



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Arizona Water Science Center
520 N Park Ave Suite 221
Tucson, AZ 85711

Office: (520) 670-6671 x 278 Fax: (520) 670-5592

September 30, 2014

Jim Upchurch, Forest Supervisor
Coronado National Forest
300 W. Congress St. 85701
Tucson, AZ

Dear Mr. Upchurch:

As requested, our hydrologists Stan Leake, Jesse Dickinson, Don Pool, and Nick Paretto have conducted a technical review of SWCA draft memorandum "Refined approaches to streamflow predictions. The memorandum documents an analysis of the potential impacts of the Rosemont mine on the hydrology of Cienega Creek, Empire Gulch, and Gardner Canyon. The potential impacts described in the report are changes in stream-flow discharge and number of days with zero flow. The approach included regression models with groundwater level as the explanatory variable and stream flow discharge as the response variable. Projected groundwater levels from numerical groundwater models are used to predict future changes in stream flow in the streams.

1. Our first comment is on the approach of using groundwater levels to explain changes in stream flow discharge. The regressions include general relations between these variables in which stream flow can be greater for higher groundwater levels, or stream flow can be lower for higher groundwater levels. However, the regression models are fitted to a limited period of approximately 2 years, which is when overlapping data are available. For management purposes, it is possible that the regression models will be used to project stream conditions as far out as decades and possibly centuries. The relation between groundwater levels in the wells and stream flow discharge may change in the future due to variable climate and landscape conditions. It may be worthwhile to consider that the regressions may not hold up during future hydroclimatic conditions.
2. The results from this regression analysis are used to predict "days with zero flow". There are several factors not discussed in this analysis that could potentially influence the flow at these locations, such as climate variables, antecedent hydrologic conditions, land-use changes, geology, and evapotranspiration. The regressions might be improved by including additional variables that would affect discharge. Additionally, the analysis

could take into account how variables may be interconnected in ways that may not be linear in response.

3. Each regression relates groundwater levels from a single well to the discharge measured at a single gage. The piezometer near Upper Empire Gulch is approximately 100 m from the streamflow measurement location, the piezometer near Upper Cienega Creek above Gardner Canyon is approximately 6 m from the gage, and the Frog Well is approximately 784 m from the USGS gage at Upper Cienega Creek. If a well is fairly close to the stream, water level changes in the well are closely linked to changes in stream flow and evapotranspiration from nearby plants. A more distant well may be less influenced by the stream and indicate more gradual changes. Another useful approach may be to use groundwater-level data from multiple wells that are both close and more distant from the stream. Water levels from distant wells may be useful for indicating differences in groundwater head gradients near the stream. Ultimately, the direction of the groundwater-level gradients control whether the stream is either gaining or losing. Gradients may also be useful in assessing the impact of groundwater drawdowns, which may affect the direction of the gradients near the stream.
4. The regressions predict that higher groundwater levels can result in more discharge, or even the opposite—that higher groundwater levels can result in less discharge. More specifically, the regression coefficients (or slope) for Upper Empire Gulch and Upper Cienega Creek above Gardener are positive, but the coefficient for the Upper Cienega Creek at USGS Streamgage regression is negative. There is no discussion concerning this occurrence and it suggests that the relation between groundwater level and streamflow may not be consistent or that other factors affect this relation, one those possibly being distance. The distance of this well is 7 to 8 times greater than the other stations.
5. Additional explanation about why the 80-percent confidence intervals (CI) were used instead of the 95-percent CI and the implications for using the regression analysis would be helpful.

Thank you for requesting the input of our scientists to help with some of the challenging technical issues facing the Coronado National Forest. Providing scientific information and expertise to benefit resource management decisions is an important part of the USGS mission. If you or your staff has technical questions regarding these review comments, please contact Stan Leake, Jesse Dickinson, Don Pool, or Nick Paretti.

Best Regards,



James Leenhouts

Director, USGS Arizona Water Science Center