Pacific Ocean and occurring in the Winter had the longest average duration and lowest rainfall intensity. The winter storms also had the highest maximum duration of 2,020 minutes for a single event (12/14/1967) compared to the maximum summer storm duration 504 minutes (8/23/1992). All of the winter storms but one had the lowest maximum rainfall intensity during the 3-consecutive day storm events, on 12/04/1994, Rain Gauge 37 received 0.07 inches in 11 minutes (0.38 in/hr) compared to its maximum summer counterpart on 8/24/1992, Rain Gauge 65 recorded 0.15 inches in 25 minutes (0.36 in/hr).

9. Conclusions

Summer storms typically originate from the Gulf Region, winter storms tend to originate from the Pacific Ocean. While it rains more frequently during the summer monsoons, the rainfall intensity is higher which results in greater runoff. The Pacific winter storms have lower rainfall intensities which allow more water to infiltrate and recharge the aquifer. On average, maximum saturation events occur more frequently during the Pacific winter storms.

Acknowledgments:
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Data Sets provided by the United States Department of Agriculture, Agricultural Research Service. Southwest Watershed Research Center, Tucson, AZ. www.tucson.ars.ag.gov/dap/
Satellite weather images provided by Weather Underground, 2013. www.wunderground.com