Question 2: Analyze an Environmental Problem and Propose a Solution — 10 points

(a) Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein. — **1 point**

- 50 m^2

(b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle. — **1 point**

- Type III

(c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population. — **1 point**

Accept one of the following:

- Darkling beetles reproduce quickly, which allows for a large amount of protein to be produced in a short period of time.
- Darkling beetles have many offspring, which allows for a large amount of protein to be produced in a short period of time.

(d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage. — **1 point**

Accept one of the following:

- Chicken production has a lower global warming potential than pork production, so it would cause less environmental damage because chicken production releases less greenhouse gas.
- Chicken production has a lower land use than pork production, so it would cause less environmental damage because there would be less deforestation/habitat destruction/soil erosion/fossil fuel use.

(e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have. — **1 point**

Accept one of the following:

- Beef has a larger impact because methane has a high global warming potential.
- Beef has a larger impact because methane is a greenhouse gas.
- Beef requires more land use, which results in loss of forests/habitat/grasslands leading to release of CO_2/reduction in carbon storage.

(f) **Describe** how water quality can be altered by cattle grazing that occurs near a stream or river. **1 point**

Accept one of the following:

- Cattle cause erosion, which increases sedimentation/turbidity in water.
- Cattle feces can add nutrients/nitrogen/phosphorus to waterways.
- Cattle feces may contaminate waterways with bacteria.

(g) **Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze. **1 point**

Accept one of the following:

- Practice rotational grazing/alternate grazing parcels.
- Eat a diet with less meat/beef.
- Fence/barricade the riparian zone.
- Provide other water sources for the cattle.

(h) Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion. **1 point**

Accept one of the following:

- Switch crops to perennial plants.
- Plant crops on terraces.
- Implement contour plowing/farming.
- Use no-till farming/cover crops.

(i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion. **1 point**

Accept one of the following:

Solution proposed in (h)	Justification of solution with additional advantage other than the reduction of soil erosion
Switch to perennial plants	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils.
Plant crops on terraces	• Allows areas to be farmed that are otherwise too steep. • Sediments and other contaminants settle out behind the terrace ridge reducing the amount of soil that runs off. • Increases groundwater absorption.
Implement contour plowing/farming	• Allows areas to be farmed that are otherwise too steep. • Increases groundwater absorption.
Use no-till farming/cover crops	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils. • Cover crops can be used as green manure.

(j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change. **1 point**

Accept one of the following:

- Crop production/yields could decrease because of:
  - Increased drought
  - Increased flooding
  - Increased insect infestation from warmer temperatures
  - Increased temperature
  - Changes in seasonal rain patterns (or temperatures)
  - Expansion of geographic range of invasive pests/species
  - Climate may be outside range of tolerance of crops

Total for question 2 10 points

Question 1: Design an Investigation — 10 points

(a) **Identify** the ecological change over time illustrated in the diagram. **1 point**

- Primary Succession

(b) **Identify** the stage in which pioneer species first appear. **1 point**

- II/2

(c) **Describe** how soil forms from stage II to stage III. **1 point**

Accept one of the following:

- Wind/rain/weather can erode the rock/parent material.
- Wind/rain can break down rocks.
- Pioneer species (lichen/algae/fungi) die off adding small amounts of organic material.
- Pioneer species (lichens/algae/fungi) help break down rocks.

(d) **Identify** a cultural ecosystem service that may be provided by a mature forest. **1 point**

Accept one of the following:

- Recreation
- Aesthetic enjoyment
- Spiritual use
- Ecotourism
- Education

(e) **Identify** a testable hypothesis being investigated by the researchers. **1 point**

Accept one of the following:

- The removal of trees/clear-cutting will lead to an increase/decrease in water quality (temperature/turbidity/dissolved oxygen).
- The removal of trees/clear-cutting will have no effect on water quality (temperature/turbidity/dissolved oxygen).
- Water quality (temperature/turbidity/dissolved oxygen) will increase/decrease between stations.
- Water quality (temperature/turbidity/dissolved oxygen) will not change between stations.

(f) **Identify** the independent variable in the experiment. **1 point**

Accept one of the following:

- Presence or absence of clear-cutting
- Intact or clearcut forest
- Location of stream monitoring stations

(g) **Describe** the purpose of forest A in the experiment. **1 point**

Accept one of the following:

- Forest A/A/It is included so the researchers can compare the temperature/turbidity/water quality in clear-cut areas (forest B) to intact areas.
- Forest A/A/It acts as a control so researchers can compare intact areas/Forest A to clear-cut areas/Forest B.

(h) **Explain** why the water temperature might change because of clear-cutting trees in forest B. **1 point**

Accept one of the following:

- Water temperature will increase because there will be no/fewer trees to block the sunlight.
- Water temperature will increase because there will be additional sediment from erosion.
- Water temperature will increase because more sunlight will reach the water surface.

(i) **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B. **1 point**

Accept one of the following:

- There could be a decrease in dissolved oxygen because fertilizer runoff leads to algal blooms/eutrophication.
- There could be a decrease in sedimentation/turbidity because the grass will decrease erosion compared to the clear-cut land.
- There could be an increase in nitrates/phosphates due to fertilizer runoff resulting in algal growth/bloom.

(j) **Explain** how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course. **1 point**

Accept one of the following:

- Aquatic organisms would die off from a lack of oxygen created by the decomposition of algae/eutrophication.
- Aquatic organisms would survive at a higher rate because there is less sediment to suffocate them/clog their gills.
- Aquatic organisms would die off due to increased toxicity from pesticide runoff.

Total for question 1 10 points

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram. **1 point**

Accept one of the following:

- Area A
- Site/area upstream from the factory

(ii) **Identify** the dependent variable in the study. **1 point**

- Turtle nesting success

(iii) Based on the information provided, **identify** a likely scientific question for the study. **1 point**

Accept one of the following:

- Does mercury content in the turtle's habitat affect common snapping turtle nest success?
- Does mercury content in the turtle's habitat affect the location/site of common snapping turtle nests?

(iv) **Describe** why researchers measured mercury levels in locations upstream from the factory. **1 point**

Accept one of the following:

- The upstream locations acted as a control group in the study.
- The site was used to compare with the high mercury turtle nests downstream.

(v) There are plans to remove trees and other vegetation along the riverbank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B. **1 point**

Accept one of the following:

- With more open area closer to the river, turtles don't have to travel as far to build nests, leading to exposure to higher levels of mercury near the river, decreasing the number of successful nests.
- With less vegetation to remove the mercury/heavy metals/endocrine disruptors/pesticides, there will be increased concentrations in the soil, decreasing the number of successful nests.
- Soil erosion along the stream would increase, which would make it more difficult for turtles to build nests there and decrease the number of successful nests.
- With less vegetation and reduced shade, the soil temperature will increase/moisture will decrease, decreasing the number of successful nests.

Total for part (a) 5 points

(b) (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism. **1 point**

Accept one of the following:

- The mercury/persistent pollutant could bioaccumulate in the tissues of organisms because the pollutants do not easily break down and can accumulate over time.
- Mercury is a neurotoxin, which can disrupt an animal's nervous system/neuron functioning.
- The mercury/persistent pollutant disrupts regular functioning of an animal's brain/kidneys/liver/immune system/reproductive system and can lead to death.

(ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem. **1 point**

Accept one of the following:

- A toxin can biomagnify in the food chain impacting top predators that will have a very high concentration of the pollutant.
- The death of top predators in a food chain leads to a trophic cascade.
- Reproductive success of individual organisms can decrease from exposure to the pollutant, altering the ecosystem's food webs/trophic levels and decreasing its stability/resulting in a decline in biodiversity.

(iii) Researchers measured methylmercury in a location downstream from the factory. **1 point**
Explain how methylmercury could be present in the stream.

- Mercury is likely released into the stream by the factory as a waste product. Bacteria/microorganisms in the water/sediments then convert the mercury into methylmercury.

(iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **1 point**
Explain how the pattern shown in the diagram supports or refutes this claim.

Accept one of the following:

- The nests near the river in Area B where there is mercury are not successful, but the nests further away are successful. This supports the claim that the high concentration in the soil negatively affects the nesting success.
- There are fewer total nests/successful nests in Area B closer to the river than in Area A indicating that the mercury in the soil has negatively affected the nesting success. This supports the claim.

Total for part (b) **4 points**

(c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area. **1 point**

Accept one of the following:

- Tilling/plowing softens/loosens soils and/or removes organic matter or leads to erosion.
- Monocropping removes nutrients and/or moisture from soil.
- Use of synthetic fertilizers disrupts the soil chemistry in areas used for agriculture.
- Irrigation can lead to waterlogging, erosion, and/or salinization of soils.
- Slash and burn removes vegetation and upper organic layers of the soil/adds nutrients to the soil.
- Use of industrialized machinery (harvesters, plows, planters) compacts soil.
- Use of polycultures/cover cropping with nitrogen-fixing plants can add nutrients to soil.
- Use of manure/organic fertilizer can increase moisture content of the soils.

Total for part (c) 1 point

Total for question 1 10 points

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the scientific question that resulted in the data presented in the graph. **1 point**

Accept one of the following:

- What is the relationship between slope and annual erosion rate for four different land use types?
- Does crop rotation/tilling/not tilling/using cover crops on various slopes increase/decrease/change erosion rates?

(ii) **Identify** the agricultural practice that could be used on a 15% slope without leading to a higher than tolerable loss of soil. **1 point**

- Crop rotation

(iii) **Describe** the effect of adding a cover crop compared to using the no-till method. **1 point**

Accept one of the following:

- Adding a cover crop reduces the annual rate of soil erosion compared to using the no-till method.
- Adding a cover crop allows planting on greater sloped land before reaching tolerable loss as compared for the no-till method.

(iv) **Identify** one natural mechanism of soil erosion. **1 point**

Accept one of the following:

- Moving/flowing water
- Rainfall
- Wind

Total for part (a) **4 points**

(b) (i) **Identify** the dependent variable stated in the hypothesis. **1 point**

Accept one of the following:

- The amount of sediment discharge
- The amount of sediment run-off

(ii) **Describe** one way to add a control to improve the design of the study. **1 point**

Accept one of the following:

- Add a plot that is bare/does not have straw bales or grass (no ground cover).
- Measure sediment discharge/runoff prior to placing straw bales or planting grass compared to discharge after the bales/grass are in place (pre-/post-tests).

(iii) **Identify** one variable that was not discussed that could affect the results of the study. **1 point**

Accept one of the following:

- Slope of the plots
- Amount of rainfall
- Composition of the roads
- Distance of the plots from road/stream
- Size of the plots
- Type of soil at the plots
- When the data are collected at the plots (how quickly after rainfall)

(iv) Based on the data in the table above, **make a claim** about the stated hypothesis. **1 point**

Accept one of the following:

- The stated hypothesis is rejected as more sediment resulted from straw bale plots (plot A) than grass planted plots (plot B).
- The data in the table shows that the grass is more effective at reducing sediment runoff. The hypothesis should be rejected.

Total for part (b) 4 points

(c) (i) **Describe** the type of survivorship curve expected for these fish species. **1 point**

Accept one of the following:

- Low survival rate in early life, followed by increased chances of survival as the organism matures.
- Most offspring die at a very young age and few reach maturity.

(ii) **Explain** why the input of sediment to a stream can negatively affect reproduction of fish that lay their eggs in the gravel of the streambed. **1 point**

Accept one of the following:

- Sediment can cover/bury eggs, which reduces the amount of oxygen, causing them to die.
- Sediment takes away usable habitat/space resulting in fewer areas for them to lay eggs causing fewer eggs to survive.
- Sediments can carry toxic/poisonous chemicals, which can negatively impact the eggs and decrease egg survival.
- An increase in sediment can increase the water temperature and result in less dissolved oxygen/too warm water, which can decrease the viability of the eggs that have already been laid.
- Sediment can increase water turbidity, which decreases fish navigation/ability to forage/efficiency of oxygen use which decreases the amount of eggs laid.

Total for part (c) 2 points

Total for question 1 10 points

AP® Environmental Science 2016 Scoring Guidelines

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
- Long generation times in bats
- Advanced age at first reproduction
- 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

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

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)

0.95×800 billion tons of iron = 760 billion tons iron ore used to make steel

OR

$0.95 \times 800 = 760$ 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

$0.7 \times 80 = 56$ 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 o severe accidents o death o 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)

- Specific air pollutant (e.g., CO, CO_2, dioxin, halogens, particulates, SO_x, NO_x)
- Ash disposal necessary
- Incinerator is expensive to construct and/or operate
- 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)

- Ground water, surface water, or soil contamination through some transport mechanism
- Reduced quality of life and property value due to landfill and supply trucks
- Release of methane or CO
- 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 – inceases 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.