

Princeton University Science Olympiad Invitational Tournament
Hydrogeology Test
ANSWER KEY

Part 1:

- 1) a) Leachate
 b) Baseflow
 c) Reclaimed Wastewater
 d) Sole Source Aquifer

- 2) (Give full points to any answer reasonably close to these)
 a) The boundary between two groundwater basins which is represented by a high point in the water table or piezometric surface. It is a hydraulic pressure boundary between two groundwater bodies from which flow occurs in different directions.
 b) The depression in the water table created by a pumping well
 c) The land area from which surface runoff drains into a stream, channel, lake, reservoir, or other body of water; also called a drainage basin.
 d) A non-pumping well that is used to measure the elevation of a water table or water quality.

- 3) Porosity refers to the amount of free space in a material
 Permeability refers to the rate that water flows through a material
 (Give 1 point for each correct definition)

- 4) a) Aquifer
 b) Aquifer
 c) Aquitard
 d) Aquiclude

- 5) A material with a small grain size has lower porosity and thus water does not flow as easily through it, but a large grain size has higher porosity and water flows more easily through it. So, a small grain size makes a material more of an aquitard, a large grain size makes a material more of an aquifer.

1 point for correct identification that small grain size = aquitard and large grain size = aquifer

1 point for explanation of porosity (may not explicitly say porosity) as the reason

- 6) The Piezometric Surface is the level a confined aquifer's water would reach if a well were drilled into it. The Water Table is the level that an unconfined aquifer's water reaches. The difference being that the Piezometric Surface refers to an unconfined aquifer and Water Table for confined aquifers

1 point for each correct definition

2 points for observation of unconfined vs. confined

- 7) a) Total Soil Water Capacity
b) Available Water Capacity
c) Field Capacity
d) Drainable Porosity

- 8) a) Casing
b) Pump
c) Screen

- 9) a) Increase
b) Decrease
c) Decrease
d) Increase

- 10) Recharge wells are dug through aquitards and aquicludes to reach confined aquifers. So, water may percolate more easily through this well into a confined aquifer. This increases the rate of groundwater recharge.

1 point for correct definition of Recharge Well

1 point for correct identification that Recharge Wells increase groundwater recharge

1 point for correct description of water flowing through well to aquifer

- 11) a) Drainage Well
b) Flowing Artesian Well
c) Injection Well
d) Injection Well

- 12) a) 0.001
b) 0.1
c) Confined Aquifer
(These values have no units)

- 22) a) Central United States
b) Australia
c) Alberta, Canada
d) Southern South America (Argentina, Brazil, Paraguay, Uruguay)
e) Texas
(Note: Be lenient with the specific locations - accept alternative names or nearby regions)

Part 2:

Follow the following link and take the team's score - they should be named with their team names:

<http://groundwater.beehere.net/admin#results/4ef90231-fd23-4fb2-bd61-4dc10676b356>

Part 3:

- 14) a) Petroleum Byproducts
b) SVOCs
c) Pathogens
d) VOCs
e) Explosives
f) Inorganics
- 15) a) LNAPL
b) DNAPL
c) DNAPL
d) DNAPL
- 16) LNAPLs are less dense, so they float on top of the groundwater and can be simply removed from the top. DNAPLs sink below the water, so extracting them is more difficult and expensive.
- 1 point for correctly identifying that DNAPLs are more dense than LNAPLs
2 points for explaining how LNAPLs float above water and DNAPLs sink
1 point for correctly identifying that extracting DNAPLs is more expensive
- 17) A, C, D, E
(Do not give partial credit)
- 18) If Well B begins pumping, drawdown will lower the water table elevation to below that of Well A. Thus, it now will be at risk of contamination.
- 2 points for correctly identifying that it will now be at risk of contamination
2 points for the correct description of the lowering of the water table
1 point for the use of the term "drawdown"

- 19) Material: Coarse Sand & Gravel
 Hydraulic Conductivity: 160.80 ft/day
 Porosity: 0.34 (no units)

1 point for each correct value (including units)
 2 additional points if all three are correct

20) (One point for each correct box)

Technique	In-situ/Ex-situ (Or both)	Type (Bio, Chem, Physical)	Cost (Low, Med, High)	Applicable to Contaminant?
Air Stripping (without Pumping)	In-situ	Physical	Medium	No
Activated Carbon Treatment (w/ Pumping)	Ex-situ	Physical	High	Yes
Phytoremediation	In-situ	Biological	Low	No
Reduction/Oxidation	Both	Chemical	High	No
Incineration	Ex-situ	Accept either Chem or Physical	High	Yes

- 21) a) The process of moving air through contaminated groundwater to separate out contaminants
 b) Carbon in Coal is activated and contaminants stick to the activated Carbon
 c) Using plants to clean up contaminants
 d) Using chemical reduction or oxidation agents to break down particles into less harmful forms
 e) Using microbes to clean up contaminants

Give full points for reasonably close answers - do not give partial credit

- 22) a) The barriers should be placed Southeast of Well A. This is because the groundwater flows Southeast out of the Well, so the barriers should be placed in the path to intercept the plume of contaminants.

2 points for correct identification of the Southeast direction
 (Give 1 point instead of 2 if the answer given is South or East, but the rest of the explanation is correct)
 1 point for noting the direction of groundwater flow
 1 point for correct description of intercepting contaminants

b) If Well A were to stop pumping, the water table around A would rise. So, since the other wells are of lower elevation, this would increase the water table gradient at A. So, this would increase the rate of water flow out of Well A, and thus water would go through the barriers faster. So, the contaminants would be removed more quickly.

1 point for correctly stating that ceasing pumping would increase the rate of remediation

1 point for correctly stating that the water table elevation around A would rise

1 point for correctly stating that the rate of water flow at A would increase

1 point for correctly describing the effect of faster water flow on the barriers

c) Iron acts as a reducing agent for contaminant molecules, which undergo dechlorination into safer molecules.

1 point if the response contains the term “agent”

1 point if the response describes the Iron reacting as a reducing agent

1 point if the response describes the contaminant undergoing dechlorination

- 23) a) Introduces air and other nutrients into the contaminated area to stimulate microbes to break down the contaminant.
b) Metals acting as an anode and cathode are electrically charged. Contaminant molecules are then attracted to the respective charged metal and stick to them.
c) The contaminated water is heated so volatile contaminants evaporate out of the water
d) The contaminated water is filtered through plant roots to extract contaminants

Give full points for reasonably close answers - do not give partial credit

24) C

- 25) a) 3
b) 2
c) 4
d) 1

- 26) a) Rainwater has higher levels of Oxygen-18 than surface water. So, if Region A has a higher concentration of Oxygen-18, it likely experiences more precipitation

1 point for correct identification that Region A experiences more precipitation

1 point for correct observation that rainwater has higher levels of Oxygen-18

2 points for correct explanation of why Region A has higher precipitation

b) Using Oxygen-18 to model groundwater recharge is most effective in dry and arid climates with very little surface water. This is because a dry environment has most of its groundwater recharged from rainwater and less from surface water, so using Oxygen-18 is more effective in measuring all of the water that percolates through the ground.

2 points for correct identification of a dry/arid climate

2 points for the correct explanation of why

24) In spring months (April), there is more rain and precipitation. So, more freshwater percolates through the ground into the groundwater, which pushes the freshwater-saltwater interface downwards. In September, there is less precipitation which moves the interface back upwards.

2 points for correct identification that there is more precipitation in April than September

3 points for correct explanation that more freshwater moves the interface down and less moves it up

1 point for mentioning what happens in both April and September