NONPOINT SOURCE POLLUTION LESSON PLAN

Get to the Point!

Focus
Nonpoint source pollution

Grade Level
9-12

Focus Question
How do scientists measure nonpoint source pollution?

Learning Objectives
- Students will describe at least five sources of nonpoint source pollution runoff.
- Students will identify at least three contaminants likely to be found in urban runoff, and discuss possible sources of these contaminants.
- Students will discuss how bioassays may be used to measure toxicity, and describe three examples.
- Students will compare and contrast toxicity tests and chemical analyses of potential contaminants, and explain how these may be used to identify areas affected by nonpoint source pollution.
- Students will be able to describe and discuss at least five actions that can be taken to reduce or eliminate contaminated runoff.

Materials Needed
- Copies of "Toxic Contaminants in Long Island Sound Sediments Worksheet," one copy for each student or student group

Audio/Visual Materials Needed
None

Teaching Time

One or two 45-minute class periods, plus time for student research

Seating Arrangement

Classroom style or groups of 3 – 4 students

Maximum Number of Students

30

Key Words

Nonpoint source pollution
Sediment
Bioassay

Background Information

Pollution is the presence of substances in the air, land, or water that can degrade human health and environmental quality. These substances may come from many sources, but some of the most serious pollution problems are the result of unwanted by-products—commonly called wastes—from human activities.

In the early 1970's, major steps were taken to reduce pollution from human activities, including passage of the Clear Air and Clean Water Acts and establishment of state and federal environmental protection agencies. Many of these efforts were targeted toward large, conspicuous sources of pollution such as factories and municipal sewage systems, and significant progress has been made in reducing pollution from these point sources. Point source pollution is pollution that comes from a single, identifiable source such as a pipe or smokestack. But many polluting substances do not originate from a single source. Rainwater, for example, may become contaminated as it moves over and through the ground, picking up pollutants from many different sources. This kind of pollution is known as nonpoint source pollution, and now accounts for most of the water pollution in the United States.

Pollutants from nonpoint sources include:

- fertilizers and pesticides from farms and home landscapes;
- oil, grease, and toxic fluids from roads, parking areas, leak-

ing underground storage tanks, and improper disposal of used motor vehicle lubricants;
- sediments from poorly managed construction sites, forest lands and stream banks;
- acid drainage from abandoned mines; and
- bacteria and nutrients from livestock, pet wastes, and faulty septic tanks.

In fact, nonpoint source pollution comes from such a wide variety of human activities that almost everyone contributes to the problem in some way, often without realizing it.

Because nonpoint source pollution is a serious and pervasive problem that costs millions of dollars in lost and damaged resources, degrades environmental quality, and threatens human health, it has been the focus of numerous state, local, and national efforts. The diversity of sources and substances that result in nonpoint source pollution often make it difficult to know exactly what actions are needed to reduce or eliminate the problem. In many cases, the first priorities are to recognize when pollution is taking place, identify the polluting substances, and determine the sources of pollutants. These tasks are part of the mission of NOAA's Center for Coastal Monitoring and Assessment (CCMA). Through the National Status and Trends Program, CCMA conducts long-term monitoring of toxic chemicals and environmental conditions at more than 350 sites along the the U.S. coasts. Monitoring typically includes measurements of:
- the concentrations of common pollutants in sediments and the tissues of living organisms;
- the toxicity of sediments to living organisms; and
- the abundance and variety of species in bottom (benthic) communities.

Often these three types of information are combined to obtain an overall indicator of environmental quality. This method is known as the sediment quality triad approach.

In this lesson, students will examine data from a study of potentially contaminated sediments, and make inferences about sources of contamination and the extent to which these sediments may be toxic to marine organisms.

Learning Procedure

1.
Discuss the concept of nonpoint source pollution, or have students complete one version of the "Nonpoint Source Pollution Self Test." Briefly discuss the concept of a pollutant. Be sure students understand that this term can apply to almost anything that is "in the wrong place at the wrong time in the wrong quantity" and has the potential to harm the environment or human health.

2.
Provide each student or student group with a copy of the "Toxic Contaminants in Long Island Sound Sediments Worksheet." If time is limited, you may want to discuss questions 1 and 2 with the entire class rather than have these be part of student research. Be sure students understand that toxicity data in Table 2 are expressed as percentages of the relevant control test.

Students should also understand that the Hazard Factor (HF) data for potential contaminants are related to previously determined ER-L and ER-M values (described in Step 3). An HF of 0 means that the concentration is less than the ER-L for that contaminant. An HF between 0 and 1 means that the concentration is between the ER-L and ER-M for that contaminant, so an HF of 0.5 means that the concentration is halfway between the ER-L and ER-M. An HF greater than 1 means that the concentration is equal to the HF multiplied by the ER-M. So an HF of 2 means that the concentration is twice the ER-M; a concentration of 3 means that the concentration is three times the ER-M, and so forth.

3.
Lead a discussion of students' answers to Worksheet questions. The following points should be included:

• Microtox® is a test that uses bioluminescent bacteria (*Vibrio fischerii*) to evaluate the toxicity of substances dissolved in solution. The underlying premise of the test is that the bacteria will emit less light if they are adversely affect by the test substance, and the reduction in light output will be proportional to the extent of the toxic effects. Light emitted by the bacteria are measured at set intervals (usually after 5 and 15 minutes), and compared to the light emitted from bacteria exposed to a control solution. The difference in light output is expressed as a percentage of the control output.

The results of Microtox® tests (and many other types of bioassays) are often expressed as EC50 concentration, which is the concentration of a material in water that is expected to cause a biological effect on 50% of a group of test animals (EC stands for effective concentraton). In the case of the Microtox® test, a biological effect on 50% of the bacteria is equivalent to a 50% reduction in light output by the bacteria. The EC50 concentration in Microtox® tests is usually estimated from the reduction in light output resulting from exposure to four different dilutions of the sample being tested.

In Table 2, the EC50 concentration for each sample station is presented as a percentage of the EC50 concentration for a control site. So a value of 25% means that the EC50 concentration of the test sediment was one-fourth of the EC50 concentration of the control sediment. In other words, one-fourth as much test sediment was needed to produce the same level of response, so the test sediment was four times as toxic as the control sediment). A percentage greater than 100% means that the test sediment stimulated light output compared to the control. This could happen, for example, if the test sediment contained a nutrient that stimulated bacterial growth or metabolism.

Students should recognize that the tests using amphipods, clam larvae, and bacteria are examples of bioassays—tests that use some response of living organisms as a measure of the effects of a particular substance or mixture of substances.

• Effects Range-Low (ER-L) is a concentration of a potential contaminant at which negative impacts have been observed in about 10% of the cases studied. Effects Range-Median (ER-M) is a concentration of a potential contaminant above which negative impacts have been observed in more than 50% of the cases studied. In some reports, ER-L is considered a threshold at which some organisms are adversely affected, while ER-M is considered a threshold at which these organisms frequently or always experience adverse effects.

• PAH is an abbreviation for polycyclic aromatic hydrocarbons, a group of over 100 chemicals that are formed by the partial burning of coal, oil and gas, garbage, or other organic substances (such as tobacco or charbroiled meat). Some PAHs are manufactured and may be found in coal tar, crude oil, creosote, roofing tar, and a few are used to manufacture medicines, dyes, plastics, and pesticides. Some PAHs have been shown to interfere with reproductive and immune systems in laboratory animals, and may be carcinogenic to humans.

• According to Table 1, Upstream Sources contribute the most potential pollutants to Long Island Sound. Students should realize that most of these pollutants do not originate in the rivers themselves, but are washed or discharged into these waters from sources that probably include most of the other categories in the Table. This reinforces the concept that nonpoint source pollution often originates from many different sources, some of which may be many miles away.

• Data in Table 1 suggest that Industrial Discharges contribute very little to the contaminants reported in the table. This reflects the fact that these facilities (which are actually point sources) were among the first targets of pollution control efforts and are now heavily regulated in terms of what they are allowed to discharge to water bodies.

• Wastewater Treatment Plants (WTPs) receive large volumes of water, but are designed primarily to treat fecal material and oxygen-consuming substances. (Notice that WTPs contribute only 1% of fecal coliform bacteria). Oil and grease, phosphorus, chlorinated hydrocarbons, and heavy metals usually are not specifically treated, so WTPs may concentrate these materials. In a sense, WTPs convert nonpoint source pollution into a point source, which might make it easier to treat contaminants. Students may wonder why these materials aren't removed or treated as well. The reason is cost: while it is technically possible, upgrading WTPs to treat these other contaminants is a very expensive task. But if water quality continues to decline, this may become a reasonable option in some areas.

• The most prevalent contaminants in Urban Runoff to Long Island Sound are lead, oil and grease, and fecal coliforms.

Potential sources of these contaminants include exterior building finishes (lead), motor vehicles (oil and grease), and pet wastes (fecal coliforms). Automobiles also have been identified as a source of copper (from brake wear) and zinc (from tires).

• More than one type of toxicity test is needed for this kind of study because different test organisms respond differently to different contaminants. If a sediment sample causes adverse responses in several different organisms, it is more likely to be toxic to many other species than if only one organism were affected. In the Long Island Sound study, the animals used to evaluate toxicity were exposed to different forms of potential contaminants: amphipods were exposed directly to sediments, and thus to potential contaminants that might be adsorbed onto the sediments as well as those that might dissolve in the surrounding water; clam larvae were exposed to solutions made by from sediments but not sediments themselves; Microtox® bacteria were exposed to chemicals that were extracted from sediments using an organic solvent.

• Chemical analyses of potential contaminants establish the concentration of these contaminants in a sample, but do not directly establish whether or not the sample will be toxic to biological organisms. Some contaminants, for example, may be tightly bound to sediments or organic particles and thus may not be "available" to cause adverse impacts in some organisms.

• Of the four toxicity tests used in this study, amphipod survival appears to be the most sensitive, since in several cases [Eastchester Bay (A), Southport Harbor (B), Housatonic River (B) and (D)] survival of these animals was reduced even when the other tests showed no negative response. The clam development test was least sensitive. Many of the sediments that were toxic to amphipods also had toxic effects on Microtox® bacteria. A notable exception is Southport Harbor (A) which showed the greatest toxicity to amphipods, but which appeared to produce a positive response in Microtox® bacteria.

• Data in Table 2 suggest that toxicity is generally correlated with the concentrations of several potential contaminants. Again, Southport Harbor (A) stands apart from this trend, since contaminant concentrations were quite low, even though sediments from this site had the highest toxicity to amphipods. Possible explanations for this discrepancy include the possible presence of a contaminant that was not among those analyzed, or undetected experimental errors.

Because the concentrations of various contaminants tended to covary (that is, when the concentration of one contaminant increased, the concentrations of several others increased as well), toxicity at a given sample site could not be directly attributed to one specific contaminant. In many cases, the adverse effects caused by several contaminants reinforce each other (this is known as synergistic effects). So, even though concentrations of individual contaminants may be below ER-L levels, in combination they may produce toxic effects.

The issue of combined effects from multiple contaminants is critical when trying to decide how polluted a particular environment may be. A striking example is related to the problem of natural and man-made chemicals that have the ability to mimic the action of human estrogen and may be linked to an increasing incidence of endocrine-related cancers and deteriorating reproductive health in humans and wildlife (for example, Wolff, 1995; Toppari *et al.*, 1996; see Resources). A study of the effects of four pesticides on human breast cells showed that low concentrations of these chemicals (too low to cause estrogen-like effects by themselves) when mixed together caused an estrogen-like response. In other words, harmless amounts of four chemicals added up to a dose that could cause harm (Payne, *et al.*, 2000).

The Bridge Connection

http://www.vims.edu/bridge/ – In the “Site Navigation” menu on the left side of the page, click on “Ocean Science Topics,” then “Human Activities,” then “Enviro-concerns,” then “Pollution” for links to resources about marine pollution.

The Me Connection

Have students write a brief essay describing the most significant sources of nonpoint source pollution in their own communities, what specific personal activities may contribute to contamination from these sources, and what they might do to reduce this problem.

Extensions

1. Visit *http://oceanservice.noaa.gov/education/kits/pollution/supp_pollution_roadmap.html* for links to additional information and activities related to nonpoint source pollution

2. Visit *oceanservice.noaa.gov/education/classroom/09_coast_manag.html* for an activity in which students construct a model watershed to demonstrate and study nonpoint source pollution.

3. Have students investigate nonpoint source pollution issues in their own watershed. A good place to start is *http://cfpub.epa.gov/surf/locate/index.cfm*, which is a gateway to individual watersheds and various databases containing relevant water quality information.

4. Nosocomial infections (infections caused by microorganisms that are resistant to antibiotics and other antimicrobials) in hospitals or hospital-like settings are responsible for over 100,000 human deaths per year. One of the ways that microorganisms develop this type of resistance is through exposure to antimicrobials that are widely prescribed by physicians and veterinarians and that enter the environment through nonpoint and point sources. Visit *http://oceanexplorer.noaa.gov/explorations/04etta/background/antimicrobial/antimicrobial.html* for more discussion of this problem, and *http://oceanexplorer.noaa.gov/explorations/04etta/background/edu/media/bump.bugs.pdf* for a lesson plan on this subject.

5. Visit *http://www.epa.gov/owow/estuaries/monitor/* for a manual on volunteer water quality monitoring in estuaries.

Resources

http://www.coastalmanagement.noaa.gov/resource.html#education – NOAA Office of Ocean and Coastal Resource Management, Resources, Publications and Outreach Materials

http://www.epa.gov/win/ – U.S.E.P.A. Watershed Information Network

http://www.epa.gov/owow/nps/eduinfo.html – U.S. EPA Web site with education resources about polluted runoff

Wolfe, D. A., S. B. Bricker, E. R. Long, K. J. Scott and G. B. Thursby. 1994. Biological Effects of Toxic Contaminants in Sediments from Long Island Sound and Environs. NOAA Technical Memorandum NOS ORCA 80. Silver Spring, Maryland.

Payne, J., N. Rajapakse, M. Wilkins, and A. Kortenkamp. 2000. Prediction and Assessment of the Effects of Mixtures of Four Xenoestrogens. Environmental Health Perspectives 108:983–987.

Wolff, M. S. and P. G. Toniolo. 1995. Environmental Organochlorine Exposure as a Potential Etiologic Factor in Breast Cancer. Environmental Health Perspectives 103(Suppl 7):141-145.

Toppari, J., J. C.. Larsen, P. Christiansen, A. Giwercman, P. Grandjean, L. J.. Guillette Jr., B. Jégou, T. K. Jensen, P. Jouannet, N. Keiding, H. Leffers, J. A. McLachlan, O. Meyer, J. Müller, E. Rajpert-De Meyts, T. Scheike, R. Sharpe, J. Sumpter, and N. E. Skakkebæk. 1996. Male Reproductive Health and Environmental Xenoestrogens. Environmental Health Perspectives 104(Suppl 4):741-803.

Farrow, D.R.G., F.D. Arnold, M.L. Lombardi, M.B. Main, and P.D. Eichelberger. 1986. The National Coastal Pollutant Discharge Inventory: Estimates for Long Island Sound. Strategic Assessments Branch, Ocean Assessments Division, National Ocean Service. National Oceanic and Atmospheric Administration. Rockville, MD.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Structure and properties of matter
- Chemical reactions

Content Standard C: Life Science
- The cell
- Interdependence of organisms
- Behavior of organisms

Content Standard D: Earth and Space Science
- Geochemical cycles

Content Standard E: Science and Technology
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenge

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Toxic Contaminents in Long Island Sound Worksheet

In 1994, NOAA's National Status and Trends Program published a study of sediment toxicity in the coastal bays that surround Long Island Sound in New York and Connecticut (Wolfe, *et al.*, 1994). The study analyzed sediment samples in four different ways:

(a) Amphipods were exposed to test sediments, and the number of animals alive after 10 days' exposure was used as an indicator of toxicity;

(b) Clam larvae were exposed to water that had been mixed with test sediments and then filtered to remove sediment particles; normal development and survival after 48 hours' exposure were used as criteria of toxicity;

(c) Microtox® bacteria were exposed to chemicals extracted from sediments using dichloromethane (an organic solvent); and

(d) Chemical analyses were conducted to determined the concentration of a wide variety of potential contaminants, including heavy metals and various organic compounds.

Use internet research and/or library resources to answer the following questions:

1. What is a Microtox® test, and what does EC50 mean?

2. Define:

Effects Range-Low (ERL)

Effects Range-Median (ERM)

PAH

Table 1 summarizes information on contaminants in Long Island Sound known to come from various sources.

Table 2 summarizes some of the results from the sediment study. Toxicity data for tests of sediments from each site are compared to similar tests using sediment from a control area that were known to be non-toxic to the test organisms. Toxicity data in Table 2 are given as a percentage of the positive response in the relevant control test. A positive response may be survival (amphipods and clam larvae), normal development (clam larvae), or intensity of bioluminescence (Microtox® bacteria). So a value of 75 means that the number of organisms that survived exposure to a test sediment was 75% of the number of organisms that survived exposure to the control sediment. A value greater than 100 means that more organisms survived exposure to the test sediment than the number of organisms that survived exposure to the control sediment.

Contaminant concentration data are presented as Hazard Factors. These factors are related to previously determined values of ER-L and ER-M. An HF of 0 means that the concentration is less than the ER-L for that contaminant. An HF between 0 and 1 means that the concentration is between the ER-L and ER-M for that contaminant, so an HF of 0.5 means that the concentration is halfway between the ER-L and ER-M. An HF greater than 1 means that the concentration is equal to the HF multiplied by the ER-M. So an HF of 2 means that the concentration is twice the ER-M; a concentration of 3 means that the concentration is three times the ER-M, and so forth.

3. Which of the sources in Table 1 contributes the most potential contaminants?

____

____

____

4. What do the data in Table 1 suggest about contaminants in Industrial Discharges?

____

____

____

5. Data in Table 1 suggest that Wastewater Treatment Plants account for a large proportion of oil and grease, phosphorus, chlorinated hydrocarbons, and some heavy metals. Why?

6. What are the major contaminants associated with Urban Runoff? What are some possible sources of these contaminants?

7. Why was more than one type of toxicity test used in this study?

8. Why are toxicity tests needed in addition to chemical analyses of potential contaminants?

9. Which of the four toxicity tests seems to be most sensitive to contaminants?

10. What do the data in Table 2 suggest about the relationship between toxicity and concentrations of potential contaminants?

Table 1

Estimates of Annual Loadings for Selected Pollutants to Long Island Sound from Seven Major Sources
(from Farrow et al. *1986)*

Pollutant	Percent of Total Loading from Major Sources[a]						
	A	B	C	D	E	F	G
Total Nitrogen	37.6	2.1	<0.1	7.3	3.7	0.1	49.2
Total Phosphorus	66.2	0.1	0.1	7.9	0.5	<0.1	25.2
Heavy Metals							
As	51.7	<0.1	1.7	8.1	3.4	<0.1	35.1
Cd	28.2	<0.1	<0.1	5.1	<0.1	<0.1	66.7
Cr	18.9	4.2	0.4	7.1	8.0	0.4	61.0
Cu	31.9	3.4	5.2	7.2	1.2	0.2	50.9
Fe	4.9	<0.1	<0.1	15.7	34.8	2.2	42.4
Hg	25.4	0.6	0.1	7.3	<0.1	<0.1	66.6
Pb	14.7	2.3	<0.1	43.0	<0.1	<0.1	40.0
Zn	22.6	2.9	1.6	12.8	1.9	0.1	58.2
Oil & Grease	66.6	0.4	0.3	32.7	-	-	-
Chlorinated Hydrocarbons	90.3	1.3	-	5.4	3.0	-	-
Fecal Coliforms	1.0	<0.1	-	47.3	-	-	51.7
Sludge	100	-	-	-	-	-	-

[a] A= wastewater treatment plants
B= industrial discharges
C= power plants
D= urban runoff
E= Cropland runoff
F= forestland runoff
G= upstream sources

(-) indicates no estimates made for this pollutant in this category.

Table 2

Results of Toxicity Tests and Concentration of Potential Contaminants from Selected Locations in Long Island Sound *(from Wolfe,* et al.*, 1994)*

	Toxicity				Contaminant Hazard Factor[a]		
Station	**Amphipod Survival**	**Clam Larvae Survival**	**Clam Development Normal**	**Microtox® EC50**	**Met**	**ClHC**	**PAH**
Manhasset Bay (A)	75.6	31.3	99.3	17.7	6.75	10.45	1.98
Manhasset Bay (E)	75.6	53.7	103.1	24.8	6.04	2.17	0.66
Manhasset Bay (G)	36.7	12.9	102.8	46.6	5.36	1.79	1.76
Cold Spring Harbor (A)	82.4	106.9	100.8	51.3	1.8	0.67	0.04
Cold Spring Harbor (B)	93.4	29.7	100.6	36.4	1.82	0.54	0.02
Cold Spring Harbor (C)	70.3	23.9	100.8	21.0	1.58	0.76	0.02
Eastchester Bay (A)	79.1	104.8	102.5	1169.9	0	0.06	0.01
Eastchester Bay (B)	62.8	110.9	108.3	35.8	3.2	2.79	0.85
Eastchester Bay (C)	61.1	94.6	102.3	129.7	4.75	1.65	1.58
Southport Harbor (A)	9.9	48.7	98.9	319.9	0	0.08	0.01
Southport Harbor (B)	99.5	105.0	100.8	249.3	0.09	0.17	0.01
Southport Harbor (C)	89.7	101.7	98.4	74.7	0.68	0.20	0.06
Housatonic River (A)	75.7	71.4	100.8	139.9	1.65	3.84	3.24
Housatonic River (B)	16.2	111.9	102.2	133.3	3.1	2.67	3.19
Housatonic River (D)	69.2	109.1	101.0	426.9	0.47	0.73	0.54

[a] – Met = heavy metals; ClHC = chlorinated hydrocarbons; PAH – polycyclic aromatic hydrocarbons

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NPS Subject Review: Self Test

1. Contamination of air, land, or water by substances that can adversely impact human health and the environment is known as __________.

2. Polluting substances are usually __________ materials.

3. Pollution is something in the __________ place at the _____ time in the __________ quantity. (one word)

4. Sometimes, it is not the type of material, but its __________ that determines whether or not the material is a pollutant.

5. Epidemics in the Middle Ages such as cholera and typhoid fever were directly related to __________ conditions caused by human and animal waste and garbage.

6. In 1347, a bacterium carried by rats and spread by fleas resulted in the outbreak of __________. (two words)

7. Any single identifiable source of pollution from which pollutants are discharged is known as ________________. (three words)

WORD BANK

runoff
combined sewer system
CAFOs
wrong
concentration
unsanitary
bubonic plague
point source pollution
economy
aluminum
soil erosion
pollution
waste
tillage

NPDES
test
beneficial insects
storm drains
atmospheric
acid rain
nutrients
retention ponds
constructed wetlands
porous
atmospheric deposition
fossil fuels
suspended sediment
spray drift

pathogenic
Norwalk
Mussel Watch
buffer strips
impervious
abandoned mines
eutrophication
hypoxia
algal blooms
toxins
shutoff valves
bare
bioaccumulation

8. __________ refers to storm water that flows over surfaces like driveways and lawns.

9. A __________ is a system in which waste material is mixed with urban runoff. (three words)

10. Large farms that raise many animals such as cows and chickens are known as __________. (abbreviation)

11. The Clean Water Act established the __________ under which factories, sewage treatment plants, etc. must obtain a permit to discharge wastes into any body of water. (abbreviation)

12. Most nonpoint source pollution occurs as a result of _______________.

13. Nonpoint source pollution not only affects ecosystems; it can also have harmful effects on the __________.

14. Water can run off of __________ surfaces without being absorbed.

15. In many towns and cities, the water flowing into _______ is not treated before emptying into nearby waterbodies. (two words)

16. Approximately two-thirds of the lead and mercury that enter the Great Lakes originate from __________ sources.

17. __________ is created when sulfur and nitrogen oxides react with oxygen, water, and other atmospheric compounds. (two words)

18. Prolonged exposure to acid rain can cause soils to lose important __________ such as calcium and magnesium.

19. . As acid rain flows over and through soils, it releases __________ into lakes and streams, which can cause fish to become chronically stressed.

20. Heavy machinery used by forestry and mining operations increases the risk of __________. (two words)

21. In the mid-Atlantic and Appalachian regions of the United States, acid drainage and associated contamination from __________ have caused pollution in various water bodies. (two words)

22. The primary __________ of concern in nonpoint source pollution are nitrogen and phosphorus.

23. __________ results in an overproduction of organic matter, especially algae.

24. Very low levels of oxygen in water bodies is known as __________.

25. Eutrophication may be associated with conditions that result in harmful __________. (two words)

26. When fish and shellfish feed on HABs, they can accumulate __________ that the algae produce.

27. Lawn fertilizers and pet wastes can cause pollution from excess __________.

28. Combustion of __________ is a major source of nutrients in the atmosphere. (two words)

29. Muddy water is caused by soil in the water known as __________. (two words)

30. Pesticides can enter a waterbody as __________ which occurs when wind blows sprayed pesticide into a nearby waterbody. (two words)

31. The process in which substances build up in the tissues of animals is called __________.

32. Hydrocarbons and heavy metals from automobiles and factories eventually end up in water bodies through _________ or runoff. (two words)

33. Disease-causing microbes are said to be __________.

34. The __________ virus causes intestinal illness and is transmitted to humans by food or water contaminated with feces.

35. __________ is a program designed to monitor levels of chemicals in oysters, mussels, and sediments. (two words)

36. __________ capture runoff or storm water to trap sediments and contaminants. (two words)

37. __________ slow runoff, absorb contaminants, and provide habitat for wildlife. (two words)

38. __________ paving materials allow rainwater and stormwater to drain into the ground beneath the paving. (two words)

39. __________ are strips of grass located between a farm field and a body of water. (two words)

40. Conservation __________ involves leaving some crop residue from a previous harvest while planting a new crop.

41. To ensure that nutrients are applied only as needed, farmers __________ their fields prior to the growing season.

42. Lady bugs, praying mantis, and spiders are examples of __________. (two words)

43. __________ on fuel pumps on docks help limit spillage into water bodies. (two words)

44. One of the most important things you can do to reduce nonpoint source pollution is to plant grass, trees, and shrubs in __________ areas.

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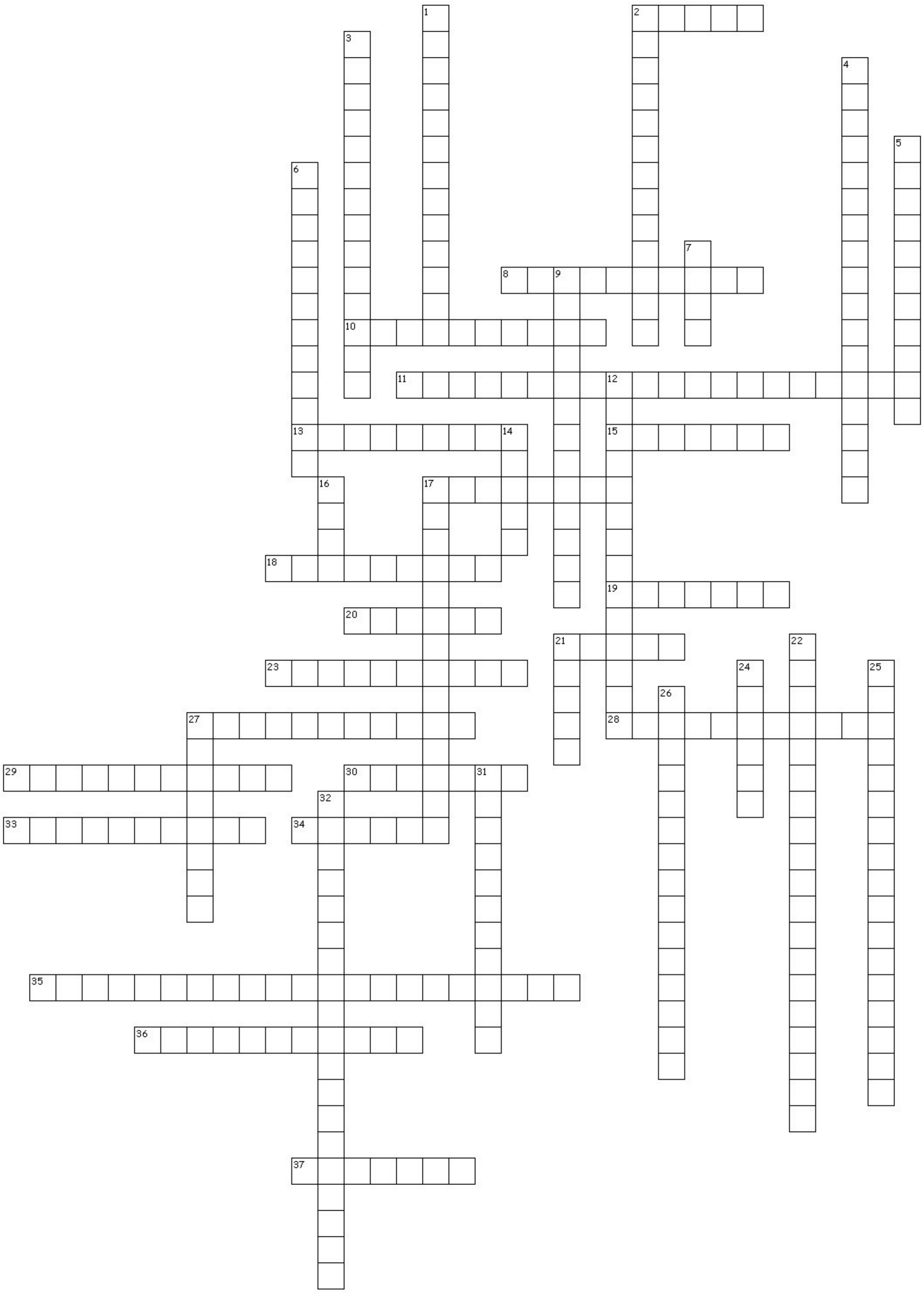
NPS Subject Review: Crossword Puzzle



Across

2. Large farms that raise many animals such as cows and chickens are known as __________. (abbreviation)
8. Epidemics in the Middle Ages such as cholera and typhoid fever were directly related to __________ conditions caused by human and animal waste and garbage.
10. Water can run off of __________ surfaces without being absorbed.
11. Any single identifiable source of pollution from which pollutants are discharged is known as __________. (three words)
13. Contamination of air, land, or water by substances that can adversely impact human health and the environment is known as __________.
15. Conservation __________ involves leaving some crop residue from a previous harvest while planting a new crop.
17. __________ is created when sulfur and nitrogen oxides react with oxygen, water, and other atmospheric compounds. (two words)
18. Prolonged exposure to acid rain can cause soils to lose important __________ such as calcium and magnesium.
19. The __________ virus causes intestinal illness and is transmitted to humans by food or water contaminated with feces.
20. __________ refers to storm water that flows over surfaces like driveways and lawns.
21. Pollution is something in the __________ place at the __________ time in the __________ quantity. (one word)
23. Disease-causing microbes are said to be __________.
27. Eutrophication may be associated with conditions that result in harmful __________. (two words)
28. Heavy machinery used by forestry and mining operations increases the risk of __________. (two words)
29. Combustion of __________ is a major source of nutrients in the atmosphere. (two words)
30. Nonpoint source pollution not only affects ecosystems; it can also have harmful effects on the __________.
33. Pesticides can enter a waterbody as __________ which occurs when wind blows sprayed pesticide into a nearby waterbody. (two words)
34. When fish and shellfish feed on HABs, they can accumulate __________ that the algae produce.

35. Hydrocarbons and heavy metals from automobiles and factories eventually end up in water bodies through _________ or runoff. (two words)
36. Approximately two-thirds of the lead and mercury that enter the Great Lakes originate from __________ sources.
37. Very low levels of oxygen in water bodies is known as __________.

Down

1. In 1347, a bacterium carried by rats and spread by fleas resulted in the outbreak of __________. (two words)
2. Sometimes, it is not the type of material, but its __________ that determines whether or not the material is a pollutant.
3. __________ results in an overproduction of organic matter, especially algae.
4. Muddy water is caused by soil in the water known as __________. (two words)
5. In many towns and cities, the water flowing into __________ is not treated before emptying into nearby waterbodies. (two words)
6. __________ are strips of grass located between a farm field and a body of water. (two words)
7. One of the most important things you can do to reduce nonpoint source pollution is to plant grass, trees, and shrubs in __________ areas.
9. __________ on fuel pumps on docks help limit spillage into water bodies. (two words)
12. __________ capture runoff or storm water to trap sediments and contaminants. (two words)
14. Clean Water Act established the __________ under which factories, sewage treatment plants, etc. must obtain a permit to discharge wastes into any body of water. (abbreviation)
16. To ensure that nutrients are applied only as needed, farmers __________ their fields prior to the growing season.
17. In the mid-Atlantic and Appalachian regions of the United States, acid drainage and associated contamination from __________ have caused pollution in various water bodies. (two words)
21. Polluting substances are usually __________ materials.
22. __________ slow runoff, absorb contaminants, and provide habitat for wildlife. (two words)

24. __________ paving materials allow rainwater and storm-water to drain into the ground beneath the paving. (two words)
25. Lady bugs, praying mantis, and spiders are examples of __________. (two words)
26. The process in which substances build up in the tissues of animals is called __________.
27. As acid rain flows over and through soils, it releases __________ into lakes and streams, which can cause fish to become chronically stressed.
31. __________ is a program designed to monitor levels of chemicals in oysters, mussels, and sediments. (two words)
32. A __________ is a system in which waste material is mixed with urban runoff. (three words)