Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

(a) **Identify** a typical type of plant that would be used in a desert-tolerant landscaping. **1 point**

Accept one of the following:

- Cactus/cacti
- Succulent plants
- Drought-tolerant plants

(b) **Justify** the removal of landscaping and lawns that use grasses not native to the local area by describing an additional advantage, other than reducing the amount of water needed for irrigation. **1 point**

Accept one of the following:

- Native desert plants support habitat/provide food for local/native wildlife.
- Less mowing leads to decreased yard maintenance time/costs.
- Desert tolerant plants need less fertilizer/pesticide.
- Creates jobs for landscapers to remove/replace turf.
- Decreased use of gas-powered yard tools reduces air pollution/noise pollution/gasoline consumption.

(c) **Describe** how a prescribed burn would reduce the severity and spread of forest fires. **1 point**

Accept one of the following:

- Prescribed burns/they remove undergrowth, decreasing fuel/flammable material.
- Prescribed burns/they thin forests/create a fire break, reducing the spread of fires.

(d) **Describe** a disadvantage of a prescribed burn in a forested ecosystem. **1 point**

Accept one of the following:

- Reduces habitat for wildlife/can harm or displace animals.
- Releases carbon dioxide, which contributes to climate change.
- Releases particulates/air pollutants, which worsens air quality.
- Runoff following a prescribed burn can degrade water quality.
- Reduces competition, which helps invasive species spread/expand.

(e) **Calculate** the number of million acre-feet (maf) of water currently in Lake Powell. **Show** your work. **1 point**

One point for the correct setup to calculate number of million acre-feet (maf) of water currently in the lake:

Accept one of the following:

- 25.16 maf × 36%
- 25.16 × 0.36

One point for the correct calculation of the number of million acre-feet (maf) of water currently in the lake: **1 point**

Accept one of the following:

- 9.0576
- 9.058
- 9.06
- 9.1

Total for part (e) **2 points**

(f) The watershed of the Upper Colorado River contributes an average of 9.60 maf of water to Lake Powell annually. The melted mountain snow found in the watershed contributes 50% of the average river flow into Lake Powell. In 2021, the river flow was 36% of the annual average. Assuming that all resources to that flow contributed with the same proportions as in prior years, **calculate** the amount of water (in million acre-feet) that was contributed by the melted mountain snow in 2021. **Show** your work. **1 point**

One point for the correct setup to calculate amount of water in million acre-feet that was contributed by the melted mountain snow:

Accept one of the following:

- 9.60 maf × 36% × 50%
- 9.60 maf × 0.36 × 0.5
- 9.60 × 0.36 × 0.5

One point for the correct calculation of the amount of water in million acre-feet: **1 point**

Accept one of the following:

- 1.728
- 1.73
- 1.7

Total for part (f) **2 points**

(g) The average household in the United States consumes 5.0×10^4 gallons of water in a year. **Calculate** the number of households that could be supported for one year by the average flow of 9.60 maf of water into Lake Powell. **Show** your work. **1 point**

One point for the correct setup to calculate the number of households that could be supported for one year by the average watershed flow:

Accept one of the following:

- $9.60 \text{ maf} \times \frac{3.26 \times 10^{11} \text{ gallons}}{1 \text{ maf}} \times \frac{1 \text{ household}}{5.0 \times 10^4 \text{ gallons}}$
- $9.60 \text{ maf} \times \frac{3.26 \times 10^{11} \text{ gallons}}{5.0 \times 10^4 \text{ gallons}}$
- $9.60 \times \frac{3.26 \times 10^{11}}{5.0 \times 10^4}$

One point for the correct calculation of the number of households: **1 point**

Accept one of the following:

- 62,592,000
- 6.2592×10^7

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 1: Design an Investigation — 10 points

(a) (i) **Identify** the land use that covers the least amount of area in the Mississippi River watershed, based on the diagram. **1 point**

- Urban

(ii) **Describe** one way that land use practice at location X in the diagram could contribute to the dead zone in the Gulf of Mexico. **1 point**

Accept one of the following:

- Fertilizer used on croplands is washed into the streams and rivers in the watershed and feeds the growth of algae once it reaches the Gulf.
- Concentrated animal feeding operations generate large amounts of organic wastes that can move into streams and rivers, feeding the growth of algae once it reaches the Gulf.
- Treated or untreated (overflows) sewage released from wastewater treatment plants feeds the growth of algae once it reaches the Gulf.

(iii) **Describe** one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico. **1 point**

Accept one of the following:

- Wastewater treatment facilities in urban areas may release nutrients in treated wastewater and/or overflows, with this effluent flowing into the Gulf.
- Impervious surfaces in urban areas can increase the movement/runoff of lawn fertilizers or high-phosphate detergents that move onto pavement areas and flow into the Gulf.

Total for part (a) **3 points**

(b) (i) **Describe** how a dead zone affects marine organisms living in the Gulf of Mexico. **1 point**

Accept one of the following:

- Many organisms are forced to migrate or will die as a result of low dissolved oxygen levels in the water.
- Many organisms are forced to migrate or will die as a result of algal blooms that block sunlight from reaching underwater plants (submerged aquatic vegetation).

(ii) **Describe** one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone. **1 point**

Accept one of the following:

- Decreased fish catch/decreased income for fishing industry
- Decreased tourism/lower tourism revenues
- Increased fuel costs for fishing vessels that need to travel farther to locate fish, therefore there will be a decrease in income/profits for fishing industry
- Increased costs for consumers as a result of a limited supply of fish

(iii) **Describe** one factor that causes the area of the dead zone in the Gulf of Mexico to increase during the summer months. **1 point**

Accept one of the following:

- Increased runoff of nitrates/phosphates/potassium from fertilizer used during the growing season leads to increased algal growth in the summer months.
- Increased precipitation/snowmelt/water volume carries more fertilizer runoff from urban or agricultural areas leading to increased algal growth.
- Higher water temperatures in the summer decrease the concentration of dissolved oxygen as warm water does not hold as much dissolved oxygen as cold water.
- Increased runoff of fertilizer or high-phosphate detergents used in urban areas leads to increased algal growth in the summer months.

Total for part (b) **3 points**

(c) (i) **Identify** a testable hypothesis for the study. **1 point**

Accept one of the following:

- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will be lower than areas without riparian buffers.
- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will be higher than areas without riparian buffers.
- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will remain the same in areas with and without riparian buffers.

(ii) **Describe** a control that the researchers could use in the study. **1 point**

- Stream sites that are 100 meters downstream from areas without riparian buffer zones

(iii) **Identify** one water quality test, other than measuring nitrates or phosphates, that the researchers could use to evaluate how riparian vegetation buffers affect water quality. **1 point**

Accept one of the following:

- Turbidity
- Total suspended solids (TSS)
- Dissolved oxygen
- Water temperature
- Fecal coliform
- Conductivity
- pH
- Biological oxygen demand (BOD)

(iv) During the investigation, researchers discovered that some of the land next to one of the streams with a riparian vegetation buffer is going to be converted from cornfields into a large-scale concentrated animal feeding operation. **Explain** one way that this change in land use could alter the results of the study. **1 point**

Accept one of the following:

- There would be a decline in water quality from increased nutrients/increased coliform bacteria in the runoff because there is animal waste in the areas near concentrated animal feeding operations that are high in nutrients/coliform bacteria.
- There would be a decline in water quality from increased turbidity/increased total suspended solids in the streams near the concentrated animal feeding operations because particles from animal wastes enter the stream/there is increased disruption of the stream bed from animals in the water.
- There would be a decline in water quality from increased water temperature because the increased turbidity/suspended solids in streams near the concentrated animal feeding operations absorb sunlight/heat.
- There would be a decline in water quality from increased conductivity because there is increased water temperature/increase dissolved salts in streams near concentrated animal feeding operations.
- There would be a decline in water quality from antibiotics/veterinary drugs in runoff near the concentrated animal feeding operations because antibiotics/drugs are used in livestock operations but not to grow crops.

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

Total for question 1 **10 points**

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

(a) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal. **1 point**

Accept one of the following:

- Lung disease/respiratory diseases (asthma, COPD, bronchitis, lung cancer)
- Neurological damage
- Birth defects
- Heart disease
- Eye irritation/respiratory irritation/headaches

Total for part (a) **1 point**

(b) (i) **Describe** an environmental problem associated with coal ash waste disposal. **1 point**

Accept one of the following:

- Leaching from landfills/clay-lined pits
- Overflowing of coal ash into bodies of water
- Leaking and contamination of groundwater, soil, or nearby bodies of water
- Coal ash washing into bodies of water as a result of severe weather events
- Dry ash carrying into nearby bodies of water, increasing turbidity/decreasing photosynthesis

(ii) A proposed solution is to dispose North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil. **1 point**

- Clay is less permeable than unlined pits and can prevent the leaching of coal ash into soil/groundwater.

Total for part (b) **2 points**

(c) (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work. **1 point**

One point for the correct setup to calculate the percent change:

- $\frac{857{,}425 \text{ people} - 757{,}278 \text{ people}}{757{,}278 \text{ people}} \times 100$
- $\left(\frac{857{,}425 \text{ people}}{757{,}278 \text{ people}} - 1\right) \times 100$

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

Accept one of the following:

- 13%
- 13.22%
- 13.224602%

(ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work. **1 point**

One point for the correct setup to calculate the year the population of Charlotte will double:

- Doubling time $= \frac{70}{1.88} = 37$ years + 2019

One point for the correct calculation year the population of Charlotte will double: **1 point**

- 2056

(iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work. **1 point**

One point for the correct setup to calculate the gallons of water used in 2018:

- $\frac{90 \text{ gallons of water}}{\text{person per day}} \times 841{,}611 \text{ people} \times 365 \text{ days}$

One point for the correct calculation of the gallons of water used in 2018: **1 point**

Accept one of the following:

- 27,646,921,350 gallons
- 2.76×10^{10} gallons
- 2.8×10^{10} gallons
- 3×10^{10} gallons

Total for part (c) **6 points**

(d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use. **1 point**

Accept one of the following:

- Plant drought resistant plant species/use artificial landscaping/use xeriscaping to reduce the need for irrigation.
- Eliminate/reduce nonessential usage of water, such as washing of cars, power washing.
- Reduce the use of sprinklers/irrigation by monitoring soil conditions, weather conditions or reducing frequency.
- Collect rainwater or gray water for irrigation.
- Water plants/lawn before sunrise/after sunset to limit evaporation.
- Switch to drip irrigation to limit evaporation.

Total for part (d) **1 point**

Total for question 3 **10 points**