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Hydrology and Earth System Sciences Discussions

Interactive comment on "Groundwater surface water interactions through streambeds and the role of phreatophytes in identifying important recharge zones" *by* T. S. Ahring and D. R. Steward

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We appreciate the review by referee #1 who stated that the research is interesting, well-written and easy to read, with minor scientific and grammatical issues that need to be addressed before the manuscript is finalized. The following comments have been addressed as follows:

Comment #1: Was there any attempt to determine if phreatophytes were removed by land owners, flooding, or other non-water availability-dependent reasons? These possibilities should be acknowledged even if they weren't taken into account.

Response: It is likely that some of the trees have been removed by landowners, however anecdotal evidence of discussion with stakeholders and dead trees standing in river corridors suggests that large scale removal by landowners has not occurred. USGS stream gage data documents that major flood event have not occurred along either river channel during the study period. Tree removal for causes other than water availability was not considered, however, we acknowledge that the paper should be modified to address the possibility that some trees may have been removed by human activity or weather events. The authors believe this removal would create a minimal amount of error in the study due to the fast-growing nature of tamarisk and the annual maintenance that would be required to create a significant difference on a large scale. The historical impact of human activity on tree distribution through fire and winter fuel burning is already acknowledged on lines 21-23, page 7615.

Revision: The authors recommend to add the following sentence on line 1 of page 7625:

"While phreatophyte distribution may also be influenced by human activity (tree cutting) and climatic conditions (flooding events); dead tree stands, interpretation of USGS gauging station data, and anecdotal evidence from conversations with local stakeholders suggests that such forcings have not significantly impacted phreatophyte distribution in the study region."

Comment #2: Was the natural meandering of the stream bed over time taken into account when interpreting the results? From the photos it appears there has been stream bed movement.

Response: A centerline was created along the river channel in both time periods for interpretation of the results. This was to take into account the meandering stream.

Revision: This comment will be addressed by adding the following text before "The total available soil .." on line 4 of page 7621.

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"The centerline of each river was digitized for both pre- and post-development, and the total available soil . . ."

Comment #3: Were the water level records corrected for barometric pressure when possible? WIZARD values are not, and several publications have indicated that barometric pressure can cause large variations in water levels, some specifically in Kansas (Butler et al., 2011, Ground Water, Vol. 49 No. 4 pp 525-533), and along the Arkansas River (See KGS index well program; Haskell well location).

Response: Barometric pressure was not taken into account since the water level changes due to barometric pressure identified in Butler et al., 2011 were typically a few centimeters or less. The seasonal pumping for irrigation results in groundwater changes on the order of 10s of meters (which is addressed also in the next comment).

Revision: The authors recommend mentioning that barometric pressure can cause variations in water levels but they were small compared to the seasonal changes and the large declines associated with aquifer pumping over a 40 year period. The changes to the manuscript are identified in the next response.

Comment #4: Were the water levels chosen taken at the same time/season? Seasonal pumping can cause large (>100ft) variations in the water levels and it is important to ensure all water levels represent the same point in time.

Response: All measurements were taken during the period of well recovery, after wells have recovered from irrigation and before pre-irrigation is applied to minimize the impact of pumping drawdown on the water table.

Revision: The authors recommend to address this and the previous comment through insertion of the following text after the sentence, "A raster map of water level was obtained by kriging the elevation from wells in Southwestern Kansas." on page 7617.

"These wells represent all WIZARD wells that were measured during the recovery period after the cones of depression have recovered from yearly irrigation and before win-

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ter pre-irrigation for the next year occurs. Fluctuations in water level elevation caused by barometric pressure on the order of fractions of meters (Butler et al. 2011) where not specifically addressed, since season pumping creates drawdown at wells in the order of 10s of meters (Steward et al. 2009).

Comment #5: Why is ASR not feasible here? There are both operational and pilot studies elsewhere in the state (e.g. Wichita, Republic). Is it because of a lack of alluvial aquifer? Please specify.

Response: Aquifer Storage and Recovery is operational east of our study region, near the City of Wichita, KS, where excess surface water, above and beyond surface water rights, is captured, treated, and transported several km to recharge pits, trenches and wells. This technology poses tremendous advantage to the water supply and addresses projected shortfalls that would have existed otherwise. ASR is not feasible in our study region because there is no water supply to draw from. The Arkansas and Cimarron Rivers both flow intermittently if at all. There are irrigation ditch companies in Kansas who have irrigation water rights that are almost never exceeded by the annual state line flow of the Arkansas River, so there is almost never any flow as far east as Garden City, KS. A large portion of the Cimarron River rarely, if ever, flows. See gaging station data in Ahring, 2009.

Revision: This is an important point, and will be addressed in the manuscript by adding the following text after the sentence ". . .it is not economically feasible to create artificial recharge projects that use injection due to treatment costs." on lines 20-21, page 7624.

"This is the unfortunate case, since rivers in the study region flow seldom if at all, and excess discharge above authorized surface water rights does not exist, as it does further east near Wichita, Kansas where Aquifer Storage and Recovery is filling the Equus Beds Aquifer for the city's municipal and industrial needs."

Comment #6: How is the statement of potential future research, specifically the need for methods to make naturally infiltrated water cleaner without treatment, related to this

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research?

Response: It is important to identify means of recharging the aquifer without treatment because western Kansas does not have the population base and high-value uses of water that a city like Wichita does to pay for water treatment required by an artificial recharge project. The water that is in the Arkansas River is more than double the EPA drinking water MCL for uranium, and it is also very high in chlorides and sulfates. This water is much cleaner during high flows, such as in the event of a flood, so a recharge project that utilized the river channel and surrounding area to capture flood flows would be highly beneficial to communities and producers along the river basin.

Revision: The authors recommend revising the paper to give some background of the poor water quality in the Arkansas River to explain why it is important to find natural recharge areas that are degrading the quality of the aquifer with poor quality river water, and explain the need to find a method of cleaning up the river water so that better quality water can be recharged. Specifically, the following text will be added to the bottom of page 7627:

"Such activities will be important to successfully filling a depleting aquifer as the existing surface water in the Arkansas River during low flow conditions contains high levels of chlorides and sulfates, and exceeds drinking water standards for uranium (Whittemore et al. 2010). This water is much cleaner during high flows, such as in the event of a flood, so a recharge project that utilized the river channel and surrounding area to capture flood flows would be highly beneficial to communities and producers along the river basin."

Comment #7: Figure 4 is very busy and difficult to view. It is recommended that it be split into several graphs (as Figure 4a-e, etc.) to better view the results.

Response: Figure 4 was originally broken up into separate figures, and the authors consolidated them to better interpret the results. In particular, it was difficult to visually compare the trends across study sites and rivers when they were presented separately.

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Revision: The authors are quite willing to make changes to make the figure easier to interpret. We suggest that we work with the copy editors to make any changes they suggest to enhance visual interpretation.

Technical Correction #1: Page 7 Line 22: Were not where

Response: The authors agree with the proposed change.

Revision: Changes will be made as suggested..

Technical Correction #2: Page 12 Lines 3-9: This section is confusing and needs re-wording.

Response: The authors agree.

Revision: The authors propose adding the sentence, “Expected tree canopy areas were calculated by assigning an equal percentage of total tree canopy area to each soil type, based upon the percentage of the soil type located within the study area.”

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 7613, 2012.