

Question 3: Analyze an Environmental Problem and Propose a Solution (Doing Calculations)

10 points

A Identify a type of surface mining the company could use to access the coal. **Point 01**

Examples of acceptable responses may include the following:

- Strip mining
- Open pit
- Mountain top removal

B Describe an environmental problem associated with surface mining. **Point 02**

Examples of acceptable responses may include the following:

- Removal of vegetation/soil/rock causes loss/destruction of habitat.
- (Surface mining) causes loss of habitat, which results in loss of biodiversity.
- Removal of vegetation can increase rates of erosion.
- (Surface mining) can lead to contamination of groundwater/surface water/waterways from runoff of sediments/pollutants.
- Removal of vegetation/soil/bedrock/parent material can release dust particles/methane.
- High energy/fossil fuel consumption is needed to operate equipment and leads to air pollution.

C Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant. **Point 03**

Examples of acceptable responses may include the following:

- Release of air pollutants/toxic metals/particulates/ NO_x / SO_x could lower air quality/result in respiratory problems.
- Release of air pollutants/sulfur dioxides/nitrogen oxides could cause acid rain.
- Greenhouse gas emissions/carbon dioxide/methane/water vapor could lead to altered precipitation/climate/weather/temperature patterns.

D Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity. **Point 04**

Examples of acceptable responses may include the following:

- Require/incentivize the plant to install scrubbers/electrostatic precipitators.
- Incentivize the use of alternative energy sources/energy efficient appliances.
- Incentivize green building design/conservation landscaping/planting trees as carbon sinks.

E Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work. **Point 05**

One point for the correct setup to calculate how many pounds of coal would be needed.

Examples of acceptable responses may include the following:

- $(11,000 \text{ houses} \times 10,640 \text{ kWh per house}) / 0.88 \text{ kWh per lb of coal}$
- $(11,000 \times 10,640) / 0.88$

One point for the correct calculation of how many pounds of coal would be needed. **Point 06**

Examples of acceptable responses may include the following:

- 133,000,000
- 1.33×10^8

F Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work. **Point 07**

One point for the correct setup to calculate the percent change in bird species per hectare.

Examples of acceptable responses may include the following:

- $(6.0 \text{ species / ha} - 7.5 \text{ species / ha}) / 7.5 \text{ species / ha} \times 100$
- $(6.0 - 7.5) / 7.5 \times 100$

One point for the correct calculation of the percent change in bird species per hectare. **Point 08**

Examples of acceptable responses may include the following:

- -20%
- 20% decrease
- -20

G Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work. **Point 09**

One point for the correct setup to calculate the year the population will reach 52,500.

Acceptable setup point:

- $(70 / 5.38) + 2022$

One point for the correct calculation of the year the population will reach 52,500. **Point 10**

Acceptable calculation point:

- 2035

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations

10 points

- (a) **Identify** a fuel used in a nuclear power plant. **1 point**

Accept one of the following:

- Uranium
- U-235
- Plutonium

- (b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants. **1 point**

Accept one of the following:

- Thermal pollution raises water temperature outside range of tolerance of organisms.
- Thermal pollution decreases dissolved oxygen.
- Water temperature increases, which decreases dissolved oxygen.
- Organisms can be wounded or killed at water intake.
- Water loss through evaporation can decrease stream flow/volume of water.

- (c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of electricity generated by nuclear power in 2021:

Accept one of the following:

- $(4.1 \times 10^{12} \text{ kWh}) \times 18.9\%$
- $(4.1 \times 10^{12}) \times 0.189$
- $\frac{4.1 \times 10^{12}}{100} = \frac{x}{18.9}$

One point for the correct calculation of the total amount of electricity generated by nuclear power in 2021: **1 point**

Accept one of the following:

- 774,900,000,000
- 7.749×10^{11}
- 7.75×10^{11}
- 7.7×10^{11}

Total for part (c) 2 points

- (d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality. **1 point**

- There is less NO_x/SO_x /ash/particulates/toxic metals/smog formed from the burning of natural gas compared to coal.

- (e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases. **1 point**

Accept one of the following:

- Trees can provide forest habitat/increase biodiversity/diversify niches in the area.
- Creates jobs for planting trees/recreational industries/harvesting wood.
- Trees create a more aesthetically pleasing environment/enhance cultural ecosystem services.
- Planting trees can decrease soil loss/erosion/sedimentation in waterways.
- Trees can provide shade/decrease ambient temperature.
- Planting trees slows water runoff/reduces flooding.

- (f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work. **1 point**

One point for the correct setup to calculate how many homes could have been provided with electricity by natural gas:

Accept one of the following:

- $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{1 \text{ m}^3} \times \frac{1 \text{ home}}{10,715 \text{ kWh}}$
- $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{10,715 \text{ kWh}}$
- $(7.4 \times 10^7) \times \frac{4.76}{10,715}$

One point for the correct calculation of how many homes could have been provided with electricity by natural gas: **1 point**

Accept one of the following:

- 32,874
- 32,873
- 33,000

Total for part (f) 2 points

- (g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work. **1 point**

One point for the correct setup to calculate how much less carbon dioxide would have been produced in 2021:

Accept one of the following:

- $\frac{(1.0 \text{ kg} - 0.42 \text{ kg})}{1 \text{ kWh}} \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 \text{ kg} - 0.42 \text{ kg}) \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 - 0.42) \times (8.99 \times 10^{11})$
- $\left(\frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{1 \text{ kg}}{\text{kWh}} \right) - \left(\frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{0.42 \text{ kg CO}_2}{\text{kWh}} \right)$, THEN
 $8.99 \times 10^{11} \text{ kg CO}_2 - 3.776 \times 10^{11} \text{ kg CO}_2$

One point for the correct calculation of how much less carbon dioxide would have been produced in 2021: **1 point**

Accept one of the following:

- 521 billion kg
- 521,420,000,000 kg
- 5.2142×10^{11} kg
- 5.21×10^{11} kg
- 5.2×10^{11} kg

Total for part (g) 2 points

Total for question 3 10 points

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations

10 points

- (a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil. **1 point**

Accept one of the following:

- Marine life is harmed/killed by being coated/suffocated by oil from spills.
- Animals are harmed/killed by ingesting spilled oil.
- Oil slicks from spills can block sunlight from entering water and inhibit photosynthesis.
- Oil that washes up on beaches/in marshes/in estuaries damages habitat.
- Noise pollution disrupts marine animals' ability to communicate/mate/eat/evade prey.
- CO₂ from combustion of fuels in boats/equipment is absorbed by ocean and contributes to ocean acidification.

- (b) **Identify** an atmospheric pollutant released during the combustion of refined oil products. **1 point**

Accept one of the following:

- Carbon dioxide (CO₂)
- Nitrogen oxides (NO_x, NO, NO₂, N₂O)
- Sulfur oxides (SO_x, SO₂, SO₃)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Volatile Organic Compounds (VOCs)

- (c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation. **1 point**

Accept one of the following:

- Ride a bike/scooter/skateboard or walk instead of driving.
- Replace a gasoline/diesel powered car with a hybrid or electric vehicle.
- Replace a gasoline/diesel powered car with one that utilizes alternative fuel (biodiesel, ethanol, hydrogen).
- Buy/Drive a more fuel-efficient vehicle.
- Work from home/telecommute to reduce miles driven.
- Choose housing that is close to employment to reduce miles driven.
- Take public transportation instead of driving.
- Carpool instead of driving alone.
- Combine trips to reduce miles driven.

(d) Justify the solution proposed in part (c) by providing a benefit to human health.

1 point

Accept one of the following:

Solution proposed in part (c)	Justification of solution with additional advantage
Replace a gasoline powered car with a hybrid or electric vehicle. Replace a gasoline/diesel powered car with one that utilizes an alternative fuel. Buy/Drive a more fuel-efficient vehicle. Work from home/telecommute to reduce miles driven. Choose housing that is close to employment to reduce miles driven. Take public transportation instead of driving. Carpool instead of driving alone. Combine trips to reduce miles driven.	- Fewer air pollutants (particulates, NO_x, VOCs, smog) leads to lower rates of - respiratory illness/problems such as asthma, COPD, lung cancer. - cardiovascular illness such as heart attacks. - eye irritation.
Ride bike/scooter/skateboard or walk instead of driving.	- Fewer air pollutants (particulates, NO_x, VOCs, smog) leads to lower rates of - respiratory illness/problems such as asthma, COPD, lung cancer. - cardiovascular illness such as heart attacks. - eye irritation. - Improved health/Decreased risk of disease/cardiovascular illness from more physical activity/exercise.

(e) A deposit is estimated to contain 260 million metric tons of gold ore. Calculate the number of grams of gold that could be extracted from the deposit. Show your work.

1 point

One point for the correct setup to calculate the number of grams of gold that could be extracted from the gold deposit:

Accept one of the following:

- $260 \text{ million metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $260 \times 10^6 \text{ metric tons} \times 5 \text{ grams}$
- $5 \times 260,000,000$

One point for the correct calculation of the number of grams of gold that could be extracted from the gold deposit:

1 point

Accept one of the following:

- 1,300,000,000
- 1.3×10^9

Total for part (e) 2 points

(f) Assuming the price of gold is \$62.56 per gram, calculate the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. Show your work.

1 point

One point for the correct setup to calculate the value of the gold that could be recovered:

Accept one of the following:

- $\frac{\$62.56}{1 \text{ gram}} \times 1,000 \text{ metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $\$62.56 \times 1,000 \text{ metric tons} \times 5 \text{ grams}$
- $\frac{\$62.56}{\text{g}} \times \frac{5 \text{ g}}{\text{metric ton}} \times 1,000$
- $1,000 \times 5 \times \$62.56$

One point for the correct calculation of the value of gold that could be recovered:

1 point

Accept one of the following:

- \$312,800
- 312,800 dollars

Total for part (f) 2 points

- (g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold ore would need to be mined to extract enough gold to manufacture 100,000 cell phones. **Show your work.** **1 point**

One point for the correct setup to calculate the number of metric tons of gold ore that would need to be mined to manufacture 100,000 cell phones:

Accept one of the following:

- $\frac{0.034 \text{ grams}}{1 \text{ cell phone}} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000 \text{ cell phones}$
- $\frac{0.034 \text{ grams}}{1 \text{ cell phone}} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000$
- $0.034 \text{ grams} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000$
- $\frac{0.034 \times 100,000}{5}$

One point for the correct calculation of the number of metric tons of gold ore that would need to be mined to manufacture 100,000 cell phones: **1 point**

- 680

Total for part (g) 2 points

Total for question 3 10 points

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

- (a) (i) Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania. **1 point**

- 64 mg/L

- (ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well. **1 point**

Accept one of the following:

- Methane concentration decreases as distance from the fracking well increases.
- Methane concentration increases as distance from the fracking well decreases.
- There is an inverse/nonlinear relationship/negative correlation between the two variables.

- (iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well. **1 point**

Accept any value between:

- 1,800 – 2,200 meters

- (iv) **Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process. **1 point**

Accept one of the following:

- Fracking fluid is injected/pumped into the well under high pressure, opening rock fissures, releasing oil and natural gas.
- Sand grains in the fracking fluid hold the newly formed cracks/fractures open to allow the oil and natural gas to flow up the well.

- (v) **Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs. **1 point**

Accept one of the following:

- Earthquakes/seismic activity
- Ground subsidence/sinkholes

Total for part (a) 5 points

- (b) (i) The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource. **1 point**

- Tragedy of the Commons

- (ii) **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions. **1 point**

Accept one of the following:

- Loss of habitat/productivity in spring-fed ecosystems as springs dry up
- Loss of habitat/productivity/degraded water quality in streams and estuaries fed by groundwater discharge
- Soil erosion as vegetation dies as a result of lowered water table and roots no longer hold soil
- Desertification as a result of lowered water table

- (iii) **Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption. **1 point**

- The ocean water flows into aquifers (saltwater intrusion), contaminating the aquifer with saltwater.

Total for part (b) 3 points

- (c) (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil. **1 point**

Accept one of the following:

- Increase fuel economy standards for motor vehicles.
- Invest in renewable energy resources.
- Use tax incentives to encourage sales of hybrid/electric vehicles.
- Subsidize projects that increase the use of public transportation/walking/cycling.
- Create tax incentives for companies offering work-from-home options.
- Increase gasoline tax/reduce oil subsidies.

- (ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change. **1 point**

Accept one of the following:

Governmental action proposed in (c)(i)	Justification of the action proposed by stating a potential environmental advantage
Increase fuel economy standards for motor vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations

	• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Invest in renewable energy resources	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Use tax incentives to encourage sales of hybrid/electric vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Subsidize projects that increase the use of public transportation/walking/cycling	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Create tax incentives for companies offering work-from-home options	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater

	depletion/contamination from fracking/drilling operations Decreased oil consumption which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Increase gasoline tax/reduce oil subsidies	- Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain - Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations - Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Total for part (c) 2 points	
Total for question 2 10 points	

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations

10 points

- (a) **Describe** why coal is considered a nonrenewable energy source. **1 point**
- Accept one of the following:
- Nonrenewable energy sources like coal exist in a fixed/finite/limited amount.
 - The formation rate of coal is less than the consumption/combustion rate of coal.
- (b) **Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant. **1 point**
- Accept one of the following:
- Natural gas combustion emits fewer greenhouse gases/less CO₂.
 - Natural gas combustion does not emit mercury/lead/cadmium/uranium.
 - Natural gas combustion emits less NO_x/SO_x/reduces acid precipitation.
 - Natural gas combustion produces less/no particulate matter/soot/smog.
 - Transport of natural gas destroys/fragments less habitat or requires less fossil fuel use than transport of coal.
 - Habitat destruction due to the impoundment of coal ash or coal slurry is negated.
 - Coal extraction destroys habitat by strip mining or mountaintop removal.
- (c) **Describe** one economic advantage of using natural gas, rather than coal, in producing electricity. **1 point**
- Accept one of the following:
- Transport of natural gas (in pipelines) costs less than transport of coal (by rail).
 - Natural gas (methane) harvested from a decomposition reaction (landfills, wastewater treatment plants, biodigesters) costs less than coal.
 - There are fewer health-related issues linked to the burning of natural gas than are linked to burning coal, leading to lower health care costs for individuals or society as a whole.
 - There are fewer pollution controls needed for a natural gas powerplant, decreasing the cost of operation/construction/permitting.
 - There are lower combustion-residue disposal costs from the operation of natural gas burning powerplants than from coal-burning power plants.
 - Natural-gas-burning power plants are much more efficient (more electricity output from the same energy input) than coal-burning power plants leading to lower fuel costs.

- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans. **1 point**

Accept one of the following:

- Install/use/replace/update carbon monoxide detectors/alarms/sensors or replace the batteries within these devices.
- Perform regular maintenance on natural gas furnaces to ensure that minimal carbon monoxide is created or that the combustion products are properly vented/exhausted to the building exterior.
- Create laws or regulations that mandate that carbon monoxide detectors must be installed in all homes of any type.
- Use PSA's, billboards, or other methods to inform/educate the public about carbon monoxide poisoning.
- Change the home heating system to a method that does not include the combustion of a fuel that may produce carbon monoxide.

- (e) **Calculate** the percent change in the average annual $\text{PM}_{2.5}$ concentration in the air from 1990 to 2016. **Show** your work. **1 point**

One point for the correct setup (must include units and multiplication by 100 to yield a true percentage) to calculate the percent change:

$$\bullet \frac{(188 \mu\text{g}/\text{m}^3 - 85 \mu\text{g}/\text{m}^3)}{85 \mu\text{g}/\text{m}^3} \times 100$$

One point for the correct calculation of the percent change: **1 point**

- 121%
- 120%
- 121.2%

Total for part (e) 2 points

- (f) Trees can remove $\text{PM}_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $\text{PM}_{2.5}$ is 2.3 kilograms per hectare. **Calculate** the decrease in $\text{PM}_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the number of kilograms of $\text{PM}_{2.5}$:

$$\bullet (50,000 \text{ ha} - 43,000 \text{ ha}) \times \frac{2.3 \text{ kg}}{\text{hectare}}$$

$$\bullet 50,000 \text{ ha} \times 2.3 \text{ kg/ha} = 115,000 \text{ kg}; 43,000 \text{ ha} \times 2.3 \text{ kg/ha} = 98,900 \text{ kg}$$

$$115,000 \text{ kg} - 98,900 \text{ kg}$$

One point for the correct calculation of the number of kilograms of $\text{PM}_{2.5}$: **1 point**

- 16,100 kilograms of $\text{PM}_{2.5}$
- 16,000 kilograms of $\text{PM}_{2.5}$

Total for part (f) 2 points

- (g) Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in $\text{PM}_{2.5}$ concentration. A city experienced a 23% increase in $\text{PM}_{2.5}$ concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the $\text{PM}_{2.5}$ concentration continues to rise at an identical rate. **Show** your work. **1 point**

One point for the correct setup to calculate the increase in hospital admissions:

$$\bullet \frac{0.23}{0.10} \times 0.01 \times 7,390 \text{ admissions}$$

$$\bullet \frac{0.23}{0.10} \times \frac{1}{100} \times 7,390 \text{ admissions}$$

$$\bullet \frac{23\%}{10\%} \times 1\% \times 7,390 \text{ admissions}$$

One point for the correct calculation of the increase in hospital admissions. **1 point**

Accept one of the following:

- 169 more admissions
- 170 more admissions

Total for part (g) 2 points

Total for question 3 10 points

2019

AP[®] CollegeBoard

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Scoring Guidelines

2019 SCORING GUIDELINES

Question 1

(a) Use the maps provided to answer the following questions.

(i) **Identify** the preferred nesting habitat for piping plovers.

(1 point for the correct identification of a preferred nesting habitat for piping plovers)

- Unvegetated sand
- Sandy areas/open sandy beaches
- Washovers

(ii) **Describe** the change in the number of piping plover nests in Assateague Island between 1999 and 2009.

(1 point for the correct description of the change in the number of piping plover nests)

- The number of nests decreased by almost half (43%).
- The number of nests decreased from 44 to 25.
- There were 19 more nests in 1999 than in 2009.

(iii) **Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.

(1 point for the correct description of a likely reason for the change in the number of piping plover nests)

- The preferred habitat was reduced because of a decrease in unvegetated sandy areas.
- The preferred habitat was reduced because of an increase in the amount of vegetation/revegetation.

(b) Coastal species are affected by more than just natural events.

(i) Special beach restrictions can help piping plovers during nesting season. **Describe** one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.

(1 point for the correct description of a restriction that could reasonably be implemented to help prevent the destruction of plover nests by human activity)

- Post warning signs/fencing/barrier tape/boardwalks around the nesting area.
- Place wire enclosures/other barriers over active nests.
- Limit specified recreational activity on beaches with plover nests (prohibit kite flying, fireworks, etc.).
- Implement motor vehicle restrictions (limit times, size of vehicles, raking, etc.).
- Require pets to remain indoors or on leashes.

2019 SCORING GUIDELINES

Question 1 (continued)

(ii) In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. **Explain** one way that these features help to preserve and protect the environment in coastal regions.

(1 point for the correct explanation of one way that features of barrier islands help to preserve and protect the environment in coastal regions)

- They block/buffer the wind and/or waves, which mitigate beach erosion.
- They reduce storm surge, which protect the interior coastline from flooding.
- They block/buffer the waves and create wetland ecosystems/pools, which serve as habitat for a variety of species (fish, turtles, migratory birds, etc.).
- They trap sediments/pollutants in wetland habitats/marsh grasses, which filter the water.

(iii) **Identify** one human action that directly threatens coastal habitats and **describe** one impact on species, other than the piping plover, that use the habitat.

(2 points; 1 point for the correct identification of a human action that directly threatens coastal habitats and 1 point for the correct description of the impact of human activity on species that use the habitat)

Identify one human action that directly threatens coastal habitats	Describe one impact on species that use the habitat
Tourism/Recreation	• Beachgoers accidentally step on or crush nests of species on the beach. • Unleashed pets on beaches may cause stress and/or disrupt nesting, survival, etc. of coastal species. • Vehicles on beach can disrupt nesting, survival, etc. of coastal species habitat. • Beachgoers leave food/garbage that attracts predators/harbors pathogens of coastal species. • Sunscreen washes off and can be toxic to coral or other coastal marine organisms.
Coastal Development	• Development (commercial, residential, recreational) can lead to the loss of suitable habitats of coastal species. • Development near beach may increase noise pollution or light pollution, which disrupts nesting/migration/survival of coastal species. • Development near beach may provide food/garbage that attracts predators/harbors pathogens of coastal species.
Littering/Solid Waste Disposal	• Coastal species get tangled up in trash (plastic) on the beach or in coastal water. • Coastal species ingest trash, which fills or blocks respiratory/digestive tract.
Offshore Oil Drilling	• Spilled oil coats coastal marine organisms, impacting survival. • Spilled oil can be toxic if ingested by coastal marine species.
Commercial Fishing	• Dredging or trawling can destroy coral/habitat for bottom-dwelling organisms. • Overharvesting can dramatically decrease coastal populations of fish or shellfish. • Coastal species can unintentionally get trapped in fishing gear.

2019 SCORING GUIDELINES

Question 1 (continued)

(c) **Identify** one economic impact on coastal communities that has resulted from rising sea levels.

(1 point for the correct identification of one economic impact on coastal communities that has resulted from rising sea levels)

- Decrease of tourist revenue
- Decrease of property value
- Increase in damage to property, land, or infrastructure requiring repair or replacement
- Increase in insurance costs
- Loss of agricultural land or aquaculture operations resulting in financial loss
- Loss of fish nurseries in wetland areas leading to less revenue for commercial fisheries
- Increase in jobs in infrastructure/construction to repair damaged structures and properties
- Increase in costs associated with preventative measures (building sea walls, raising building, etc.)

(d) **Describe** TWO methods that may be used locally to protect coastal communities from rising sea levels.

(2 points; 1 point for each correct description and method that may be used locally to protect coastal communities from rising sea levels)

- Raise structures to reduce or prevent water damage.
- Move/build structures back from the beach (setbacks) to reduce or prevent water damage.
- Install pumps to reduce flooding.
- Build structures, such as sea walls, to protect area from wave action/storm surge/flooding/erosion.
- Plant vegetation along appropriate shoreline to decrease erosion.
- Replenish sand to address problems from erosion or to increase width of beach.
- Build jetties/groins to act as a barrier from waves.

2019 SCORING GUIDELINES

Question 2

As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oil sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

(a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.

(1 point for the correct identification of an ecological benefit provided by forests)

- Absorb carbon dioxide/produces oxygen (gas exchange)
- Maintain ecological and/or species diversity
- Provide food for organisms
- Moderate/regulate (local) climate
- Purify/filter water or air
- Reduce soil erosion
- Absorb/store/regulate water
- Help maintain stream temperature/stream flow
- Aid in nutrient cycling
- Aid in soil formation

(b) **Identify** one economic benefit that is provided by forests.

(1 point for the correct identification of an economic benefit provided by forests)

- Source of forest products (timber, medicine, nuts, crops such as shade-grown coffee, etc.)
- Tourism
- Jobs in recreation/tourism/forestry
- Reduction in air pollutants, which can
 - reduce health care costs
 - improve crop yields

(c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

(2 points; 1 point for each correct description of an environmental consequence that results from the extraction of bitumen or the transport of synthetic oil to customers)

- Release of greenhouse gases/air pollutants such as NO_x from fossil fuel combustion that powers equipment/transportation/oil processing
- Release of air pollutants (NO_x, SO_x, or particulates) during mining operations or oil processing
- Storage and disposal of large amounts of solid/liquid mining waste, which can be toxic to organisms
- Pollution of surface water and/or groundwater from oil spills/leaks during transport
- Sediment pollution in surface water and/or groundwater from strip mining
- Disturbance from pipelines, such as habitat fragmentation, disruption of migratory routes, etc.
- Noise pollution from use of machinery during processing or transport
- Diversion/use of water from surface water and/or groundwater for processing oil

2019 SCORING GUIDELINES

Question 2 (continued)

- (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$7.3 \times 10^{10} \text{ barrels of bitumen} \times \frac{1 \text{ day}}{1.0 \times 10^6 \text{ barrels of bitumen}}$$

$$= 7.3 \times 10^4 \text{ days}$$

$$= 73,000 \text{ days}$$

(Note: Units are not required in the answer)

- (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

(2 points; 1 point for the correct setup and 1 point for the correct answer; incorrect answer from (d), used correctly, can still earn points in part (e))

$$7.3 \times 10^4 \text{ days} \times \frac{1 \text{ year}}{365 \text{ days}}$$

$$= 2 \times 10^2 \text{ years}$$

$$= 200 \text{ years}$$

(Note: Units are not required in the answer.)

- (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$\frac{3 \times 10^7 \text{ barrels of synthetic oil}}{1 \text{ month}} \times \frac{2 \text{ barrels of fresh water}}{1 \text{ barrel of synthetic oil}} \times \frac{12 \text{ months}}{1 \text{ year}}$$

$$= 7.2 \times 10^8 \text{ barrels of fresh water}$$

$$= 720,000,000 \text{ barrels of fresh water}$$

(Note: Units are not required in the answer)

2019 SCORING GUIDELINES

Question 3

The graph shows measurements of atmospheric levels of carbon dioxide (CO₂) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.

(a) Use the graph above to answer the following questions.

- (i) **Determine** the concentration of CO₂ (in ppm) recorded at Mauna Loa in 2005.

(1 point for identifying from the graph the correct value of concentration of CO₂ recorded at Mauna Loa in 2005)

380 ppm (+/- 5 ppm)

- (ii) **Determine** the pH recorded at Station ALOHA in 2005.

(1 point for identifying from the graph the correct value of pH recorded at Station ALOHA in 2005)

8.08 (+/- 0.02)

(b) Changes in atmospheric carbon dioxide affect Earth's oceans.

- (i) **Predict** the effect of increased concentration of atmospheric CO₂ on the concentration of CO₂ in the ocean.

(1 point for correctly predicting the effect of an increase in concentration of CO₂ in the ocean)

- Oceanic CO₂ will increase.
- Dissolved oceanic CO₂ will increase.

- (ii) Based on the data, **identify** the relationship in the concentration of atmospheric CO₂ and the pH of the ocean water.

(1 point for correctly identifying the relationship between the concentration of atmospheric CO₂ and the pH of ocean water based on data)

- As atmospheric CO₂ increases, pH decreases.
- As more CO₂ dissolves in the water, it becomes more acidic/less alkaline.
- As atmospheric CO₂ increases, H₃O⁺ or H⁺ ions increase.

- (iii) **Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO₂) and water (H₂O).

(1 point for the correct balanced chemical equation that represents the reaction between oceanic carbon dioxide and water)

- CO₂ + H₂O → H₂CO₃ (carbon dioxide plus water produces carbonic acid)
- CO₂ + H₂O → H⁺ + HCO₃⁻ (carbon dioxide plus water produces one hydrogen ion and one bicarbonate ion)
- CO₂ + H₂O → 2H⁺ + CO₃²⁻ (carbon dioxide plus water produces two hydrogen ions and one carbonate ion)

2019 SCORING GUIDELINES

Question 3 (continued)

- (iv) **Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.

(1 point for correctly identifying the specific environmental problem that directly results from the decrease in pH of Earth's oceans)

Ocean Acidification

- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.

- (i) **Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.

(2 points; 1 point for correctly explaining the impact of a decrease in pH on shells or exoskeletons and 1 point for an impact on survival of organisms)

Chemical impact on shell/coral formation	Impact on survival of organism
A decrease in pH levels could • Cause shells/exoskeletons to dissolve • Prevent the growth of new coral/shells • Prevent renewal/maintenance of existing coral/shells	Organisms, such as mollusks and coral, would be threatened with • Reduced fitness/decreased number of offspring • Increased predation risk • Increased threat of disease

2019 SCORING GUIDELINES

Question 3 (continued)

- (ii) Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystem and **describe** how the threat damages the coral reefs and coral reef ecosystems.

(2 points; 1 point for the correct identification of an additional anthropogenic threat to the world's coral reef ecosystem and 1 point for correctly linking a description of the identified threat to the damage to coral reefs and coral reef ecosystems)

Identify one additional anthropogenic threat to the world's coral reef ecosystems	Describe how the threat damages coral reefs and coral reef ecosystems
Increased ocean temperature	• Coral bleaching (loss of the algal symbiont) • Reduction of dissolved oxygen concentration
Recreational activities, such as watercraft, scuba, snorkeling, swimming, etc.	• Physical damage to/destruction of coral reefs
Fishing practices, such as bottom trawling, dynamite fishing, overfishing, etc.	• Physical damage to/destruction of coral reefs • Removal of key species disrupts the food web/causes a trophic cascade
Nutrient pollution (from agricultural runoff, wastewater treatment plants, etc.)	• Cultural eutrophication and eventual decrease in dissolved oxygen levels • Excessive algal growth reduces light penetration
Sediment pollution (from logging operations, mining, etc.)	• Increased turbidity/reduction in light penetration • Deposited sediments cover/smother coral reefs
Chemical pollution, such as oil spills, pesticide runoff, sunscreen, etc.	• Disruption of reproduction and growth cycles • Disruption of metabolic processes • Endocrine disruption/DNA damage • Reduction in light penetration
Plastic/solid waste pollution	• Physical damage to/destruction of members of the coral reef ecosystem • Reduction of light penetration
Introduction of invasive species (lionfish/turkey fish, Philippine mantis shrimp, etc.)	• Invasive species can outcompete native species

2019 SCORING GUIDELINES

Question 4

One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles away from national parks.

- (a) Based on the data provided in the graph, **identify** the national park that had the greatest loss of visibility as of 2015 when compared with the historical natural visibility.

(1 point for the correct identification of the national park that has had the greatest loss of visibility)

Sequoia National Park

- (b) Visibility in national parks can be affected by many different air pollutants.

- (i) **Identify** a primary air pollutant.

(1 point for the correct identification of a primary air pollutant)

- Carbon dioxide (CO₂)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_x)
- Nitrous oxide (N₂O)
- Particulate Matter (PM)
- Sulfur dioxide (SO₂)
- Methane (CH₄)
- Volatile organic compounds (VOCs)

- (ii) **Describe** how a primary air pollutant becomes part of the atmosphere.

(1 point for the correct description of how a primary air pollutant becomes part of the atmosphere)

- Primary pollutants are released directly from a specific source, such as a smokestack, tailpipe, leaking pipelines, etc.
- Primary pollutants are released from the combustion of fossil fuels.
- Some pollutants (CO, PM) are a result of incomplete combustion of hydrocarbons.
- Some pollutants (methane, nitrous oxide, ammonia) are released directly from a biological source, such as cows, swamps, etc.

- (iii) **Identify** a secondary air pollutant.

(1 point for the correct identification of a secondary air pollutant)

- Ozone (O₃)
- Sulfuric acid (H₂SO₄)
- Sulfur trioxide (SO₃)
- Nitric acid (HNO₃)
- Peroxyacyl nitrates (PANs)
- Nitrogen dioxide (NO₂)
- Aldehydes

2019 SCORING GUIDELINES

Question 4 (continued)

- (iv) **Describe** how a secondary air pollutant is formed within the atmosphere.

(1 point for the correct description of how a secondary air pollutant is formed within the atmosphere)

- Secondary air pollutants are formed when primary pollutants react with other compounds.
- Ozone (O₃) forms when primary pollutants such as NO_x and VOCs react with oxygen in the presence of sunlight.
- Sulfuric acid forms when SO_x reacts with water.
- Nitric acid forms when NO_x reacts with water.

- (c) In 1990 Great Smoky Mountains National Park had a visibility of 25 miles. Visibility data for 2015 can be determined from the graph above.

- (i) **Calculate** the percentage of increase in visibility from 1990 to 2015.

(1 point for the correct calculation of the percentage of increase in visibility from 1990 to 2015. Students are not required to show work.)

$$80\% \text{ increase in visibility } \left(\frac{45 \text{ miles} - 25 \text{ miles}}{25 \text{ miles}} \times 100 = 80\% \right)$$

- (ii) **Discuss** TWO specific actions that the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park.

(2 points; 1 point for each correct and realistic discussion of a specific action the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park)

- Require or offer incentives for utilities/corporations to reduce emissions by specific methods, such as cap-and-trade, pollution-prevention control devices, alternative energy sources, environmental standards on new equipment, etc.
- Limit vehicle traffic in the park through increased parking fees, free/required shuttles, HOV priority parking, etc.
- Enact stricter standards for emissions on motor vehicles.
- Offer incentives to switch from gasoline-powered vehicles to electric vehicles or natural-gas powered vehicles.
- Offer tax credits or subsidies to homeowners to increase the use of renewable energy sources.
- Limit incineration practices/prohibit campfires to reduce air pollutants.

2019 SCORING GUIDELINES

Question 4 (continued)

(d) Excluding air pollution, **discuss** TWO additional ways national park ecosystems are being degraded by high levels of visitor use.

(2 points; 1 point for each correct discussion of an additional way national park ecosystems are being degraded by high levels of visitor use)

- Littering or inappropriate disposal of trash can negatively impact the health of wildlife.
- Littering or inappropriate disposal of trash can negatively impact water quality.
- Infrastructure construction/maintenance can result in habitat fragmentation.
- Driving or walking off road/path damages vegetation, increases erosion, or increases soil compaction.
- Noise pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Light pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Interactions with humans or pets adversely impacts wildlife by disrupting mating, ranging, foraging, etc.
- Visitors transporting nonnative species to the park results in an increase in invasive species.
- Camp fires from visitors can lead to wildfires.
- Removal of individual organisms for food, trophies, or human use can disrupt the food web.
- Water used for bathing and sanitation can lead to pollution of water resources.

2018

AP[®]

CollegeBoard

AP Environmental Science

Scoring Guidelines

2018 SCORING GUIDELINES

Question 1

Read the following article from the *Fremont Daily Times* and answer the questions that follow.

(a) The students want to reduce the school's carbon footprint.

(i) **Define** carbon footprint.

(1 point for correct definition of carbon footprint)

- The amount of carbon dioxide and/or other carbon compounds released to the environment by a product, process, or activity
- A measurement of the amount of carbon released by human activities

(ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.

(1 point for correct identification of a way the school's heating system is adding to its carbon footprint)

- The burning/combustion of fossil fuels releases carbon dioxide
- The incomplete combustion of fossil fuels releases carbon monoxide

(iii) **Describe** one realistic way to reduce the contributions of the heating system to the school's carbon footprint

(1 point for correct description of a realistic way to reduce the contributions of the heating system)

- Switch to renewables (solar, wind, etc.)/switch to a more efficient fossil fuel (natural gas, propane)/switch to a provider that uses nuclear energy.
- Decrease the temperature/thermostat in the school during the winter/program thermostat to lower energy consumption during certain times.
- Purchase credits through environmental agencies for carbon-offsetting projects.
- Increase insulation or implement other efficiency/design methods to reduce energy demand (green roof, double paned glass, south-facing windows for passive solar heating, change air filters, etc.).

(b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.

(2 points; 1 point for each correct identification of an environmental benefit of a green roof)

- Insulation/reduced use of fossil fuels for heating and/or cooling
- Habitat for wildlife and/or plants/increases biodiversity
- Area to grow crops/production of food locally
- Reduction in the number of heat islands in the environment/urban heat island mitigation
- Photosynthesis/carbon capture/CO₂ storage/oxygen release
- Stormwater treatment/runoff reduction
- Filters particulates, VOCs, O₃ from air

2018 SCORING GUIDELINES

Question 1 (continued)

- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.

(2 points; 1 point for each correct description of a practice that decreases the environmental impact of the school)

- Offer more vegetarian options/serve fewer animal products, etc. to reduce impact from meat production.
- Use some locally sourced food to reduce transportation.
- Grow food at the school to reduce transportation.
- Compost food waste to reduce the amount disposed in landfills.
- Donate leftover food to reduce food waste.
- Use energy-friendly practices (LED lighting, serve more cold-cut sandwiches, etc.) to decrease energy use.
- Purchase bulk packaged items to reduce material waste.
- Use recyclable food containers/don't use disposable straws/food containers/trays to reduce material waste.
- Install a water fountain/stop selling single-serving water bottles to reduce material waste.
- Use reusable take-out containers/offer savings or credit for reusing containers to reduce material waste.
- Allow students to choose appropriate portions to reduce food waste.
- Purchase organic foods to reduce pesticide use.
- Use gray water to irrigate landscaping to reduce potable water use.

- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.

(2 points; 1 point for each correct discussion of benefits of using native plants)

- Native plants require less pesticides because they are better adapted to their environment.
- Native plants require less fertilizer because they are better adapted to their environment.
- Native plants require less irrigation water because they are better adapted to their environment.
- Native plants increase biodiversity by providing native habitat areas.
- Native plants support native food webs/native food production by providing native habitat areas.
- Native plants reduce the amount of land available for the establishment/spread of invasive species.
- Native plants save the school money by requiring less water/fertilizer/pesticides/upkeep.

2018 SCORING GUIDELINES

Question 1 (continued)

- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

(1 point for correct discussion of benefits of using flooring made of plant material)

- Plant-based material is more easily compostable/is biodegradable/can be reused/repurposed, unlike carpet.
- Plant-based material is from a renewable resource making it more sustainable than carpet. Plant-based material is a carbon sink/reservoir, so growing plant materials removes CO₂ from the atmosphere, unlike carpet.
- Plant-based materials require less fossil fuels/toxic chemicals for production than synthetic fibers found in carpets.
- Plant-based materials produce less indoor pollutants (off-gas pollutants/VOCs/release toxins) than carpet.
- Plant-based materials harbor fewer pathogenic vectors/diseases/allergens (fleas, ticks, dust mites, mold spores, etc.) than carpets.
- Plant-based material when cultivated provides habitat for native species.

2018 SCORING GUIDELINES

Question 2

An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

- (a) **Describe** one environmental benefit associated with an offshore wind project.

(1 point for correct description of an environmental benefit associated with an offshore wind project)

- Reduced environmental damage from decreased reliance on fossil fuels, such as:
 - Less habitat/ecosystem destruction due to less exploration and extraction (less mining or drilling, etc.)
 - Less air/soil/water pollution (less exhaust emissions, pipeline leaks, tanker leaks) due to less transportation of fossil fuels
 - Less air pollution (no/fewer particulates, VOCs, NO_x, SO_x, CO₂, or greenhouse gases) due to less fossil fuel combustion
- Reduced environmental damage from decreased reliance on nuclear power, such as:
 - No risk of radioactive releases with accidents
 - No hazardous/radioactive wastes to store
 - Less exploration/ extraction/processing for uranium ore
- Increased aquatic habitat/artificial reefs for barnacles, sponges, other invertebrates, fish

2018 SCORING GUIDELINES

Question 2 (continued)

- (b)
- Identify**
- and
- describe**
- one potential economic effect of an offshore wind project.

(2 points; 1 point for correct identification of a potential economic effect and 1 point for correct description of an identified economic effect. The description point cannot be earned without correct identification of a potential economic effect.)

Identify one potential economic effect	Describe one potential economic effect
Job creation (+)	Jobs will be created in construction, operation, maintenance, etc.
Additional income (+)	- Local municipalities receive more taxes (income, sales, property) paid by utility and workers - Wind power company will make money/profits in the long run
Decreased electricity costs (+)	Electrical production costs will be lower, which will reduce electricity rates for consumers
Less reliance on foreign energy resources (+)	Transportation costs to deliver fuels will be reduced
High initial construction/high maintenance costs (-)	- Local taxes/fees/rates will increase to support construction costs associated with building of facility - Parts and personnel must be transported off-shore for construction, repairs and maintenance
Decreased property value (-)	Property values will decrease in coastal areas due to unfavorable aesthetics
Loss of income (-)	- Turbines negatively affect the aesthetics, which negatively impacts tourism, fishing, whale watching, etc. - Local fishing opportunities will be disrupted - Less revenue for fossil fuel companies as demand decreases
Job loss (-)	Jobs will be lost in the traditional energy production sectors (coal, nuclear)
Subsidies cost (-)	State subsidies to offset cost of building offshore and transmission lines to coast will increase; costs may be recovered with increased taxes

2018 SCORING GUIDELINES

Question 2 (continued)

- (c)
- Describe**
- one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

(1 point for correct description of energy source from ocean)

- Use of tidal movement/currents to turn turbines
- Utilize a device designed to capture energy from wave motion
- Harness the solar energy absorbed by the oceans/use natural thermal gradient in tropical and temperate oceans to create electricity (OTEC — Ocean Thermal Energy Conversion)
- Harvest algae and convert to biofuel

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d)
- Calculate**
- how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$(0.80) \times (2.0 \times 10^6 \text{ MWh}) = 1.6 \times 10^6 \text{ MWh}$$

- (e) Customers in the service area pay \$0.20/kWh for electricity.
- Calculate**
- how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 \text{ MWh} \times \frac{\$(2 \times 10^{-1})}{\text{kWh}} \times \frac{1 \times 10^3 \text{ kWh}}{1 \text{ MWh}} = \$3.2 \times 10^8 = \$320,000,000 = \$320 \text{ million}$$

- (f) Assuming all turbines are operating,
- calculate**
- how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 \text{ MWh} \times \frac{1 \text{ turbine}}{4 \text{ MW}} \times \frac{1}{2 \times 10^2 \text{ turbines}} = 2 \times 10^3 \text{ hr} = 2,000 \text{ hours}$$

2018 SCORING GUIDELINES

Question 3

An Arctic food web includes the following organisms.

- (a) Refer to the diagram above to complete the following table.

(3 points; 1 point for correct identification of each organism in the table)

	Organism from Arctic food web
(i) Identify a primary producer	Diatom (phytoplankton)
(ii) Identify a primary consumer	Krill (zooplankton)
(iii) Identify a secondary consumer	Cod or seal

- (b) Other than showing which organisms are consumed by others, **describe** what is indicated by the direction of the arrows in the diagram.

(1 point for correct description of what is indicated by the direction of the arrows)

- Shows the flow of energy among trophic levels
- Shows the flow of matter through trophic levels

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(1 point for correct description of how the change in sea ice habitat affects ability to hunt and feed)

- Decreasing area of hunting ground (area of ice used for hauling out/fewer seal breathing holes/seals are a less available food source because of more open water) makes it more difficult for polar bears to get food
- Increasing area/distance between hunting ground means the polar bears have to exert more energy to swim to find food/physical exhaustion from swimming results in less energy available for hunting
- Increasing physiological stress (dehydration, exhaustion, cub mortality, etc.) because polar bears are not physiologically adapted to warmer temperatures
- Increasing the time between successful kills results in bears spending more time waiting/hunting for prey

2018 SCORING GUIDELINES

Question 3 (continued)

- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

(2 points; 1 point for correct explanation of the connection between melting ice and the increased absorption of sun's energy and 1 point for correct explanation that increased absorption of sun's energy leads to increased melting of ice. For the second point the student must complete the positive feedback loop.)

- Melting of sea ice leads to a decrease in albedo, or reflectivity, leads to water surfaces absorbing more of the sun's energy.

AND

- Increasing absorption of sun's energy warms the water surface further, which leads to further ice melt (completes positive feedback loop).

- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

- (i) **Provide** one reason a species may migrate a long distance.

(1 point for a correct reason why a species may migrate a long distance)

- Limited food/water supply leads to migration to locations with more food/water supply
- Food supply migrates and species follow prey
- More hospitable climate during certain seasons
- Availability of mates/breeding/birthing occurs in different location
- Protection of offspring from predators

2018 SCORING GUIDELINES

Question 3 (continued)

- (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(1 point for correct description of one commercial activity, other than whaling)

- (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(1 point for correct strategy linked to activity in (iii))

Description of commercial activity	Description of one strategy
- Fishing nets entangle whales as by-catch. - Fishing gear can accidentally trap.	- Require change of fishing method (location, timing, or materials) that traps whales to reduce the number of whales trapped in nets/gear - Fines for discarded fishing gear (long-line gear, ropes for hauling pots up, etc.) so less gear is discarded reducing the number of whales trapped in gear
Ships and whales use the same channels, which can increase number of ship strikes.	- Improved navigational technology to spot whales that are close to ships in order to avoid collisions - Increased education of ship captains and crews about whale habitat/migration routes/feeding behaviors in order to reduce ship collisions with whales - Expansion of low-speed navigational zones around ports to reduce ship collisions with whales
Noise pollution from seismic surveys/sonar/engine noise can disrupt a whale's internal navigational system.	- Reduction of seismic survey activity/sonar use in coastal areas to reduce exposure to noise pollution - Installation of quieter motors to reduce or eliminate noise pollution

2018 SCORING GUIDELINES

Question 4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

- (a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

- (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

(2 points; 1 point for each correct identification of an air pollutant released during the burning of biomass)

- (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

(1 point for correct identification of a specific respiratory illness linked to identified pollutant)

Identification of TWO air pollutants	Identification of a specific human respiratory illness linked to identified pollutant
- Carbon monoxide (CO) - Particulate matter (PM)	- CO poisoning - Asthma - Chronic obstructive pulmonary disease (COPD) - Emphysema - Bronchitis - Lung cancer
Nitrogen oxides (NO_x)	- Pneumonia - Asthma
Sulfur oxides (SO_x)	- Bronchitis - Emphysema - Asthma
Trace metals, such as lead, mercury, arsenic, and cadmium	Bronchitis
Methane (CH₄)	Bronchitis
Volatile organic compounds (VOCs)	Asthma

2018 SCORING GUIDELINES

Question 4 (continued)

- (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, which could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

(2 points; 1 point for correct identification of a realistic approach to reducing the impact and 1 point for correct description of reduction of illness linked to identified approach)

Identify one realistic approach	Describe how this approach would reduce the incidence of respiratory illness
Ventilate through structural change (chimney construction, opening windows and doors)	Removes some or all of the air pollution from indoors/transfers pollutants out of the home, leading to less respiratory illness
Switch to cleaner-burning/more efficient cooking stove	Requires less fuel to be burned releasing fewer air pollutants into the home, leading to less respiratory illness
Switch to a different energy source (solar, natural gas, biogas, electric)	Produces less or no indoor air pollutants, leading to less respiratory illness
Cook outdoors	Move the source of the air pollutant outside/leads to less or no concentrated air pollution inside, leading to less respiratory illness

In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

- (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

(1 point for correct discussion of why children under the age of five are at a greater risk)

- Children have an underdeveloped or less-developed immune systems leading to a greater risk of illness following exposure.
- Children have a lower body mass leading to a higher relative dose of air pollution.
- Children spend more time indoors leading to higher exposure to air pollution.
- Children have smaller respiratory systems (narrow airways) so mild inflammation may cause more severe respiratory distress.

2018 SCORING GUIDELINES

Question 4 (continued)

In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

- (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, or mold) listed above and complete the following table.

- (i) **Identify** a source for each indoor air pollutant

(2 points; 1 point for correct identification of a source of each indoor air pollutant chosen)

- (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

(2 points; 1 point for correct description of method of reduction for each indoor air pollutant chosen)

	Identification of a source	Description of a method for reducing exposure
Asbestos	• Building materials (cement, floor tiles, ceiling panels, drywall, popcorn ceiling) • Insulation • Naturally occurring in soil and rocks in a dirt-floor basement or crawlspace	• Safely remove asbestos-containing materials/abatement • Encapsulate/cover and seal materials/construct temporary enclosure • Leave undisturbed
Radon	• Soil, rocks, Earth's crust • Gas from uranium containing rocks • Gas penetrates foundation	• Seal floors, walls, and joints • Install structural exhaust venting • Install subfloor depressurizing system
Mold	• Water from flooding, natural disasters, or leaks • Poorly vented or maintained damp environments	• Replace or repair damaged surfaces/structures • Clean and/or disinfect affected areas • Dehumidify or ventilate inside air • Improve drainage (from roof or yard, sump pump the basement)

AP[®] Environmental Science

2016 Scoring Guidelines

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2016 SCORING GUIDELINES

Question 1

Read the following article from the *Fremont New Tribune*.

- (a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.

(1 point for a correct explanation for why diseases seldom cause extinction)

- Genetic diversity in wild populations enables some resistant organisms to survive and reproduce.
- Disease organisms often co-evolve with their hosts, allowing the host to evolve adaptations that resist the disease.
- Disease organisms/pathogens that cause the extinction of their host population jeopardize their own survival.
- Initial deaths thin (reduce density of) populations and make the disease less likely to spread.

- (b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.

- (i) **Describe** TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.

(2 points: 1 point for each description of a threat. Only the first two descriptions can earn a point.)

- Difficulty finding mates when populations are small, widely dispersed, or have a skewed sex ratio
- Competition from other species with a similar niche (e.g., nesting sites, food)
- Problems associated with a reduction of genetic diversity (small gene pool, lack of hybrid vigor, diseases that affect one will affect all members of the population, bottle-neck, etc.)
- Susceptibility to reduced fitness as a result of decreased protection by the group (e.g., not enough individuals to create heat, less protection by group members, increase in probability of becoming prey without the advantage conferred by group size)
- Increased vulnerability to environmental disturbances (need to name specific disturbance)

- (ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.

(1 point for a correct discussion of a correct aspect of bat biology that might slow their recovery)

- Low fecundity/ few babies per year
- Advanced age at first reproduction
- Long generation times in bats
- Increased parental care

- (c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.

(2 points: 1 point for each correct description. Only the first two descriptions can earn a point.)

2016 SCORING GUIDELINES

Question 1 (continued)

- Increase in bat food sources.
- Increase in West Nile and other insect-borne diseases
- Decrease in the spread of rabies
- Decrease in fungus that causes WNS
- Decrease in bat guano (tied to organism)
- Decline in plants pollinated or dispersed by bats
- Decline in bat predators due to decreased food supply.
- Increase in numbers of animals with similar food and habitat needs
- Causes a trophic cascade

(d) The Eastern deciduous forest, in which the little brown bats live, is an important ecosystem.

Identify TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

(2 points: 1 point for each correct ecosystem service with an explanation of how the service benefits human society)

Acceptable responses may include the following:

Ecosystem Service	Benefit to Humans
Resource material (tree/forest)	Lumber, building materials, fuel, paper, food
Oxygen production	Human respiration
Soil formation/protection	Forestry, agriculture, flood control, water quality
Protection of water supplies	Drinking water, recreation, irrigation, fishing
Habitat (e.g. specify shade, temperature moderation, etc.)	Animals or plants desired by humans for fishing, hunting, food
Biodiversity	Food, medicine, gene diversity, breeding stock
Carbon sink (sequestering)	Slows climate change
Aesthetics/cultural/social	Connection with nature (inspiration for art, music, poetry, etc.), research, education, recreation, tourism

WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades.

(e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.

(2 points: 1 point for a correct reason for the increase in emerging infectious diseases. 1 point for a correct explanation of how the reason likely increases the emerging diseases affecting human populations.)

Acceptable responses may include the following:

2016 SCORING GUIDELINES

Question 1 (continued)

Reason for Increase	Explanation
Climate change, global warming	Allows pathogens and disease vectors to survive in places that were previously too cold or dry
Increase in global travel	Increased likelihood of contracting/spreading disease
Increased exposure to animals (zoonotic)	Changes in agricultural practices increase rodents, etc; trade in exotic species, intrusion into wild habitats, urban sprawl
Increase in population density/distribution	Increased likelihood of contracting /spreading disease from others
Lack of vaccinations	Increase human susceptibility to disease, reduce herd immunity
Antibiotic resistance	New disease strains evolve
Decrease in medical care/public health	Poverty, war, migration, human behavior (refusing to use condoms/sharing needles/refusing aid)

SCORING GUIDELINES

Question 2

Use the data below to respond to the following. For each calculation, show all your work.

Calculate the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

(1 point for the correct answer with work shown)

1.6 billion tons of iron ore – 1.2 billion tons of pig iron = 0.4 billion tons of waste

OR

$$1.6 \times 10^9 - 1.2 \times 10^9 = 4 \times 10^8$$

Calculate the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

(2 points: 1 point for the correct setup and 1 point for the correct answer)

$$\frac{1.2 \text{ billion tons pig iron}}{1.6 \text{ billion tons iron ore}} \times 800 \text{ billion tons iron ore} = 600 \text{ billion tons iron}$$

OR

$$\frac{1.2}{1.6} = 0.75 \quad 0.75 \times 800 \text{ billion} = 600 \text{ billion} \quad \text{OR} \quad \frac{1.2}{1.6} = \frac{x}{800}$$

OR

$$\frac{1.2 \times 10^9}{1.6 \times 10^9} \times 8.0 \times 10^{11} = 6.0 \times 10^{11}$$

Calculate the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

(1 point for the correct answer with work shown)

$0.95 \times 800 \text{ billion tons of iron} = 760 \text{ billion tons iron ore used to make steel}$

OR

$$0.95 \times 800 = 760 \text{ billion}$$

OR

$$9.5 \times 10^{-1} \times 8 \times 10^{11} = 7.6 \times 10^{11}$$

Calculate the weight (in tons) of coal that is conserved each year in North America by recycling steel.

(1 point for a correct answer with work shown)

$$\frac{0.7 \text{ fewer tons coal used}}{1 \text{ ton steel recycled}} \times 80 \text{ million tons steel recycled} = 56 \text{ million tons coal saved per year in North America}$$

OR

$$0.7 \times 80 = 56 \text{ million}$$

OR

$$7.0 \times 10^{-1} \times 8.0 \times 10^7 = 5.6 \times 10^7$$

SCORING GUIDELINES

Question 2 (continued)

Describe TWO environmental problems that are associated with abandoned coal mine sites.

(2 points: 1 point for each correct description of an environmental problem. Only the first two descriptions can earn a point.)

- Subsidence/sinkholes as shafts collapse
- Habitat destruction/slow to recover
- Stream/water quality degradation
- Acid mine drainage
- Heavy metal runoff
- Tailings alter landscape and drainage patterns
- Increased soil erosion
- Particulate/dust pollution
- Animals fall in
- Methane release
- Underground fires difficult to extinguish

Describe one method that can be used to mitigate one of the problems you identified in part (c).

(1 point for a correct description of a mitigation method for one of the two environmental problems described in part (c))

- Plant trees or other plants to restore cover/reduce erosion
- Fill in/fence off abandoned shafts to stop subsidence or reduce access
- Prevent acid mine drainage and leaching from sites using retaining ponds, berms, other BMPs
- Treat acid mine drainage with limestone
- Return tailings to excavation sites
- Recontour the land
- Place gravel on surface to reduce wind erosion

Discuss one reason why surface coal mining is generally less expensive than subsurface mining.

(2 points for correct identification of a reason linked with a discussion of why surface mining is less expensive)

Reason	Economic Discussion
Wages	Fewer workers needed above ground Workers paid less above ground
Healthcare	Workman's compensation Insurance
Safety	Increased likelihood below ground of ○ severe accidents ○ death ○ black lung
Legal costs	Lawsuits from injuries, accidents, rescues

SCORING GUIDELINES

Question 3

Municipal solid waste (MSW) is the trash collected from households and businesses.

- (a) Use the data provided in the graph to respond to the following.
- (i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
(1 point for a correct explanation for the change in per capita generation from 2000 - 2012)
- People or businesses practicing one of the following: refuse, reduce, reuse, recycle, or repurpose.
 - Lighter materials contribute to less MSW creation (e.g. plastic bottles not glass bottles)
 - Less material used in products (newspapers smaller, aluminum cans less massive)
 - Technology reduces waste generation (e.g., reading magazines online → less paper)
 - Economic recession → less consumption → less MSW produced
- (ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.
(1 point for the correct answer with work shown)

$$\frac{(250 \text{ million tons} - 150 \text{ million tons})}{150 \text{ million tons}} \times 100 = 66\% \text{ to } 67\%$$

- (b) Two ways of managing MSW are incineration and disposal in landfills.
- (i) **Identify** one disadvantage of waste incineration.
(1 point for a correct identification of a disadvantage of waste incineration)
- | | |
|---|--|
| <ul style="list-style-type: none"> • Specific air pollutant (e.g., CO, CO₂, dioxin, halogens, particulates, SO_x, NO_x) • Ash disposal necessary • Incinerator is expensive to construct and/or operate | <ul style="list-style-type: none"> • MSW supply and quality may be limited requiring additional fuel • Reduced quality of life and property value due to incinerator and supply trucks |
|---|--|
- (ii) **Identify** one disadvantage of waste disposal in landfills.
(1 point for a correct identification of a disadvantage of waste disposal in landfills)
- | | |
|---|--|
| <ul style="list-style-type: none"> • Ground water, surface water, or soil contamination through some transport mechanism • Reduced quality of life and property value due to landfill and supply trucks | <ul style="list-style-type: none"> • Release of methane or CC • Odor source • Attracts vermin • Habitat destruction • Preclusion of other land uses • Explosion/seepage hazard from methane produced |
|---|--|

SCORING GUIDELINES

Question 3 (continued)

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

Describe the specific steps of a process use to produce electricity from waste buried in a landfill
(3 points – 1 point for each step in the process of generating electricity from landfill gas)

Step	Description of Step
Acquire fuel (chemical energy)	Methane collected or gathered
Use fuel (chemical → mechanical)	Fuel is combusted to produce steam or hot air
Generate electricity (mechanical → electricity)	Steam or hot air spins/turns/rotates a turbine/generator to generate/produce electricity

- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
(1 point for a correct description of a human health problem associated with piles of discarded tires)
- Discarded tires provide habitat for mosquitoes/pests that can be disease vectors.
 - Tires may catch fire and release air pollutants that cause respiratory issues in humans.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- (i) Other than reducing the volume of waste, **identify** one advantage of composting.
(1 point for a correct identification of an advantage of composting)
- The resulting compost can be used or sold as fertilizer or soil amendments.
 - Municipal composting facilities may provide jobs.
 - MSW may emit less foul odor if organic material is composted.
 - Tipping fees and trash removal costs may be reduced due to removal of dense compostable material.
- (ii) **Identify** one disadvantage of composting.
(1 point for a correct identification of a disadvantage of composting)
- Compost may attract undesirable animals (vermin).
 - Compost may emit foul odors or spontaneously combust.
 - Nutrients released from decomposing organic matter may run off into surface waters and cause water quality problems.
 - Compost may release methane.
 - Composting organic material requires a great investment of time and labor by humans.

2016 SCORING GUIDELINES

Question 4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and provide ecosystem functions.

- (a) **Describe** how TWO climate factors affect the rate of soil formation.

(2 points: 1 point for each correct description of how a climate factor affects the rate of soil formation. Only the first two descriptions can earn a point.)

Climate Factor		Effect
Temperature	High	Increases rates of biological activity (decomposition) and chemical activity – increases rates of soil formation
	Low	Decreases rates of biological activity (decomposition) – decreases rates of soil formation Increases the rate of weathering (frozen water expands, breaking rock) – increases the rate of soil formation
Precipitation/ Humidity	High	Increases biological activity and weathering – increases the rate of soil formation Increases erosion, runoff – decreases the rate of soil formation
	Low	Decreases biological activity and weathering – decreases the rate of soil formation
Wind		Can carry in particles – increases rates of accumulation Can hasten rates of soil erosion – decreases rates of accumulation

(Note: No point earned for merely identifying a climate factor.)

- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.

- (i) **Identify** one specific biotic component of the A horizon.
(ii) **Identify** one abiotic component of the A horizon.

(2 points: 1 point for a correct identification of a specific biotic factor and 1 point for a correct identification of an abiotic factor.)

Examples of components include:	
Biotic	Humus, microorganisms, bacteria, earthworms, macroinvertebrates, roots, fungi, beetles, decomposers, insects
Abiotic	Sand, silt, clay, water, air, nutrients (N,P, K compounds), decomposing parent material, minerals, rocks, pebbles

2016 SCORING GUIDELINES

Question 4 (continued)

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.

- (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
(1 point for a correct agricultural practice that leads to elevated nitrate levels in groundwater.)
- Application of fertilizer
 - Improper sealing of feedlots
 - Improper construction or maintenance of animal waste lagoons

- (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in ground water.

(1 point for a correct description linked to the practice identified in part (c)(i).)

- Nitrates infiltrate/percolate/seep into ground water.
- Nitrates entering surface waters that recharge aquifers (must connect surface with ground water).

- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.

- (i) **Explain** one way acid deposition onto soil can affect plant health.
(1 point for a correct explanation of one way acid deposition onto soil can affect plant health.)
- Increased soil acidity may be outside of the optimal range of tolerance for the plant, resulting in poor plant growth or death.
 - Acid can leach cations/metal ions/nutrients from soil, making them less available to plants, thus decreasing growth.
 - Aluminum is released and can be toxic to plants.
 - Acid can diminish the ability of soil to buffer, leading to poor plant growth.
 - Increased soil acidity can damage plant root systems, stressing plants.
 - Sulfur and nitrogen from acid deposition can build up to levels toxic to plants (or can fertilize the soils).

- (ii) **Describe** one method for remediating soil affected by acid deposition.

(1 point for a correct description of a method of remediation.)

- Add crushed limestone / lime / marble dust / bone meal / crushed egg shells or oyster shells

- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

(2 points: 1 point for each correct description of how a change in climate has resulted in soil degradation.)

- Increased global temperatures and decreased precipitation cause desertification.
- Increased temperatures lead to increased evaporation of irrigation water, resulting in soil salinization.
- Increased erosion and/or leaching can result from increased precipitation in certain areas.
- Increased temperature can lead to faster breakdown of organic matter (less organic matter in the soil).
- Increased temperatures and shifting climatic belts result in longer growing seasons, which can deplete nutrients from the soil.
- Rising sea levels can result in flooding of coastal areas, leading to salinization of soil and increased soil erosion.
- Increased temperatures can lead to soil desiccation.