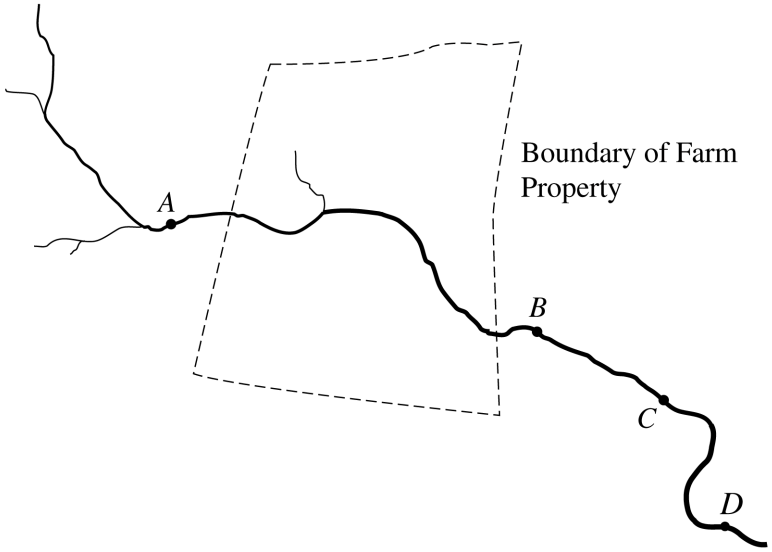
4. Students in an environmental science class at Fremont High School tested the water quality in a stream near their school. They were concerned about the possible pollution of the stream, which flows through a farm on which hogs are raised. Shown below are a diagram that indicates the sites where the students collected water samples (labeled *A* through *D*, upstream to downstream) and a table of the results of the students' water tests.



Results of Water Tests

	A	***B***	***C***	***D***
Dissolved Oxygen (ppm)	6.4 ± 0.3	2.5 ± 0.1	3.0 ± 0.2	5.8 ± 0.2
Phosphate (ppm)	0.9 ± 0.05	1.2 ± 0.09	1.1 ± 0.08	1.0 ± 0.09
Nitrate (ppm)	0.9 ± 0.3	19.3 ± 1.1	12.5 ± 1.0	6.2 ± 0.5
pH	5.5	5.4	5.6	5.4

(a) Assess the likelihood that animal waste is contaminating the water. Discuss the scientific basis of your assessment.

(b) Describe two additional tests that could be used in monitoring the quality of the water in the stream. For each test, describe the patterns you would expect from sites *A* through *D*.

(c) Describe a sequence of ecological changes that might result from the discharge of animal waste into a body of water.

(d) The Clean Water Act was first passed in the United States in 1972 and has been amended several times since then. Describe two specific provisions of this legislation that would be likely to apply to the quality of the stream water.

END OF EXAMINATION

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Question 4

4. (a) 3 points maximum

1 point for indicating that animal waste is likely to be contaminating the water **IF** it is supported by a rational explanation of the data.

1 point for linking the decrease in dissolved oxygen level to decomposition of animal waste and/or an increase in biochemical oxygen demand.

1 point for linking the increase in nitrate level and/or an increase in phosphate level to their presence in animal waste.

1 point for using the trend in stream recovery, in regard to the water quality results, as evidence of contamination by animal waste.

4. (b) 3 points maximum

1 point for stating **each** water test **and** an appropriate pattern expected from sites A through D for that test. Only the first **two** tests given are graded.

1 point only for a descriptive elaboration of the parameter, **OR** method of testing, of ONE or BOTH of the stated tests.

Examples of suitable water tests include:

Fecal Coliform/Coliform, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Temperature, Turbidity/Total Suspended Solids (TSS), Heavy metals, (e.g., lead, mercury, cadmium), Carbon dioxide, Nitrite, Salinity, Ammonia, Other macro or micronutrients (e.g., K, S), Chlorine, Iron, Selenium, Hardness, Sulfate, Sulfite, Methane, Conductivity/Total Dissolved Solids (TDS), Alkalinity/Acid Neutralizing Capacity (ANC), Color, Odor, Synthetic organics, (e.g., pesticides, PCBs), Qualitative Habitat Evaluation Index (e.g., stream substrate analysis), Biodiversity Index – the different numbers and types of species, (e.g., macroinvertebrates, bacteria, algae, amphibians, fish, plants).

Question 4 (cont.)

4. (c) 3 points maximum

Only the **first** described sequence is graded. Credit will only be given for ecological changes that are **linked** to the presence of animal waste and are **connected** to a single sequence.

0 points would be awarded for simply stating that 'eutrophication' occurs.

An example of a suitable sequence could be:

1 point for indicating that as stream fertility increases due to higher nitrate/phosphate levels, an algal bloom occurs.

1 point for indicating that as the dead algae and/or organic materials are decomposed, a reduction in the level of dissolved oxygen occurs.

1 point for indicating that an increase in suspended solids could lead to an increase in temperature and/or a decrease in the rate of photosynthesis, resulting in lower dissolved oxygen levels.

1 point for indicating that a shift in benthic plants, phytoplankton, macroinvertebrates, and/or fish communities would result from a specific cause.

1 elaboration point is possible for identifying a suitable species as the example of a shift in biodiversity.

Suitable examples of an indicator species could be:

Pollution sensitive	**Somewhat pollution tolerant**	**Pollution tolerant**
caddisfly larvae	beetle larvae	aquatic worms
hellgrammite	clams	blackfly larvae
mayfly nymphs	crane fly larvae	leeches
gilled snails	crayfish	midge larvae
riffle beetle adult	damselfly nymphs	pouch (and other) snails
stonefly nymphs	dragonfly nymphs	catfish
water penny larvae	scuds	carp
trout	sowbugs	
	fishfly larvae	
	alderfly larvae	
	atherix	
	bass	

Question 4 (cont.)

Other acceptable species could include: duckweed, pfiesteria.

1 point only would be awarded for indicating that a human health effect could occur from the contaminated water. For example, if humans are exposed to water with high fecal coliform counts, from human or animal wastes, other organisms may also be present that could lead to diseases such as typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections.

4. (d) 2 points maximum

1 point each for describing any **two** of the following provisions of the Clean Water Act. Only the first **two** stated examples are graded.

The Clean Water Act serves to:

- regulate the discharge of pollutants into U.S. waterways
- attain water quality levels that make these waterways safe to fish and/or swim in
- restore and maintain the chemical, physical, and biological integrity of the nation's water
- set water quality standards to limit pollutants
- require states and tribes to complete an assessment of all state rivers impacted, or potentially impacted, by non-point pollution (Section 319)
- reduce polluted runoff from urban areas and animal feeding operations (Section 319)
- provide enforcement mechanisms (e.g. civil actions/criminal penalties) to ensure compliance
- develop management plans to address problems
- establish ongoing monitoring of local waterways
- require discharge permits for effluent emissions
- provide financial assistance to fund improvements/education/training
- prevent habitat destruction
- establish best practical control technology (BPT) to reduce pollution
- establish best available, economic achievable technology (BAT) to reduce toxics
- establish best management practices (BMPs) to reduce pollution.