Drilling into Science: A Hands-on Cooperative Learning Oil Exploration Activity designed for Middle School and High School Students

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As stories of rising oil prices and impending oil shortages continue to make front-page news, it becomes increasingly important that K-12 students are exposed to some of the fundamental concepts behind the exploration, discovery, and production of this valuable natural resource. As part of a collaborative effort for the National Science Foundation's GK-12 program at Rutgers University, we have developed an interactive oil exploration activity, which allows students to investigate some of these topics. Students become geologists and oil prospectors for the day as they work their way through a set of real geologic data in hopes of becoming the group that finds the most oil. This hands-on activity meets many of the state mandated educational standards and can be used to supplement any earth science or natural resources unit.

Students begin this activity by discussing many of the basics of petroleum geology, including the formation, exploration, production, applications, and controversies of petroleum usage. Students will then analyze a series of geologic maps in which they will need to use what they know about petroleum geology to determine the best locations to drill for oil. Once the drilling locations are selected, students will actually drill for oil in their own "oil field", which consist of covered containers filled with sand and buried oil reservoirs. During the drilling, students are responsible for keeping track of their drilling expenses and for collecting data on their discovered reservoirs. The activity will conclude with a series of calculations in which the students will determine which group made the most money by subtracting their total drilling costs from the amount of money earned from each oil reservoir discovery. All lesson plans, handouts, and setup instructions are available upon request from the author.

Drilling into Science!!- A Hands on Natural Resource Lab
In this lesson students will learn about the generation and exploration of petroleum by becoming geologists and oil prospectors for a day. Students will use science and math to work through a set of data to drill for and hopefully discover oil.

Materials
Several large (at least 8.5 by 11 inches) flat opaque waterproof containers (large plastic containers or aluminum catering trays work well)
Aluminum foil
Bag of unscented cat litter
Small paper cups
Several sets of chopsticks
Several straight pins
Bottle of Syrup (or other dark viscous liquid)
Plastic Wrap
Accompanying worksheet and handouts
Colored pencils

Directions
- Fill up three small paper cups and cover with plastic wrap for each container you will be using with your viscous liquid. Using the attached maps, place these cups in the bottom of the containers according to the Answer Key.
- Fill the rest of the container with cat litter up to the top and cover the entire top with aluminum foil. Make sure to place a scale or grid on the corners of the aluminum foil so the students know where to drill.
- Tape one straight pin to the bottom of each chopstick. Take a marker and mark off 1 cm increments on the chopstick so that the students know how far they are drilling.
- Print out the Reservoir Cards and Recovery Cards

Background
Spend a few minutes or an entire day before the drilling activity going over the basics behind petroleum geology. Make sure you cover how petroleum is formed and the conditions necessary to store the oil underground. Also spend some time going over some of the following topics, any of which can be extended into another day of discussion.
- What is petroleum used for (not just used for fueling our cars)?
- The refining process (how does it get from the ground to our gas pumps)?
- The pros and cons of using petroleum.

Activity

Tell the students that they are going to be geologist for the day and will be analyzing a data set to drill for oil. Show them the oil reservoir that they will be working with. Be sure to explain that you cannot look for oil everywhere on the earth because certain conditions need to exist in order for oil to be present. Discuss that most of these places are very hard to get to and even harder to get information about because the oil reservoirs are very deep underground or on the bottom of the ocean.

Introduce the idea of remote sensing or seismic surveying, which are ways that geologists can gather information about an area that is hard to get to. Luckily, some geologists have already done the surveying for our reservoir and have produced several "Play Maps" to help us with our drilling. Refer to the three attached maps labeled Reservoir, Trap, and Source. These three maps provide critical information for locating viable oil reserves because they include the three components necessary for creating and storing large quantities of oil. Therefore, oil reserves are only found in locations where you find all three of these conditions together.

1. Source- This indicates areas that have been buried and heated up enough to turn the organic deposits (dead plant and animal material) into oil. Without this step, no oil will be formed.
2. Reservoir- This indicates areas that contain sand and soil deposits that are capable of storing the oil. Without a suitable reservoir, the oil cannot be pumped out.
3. Seal- This indicates areas that contain rock layers or deposits that are capable of sealing the oil. The seal acts as an upper boundary to the oil, and without which, the oil would be lost to the sediments.

- Break the students up into groups and hand out a set of "Play Maps" and a piece of tracing paper to each group (or the blank base map). Tell them to make a master map by tracing the outlined regions on the reservoir, seal, and source maps onto the tracing paper. From this master map have the students select the "Sweet Spots" on the map (where all three conditions overlap).
- After each student makes their own "Play Map", each group must decide where they are going to drill for oil. Give each group one drill rig (chopstick with pin on end) and let them go drilling for oil. Give them a drilling budget (~ $2.5 Million dollars) and make sure they know they must keep tracking of all their drilling expenses because it will need to be added up at the end. Use the following values for drilling expenses
    - Add $225,000 every time you move to a new drill location.
    - Add $100,00 for every 1 cm you drill
    - Add $1,000,000 for a broken drill bit.
- If the students hit oil, let them draw an "Amount of In-Place Oil" and "Recovery Rate" card and have them record the values in their chart.
- Give the students some time to drill for oil and have them stop with enough time left in the period to do the calculations.

- Calculate the Amount of In-Place Oil (X)- Need to convert your reservoir size to the amount of oil because not all of the reservoir is oil (some of it is rocks, sand, etc…)

Amount of In-Place Oil (X) = (Reservoir Volume * 0.25) * 0.80

- Calculate the Total Recovery (R)- There is no way to pump out all of the oil from a reservoir, so depending on the current technology your recovery rates will vary.

Total Recovery (R) = Amount of In-Place Oil (X) * Recovery Rate * 0.90

- Convert to Million Barrels of Oil (MBO)

Million Barrels of Oil (MBO) = Total Recovery (R) * 6290

- How much money did you make? (M)

Total Money (M) = (MBO/50) * $1,000,000

(Note: I simplified this calculation to make the numbers easier for the kids to handle. But you can just have them multiply the total amount of MBO by the current price of a barrel of oil. Current price ~ $132).

- Have them see how much money they made and report the results to the class. Discuss the results with the class to see who the best prospector was. Talk about how this process could be improved in real life (i.e. improved recovery rates, better seismic and remote sensing techniques).

 **35%**	 **50%**
 **25%**	 **40%**
 **45%**	 **1.0 km^3**
 **2 km^3**	 **2.5 km^3**
 **0.5 km^3**	 **1.5 km^3**

Reservoir Volume Cards	**Reservoir Volume Cards**
Reservoir Volume Cards	**Reservoir Volume Cards**
Recovery Rate Cards	**Reservoir Volume Cards**
Recovery Rate Cards	**Recovery Rate Cards**
Recovery Rate Cards	**Recovery Rate Cards**

Drilling into Science!!

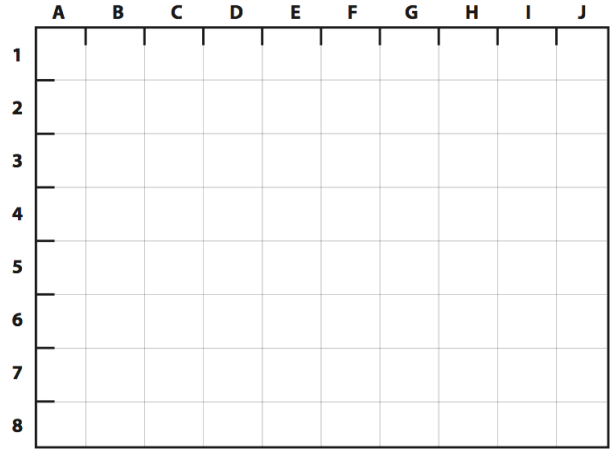
Name_____
Date _____
Class_____

You are geologists and we need your help figuring out where to look for oil. You have a 2.5 Million dollar budget.

1. Using the master maps provided to you, trace each map onto the blank base map, overlapping the maps until the source map, reservoir map, and seal map are complied onto one piece of paper.

2. Identify the "sweet spots" on your maps. These are the spots that contain a source, reservoir, and seal all overlapping.

3. Discuss and compare your "sweet spots" within your groups and decide on five spots that you are going to drill. Mark the five spots on the chart provided below.



4. Show your teacher your completed chart to obtain your drill bit.

5. Using the information below estimate your drilling costs before you begin drilling. You do not want to go over your 2.5 Million dollar budget.

Every time you move the drill to a new location it costs $225,000
For every centimeter that you drill it costs $100,000
If you break a drill bit it costs $1,000,000

****If you find oil your budget can be increased****

You Are Now Ready To Drill

6. Record the information required for each hole in the chart below.
7. If you find oil, let one of the teachers know and have them give you a "Reservoir Volume" and "Recovery Rate".
8. Record the numbers in the appropriate place in the chart below.
9. After each hole drilled calculate the total money spent on that hole (space is provided after the chart). Remember do not go over budget.

	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5
cm drilled					
Oil?? (yes/no)					
Reservoir Volume (RV)					
Recovery Rate (RR)					
Total Money Spent					

Use this space here to calculate the amount of money spent of each hole.

Total Money Spent = $ 225,000 + (cm drilled * $100,000)

Hole 1- $225,000 + (cm drilled · $100,000)= Total Money spent

Answer _____

Hole 2- $225,000 + (cm drilled · $100,000)= Total Money spent

Answer _____

Hole 3- $225,000 + (cm drilled · $100,000)= Total Money spent

Answer _____

Hole 4- $225,000 + (cm drilled · $100,000)= Total Money spent

Answer _____

Hole 5- $225,000 + (cm drilled · $100,000)= Total Money spent

Answer _____

TOTAL FOR ALL HOLES DRILLED _____

If you found oil in any of your holes, use the following equations to calculate how much money you would make for each of these finds. Follow each of the steps. SHOW ALL OF YOUR WORK!!!!!!

****Use the chart that you filled in to complete these problems.

Hole 1

Step 1- Calculate the Amount of In-Place Oil (X)-

Amount of In-Place Oil (X) = (Reservoir Volume * 0.25) * 0.80

X=(RV * 0.25)*0.80

Step 2- Calculate the Total Recovery ®-

Total Recovery (Y) = Amount of In-Place Oil (X) * Recovery Rate (RR) * 0.90

Y=X*RR*0.90

Step 3- Convert to Million Barrels of Oil (M)

Million Barrels of Oil (MB) = Total Recovery (Y) * 6290

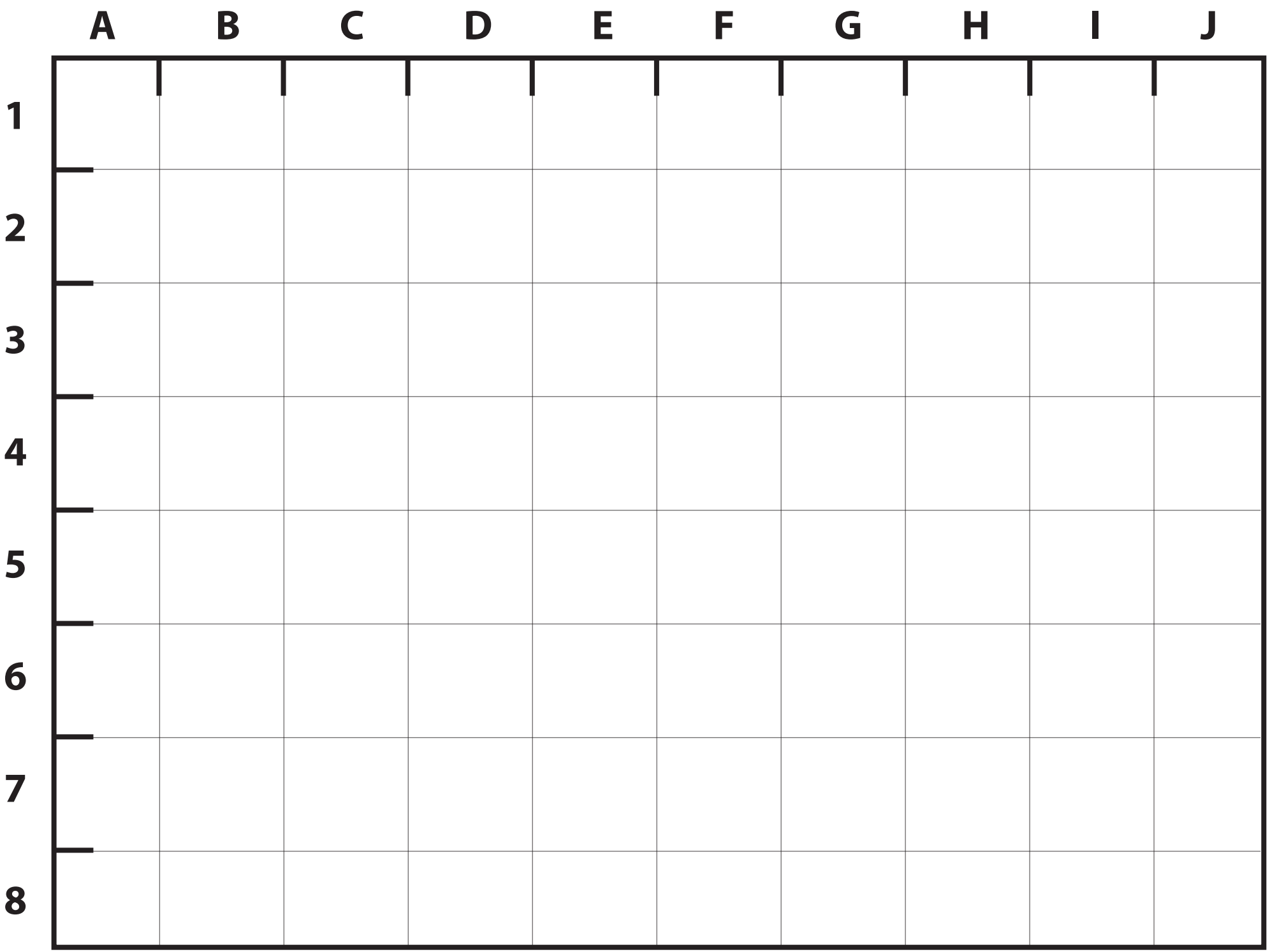
MB=Y*6290

Step 4- Calculate How much money you made? (M)

Total Money (M) = (MB/50) * $1,000,000

M=(MB/50) * $1000,000

*****REPEAT THESE 4 STEPS FOR EACH HOLE THAT YOU FOUND OIL IN ON A SEPARATE PIECE OF PAPER*****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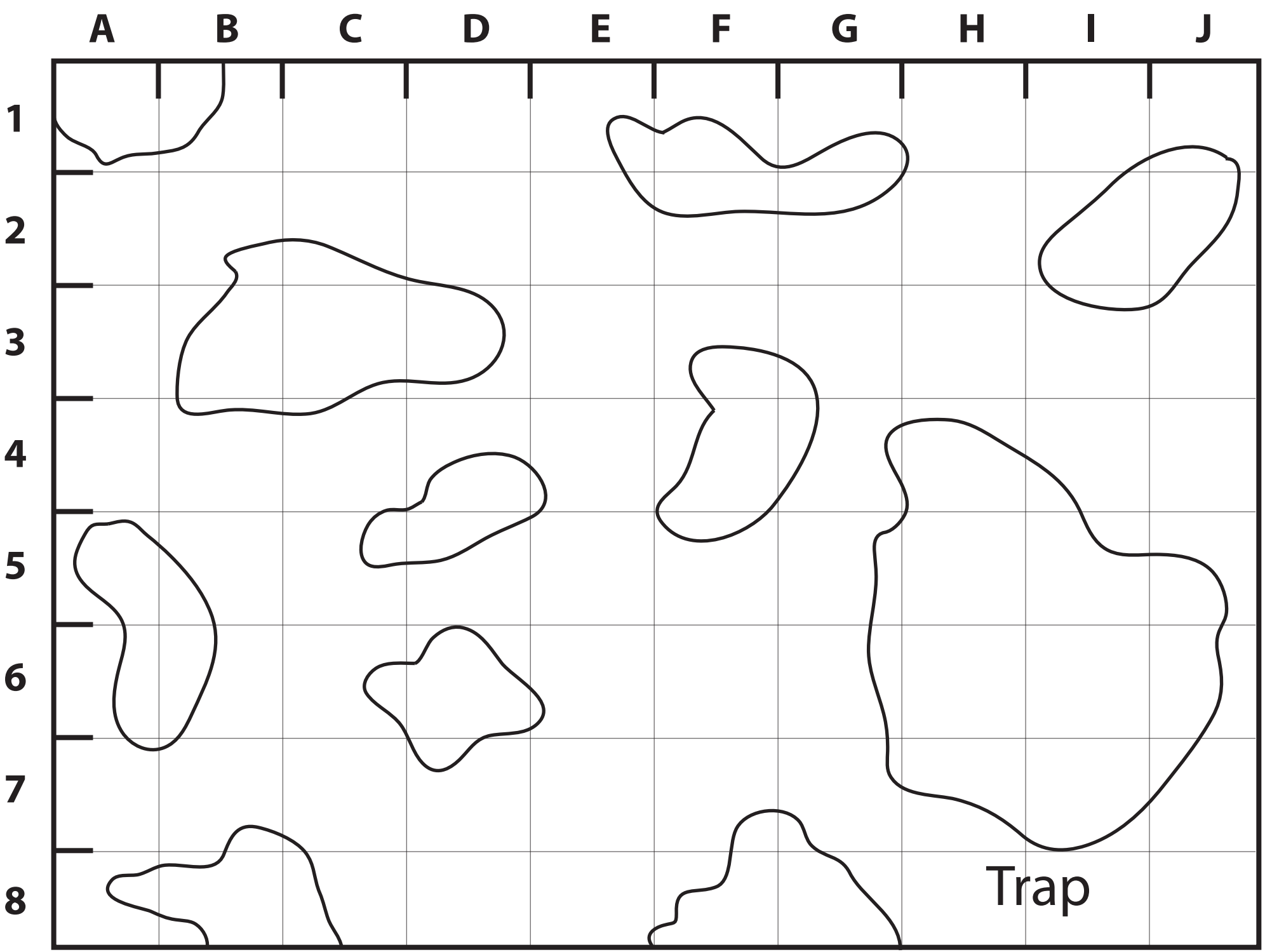
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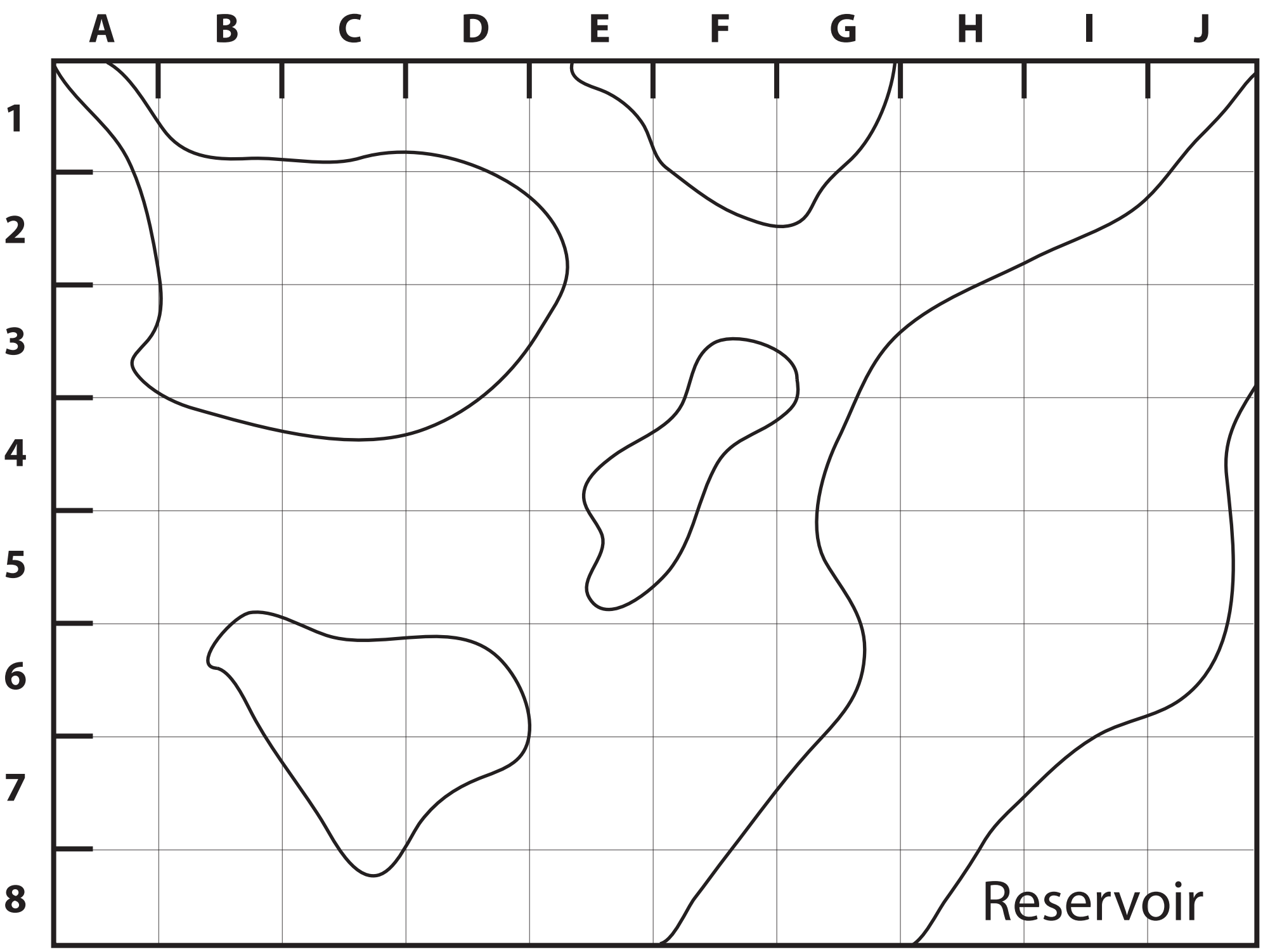
Trap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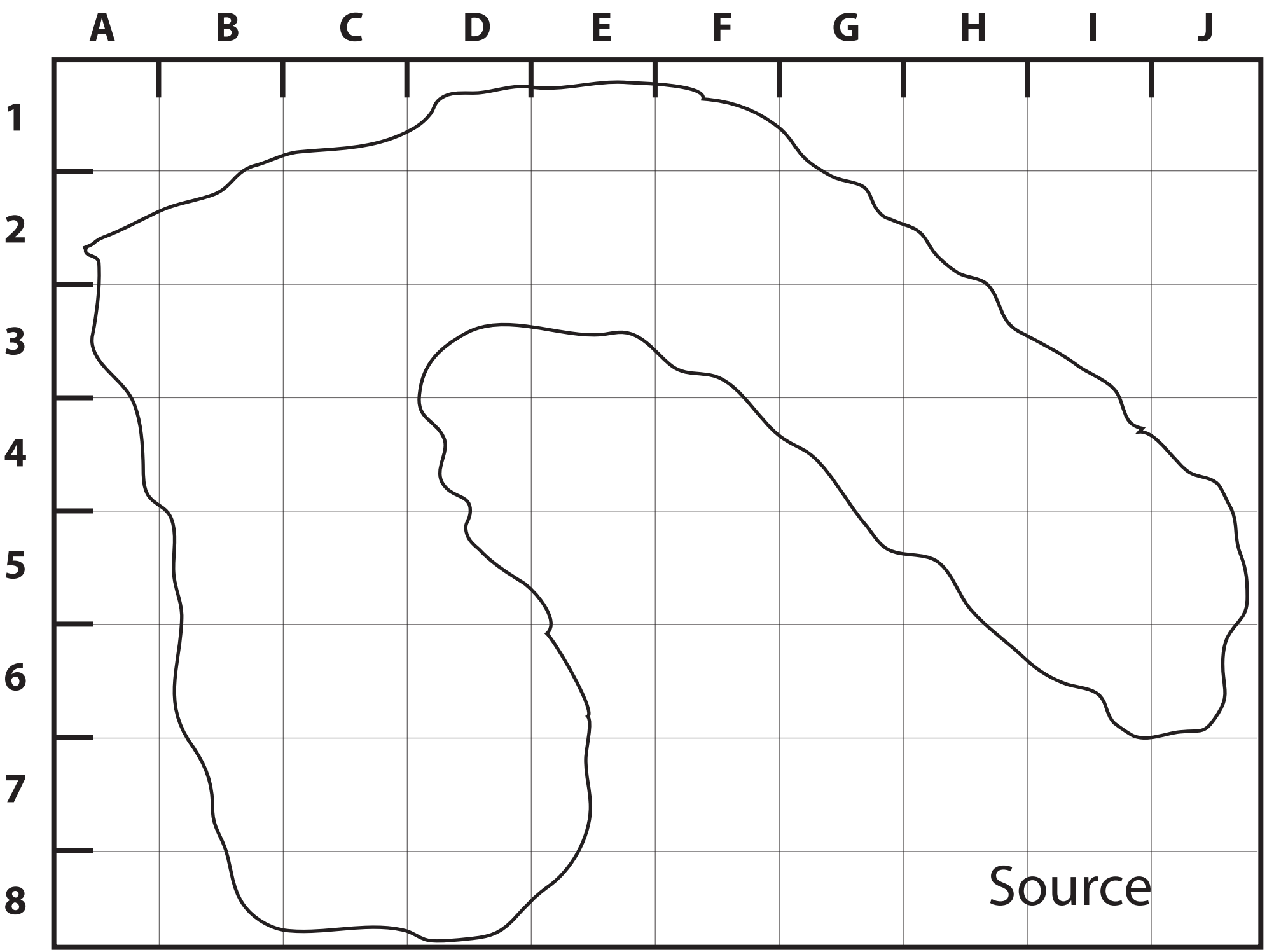
Reservoir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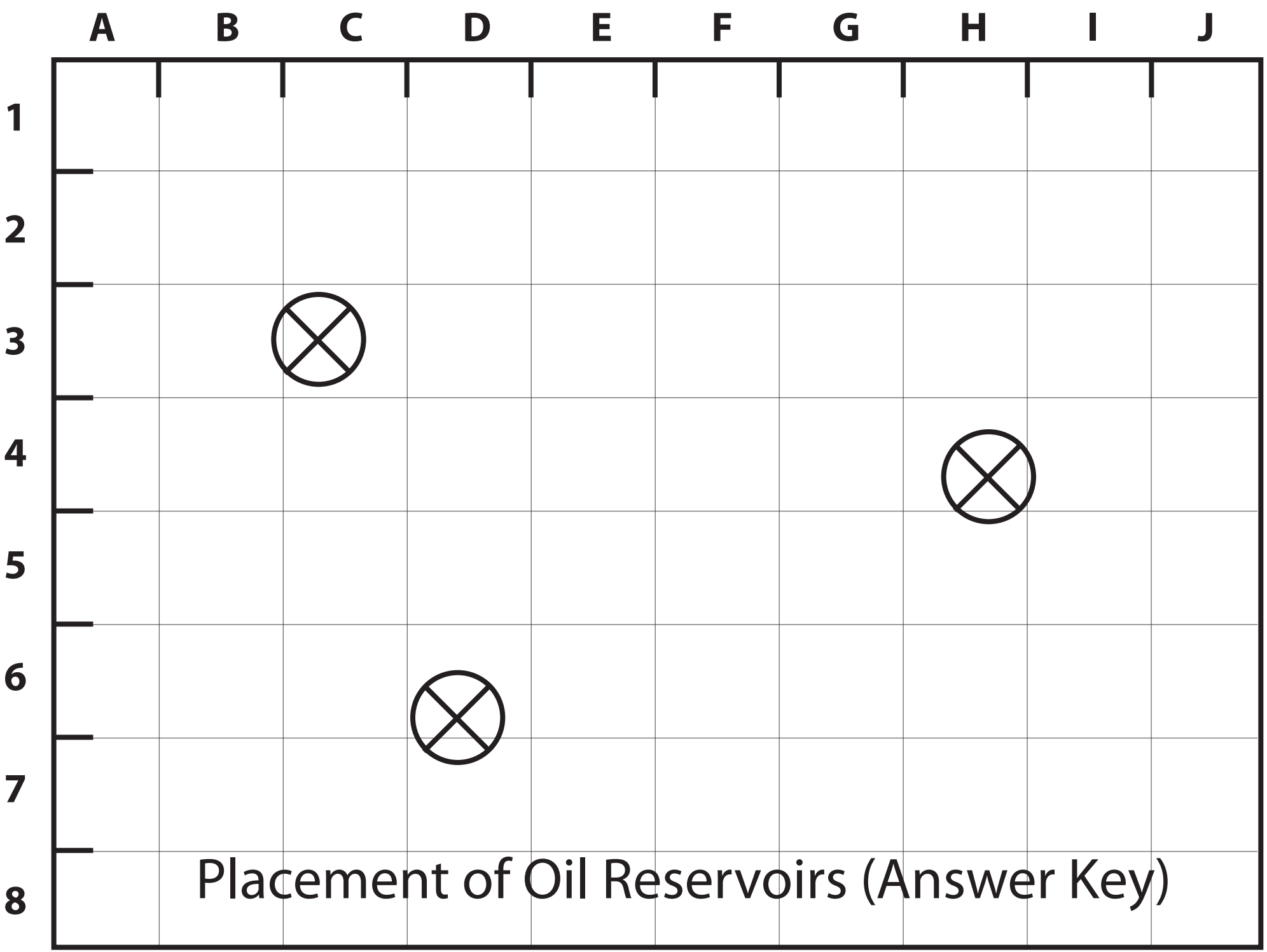
Source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Placement of Oil Reservoirs (Answer Key)