

ENVIRONMENTAL SCIENCE

SECTION II

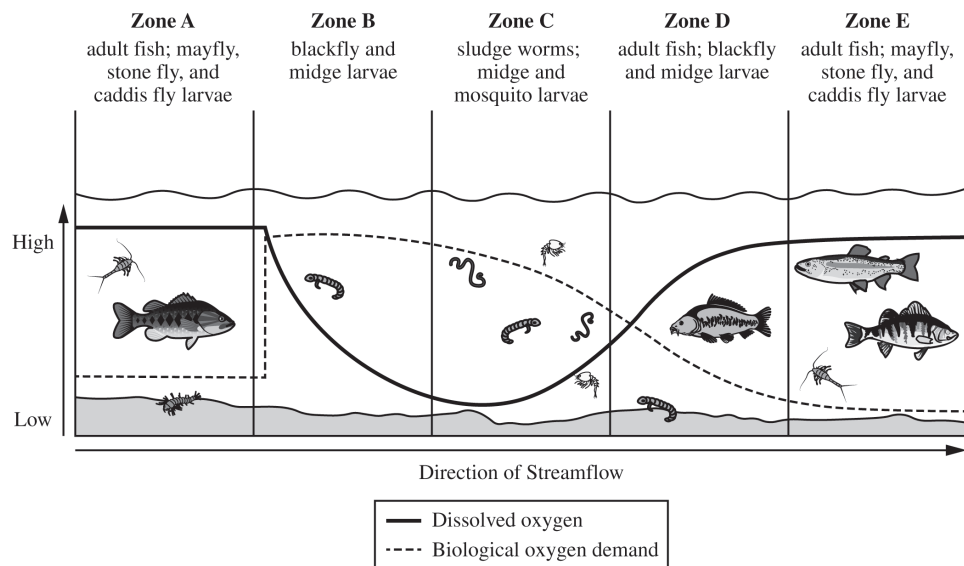
Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem



- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen..
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.
- (c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

- (d) **Identify** the dependent variable in the researchers' investigation.
- (e) **Identify** a testable hypothesis for the researchers' investigation.
- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

- (g) **Explain** how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.
- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

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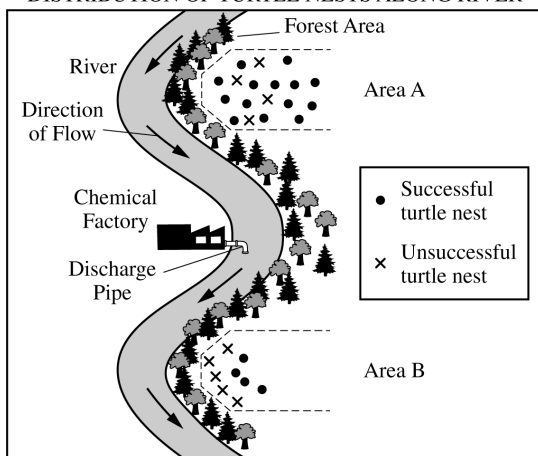
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1. Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.

DISTRIBUTION OF TURTLE NESTS ALONG RIVER



- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (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. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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Time—90 minutes

4 Questions

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

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

Fremont Daily Times

Scientists Discuss Threats from Plastic Pollution

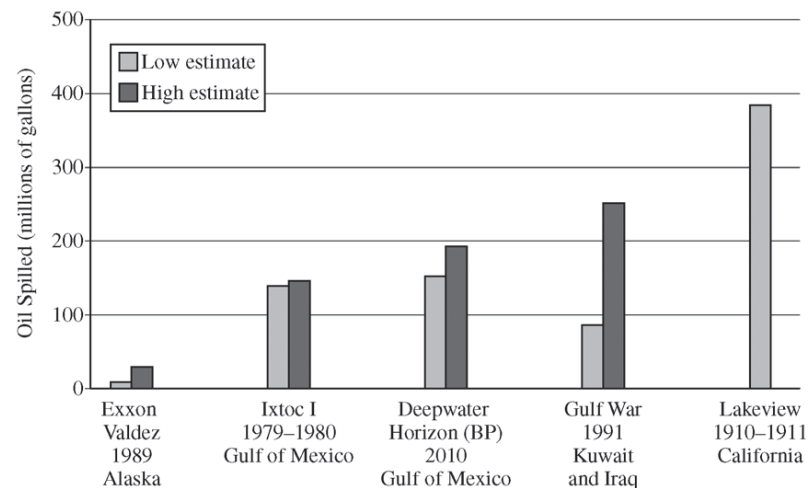
In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake

them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

- Describe** TWO effects that ingesting microbeads has on aquatic organisms.
- Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. **Describe** how nitrate levels can negatively affect water quality in some aquatic ecosystems.
- While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants.
 - Identify** one way large pieces of plastic are removed from wastewater during primary treatment.
 - Prior to discharge, wastewater is often disinfected. **Identify** one technique commonly used to disinfect wastewater.
 - Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. **Identify** one advantage and one disadvantage of this practice.
- Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem.
 - Provide** one reason why mangrove trees are being removed by humans.
 - Identify** one ecosystem service provided by intact mangrove ecosystems.

VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.
- Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.
 - Describe** TWO environmental problems that can result from oil spills in coastal areas.
 - Identify** one economic impact that results from oil spills in coastal areas.
 - Chemical dispersants have been used in cleanup efforts following major oil spills.
 - Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.
 - Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.
 - Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.
 - Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).

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1. Read the article below and answer the questions that follow.

The Fremont Plaindealer

May 1, 2013

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.”

Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- (i) “Nuclear power plants produce no dangerous solid waste.”
 - (ii) “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- (i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - (ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - (iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

2. Like many communities, Fremont has a combined sewer system that collects both sewage and storm water. When storm water runs into storm drains that connect to the city’s sanitary sewer system, the storm water and sewage flow together to the Fremont Wastewater Treatment Plant (FWTP). During a major storm event, however, the combined volume of storm water and sewage may exceed the plant’s capacity, and the overflow bypasses the FWTP. The untreated overflow is discharged into Fremont Creek along with the treated waste.

Recently parts of Fremont received 5 cm of rain in 60 minutes. The storm caused widespread flooding in the northeast section of town. Especially hard hit was the Shoppes at Fremont shopping center.

Use the data from the table below to answer the questions that follow. Show all calculations.

Fremont Water Data
The shopping center’s parking lot is 200 meters long and 100 meters wide.
Fremont has an area of 10 km ² .
Impervious surfaces cover 20 percent of Fremont’s area.
The FWTP typically treats 5,000 m ³ of domestic sewage per day.
The FWTP has the capacity to treat 10,000 m ³ of combined sewage and storm water per day.

- (a) **Identify** TWO specific pollutants in storm-water runoff that degrade the quality of surface water.
- (b) **Calculate** the volume of water (in m³) that runs off the Shoppes at Fremont parking lot after a 5 cm rainfall event. Assume that all the water that falls on the parking lot runs off.
- (c) **Calculate** the volume of storm-water runoff (in m³) generated in all of Fremont by the 5 cm rainfall event. Assume that only the impervious surfaces generate runoff.
- (d) Assume that all the runoff that you calculated in part (c) is captured by the storm sewers in one day. **Calculate** the volume of untreated water (in m³) that bypasses the plant as a result of the storm. (Note that the plant still receives 5,000 m³ of domestic sewage per day.)
- (e) **Describe** TWO ways that the volume of storm-water runoff can be reduced.
- (f) **Describe** one environmental problem (other than pollution from runoff and from untreated sewage) that results from having extensive paved areas.