MR. BROWN'S SCIENCE LABS

Groundwater
Regents-Style Cluster Questions

NYS Earth & Space Science • Aligned with January 2026 Regents

5 Clusters • 25 Questions • 25 Points

Student Name:	
Class Period:	
Date:	
Teacher:	Mr. Brown

Instructions: Answer all 25 questions. Each question is worth 1 point for a total of 25 points. For multiple-choice questions, circle your answer choice. For constructed-response questions, write your responses on the lines provided. Use the 2024 Edition Earth and Space Sciences Reference Tables when needed. Show clear reasoning where justifications are required.

Cluster 1: The Long Island Aquifer System (Questions 1–5)

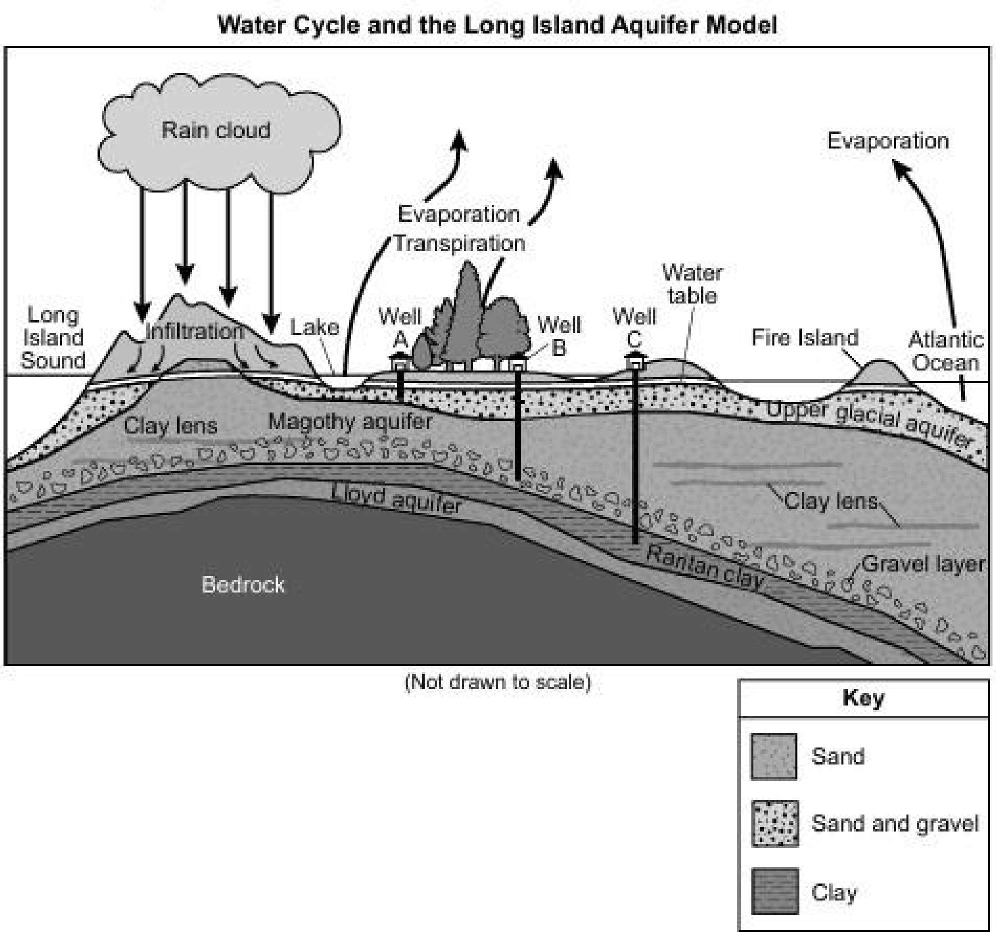
Base your answers to questions 1 through 5 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

The Long Island Aquifer System

Long Island, New York, sits on top of one of the largest sole-source aquifer systems in the United States. Nearly 3 million Long Island residents depend entirely on groundwater for their drinking water. The Long Island aquifer system consists of three main aquifers stacked beneath the surface: the Upper Glacial aquifer (closest to the surface), the Magothy aquifer (the largest and most productive), and the Lloyd aquifer (the deepest, separated from the Magothy by a thick layer of Raritan clay).

Rainwater falls on Long Island and infiltrates downward through porous sandy soil to recharge these aquifers. Some water is taken up by plants and returned to the atmosphere through transpiration. The Lloyd aquifer is largely confined and recharges very slowly, so once water is removed from it, the supply is not quickly replaced. Wells along the coast can also be affected by saltwater intrusion when too much fresh water is pumped out.

The cross-section below shows the water cycle and the Long Island aquifer system, including the locations of three wells (A, B, and C) drawing from different layers.



Cross-section of the water cycle and Long Island aquifer system.

1 Complete each of the three statements below to correctly describe how groundwater moves through the Long Island aquifer system by placing an **X** in the box to indicate the phrase that correctly completes each statement. [1]

Statement 1: Rainwater enters the Long Island aquifer system primarily through

- ☐ infiltration into the porous sand at Earth’s surface
- ☐ runoff over the impermeable clay lens at Earth’s surface

Statement 2: The Lloyd aquifer recharges slowly because it is

- ☐ confined above and below by layers of clay
- ☐ exposed directly to the atmosphere at Earth’s surface

Statement 3: The water table represents the boundary between

- ☐ saturated and unsaturated zones beneath Earth’s surface
- ☐ saltwater and freshwater zones beneath Earth’s surface

2 Several statements about the Long Island aquifer system are listed below.

Statement 1: Wells A, B, and C all draw water from the same single aquifer.

Statement 2: Sand and gravel layers shown in the model are permeable and allow water to flow through them.

Statement 3: The clay layers act as barriers that slow or prevent groundwater movement between aquifers.

Statement 4: Evaporation and transpiration only occur after groundwater is pumped to Earth's surface.

Statement 5: Infiltration of rainwater is the primary way water is added to the Upper Glacial aquifer.

Statement 6: The Lloyd aquifer is recharged faster than the Upper Glacial aquifer.

Which three statements correctly describe how water moves through the Long Island aquifer system? [1]

(1) Statements 1, 4, 6
(2) Statements 2, 3, 5
(3) Statements 3, 4, 5
(4) Statements 1, 2, 6

3 A homeowner on Long Island claims that drilling a deeper well into the Lloyd aquifer is a more sustainable long-term water source than a shallow well in the Upper Glacial aquifer. Using all the information provided, which statement provides the most correct evidence to evaluate this claim?

(1) The Lloyd aquifer has higher rates of recharge from rainfall and is less likely to be affected by surface contamination from septic systems and lawn fertilizers.
(2) The Lloyd aquifer is confined by clay layers that protect it from surface contamination, but its very slow recharge rate makes it vulnerable to long-term overuse.
(3) The Lloyd aquifer contains saltwater that can be filtered for drinking, while the Upper Glacial aquifer is more easily contaminated by saltwater intrusion.
(4) The Lloyd aquifer is recharged daily by rainfall, while the Upper Glacial aquifer is only recharged during major storms.

4 A geologist collected a sediment sample from a layer feeding Well B and recorded the following observations.

Observations:

A. The sediment is composed of well-rounded grains.

B. Grains range in diameter from approximately 0.05 cm to 0.2 cm.

C. The sample feels gritty and pours easily.

D. Water passes quickly through a column of the sample.

E. The sample is gray-tan in color.

F. When wet, the sample holds its shape and feels sticky.

Which statement correctly identifies the sediment in the sample using three of these observations? [1]

(1) Observations A, B, and D identify **sand** with high permeability.
(2) Observations C, E, and F identify **clay** with high permeability.
(3) Observations A, B, and F identify **silt** with low permeability.
(4) Observations B, D, and F identify **clay** with high porosity.

5 A student makes the following claim:

> *Pumping large amounts of fresh water from Well A near Long Island Sound will cause saltwater intrusion into the freshwater aquifer below the well.*

Place a check mark in either the **Support** or **Refute** box.

☐ **Support** ☐ **Refute**

Justification: Use evidence from the cross-section to justify your response. [1]

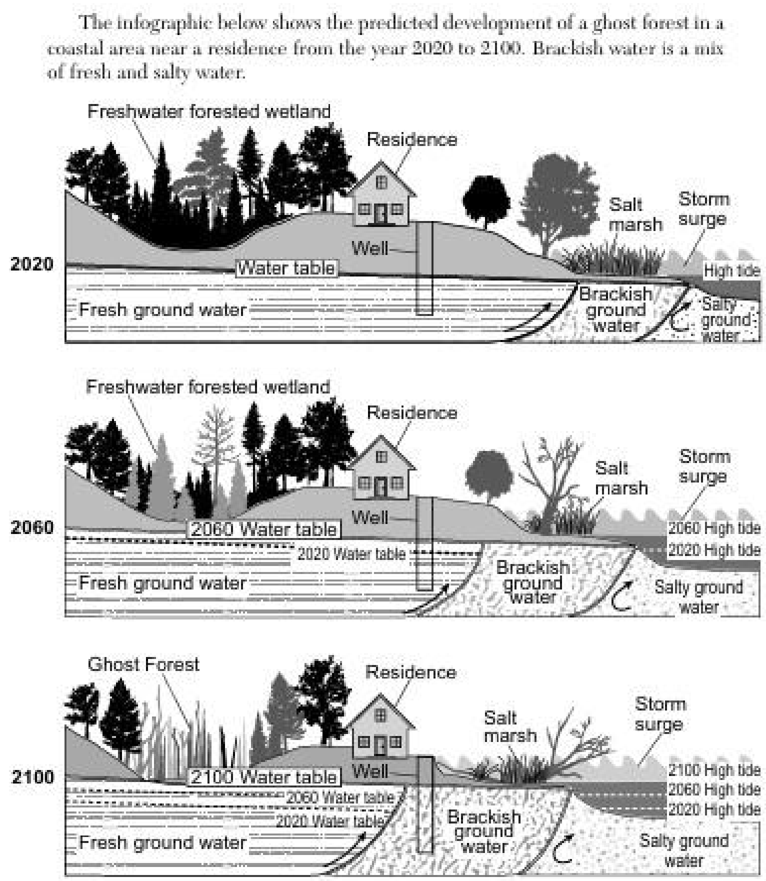
Cluster 2: Coastal Ghost Forests & Saltwater Intrusion (Questions 6–10)

Base your answers to questions 6 through 10 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Coastal Ghost Forests

Along many coastal areas of the eastern United States, including Long Island and the Atlantic coastal plain, dead and dying trees are replacing once-thriving freshwater forested wetlands. These “ghost forests” form when saltwater intrudes into freshwater ecosystems and kills salt-intolerant trees. As global sea level rises and storm surges become more frequent, ocean water pushes farther inland and downward, contaminating shallow aquifers that homeowners and farmers depend on for drinking water and irrigation.

Brackish water is a mix of fresh and salty water. The infographic below shows the predicted development of a ghost forest in a coastal area near a residence from the year 2020 to 2100. The position of the water table, the high-tide line, and the inland extent of brackish groundwater all shift over time.



Predicted coastal ghost forest development from 2020 to 2100.

6 Complete each of the three statements below to correctly describe the changes shown in the infographic by placing an **X** in the box. [1]

Statement 1: Between 2020 and 2100, the freshwater forested wetland is replaced by a ghost forest because

☐ freshwater is moving inland and drowning the trees
☐ saltwater is intruding inland and killing salt-intolerant trees

Statement 2: The water table near the residence rises between 2020 and 2100 primarily because

☐ rising sea level pushes the underlying groundwater higher inland
☐ rainfall over the residential area is steadily increasing each year

Statement 3: The well next to the residence will eventually become unusable for drinking water because

☐ the brackish groundwater zone will reach the bottom of the well
☐ the freshwater aquifer beneath the area will dry out completely

7 A coastal homeowner claims that drilling a deeper well is a permanent, long-term solution for protecting their drinking water from 2020 to 2100. Using all the information provided, which statement provides the most correct evidence to evaluate this claim?

(1) Drilling a deeper well will solve the problem because deeper aquifers are not affected by saltwater intrusion in coastal regions.

(2) Drilling a deeper well will solve the problem because storm surge only affects surface water and never reaches groundwater.

(3) Drilling a deeper well alone will not solve the problem because the brackish groundwater zone is also expanding both downward and inland over time.

(4) Drilling a deeper well will fail because freshwater aquifers will be completely replaced by saltwater everywhere on Earth by 2100.

8 A scientist studied tree samples in the area shown in the 2100 portion of the infographic and recorded the following observations.

Observations:

A. Tree rings are much narrower in the most recent 30 years than in earlier years.

B. Tree roots show high concentrations of sodium and chloride ions.

C. Tree bark is intact and the inner wood is still green.

D. Lower trunks show clear signs of prolonged saltwater exposure.

E. Tree species composition has shifted from oak to pine.

F. Surrounding soil pH has dropped sharply in the past decade.

Which statement correctly identifies the cause of tree death using three of these observations? [1]

(1) Observations C, E, and F identify **acid rain** as the cause of tree death.

(2) Observations A, B, and D identify **saltwater intrusion** as the cause of tree death.

(3) Observations B, C, and F identify **drought** as the cause of tree death.

(4) Observations A, D, and E identify **wildfire** as the cause of tree death.

9 Using the infographic, place the four conditions below in the correct order in which they occur from **earliest** to **most recent**. Justify your response using one principle of climate change or sea-level change. [1]

Items to rank:

- The 2100 high-tide line reaches farthest inland.
- The 2020 freshwater forested wetland is healthy.
- The 2060 water table has risen above the 2020 level.
- The 2020 high tide reaches the salt marsh.

Earliest: ______________________________

____

____

Most recent: ______________________________

Justification: How does this sequence reflect the relationship between rising sea level and inland groundwater changes?

____

____

10 A coastal engineer makes the following claim:

> *Building a tall seawall along the shoreline in 2030 would prevent the formation of the ghost forest shown in the 2100 infographic by stopping all saltwater intrusion into the residential area.*

Place a check mark in either the **Support** or **Refute** box.

☐ **Support** ☐ **Refute**

Justification: Use evidence from the infographic to justify your response. [1]

____

____

____

Cluster 3: Groundwater Contamination from a Landfill (Questions 11–15)

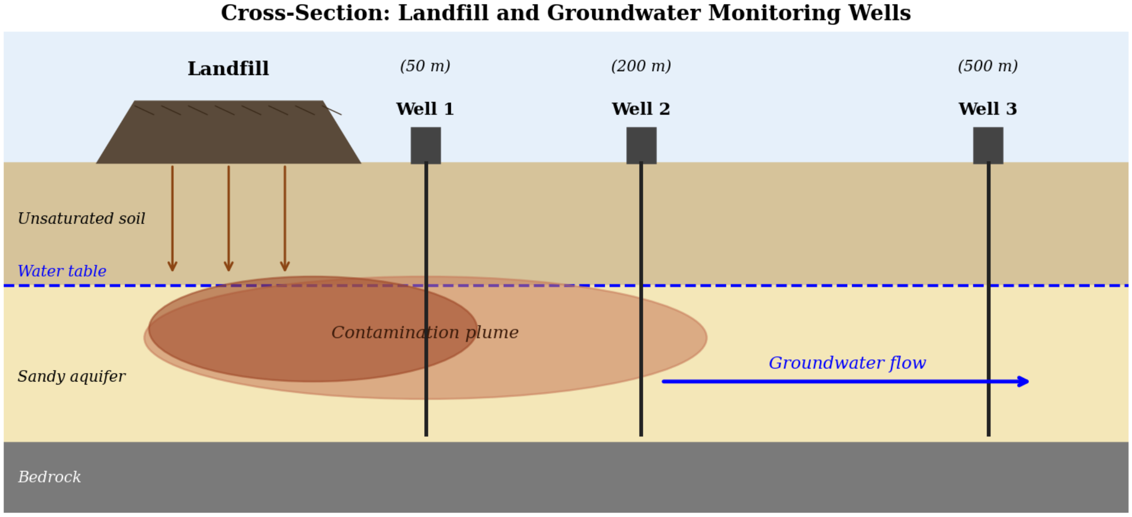
Base your answers to questions 11 through 15 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Tracking a Contamination Plume

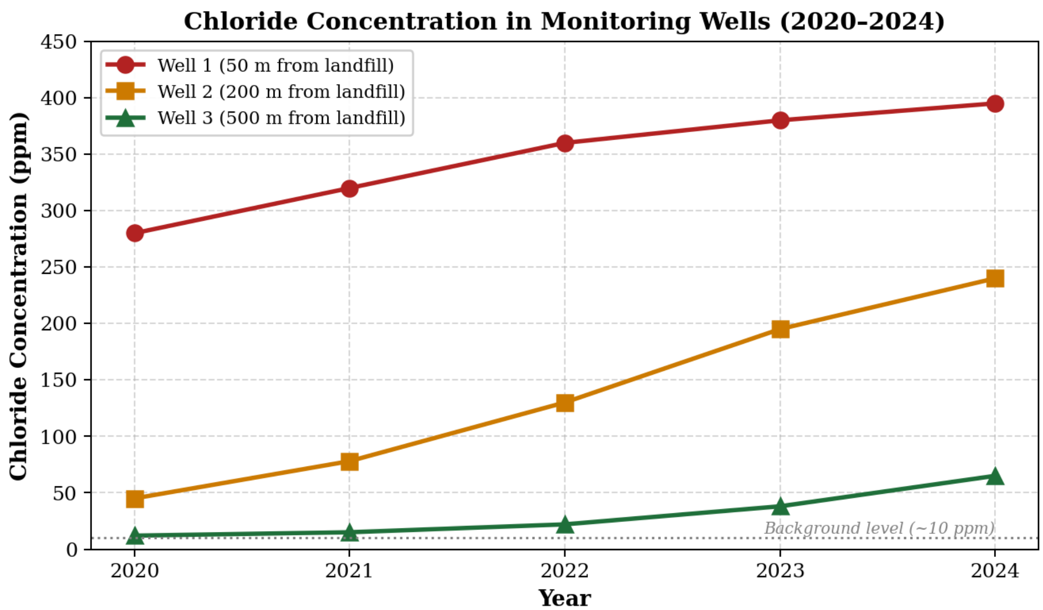
A small town in upstate New York is concerned about possible groundwater contamination from an old, unlined municipal landfill. Liquid that drains downward through landfill waste is called *leachate*. Leachate often contains dissolved metals, salts (especially chloride), and trace organic compounds. When leachate reaches the water table, it forms a contamination "plume" that moves laterally with the natural groundwater flow.

Hydrogeologists installed three monitoring wells at increasing distances downstream from the landfill: Well 1 (50 m), Well 2 (200 m), and Well 3 (500 m). They measured the chloride concentration, in parts per million (ppm), in each well every year from 2020 to 2024. The natural background level of chloride in clean groundwater in this region is approximately 10 ppm. The cross-section and graph below show the data.

Cross-Section: Landfill and Groundwater Monitoring Wells



Cross-section showing the landfill, leachate pathway, and three downstream monitoring wells.



Chloride concentration measured in each monitoring well, 2020–2024.

11 Complete each of the three statements below to correctly describe the movement of leachate from the landfill by placing an **X** in the box. [1]

Statement 1: The chloride concentration in Well 1 is much higher than in Well 3 because Well 1 is

☐ closer to the source of contamination
☐ farther from the source of contamination

Statement 2: Between 2020 and 2024, the chloride concentration in Well 3 increases because the

☐ landfill is producing less leachate over time
☐ contamination plume is moving outward through the aquifer

Statement 3: Liquid leachate moves downward from the landfill toward the water table primarily by

☐ infiltration through the unsaturated soil
☐ runoff across the surface of the soil

12 Several statements about the data from the monitoring wells are listed below.

Statement 1: The well closest to the landfill shows the highest chloride concentration in every year measured.

Statement 2: Chloride concentration in all three wells decreased between 2020 and 2024.

Statement 3: The contamination plume moves outward from the landfill in the direction of groundwater flow.

Statement 4: Wells located far from the landfill will never be affected by the contamination plume.

Statement 5: The contamination has spread to Well 3 by 2024, raising chloride above background levels.

Statement 6: All three wells already had chloride above 200 ppm in 2020.

Which three statements correctly describe the data from the monitoring wells? [1]

(1) Statements 2, 4, 6
(2) Statements 1, 3, 5
(3) Statements 1, 2, 6
(4) Statements 3, 5, 6

13 A town engineer claims that capping the landfill with an impermeable clay layer is a more effective solution than relocating the contaminated wells for protecting the town's drinking water. Using the data and reading, which statement provides the most correct evidence to support this claim?

(1) Capping the landfill with clay prevents new water from infiltrating through the waste, which slows the production of leachate and limits further expansion of the contamination plume.

(2) Capping the landfill removes all chloride that has already entered the aquifer and immediately restores the wells to safe levels.

(3) Relocating wells does not help because the contamination plume will eventually reach all groundwater on Earth.

(4) Capping the landfill cleans contaminated groundwater faster than any natural process and is always cheaper than relocating wells.

14 Write the correct letter from the choices below on the line at the end of each sentence to complete each statement about groundwater contamination from the landfill. [1]

Choices for Statement 1:

A – move quickly only through clay layers and bedrock

B – move more easily through sand and gravel because they are porous and permeable

Choices for Statement 2:

C – allow leachate to spread laterally with the natural groundwater flow

D – stop all leachate from leaving the landfill, regardless of the soil type

Choices for Statement 3:

E – decrease as the plume mixes with cleaner water away from the source

F – increase the farther a well is located from the source

Statement 1: Liquid leachate from the landfill will _______.

Letter: _______

Statement 2: A sandy aquifer beneath the landfill will _______.

Letter: _______

Statement 3: Chloride concentrations measured in monitoring wells will _______ with distance from the landfill.

Letter: _______

15 A hydrogeologist sampled water from Well 2 in 2024 and recorded the following observations.

Observations:

A. Chloride concentration is 240 ppm.

B. Water is clear with no visible particles.

C. Dissolved iron is below detection limits.

D. Conductivity is twice the regional average.

E. pH is 7.2 (approximately neutral).

F. Tested positive for trace organic compounds typical of household waste.

Which statement correctly identifies the most likely source of contamination using three of these observations? [1]

(1) Observations A, D, and F identify a **leaking landfill** as the most likely source of contamination.
(2) Observations B, C, and E identify **natural mineral weathering** as the most likely source.
(3) Observations A, B, and E identify **road-salt runoff alone** as the most likely source.
(4) Observations C, D, and E identify **acid mine drainage** as the most likely source.

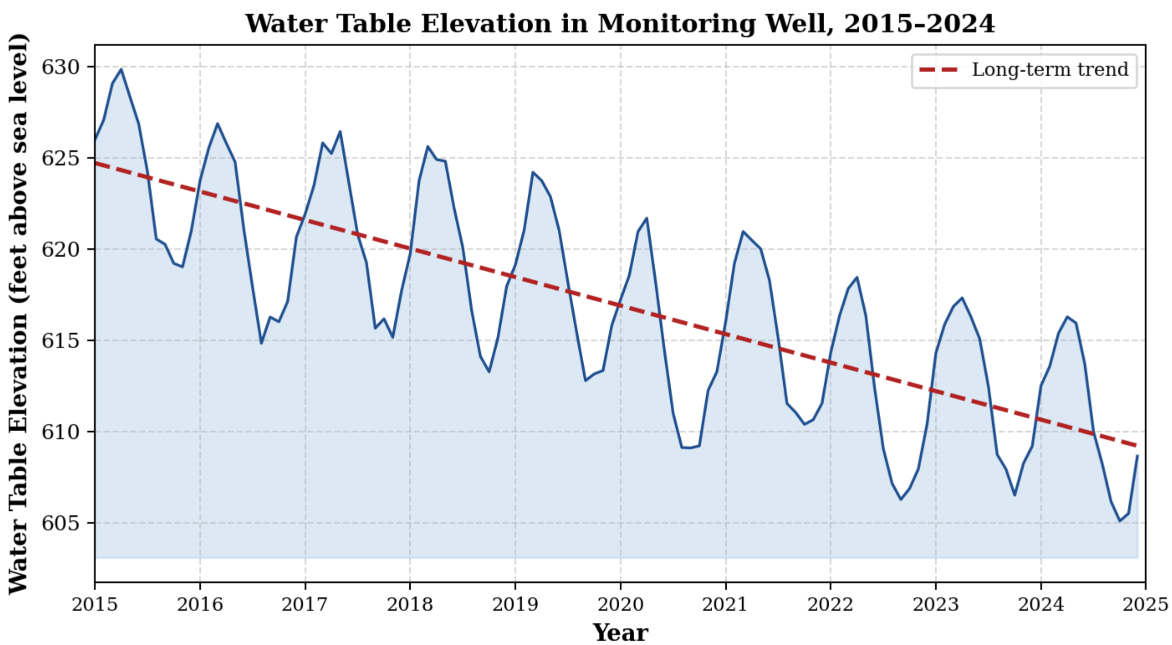
Cluster 4: Aquifer Depletion in Western New York (Questions 16–20)

Base your answers to questions 16 through 20 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Falling Water Tables in a Farming Community

Many small communities in western New York rely on local aquifers for both drinking water and agricultural irrigation. During recent dry summers, several towns have reported dropping water levels in their wells. Hydrologists track water-table elevation in monitoring wells across the region.

The graph below shows the water-table elevation, in feet above sea level, in a representative monitoring well from January 2015 through December 2024. Each year shows a seasonal cycle: the water table is highest in spring (after snowmelt and spring rains recharge the aquifer) and lowest in late summer (after months of evaporation, transpiration, and heavy irrigation pumping). The dashed red line shows the long-term trend across the entire period.



Water table elevation in monitoring well, 2015–2024, with long-term trend shown.

16 Complete each of the three statements below to correctly describe the patterns shown in the graph by placing an **X** in the box. [1]

Statement 1: The water table in this monitoring well is higher in spring than in late summer because

☐ rainfall and snowmelt recharge the aquifer in spring
☐ farmers always pump less water from the aquifer in late summer

Statement 2: Between 2015 and 2024, the long-term water-table elevation in this aquifer has

☐ steadily declined
☐ remained essentially constant year after year

Statement 3: A continued decline in the water table will most likely cause

☐ an increase in the amount of available drinking water from shallow wells
☐ shallow wells to go dry and need to be drilled deeper

17 A scientist measured water-table elevations during one year (2024) at four different times. Place the four times below in the correct order from **highest** water-table elevation to **lowest** water-table elevation. Justify your response using one principle of the water cycle. [1]

Items to rank:

- Late August (after a dry summer with heavy irrigation pumping)
- Late March (after spring snowmelt and rainfall)
- Late June (after a wet spring, before summer drought)
- Late January (frozen ground, little infiltration possible)

Highest: ______________________________

____

____

Lowest: ______________________________

Justification: How do recharge and water demand change with the seasons in this community?

____

____

18 A farming community is choosing between two solutions for the falling water table: **Option A** drills all new wells 100 feet deeper than current wells, and **Option B** reduces total groundwater pumping by 30% while building stormwater recharge basins. A hydrologist claims Option B is more effective for long-term sustainability. Using all the data, which statement provides the most correct evidence to support this claim?

(1) Option B addresses the cause of the decline by allowing the aquifer to recharge faster than it is depleted, while Option A only delays the problem and accelerates total aquifer depletion.

(2) Option A is better because deeper wells will always reach a more abundant supply of fresh water than shallow wells.

(3) Option B will completely eliminate the need for any wells in the region.

(4) Option A will reverse the long-term decline of the water table immediately after the new wells are drilled.

19 Write the correct letter from the choices below on the line at the end of each sentence to complete each statement about aquifer recharge. [1]

Choices for Statement 1:

A – allow surface water to slowly infiltrate down to the water table

B – prevent any surface water from reaching the aquifer below

Choices for Statement 2:

C – increase the rate of evaporation from the soil and reduce groundwater recharge

D – capture stormwater that would otherwise run off into streams and rivers

Choices for Statement 3:

E – help stabilize the long-term water-table elevation in the aquifer

F – have no effect on the long-term water-table elevation in the aquifer

Statement 1: Permeable surfaces such as gravel parking lots will _______.
Letter: _______

Statement 2: Engineered recharge basins will _______.
Letter: _______

Statement 3: Reducing pumping while increasing the number of recharge basins will _______.
Letter: _______

20 A regional planner makes the following claim:

> *Paving more land in this farming community with asphalt parking lots and roads will help solve the falling water-table problem because the asphalt will reduce the rate of evaporation from the soil.*

Place a check mark in either the **Support** or **Refute** box.

☐ **Support** ☐ **Refute**

Justification: Use evidence from the reading and your knowledge of the water cycle. [1]

Cluster 5: Engineering a Managed Aquifer Recharge System (Questions 21–25)

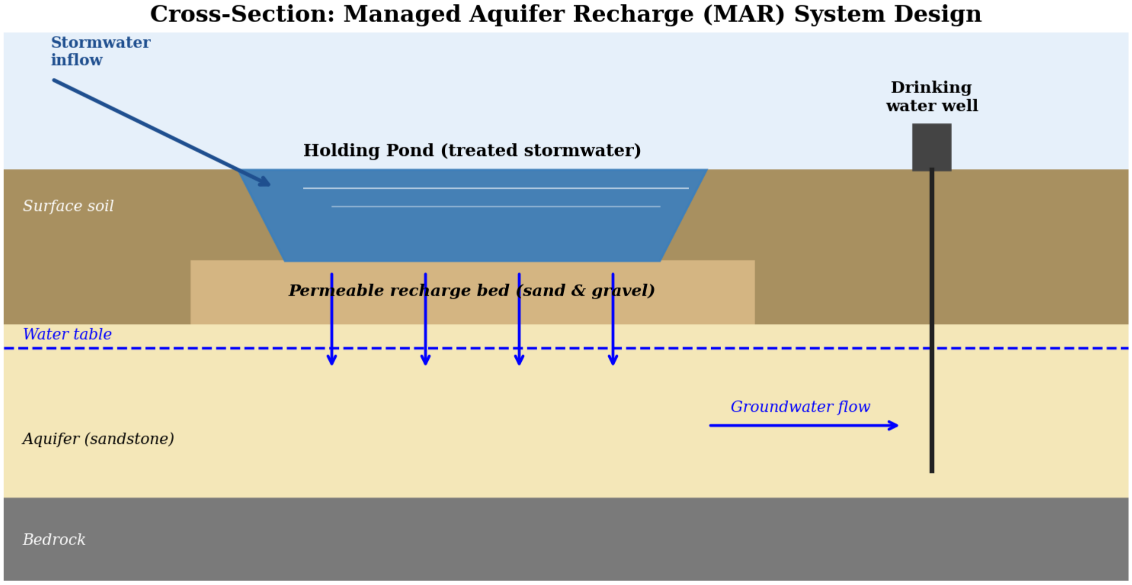
Base your answers to questions 21 through 25 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Designing a Managed Aquifer Recharge (MAR) System

To address falling water tables, communities are designing *managed aquifer recharge* (MAR) systems. In one common design, treated stormwater is collected in a large holding pond and slowly released through a permeable bed of sand and gravel into the aquifer below. This system mimics natural infiltration and helps refill depleted groundwater supplies.

Engineers must consider two important properties of Earth materials when choosing what to use for the recharge bed. *Porosity* is the percentage of open space in the rock or soil that can hold water. *Permeability* is how easily water moves through that material. Sand and gravel have moderate porosity but very high permeability, while clay has high porosity but very low permeability. The cross-section and data table below show the design and material properties.

Cross-Section: Managed Aquifer Recharge (MAR) System Design



Cross-section of a managed aquifer recharge (MAR) system design.

Properties of Earth Materials

Material	Porosity (%)	Permeability
Clay	50	Very low
Silt	45	Low
Fine sand	35	Moderate
Coarse sand	30	High
Gravel	25	Very high
Solid bedrock (granite)	1	Very low

21 Complete each of the three statements below to correctly describe the design of the managed aquifer recharge (MAR) system by placing an **X** in the box. [1]

Statement 1: Coarse sand is a better material for a recharge bed than clay because coarse sand has

- ☐ higher porosity but lower permeability than clay
- ☐ lower porosity but much higher permeability than clay

Statement 2: Granite bedrock would be a poor recharge layer because granite has

- ☐ very low porosity and very low permeability
- ☐ very high porosity but very low permeability

Statement 3: A recharge basin built directly over a thick clay layer will most likely

- ☐ allow rapid recharge of the deep aquifer below
- ☐ trap water at the surface and slow recharge of the deep aquifer

22 An engineer collected a soil sample from a proposed MAR basin location and recorded the following observations.

Observations:

A. The sample is made of well-rounded grains.

B. Most grains are between 0.5 cm and 1.0 cm in diameter.

C. Water poured onto the sample drains within seconds.

D. The sample feels gritty and does not stick together when wet.

E. Tested porosity is approximately 26%.

F. The sample contains thick layers of fine clay between coarser grains.

Which statement correctly identifies the soil sample and its suitability for a recharge bed using three of these observations? [1]

(1) Observations A, B, and C identify **gravel**, which is highly suitable for a recharge bed.

(2) Observations A, D, and F identify **clay**, which is highly suitable for a recharge bed.

(3) Observations B, E, and F identify **silt**, which is highly suitable for a recharge bed.

(4) Observations C, D, and E identify **granite bedrock**, which is highly suitable for a recharge bed.

23 Several statements about managed aquifer recharge (MAR) systems are listed below.

Statement 1: MAR systems work best when the recharge bed is highly permeable and the underlying aquifer has space to receive water.

Statement 2: MAR systems should be built directly on solid granite bedrock for the most efficient recharge.

Statement 3: MAR systems can help offset water-table decline caused by overpumping.

Statement 4: Pretreating stormwater is unnecessary because the natural soil filters out everything completely.

Statement 5: A single small MAR basin can fully recharge an entire regional aquifer in a single rainfall event.

Statement 6: Coarse sand and gravel layers are commonly chosen for the recharge bed because of their high permeability.

Which three statements correctly describe how managed aquifer recharge (MAR) systems work? [1]

(1) Statements 1, 3, 6
(2) Statements 2, 4, 5
(3) Statements 1, 2, 4
(4) Statements 3, 5, 6

24 A town is choosing between two recharge-bed designs: **Design A** uses a 1-meter thick layer of **coarse sand and gravel**, and **Design B** uses a 1-meter thick layer of **clay**. The town engineer claims Design A will be more effective at recharging the aquifer. Using the data table, which statement provides the most correct evidence to support this claim?

(1) Design A’s coarse sand and gravel have very high permeability, allowing water to infiltrate rapidly to the aquifer, while Design B’s clay has very low permeability and would block water from reaching the aquifer.
(2) Design A is better because clay has higher porosity than sand, so a clay-bottomed basin would lose all of its water to surface evaporation.
(3) Design B is better because clay traps water at the surface, providing a clean drinking-water reservoir for the town.
(4) Design A is only better because gravel is less expensive than clay; both materials would actually recharge the aquifer at the same rate.

25 A community member makes the following claim:

> *Building a managed aquifer recharge (MAR) system will completely solve all of our water shortage problems forever, even if our community keeps doubling the amount of water we pump from the aquifer every five years.*

Place a check mark in either the **Support** or **Refute** box.

☐ **Support** ☐ **Refute**

Justification: Use evidence from the reading and the data table. [1]

Grade Summary

Each question is worth **1 point**. Total possible: **25 points**.

Cluster	Topic	Points Earned	Possible
1	The Long Island Aquifer System	_____	5
2	Coastal Ghost Forests	_____	5
3	Landfill Contamination	_____	5
4	Aquifer Depletion in W. NY	_____	5
5	Managed Aquifer Recharge	_____	5
	TOTAL	_____	**25**
	FINAL GRADE (% of 25)	_____ **%**	**100%**

TEACHER ANSWER KEY

Each correct answer = 1 point. Total = 25 points.

Cluster 1: The Long Island Aquifer System

1. S1: infiltration into porous sand; S2: confined above and below by layers of clay; S3: saturated and unsaturated zones beneath Earth's surface.

2. (2) Statements 2, 3, 5 — sand/gravel are permeable; clay layers block flow; infiltration recharges the upper glacial aquifer.

3. (2) — confining clay layers protect the Lloyd aquifer from surface contamination, but slow recharge makes it vulnerable to long-term overuse.

4. (1) — well-rounded medium-sized grains that are gritty and let water pass quickly = sand with high permeability.

5. SUPPORT — Well A is closest to Long Island Sound (saltwater); heavy pumping lowers freshwater pressure and allows saltwater to migrate inland and upward into the freshwater aquifer.

Cluster 2: Coastal Ghost Forests

6. S1: saltwater is intruding inland and killing salt-intolerant trees; S2: rising sea level pushes underlying groundwater higher inland; S3: brackish groundwater zone will reach the bottom of the well.

7. (3) — drilling deeper alone fails because the brackish groundwater zone expands both downward and inland over time.

8. (2) — narrow recent rings, sodium/chloride in roots, and salt exposure on trunks all point directly to saltwater intrusion.

9. EARLIEST → MOST RECENT: 2020 freshwater wetland is healthy → 2020 high tide reaches the salt marsh → 2060 water table has risen above 2020 level → 2100 high tide reaches farthest inland. Justification: rising sea level over time pushes the high-tide line and brackish groundwater progressively inland.

10. REFUTE — a seawall blocks surface storm surge but does NOT stop subsurface saltwater intrusion through the aquifer; the infographic shows the brackish groundwater wedge moving inland underground, beneath any seawall.

Cluster 3: Landfill Contamination

11. S1: closer to the source of contamination; S2: contamination plume is moving outward through the aquifer; S3: infiltration through the unsaturated soil.

12. (2) Statements 1, 3, 5 — Well 1 always highest; plume moves with groundwater; Well 3 contamination above background by 2024.

13. (1) — capping with clay prevents infiltration into the waste, reducing new leachate and slowing plume expansion.

14. Statement 1 → B (leachate moves more easily through porous, permeable sand & gravel); Statement 2 → C (sandy aquifer spreads leachate laterally with groundwater flow); Statement 3 → E (chloride decreases with distance as it mixes with cleaner water).

15. (1) — high chloride, high conductivity, and trace household organics together identify a leaking landfill source.

Cluster 4: Aquifer Depletion in Western NY

16. S1: rainfall and snowmelt recharge the aquifer in spring; S2: steadily declined; S3: shallow wells to go dry and need to be drilled deeper.

17. HIGHEST → LOWEST: Late March → Late June → Late January → Late August. Justification: spring snowmelt + rain produces maximum infiltration / recharge; late summer combines high evapotranspiration with peak irrigation pumping, driving the water table to its annual minimum.

18. (1) — Option B addresses the cause (recharge < discharge); Option A only delays the problem and accelerates depletion.

19. Statement 1 → A (permeable surfaces allow infiltration); Statement 2 → D (recharge basins capture stormwater); Statement 3 → E (combining reduced pumping + increased recharge stabilizes the long-term water table).

20. REFUTE — paving with impermeable asphalt PREVENTS infiltration of rainwater into the aquifer; less recharge will worsen, not solve, the falling water table.

Cluster 5: Managed Aquifer Recharge

21. S1: lower porosity but much higher permeability than clay; S2: very low porosity and very low permeability; S3: trap water at the surface and slow recharge of the deep aquifer.

22. (1) — well-rounded large grains that drain in seconds = gravel, ideal for a recharge bed.

23. (1) Statements 1, 3, 6 — permeable bed + receiving aquifer needed; MAR offsets overpumping; sand/gravel chosen for high permeability.

24. (1) — coarse sand & gravel have very high permeability so water reaches the aquifer; clay's very low permeability blocks recharge.

25. REFUTE — MAR can only replace water at a finite rate set by available stormwater and the recharge bed's permeability; doubling pumping every 5 years is exponential demand that no MAR system can match indefinitely. Recharge rate must be ≥ pumping rate to be sustainable.