The Impact of Center Pivot Irrigation in the Snake River Plain Aquifer

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Abstract

Groundwater depletion is happening at alarming rates in the Snake River Plain aquifer mainly due to the extensive center pivot agriculture in the area. This area is relatively new to depletion monitoring, since depletion has only been taking place since the 1950s, it is startling and indicative of the future. Observation well data was collected from across the eastern Snake River Plain aquifer to show the patterns of depletion, which was then compared to the locations of the center pivot agriculture to investigate the role of distance to center pivot agriculture. The range of depletion was 0.41-0.69 ft/yr with observation wells being from 0.10-11.28 mi from the nearest center pivot agriculture. While these values show significant depletion, they are not following an observable trend between distance and depletion, leading to the assumption that center pivot agriculture is causing depletion across the aquifer as a whole, however it is not causing this local affect that would be expected. Rather the impact of specific locations is based on the geology of the eastern section of the aquifer which is composed of alternating structure between sedimentary and basaltic layers. Since the water is stored in the basaltic layers and the sedimentary layers are largely impermeable, the water flow is only able to flow in a southwest direction as it originates from the northeast.

Question

What is the impact of center pivot irrigation on groundwater depletion in the Snake River Plain Aquifer?

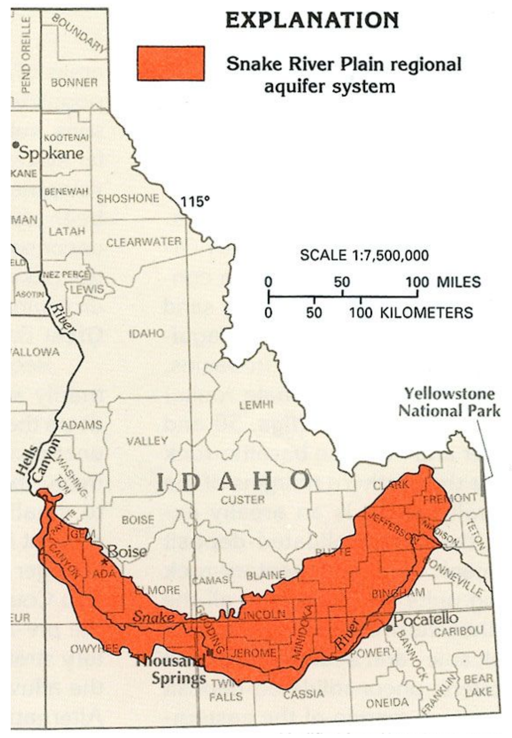


Figure 1: Location of the Snake River Plain Aquifer. Box in the middle is the placement of figure 2, where the observation wells are located. Figure from https://pubs.usgs.gov/ha/ha730/ch_h/H-Snake_River1.html.

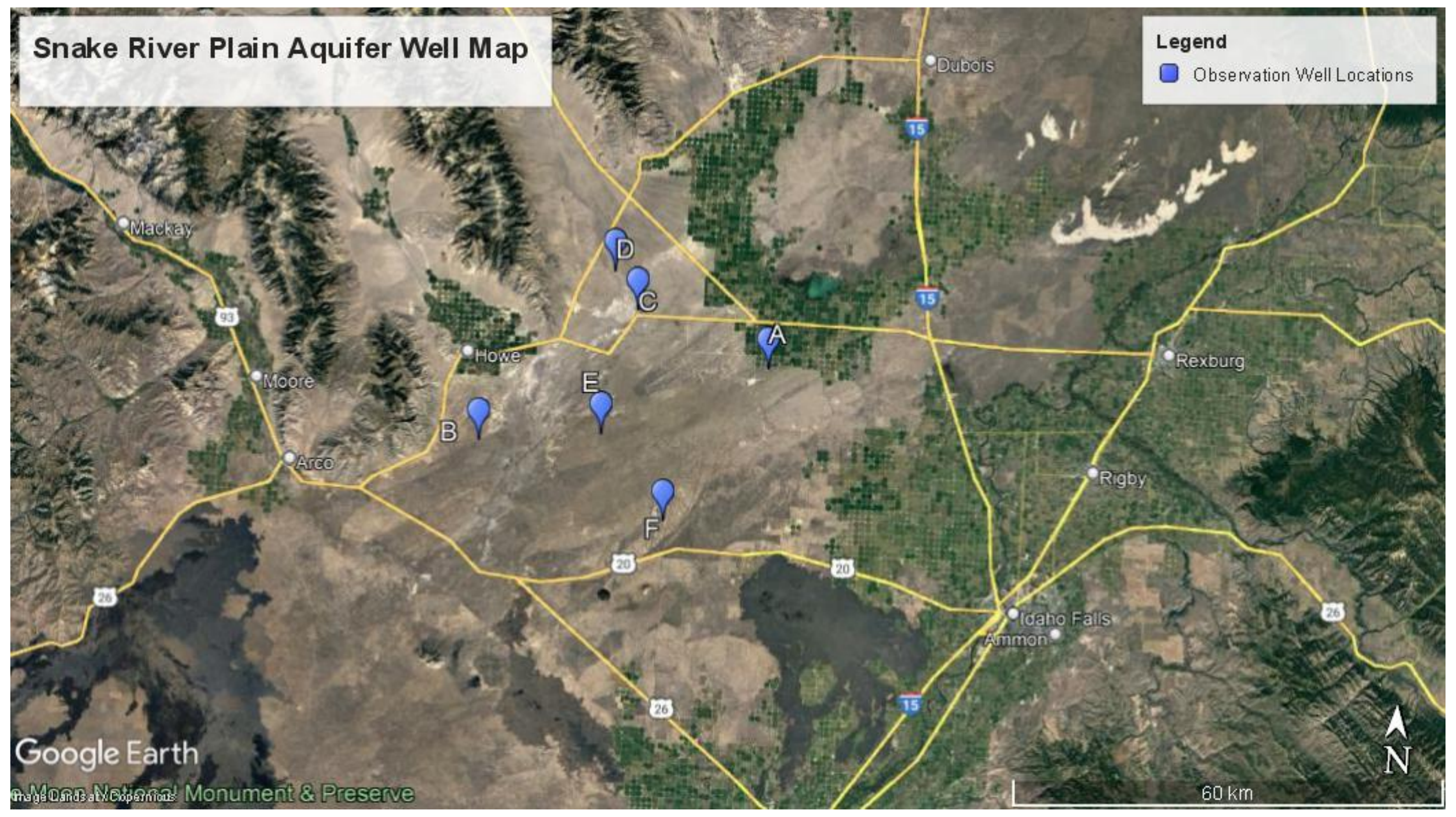


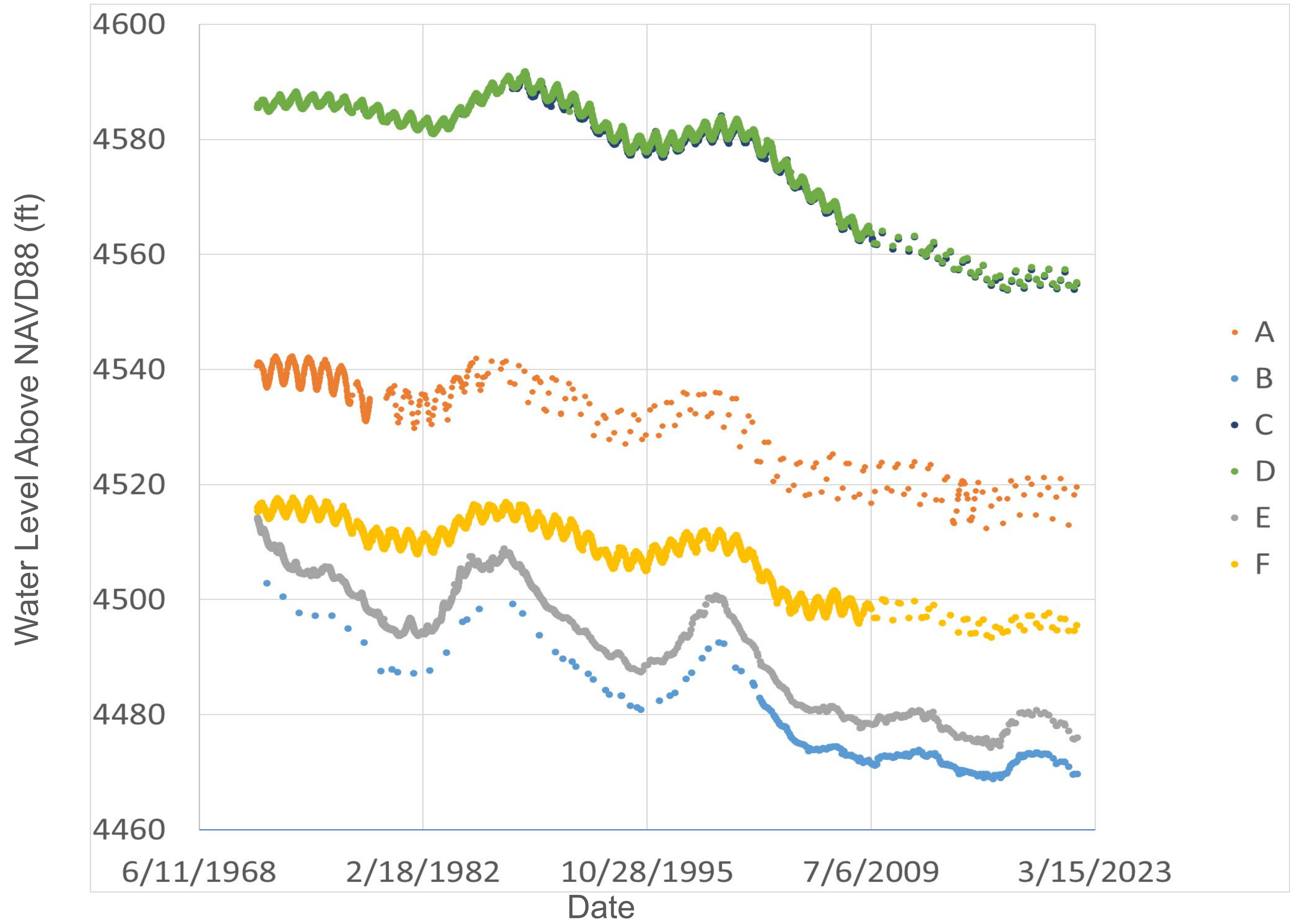
Figure 2: Locations of the USGS observation wells within the Eastern Snake River Plain Aquifer.

Results

Observation Well	Distance to Center Pivot Agriculture (mi)	Depletion Rate (ft/yr)
A	0.10	0.43
B	5.46	0.65
C	6.72	0.62
D	7.30	0.62
E	10.22	0.69
F	11.28	0.41

Table 1: The distance to the closest center pivot agriculture in miles, compared to the depletion rate in the well in ft/year. Map of listed wells in figure 2.

Figure 3: (pictured right) Graph of depletion from USGS observation wells in the Snake River Plain Aquifer. The three main drops in the graph are due to the drought cycles present. The overall depletion is as a result of agriculture primarily in the form of center pivot irrigation, pumping water from the aquifer and not allowing enough time for recharge.



Discussion

There is a substantial difference in the rates of depletion across the aquifer, with depletion averaging between 0.41-0.69 ft/yr over the last 50 years (Figure 2). There is a disproportionate impact across the aquifer from the impacts of irrigation.

Based on the impact of irrigation, the drought cycle impact was intensified. During the drought cycles, irrigation efficiency increased allowing for increased production which caused decreased recharge. Based on decreased recharge the aquifer was never allowed to reset back to original levels after drought cycles as it had done previously.

While irrigation in the form of center pivot irrigation is causing the depletion in the aquifer it is not directly tied to the distance from the aquifer. If it were linked then it could be expected that the greatest depletion would be closest to the center pivot which is not seen.

Without an identifying link between the distance to center pivot irrigation and depletion it concludes that depletion caused by irrigation is happening on an aquifer scale rather than local scale.

The most likely cause of depletion patterns is due to the geologic layers of basalt interfingered with sedimentary layers. The basaltic layers are much more transmissive then the sedimentary layers which combined with the steep hydraulic gradient control the water movement, limiting the horizontal movement making the water flow in the southwest direction.

Introduction

The Snake River Plain Aquifer is about 28,000 square kilometers and contains 50% of the agricultural land and 85% of irrigated land in Idaho (Mundorff et al., 1964). This combined with extensive agriculture which happens in the area is leading to major depletion of the groundwater. This groundwater is primarily stored in the basaltic layers, with the fastest recharge happening on the eastern side of the aquifer (Whitehead 1994).

Agriculture in the Snake River Plain Aquifer is primarily through groundwater which recharges from the Teton Mountains in the form of snowmelt and flows into the Snake River Plain Aquifer (Plummer et al., 2000). Groundwater recharge peaked in the Snake River Plain in the early 1950s and then decreased due to irrigation (Plummer et al., 2000). Traditionally this area was farmed with a mix of surface water and groundwater, but with the introduction of more efficient irrigation, allowed for increased production and lack of recharge there has been a change towards groundwater which has had a long-term downward trend (Plummer et al., 2000). This trend downward has been noticed from the 1950s and has continued to this day.

The use of center pivot irrigation ties its roots back to the Great Plains during the dust bowl. In the early 19th century when the region was being discovered by the first Euro-Americans they saw the prairies as a waste, likely due to the desert during the drought years (Anderson, 2018). This by the end of the 19th century would lead to irrigation, and in 1948 lead to the addition of center pivot irrigation. This would go on to transform agriculture and increase the ability to farm in many locations previously unsuitable.

Methods

- Using USGS observation well data, graphing the depletion compared to the distance.
- Calculating the distance from each of the observation wells to the closest center pivot agriculture location (Figure 2).
- Mapping locations of the wells compared to center pivot agriculture, looking for trends.
- Calculate depletion rates, from 1972 to present. Based on average values from 1972 as starting value and the last year (February 2021-February 2022) as current value (Table 1).
- Comparing results to known geological data for the eastern part of the aquifer to line up patterns based on the basaltic and sedimentary layers.

Conclusion

The primary cause of the Snake River Plain Aquifer depletion is due to the impact of irrigation, primarily in the form of center pivot irrigation. However, the locations in the aquifer that are most impacted are not directly tied into the distance from center pivot but rather the geology. This geologic pattern is seen in the fingering of the basaltic and sedimentary layers. This matches the pattern that is seen with similar depletion rates along the layers in the southwest direction. This is seen based on the similar depletion rates which are seen in that direction. As a whole depletion due to irrigation is affecting the entire aquifer, with severity based on the geologic makeup.

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References

Groundwater facts. (n.d.). NGWA. Retrieved November 25, 2021, from https://www.ngwa.org/what-isgroundwater/About-groundwater/groundwater-facts

Idaho Potato Museum. Why Idaho? The correct combination of the elements? (2016, July 16). Idaho Potato Museum. https://idahopotatomuseum.com/why-idaho-the-correct-combination-of-theelements/

Lindholm, G. F. (1994). Summary of the Snake River Plain Regional Aquifer-System Analysis in Idaho and Eastern Oregon. US Geological Survey. https://pubs.usgs.gov/pp/1408a/report.pdf

Mundorff, M. J., Crosthwaite, E. G., & Kilburn, C. (1964). *Ground Water for Irrigation in the Snake River Basin in Idaho*. US Geological Survey. https://pubs.usgs.gov/wsp/1654/report.pdf

Plummer, L., Rupert, M., Busenberg, E. and Schlosser, P. (2000), Age of Irrigation Water in Ground Water from the Eastern Snake River Plain Aquifer, South-Central Idaho. Groundwater, 38, 264- 283. https://doi.org/10.1111/j.1745-6584.2000.tb00338.x

USGS, 2022 Groundwater Levels for the nation, accessed on April 22, 2022.

Vanderhoof, M., Christensen J. and Alexander, A. (2019) Influence of multi-decadal land use, irrigation practices and climate on riparian corridors across the Upper Missouri River headwaters basin, Montana. Hydrology and Earth System Sciences, 23, 4269-4292. https://doi.org/10.5194/hess-23-4269-2019

Whitehead, R. L. (1994). *Ground Water Atlas of the United States Hydrologic Investigations Atlas 730-H*. US Geological Survey. https://pubs.usgs.gov/ha/730h/report.pdf