Exploring Groundwater lab **Instructor notes**

*Lab in Google Slides:* This lab is designed for online asynchronous delivery. Students can complete it by themselves, or in groups; all at once or in parts. Whatever works for your course. The lab was created in Google slides to allow students drawing capabilities during parts 2 and 3 and downloaded to a powerpoint file. To upload the slides into Google Slides, you can use File->Import to import the powerpoint file to its original version. Make sure to instruct students how to save their own copy of the lab as well so only they have access to their work. This activity could also work in person if printed handouts are given.

*Instructors can easily customize this lab by:*

* Changing the aquifer systems for parts 1 and 4 to reflect local groundwater systems. The data is available on the USGS website (https://groundwaterwatch.usgs.gov/default.asp), but you will have to investigate what wells students could use to find annual and overall trends in water use. You may also have to rewrite Part 4 to reflect the chosen groundwater system used for comparison.
* For part 3, instructors can choose whether to include both scenarios A and B or just one of them.

**Optional Pre-lab activity: Vocabulary self-assessment**

Instructors can have students complete a Groundwater Term Game prior to lab to make sure they understand proper Groundwater-related terminology. If you want proof that students complete the game, students can take a screenshot of their score. The game can be repeated until they reach a perfect score of 12/12.

 Link to game: <https://www.pbslearningmedia.org/resource/a019b2e6-8c43-4093-915c-9e3082ea3910/the-groundwater-term-game/>)

**Answer Key**

We created a separate answer key google slides which contains general answers to questions and the completed contour map and cross-section.

Explanation and tips

**Part 1:** Students will explore well data from the USGS active groundwater level network. From the USGS link, make sure they click on Douglas County from the county list below the map. It is not completely obvious that the county name is a link. Within Douglas Country, students are asked to analyze 3 continuous wells that access the Upper Dawson aquifer. They will probably click on the map to find the wells, but if they have difficulty, the following wells can be found in the list below the map: UDAW 5, UDAW 3, UDAW 10, UDAW 4, and UDAW 9. In case this data cannot be accessed, a pdf with the data for all these wells are included with the lab materials.

 A large goal of this activity is to allow students to search for the important information that they need to fill out the table in the lab. If a student is struggling to find the appropriate information, it might be helpful for instructors to point them to reading the axes of the graphs or labels in the charts rather than pointing them specifically to where the data is.

**Part 2:** Part 2 leads students to explore porosity and permeability in a deeper manner than just watching the video. If students struggle with the thought experiment, you could offer more direct thinking questions, such as “Is sediment completely solid?”, “Think of how a sponge holds water, how would you measure how much water a sponge holds?”, “Might you need a container so you can measure volume?”, “How could you see how water flows through sediment, what tools might you need so you can contain the sediment?”, “What are you measuring to see how well water moves? Speed, volume, something else?”, etc.

 The rest of Part 2 is more structured. Students might need a reminder where the drawing tools are and how to draw bars or lines for the graphs.

**Part 3:** Part 3 leads students through a water table contouring exercise and a few scenarios using the contour map. Students might need help with the contouring task. An explanation and a video are provided, but students may need additional explanations and/or a review on how to use the drawing tools in Google Slides. You might want to stress that the contours don’t need to be perfect and they can simply eyeball where the contours should pass between the data points.

**Part 4:** In Part 4, students will investigate how Tucson, AZ managed to improve their groundwater supply and use this example to make recommendations to Douglas County. The Tucson Water report is available in the WellData pdf (as well as the water well data from 1 Tucson well) if it is no longer available online.

Overall, students should focus on how Tucson recharged their aquifer system using water from the Colorado river and how they developed water resources other than groundwater. Students should also determine if similar solutions could be implemented in Douglas County (there are other methods used and described as well). If students are stuck, ask them what is needed to recharge an aquifer (water source, area for recharge basins or other methods, and sediments or rocks that allow the water to get into the correct aquifer units). Does Douglas County have these things? Could they implement an aquifer recharge system or other methods that could help; where? These questions should lead students to the right information and line of thinking.

Suggested Rubric: 80 points total, suggested points per item are given in the key.

Part 1: 15 pts

Part 2: 18 pts

Part 3: 27 pts

Part 4: 20 pts