How many people can the aquifer support?

Groundwater, Drought, and Natural Resource Management

Task 2: Indicators of Aquifer Sustainability

Task Overview

In this lesson students begin their investigation into the ways groundwater and surface water are connected. Students will observe the effect of adding wells to an area and will begin constructing a computational model that predicts the health of the aquifer.

Lesson NGSS Practices, Crosscutting Concepts, Disciplinary Core Ideas

Disciplinary Core Ideas:

ESS2.A: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS3.A: Resource availability has guided the development of human society.

ESS3.C: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Science & Engineering Practices:

Developing and using models

Planning and carrying out investigations

Analyzing and interpreting data

Crosscutting Concepts:

Patterns

Cause and effect

Stability and change

Materials:

Access to computers and the Internet

Student Handouts, *Aquifer Exploration* and

Poster paper, markers

Safety Concerns:

None

I. Opening Activity: Irrigation - The Dust Bowl's Legacy

Ask students what they believe to be the historical lessons learned from the Dust Bowl after watching yesterday's video and after their initial exploration of the simulation.

Answers will vary but may include suggestions such as *improved farming techniques*, *a change in farming practices especially during times of drought, etc.*

Show students the following clip from Ken Burns' *The Dust Bowl* series (1 minute, 19 seconds). This clip makes the point that irrigation, a practice that became popular and over-used during the 1930s, is still a conventional farming practice throughout America.
https://www.youtube.com/watch?v=SdbHx4TFGjU

Use this video as a way to build upon yesterday's observations. Students will be adding wells to the online simulation today, choosing how much water the farm can pump and how much the city can pump. They will begin to investigate the qualifications of a sustainable aquifer, by examining the causes and effects of pumping water from a well.

II: Indicators of Aquifer Sustainability

Students begin working on Task 2 Handout in which students identify the characteristics of aquifer sustainability. Students will identify four potential indicators of sustainability and use a Claim-Evidence-Reasoning chart in order to support their claims with evidence.

III: Class Discussion

After students have completed their Claim-Evidence-Reasoning chart, each student group should share their identified indicators of aquifer sustainability with the class. Student responses, including the evidence for their claims, should be recorded for all students to see as the discussion progresses. Students should discuss the merits of each idea listed by their classmates.

Possible indicators of aquifer sustainability may include: the area of the wetlands, water table depth for a single/group/cross-section of wetland cells, water table depth for farm or city wells, or river outflow.

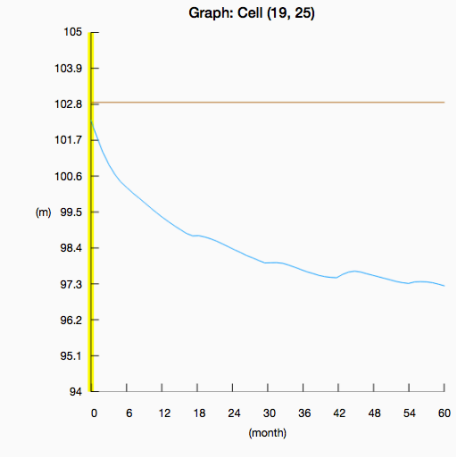
After discussing the indicators and their merits, allow student groups the opportunity to make revisions or changes to their own identified indicators of aquifer.

Students groups should then *choose two* of their indicators for use in developing their computational model.

IV: Data Collection and Computational Models

Before students get started on data collection, it is important to review with them the proper ways of collecting data in order to compare variables. Review *independent* and *dependent variables* and what that may look like in the context of the simulation. Do the following example, or similar, with the students.

- Load the *City* pre-determined scenario
- Select a wetland cell such as (19, 25)
- Ask students to identify the independent and dependent variables for this graph.
- Observe the graph with the students, and discuss what type of data could be taken from this graph. For instance, The Month of June could be the independent variable, and depth below the surface the dependent variable. (*Note: reading the graph itself may not be accurate. By moving the animation slider within the simulation, the data bar under the map will display the correct information while highlighting the desired spot on the graph.)*

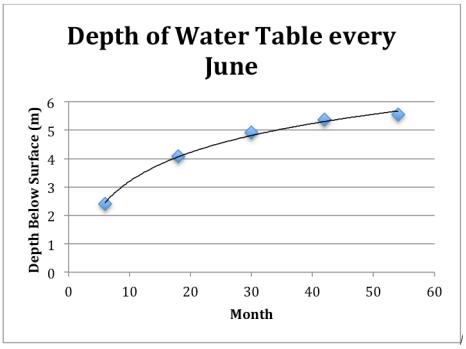


- Walk students through constructing a data table (in lab notebooks or in a spreadsheet)

Month	6	18	30	42	54
Water Table depth below surface (m)	102.84 m – 100.43 m = 2.410	4.083	4.906	5.360	5.535

- Set up a graph with axes and plot points – highlight proper labeling and title.
- Sketch a best fit line, reminding students that we never "connect the dots"
- *If appropriate to students' mathematical abilities, encourage them to add a trend line that best fits the data.*

- Ask students if they think that this point is representative of the entire aquifer? Select another point (near the farm, for instance) and observe the graph in the simulation.
  - Ask the students why they think this plot was so different. (*The wetlands are very close to the three city wells)*
  - What does this point indicate for the aquifer? (*This wetland cell is no longer a wetland cell after a few years of pumping. This indicates that the wetlands are shrinking due to pumping in this scenario.)*
  - What does this indicate to us about how we should collect data? (*Students should use at least two of their indicators of aquifer sustainability and check to make sure their results make sense across the aquifer. If they can't explain*



disparities in their data, they should consult with the teacher for next steps for further investigation.)

Students collect data for two Indicators of Aquifer Sustainability. Data should be recorded in a spreadsheet or in lab notebooks.

Note: While students collect data it is important to monitor the ways in which they are doing this. For instance, students should have a clear procedure for how often they are collecting data (e.g. water table depth for cell (12, 20) every January (months 1, 13, 25, etc.) rather than every month.

Students should graph their data. Remind students that they are looking for trends and patterns in their data that suggests a relationship.

Examples of Collected Data:

- Wetland Area vs. Month
- Water Table Depth (of a single cell) vs. Month
- Water Table Depth (of a single cell) vs. Different Total Pumping Rates
- Pumping Rates vs. Wetland Area
- Pumping Rates vs. Water Table Depth at a Well
- Pumping Rates vs. Water Table Depth (of a single cell)
- Pumping Rates vs. Average Water Table Depth of a Cross-Section

V: Gallery Walk

Student groups should sketch their graphs on to poster paper to share with the class in a gallery walk. Have students write questions or provide constructive feedback on post-it notes and stick them to other group's posters during the gallery walk. These comments should be constructive, provide feedback to that group in terms of their choices of Indicators of Aquifer Sustainability, and the merits or limits of the models, or questions about their work so far. The sentence frames below may help students deliver appropriate feedback:

Your model does a good job explaining _____.
Did you consider _____?
I suggest _____.
How does your model explain _____?

VI: Closing

Give students time to reflect on the comments and questions left on their posters. Either discuss common themes in the feedback as a class, or provide students time to write reflections about the feedback they received from their peers.