March

Human impacts on a watershed

What is **pollution**? Where does it come from? How does it impact our watershed? What impact does human activity have on specific organisms within a watershed? How do these impacts threaten and/or endanger the survival of entire species? These are some of the topics discussed in this chapter and in the March edition of ***The Salmon Times.***

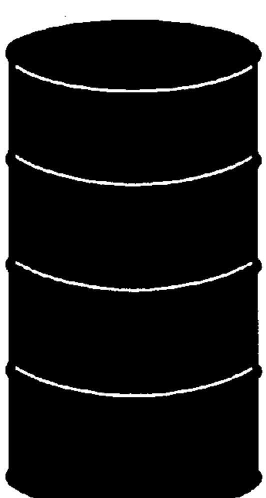
As we discussed briefly in the February chapter, humans have been using and sometimes misusing rivers and other water sources, for many years. One of the ways we misuse water in our watersheds is to **pollute** it. Pollution is when either a "foreign substance" enters a system (water, air, soil, organism) or a naturally occurring substance enters a system in an excessive quantity. To clarify, pollution is when things like trash, paint, detergents, and **sewage** ("foreign substances") get dumped into a water body or onto the ground. Chemicals emitted from smoke stacks, and the exhaust from cars, are forms of air pollution. The second half of the definition refers to pollution as being excessive amounts of naturally occurring substances. An example of this type of pollution is when the top soil from a newly plowed field washes into a river during a heavy rain storm.

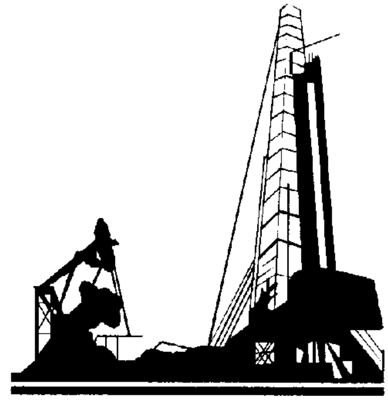
Pollution is a complicated topic, and it doesn't get any easier when we try to get a handle on the possible sources of pollution. Pollutants can enter a system either directly or indirectly; and from either specific, identifiable sources (e.g. pipes) or from diffuse, unidentifiable sources (e.g **storm water runoff**). For example, if a person walks down to a river and dumps a gallon of used oil into the river, they have directly polluted the river. If that same person dumps the oil in their yard and it runs into the river, then they have indirectly polluted the river, but directly polluted the ground surface. Get it? If you do, then you have begun to grasp one of the biggest concepts in "pollution lingo", the difference between **point source pollution** and **nonpoint source pollution**!

Getting a grasp on this concept of point source versus nonpoint source pollution will help in understanding where the pollution that impacts our watersheds comes from. Point source pollution and nonpoint source pollution refer to where pollution comes from and how it enters the air, water, or soil. The terms point

Illustration by Jon Luomo, from "Waterways: Links to the Sea" source pollution and nonpoint source pollution are most often used in referring to water pollution. Point source pollution refers to pollution sources that you can actually point to such as pipes carrying waste streams from industrial plants, chemical plants, and **waste water** (sewage) **treatment plants** to rivers. A hole in the hull of an oil tanker that spills oil into the ocean could also be considered a point source, although the term is more often used in referring to stationary sources. Concentrated sources of pollution are point source of pollution.

Nonpoint source pollution is the opposite of point source pollution, and can be defined as **contamination** from sources that are difficult to identify and locate. Nonpoint sources of pollution are more diffuse. For example, pesticides found in a river probably entered the river in storm water or irrigation runoff from a farm or lawn. The exact spot where the pesticides entered the river cannot be identified. Likewise, **acid rain** and **airborne contaminants** that fall to the ground in New England are believed to be the result of factories further west, although a specific plant can not be held solely responsible. These are big examples, but many of the things we do every day, like fertilizing lawns, walking pets, changing motor oil, and driving, also contribute to nonpoint source pollution. These activities deposit pollutants (such as soot, dust, oil, animal waste, litter, sand, salt, and chemicals) on lawns, streets, parking lots, and into the air. The rain then washes the pollutants into streams or into storm water systems that eventually flow into larger water bodies. Some of the pollutants will also seep into the ground with the rain water and





end up in the ground water, which eventually discharges to a surface water body.

Going to the Source

Chemical Pollutants: Pollution may disrupt the delicate balance within an ecosystem, killing off some species and prompting others to grow out of control. For example, chlorine (a **biocide**) is believed to have changed the chemical balance in many of Maine's rivers so much that entire populations of several once abundant fish species such as alewife, salmon, and smelt, have (1) found other water bodies to inhabit, (2) reproduced in smaller numbers, and/or (3) have died off in large numbers. Chlorine is used as a biocide in many sewage treatment plants, swimming pools, and is found in many household cleaners. It is also used as a bleaching agent in paper mills.

Pollution also threatens the health of humans and other organisms; and can cause economic, aesthetic, and recreational damage to the surface water bodies within our watersheds. Some of the most well known examples of how pollution impacts organisms relate to the impact of pesticides on bird populations. Some pesticides, such as the chlorinated hydrocarbon DDT, cause birds to lay eggs with very thin shells, reducing the chance of successful reproduction. What many people do not understand is how the pesticides get into the birds. Pesticides are applied to crops (usually sprayed on); when it rains some of the pesticides are washed off the crops and/or soil, and run into rivers and streams. Once in the stream, the pesticides may settle on plants or other **substrates**, or may remain in the water column. These pesticides are eventually ingested by fish and other organisms (either directly from the water, or in/on their food). Some of the fish are then eaten by birds, or other fish, passing the contaminant up the food chain. Humans may also eat the fish or the birds and are, therefore, also impacted by things like pesticides that are passed up the food chain. In fact, many pesticides are found in higher concentrations in organisms higher on the food chain (see **bioaccumulation** of chemicals). The effects of these chemicals are not always immediate, many of them can be stored in our bodies for years before the effects are evident. Once the dangers of DDT were recognized, its use was banned in the United States.

Human and animal waste: These wastes contain a lot of nutrients (nitrates, phosphates, etc...) that plants need in order to grow. At first that sounds good, but when a lot of these nutrients enter a stream, pond, river, etc... at the same place and time it provides a huge food supply, causing an abundance of phytoplankton or **algae** to grow. After a time, these organisms will die off in large numbers and begin to decompose. The decomposers (aerobic bacteria) deplete the dissolved oxygen in the water. If the dissolved oxygen level gets too low other species will not be able to "breathe".

In addition to containing a lot of nutrients, human and animal wastes also contain many different kinds of bacteria. Some bacteria are good and help to break down the wastes; but too much bacteria, or the wrong kind of bacteria, can spread disease to animals and people. Disease producing organisms are called **pathogens**. As with the pesticides, organisms in the water will **ingest** the bacteria with their water or food. The bacteria might kill the organism, or it may be passed along to whatever eats it. Get the idea?

Thermal pollution: This occurs when the temperature of a surface water body (e.g. river, stream, pond) is raised or lowered beyond its normal range in temperature. A drastic change in the water temperature can be due to either the addition of heated or cooled water to the surface water body, or a change in the amount of **solar radiation** reaching the water surface.

We all use electricity in our homes and schools, and in most cases that electricity comes from a power plant. Power plants, and many industries, use water to cool the ma-

BIOACCUMULATION OF CHEMICALS:

Bioaccumulation refers to the increasing concentration of toxics (chemicals) in organisms higher in the food chain (food web). For example, the concentration of a chemical would be lowest in a first order consumer such as a silverside (a small fish), and would be higher in the organisms feeding on them, such as billfish, and still higher concentrations would be found in osprey or other billfish consumers (predators). Bioaccumulation occurs with only certain substances (notably, the chlorinated hydrocarbons such as DDT, lindane, chlordane, and 2,4-D) that, due to their chemical characteristics, are stored in the fatty tissues of an organism. The concentrations within organisms increase with their place on the food chain because organisms higher on the food chain consume a greater number of other organisms, and those organisms have a higher concentration than what they had consumed. The size of an organism, and the percentage of body mass made up of fatty tissue, will determine how much of a substance can accumulate without it having lethal effects. The greater the proportion of the organism consisting of fatty tissue the more chemical it can accumulate. This fact also contributes to the increased concentrations at higher levels on the food chain, because the body weight of organisms (and percentage of fatty tissue), increases with consumer level (eg., primay, secondary...), within the food chain .

chinery in their plants. This water is taken from a river, stream, or lake; and is usually returned to that surface water body at a higher temperature than when it was withdrawn. In fact, unless the water is effectively cooled before being returned to the surface water body, it will be an average of 10 degrees Celsius (°C) warmer than when it was withdrawn. This may not seem like a lot to us, but it can cause **thermal shock** in many organisms, resulting in temporary suspension of life processes (e.g. breathing, feeding) or even death. This drastic temperature change can also lead to changes in the metabolism and reproduction rates of plants and animals.

Another effect of thermal pollution is that heated water holds less oxygen [lower dissolved oxygen (DO)] and leads, indirectly, to an increased **oxygen demand** in organisms living in the area of the outfall (where the water is returned to the stream). In other words, there is less oxygen in the water (lower DO), so organisms have to work harder to get enough oxygen to live (higher oxygen demand) and therefore, have less energy for things like reproduction and avoiding predation. In addition, the solubility of chemicals increases with the water temperature. That means that more chemical pollutants can be dissolved in the warmer water. This results in an increased impact on the organism.

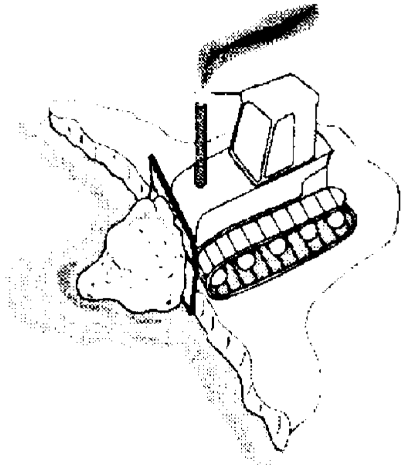
Because of the Clean Water Act of 1972, factories, treatment plants, etc., that want to discharge waste water to surface water bodies must obtain a National Pollution Disharge Elimination System (NPDES) permit from state government.

Another way humans contribute to thermal pollution is by changing the amount of solar radiation reaching surface water bodies. The relationship between water temperature and solar radiation is fairly simple; surface water bodies absorb heat from the sun rays that reach the water surface. The greater the amount of water exposed to direct sunlight, the more heat the water will absorb, and the higher the water temperature will be. One way people change the amount of solar radiation reaching water surfaces is by cutting down trees along river banks. Normally, in small to moderate size rivers and streams, a fair percentage of the stream is shaded by tree branches that hang out over the water. These branches provide shade, and reduce the amount of solar radiation reaching the water surface. When the **overstory** trees along a river bank are removed for such things as lumber or clearing for construction, the amount of shading is greatly reduced. Therefore, the amount of solar radiation reaching the surface of the water is increased proportionally, and the water heats up. This water heating (or cooling if human activity blocks sunlight) has the same impacts on fish as thermal pollution from other sources.

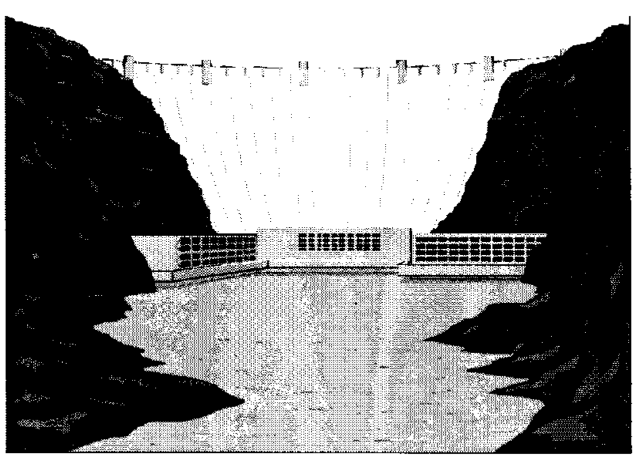
The American Burying Beetle
Strange name? Perhaps, but it is well named. The american burying beetle buries carcasses of birds, rodents, and other small animals, in which they carve a space and lay their eggs. Why carcasses? Because when the larvae hatch they munch on the walls of their home! This little beetle used to be found in 32 states, now it is found only in Oklahoma and on one New England island (the identity of which is kept secret to protect the beetle from collectors). The main cause for the decline of this beetle was the pesticide DDT, to which it fell victim.

Illustration by Kathy Brown-Wing, USFWS

Construction sites and dams: People have undertaken some very big projects that directly affect rivers and streams within our watersheds. These big projects include things like building dams or altering stream channels. A dam is a structure that blocks a **river channel** and restricts the amount of water flowing downstream. Dam construction projects are undertaken for a number of reasons including flood control, generation of hydroelectric power, and creation of lakes or reservoirs. Since a dam blocks a river or stream and only lets some of the water flow downstream, there is a backup of water behind a dam. This backed up water floods a lot of land behind the dam and creates a lake or reservoir. Over the years we have learned that not all dams work well at controlling flooding. When there is a flood larger than the design flood for the dam, the dam cannot control all of the flood waters. Dams will generally work in controlling the normal high water flow from rain storms and snow melt; however, reservoirs have limited storage capacity. Therefore, when there is an unusually big storm, or all the snow on the surrounding hills melts at once, the water storage capacity could be exceeded and the water may overflow (breach) the dam. When a dam is breached, it causes worse flooding than if the dam had not been there because it has so much water stored up behind it. Not only that, but when there is a dam upstream, people will start to build houses and stores on the **flood plain** (the flat area on either side of a river channel that acts as the stream bed at times of high water). The presence of these buildings reduces the storage capacity of the land, because land covered with pavement cannot absorb water.



The construction of dams impacts aquatic organisms and the nature of the stream itself. As water slows down and backs up behind a dam, it deposits the sediment it had been carrying. This causes a build up of sediment behind the dam, often changing the composition of the stream bottom (i.e. a stream that may have been rocky will become sandy as the excess sand is deposited by the blocked stream waters).



There are other human activities that alter the flow of streams and the composition of the stream bottom. For example, channelizing a stream (straightening a section of a stream and making the walls and bottom of the stream concrete), building retention walls along the banks of streams, and even entirely rerouting streams. Channelizing a stream can cause problems because it takes less energy to flow through a straight, concrete "river bed" than through a natural, curved, irregular river bed. More energy is retained by the stream and expended on the banks of the natural river downstream. Retention walls do much the same thing, although if they are only on one side, the river will cut away at the opposite bank, gradually changing the course of the river.

Soil erosion and deposition: Most people do not think of soil as a pollutant. However, soil washing into streams, from things like construction sites and newly plowed fields, impacts organisms that use the stream in much the same way excess nutrients from human and animal wastes do. Excess soil (sediment) will increase the turbidity of a stream, making it difficult for fish to see their prey and reducing the amount of sunlight that reaches the plants growing in the water. If the water gets too cloudy plants and animals will die because they can not find food and/or don't have sunlight for photosynthesis. If the plants die then the insects and small fish that eat those plants will either have to move or they will die too. It's a chain reaction.

Aesthetic impacts: We mentioned earlier that pollution can cause economic, aesthetic, and recreational damage to the water bodies within our watershed. What does that mean? Well, it's easier to give examples. Who wants to swim in a murky pond or stream? Who wants to drink brown water? Who wants to buy a home next to a pond that is covered with algae all summer? The list of such questions is endless, and the answer is generally, no one. When surface water bodies are overloaded with sediment, the algae and bacterial count too high, or the fish contaminated, it is obvious that these resources are not being cared for and they lose their value as recreational, aesthetic, and economic resources.

Habitat alteration: There are many other human activities that impact organisms within our watersheds. For example, replacing open fields or forests with houses or shopping malls reduces the amount of land available for wildlife **habitat**. It also increases the amount of storm water runoff entering surface water bodies. Animal habitats are often divided during the construction of roads through woodlands or fields. Many animals are killed on these roads as they move from one area of their habitat to another.

Impacts on Salmon

As we have discussed since the first day of the Adopt-A-Salmon Family Program, the Atlantic salmon is an anadromous fish. That means that it is born in a river, spends part of its life in the ocean, and returns to the river of its birth to spawn. In order to get back to the place where it was born and spawn, the salmon must overcome fish hooks, fish nets, dams, and various kinds of pollution, as well as the natural hazards of their upstream journey. In fact, these human-created obstacles were the primary cause of the Atlantic salmon's decline and its extirpation in the Merrimack and Connecticut rivers.

One cause of the decline of the Atlantic salmon which has not been discussed as yet, is fishing. Over fishing is one of the top causes for the decline in the Atlantic salmon. Over fishing is when so many fish are caught each year that there are not enough fish left to reproduce at a rate that will sustain the population. Over a period of years the fish population declines until there aren't any fish left. Part of the reason fishing caused such a problem for the salmon is that it is not limited to rivers. Both riverine and ocean fishing have contributed to the decline in the salmon population. Many states have taken action in recent years to curb the impact of riverine sport fishing on salmon. This has been done through the passing of state laws and regulations that are designed to protect wild Atlantic salmon. The protection of salmon from over fishing on the high seas required a very different (and more expensive) solution. Over the past few years efforts have been undertaken to buy out many of the big ocean fisheries, in essence, paying people not to fish. These efforts appear to be having the desired effect and over fishing of salmon is no longer a major problem. Have you ever had salmon for dinner? Maybe, maybe not, but a lot of people have. Typically, the Atlantic salmon people eat at restaurants or buy at the grocery store in New England today comes from fish farms.

Major Reasons for Salmon Decline:

Dams
Fishing
Pollution

Dams have also been a major contributor to the decline of the Atlantic salmon, and have posed very obvious physical barriers. Although **fish ladders, fish lifts**, and downstream bypasses have now been built at many dams, this was not always the case. For years there was just no way for the salmon to get around or over these huge man-made structures (either to go down to the ocean or upstream to spawn). When swimming either upstream or downstream, salmon are attracted to the strongest water current. This has posed a particular problem in the downstream journey where there are hydrodams (dams that use the water power to generate electricity). At hydrodams the strongest current is typically the turbine intake. When this is the case, the salmon follow the water current into the turbine, and a large percentage get caught in the turbine and killed. This problem has been lessened by putting in downstream bypasses. These structures basically consist of a tunnel from one side of the dam to the other, which the fish can pass through unharmed. (Note: downstream bypasses are only effective if the current in the bypass is strong enough to attract the fish).

Alteration of the stream bed composition has also resulted from dam construction, as well as from building construction and agriculture. Salmon, as with many other wildlife species, are impacted by this change. In October or November the female salmon prepares a redd in the gravel bottom of a cold water stream. The redd consists of a depression in the gravel with a gravel cover over the eggs once they are laid and fertilized. However, if the stream bed has been eroded there will be no gravel left in which to prepare the redd. Alternatively, if a lot of sediment has been deposited the salmon won't even attempt to spawn.

One additional way in which the construction of dams impacts salmon populations has to do with the level of the river flow. Dam operators periodically vary the amount of water flowing through a dam and therefore, through a river channel. A salmon may build a redd downstream of a dam when flows are high and there is a lot of water. However, if a dam operator decides to decrease the amount of water flowing through a dam, what was once a perfectly healthy redd of salmon eggs may end up above the **water line** during a period of low flow.

The Atlantic salmon, like all wildlife, is sensitive to chemical contaminants in the environment. Various types of water pollution (physical, chemical, thermal) impact the salmon in different ways. For instance, as mentioned previously, physical pollution such as excessive silt and sediment entering a stream, changes the composition of the stream bed and affects reproduction.

Are Salmon Endangered?

Did you know that the Atlantic salmon is not currently protected under the Endangered Species Act of 1973? That's right! Yet there are only seven rivers in New England that are believed to have wild populations of Atlantic Salmon. 150 years ago there were wild Atlantic Salmon populations in most, if not all, of the major rivers throughout New England and a lot of the smaller ones too.

Extinction is Forever

Just as pollution, over fishing, and habitat destruction have impacted the Atlantic salmon, the same types of human activities have impacted many other species of plants and animals. If fact, hundreds of plant and animal species have become **extinct** (disappeared forever) over the last few hundred years and the majority of these disappearances can be linked to human activity. Why does this happen? Why can't these species survive? Those are questions without singular answers. In many cases, human activities have destroyed the natural habitat of the organisms, and left them with no place to live. In other cases, human activity has eliminated or contaminated (e.g. through use of pesticides) the food supply of the organisms.

Nothing can be done to bring back those species that are already extinct, but steps can be taken to keep more species from becoming extinct. Species that haven't yet disappeared, but face great peril, are called either **threatened** or **endangered**. These terms are used and defined in the Endangered Species Act of 1973, which among other things, gives the U.S. Fish and Wildlife Service and National Marine Fisheries Service the responsibility for protecting and managing threatened and endangered species. An endangered species is one that is at risk of becoming extinct in the very near future. A threatened species is one with a lesser risk of extinction in the short term, but one which is likely to become endangered if nothing is done to deal with the problems threatening it in the first place. In either case, action is needed to prevent permanent loss of these plants and animals.

Getting Involved

There are many things a teacher, or group of teachers, can do to help protect threatened and endangered species. One of the most important things is to inform students (and hopefully their parents) about the plight of these plants and animals, including how human activities have impacted and continue to impact these species. It is a well known fact that actions speak louder than words, so if you want the children to understand the importance of protecting these species, they need to see it in action. Easy to say, but difficult to do in a classroom, right?! Well, one thing you can do in a classroom is to practice waste reduction, reuse, and recycling. This will help endangered or threatened species because, for example, the less paper we use the fewer trees will be cut down, and the less forest habitat will be destroyed. This logic works with almost everything. The less water we use the less we have to filter and treat to make it drinkable. The less water we have to treat the fewer treatment chemicals will be needed... get the idea? The class could also get involved in community activities like lake or shoreline cleanup days, energy conservation programs, etc.... The resources list at the end of this chapter and the May chapter of the *Teacher's Guide* may help with ideas to implement in the classroom and at home.

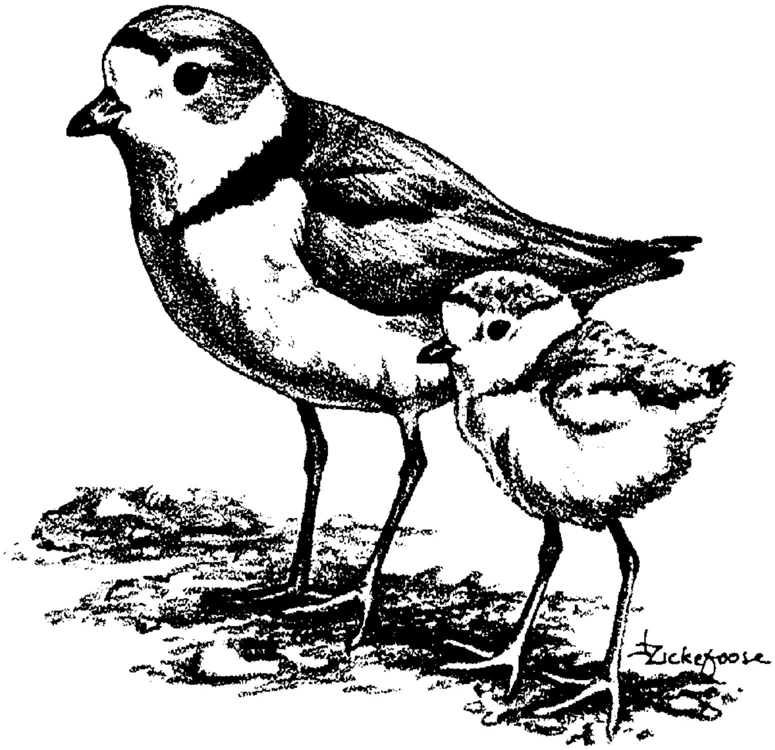


Illustration by Julie Zickefoose, USFWS

The Piping Plover is presently on the U.S. Endangered Species List

Word Power

*algae	*leach fields	*sewage	bioaccumulation
*buffering capacity	*nonpoint source pollution	*storm water	biocide
*contaminated	*organic matter	*thermal pollution	contamination
*discharge	*pathogens	*thermal shock	endangered
*extinct	*phytoplankton	*threatened	outfall
*fatty tissue	*point source pollution	*toxic	overstory
*fish ladders	*pollutants	*waste water	oxygen demand
*fish lifts	*pollution	*waste water treatment plant	pollute
*ingested	*river channel	acid rain	solar radiation
*landfills	*septic systems	airborn contaminant	substrate

Household Hazardous Waste

PRODUCT	INFORMATION	DISPOSAL
Dish, laundry, and bar soaps, toothpaste, etc.	If they have no phosphates, these have minimal harm to the environment.	These CAN go down the drain.
Food Items	Waste foods are good fertilizers and can be returned to the soil instead of polluting waters.	Put in a compost pile.
Motor oil	This can be recycled. Keep in a tightly closed container and return to a community recycling center or service station.	POISONOUS! Never dump down the drain.
Medicines, household cleaners, pesticides, paints, and other chemicals	Keep in tightly stored containers.	POISONOUS! Never dump down drain. Don't throw them out with your other trash.

Source: *Waterways: Links to the Sea*

Alternative Household Products

The following alternative compounds are made from substances that are fairly easy to obtain and may be gentler on the environment. Some may still contain toxic ingredients. Keep these out of reach of children. Never mix chlorine bleach and ammonia together. They react and create deadly fumes.

Air freshener	Set vinegar out in an open dish; light match or candle to dispel bathroom odors; use baking soda in refrigerator, in cat litter box, in diaper pail, on floral and herbal pot pourri; and on rugs (vacuum afterward).
Ant control	Mix two tablespoons of boric acid, two tablespoons of sugar, and one cup of water. Soak paper towels, place on dishes, and set out for ants. Keep dishes away from children.
Drain cleaner	Pour 1/2 cup of baking soda followed by 1/2 cup of vinegar; let set for 15 minutes, follow with boiling water, snake or plunger. To prevent clogging flush drain weekly with boiling water.
Houseplant insecticide	Mix 2 tablespoons of dishwashing liquid with 2 cups of water and spray on leaves.
Oven cleaner	Let mixture of 2 tablespoons castile soap, 2 tablespoons of borax and 2 cups of water set in oven for 20 minutes; scrub with baking soda and salt.
Silver cleaner	Soak silver in one quart of warm water, containing one teaspoon of baking soda, one teaspoon of salt, and a piece of aluminum foil.
Toilet bowl cleaner	Coat bowl with paste of lemon juice and borax; let set and scrub off.
Window/mirror cleaner	Fill an eight ounce cup or empty spray bottle with three tablespoons of ammonia, one tablespoon of vinegar and cool water.

Adapted from UNH Cooperative Extension fact sheet - *Hazardous Materials in Your Home* and *Household Hazardous Waste Wheel* by Environmental Hazards Management Institute of Durham, NH.

Movement of Water in the Ground

Concepts:

Water moves through the ground by filling in the spaces between soil particles. This is how rain water moves down through the soil. Water stops moving down in the ground when it reaches a place where all the spaces between particles are filled and the soil or rock is saturated. The surface below which the soil and/or rock are saturated is called the water table. The saturated zone below the water table is the groundwater aquifer.

Objectives:

(1) To demonstrate how water moves through soil/rock;
(2) To relate the concept of water movement in soil to rain water entering the ground; and
(3) To introduce the concept of the water table and the zone of saturation.

Subjects:

Science (geology, hydrology)

Materials:

- Clear 2-liter plastic bottle
- Sand or potting soil
- Gravel (rocks for fish tank would also work)
- Water
- Food coloring
- Shallow pan

Preparation:

1) Remove label from plastic bottle.
2) Cut top off plastic bottle.
3) Punch holes in the bottom of the bottle with knife, awl, or scissors so that water can drain out the bottom.
4) Fill the bottle approximately 3/4 with a mixture of sand or potting soil and gravel (alternatively, you can use all gravel for this activity).
5) Place plastic bottle in shallow pan.
6) Fill a container with water and add food coloring (yellow not recommended for this activity).

Procedure:

1) Gather the students around the setup and ask them to predict what will happen when you pour the water over the sand and gravel. (They may know that it will go down, in which case you can ask them up front how it will move down or ask them to predict a pathway.)

2) Slowly pour the water over the sand and gravel and watch it filter through the bottle and into the pan.

3) Explain that the water moves through the spaces between the soil particles or pebbles (gravel). Apply this concept to rainwater moving down through the ground to the groundwater.

The groundwater aquifer is a layer or zone in the ground where the soil is saturated (all the spaces between the particles are filled with water). The top of this saturated zone is called the water table. If we had not had holes in our bottle then a "water table" would have developed in our bottle. Draw a diagram on the chalkboard (refer to October chapter of *Teacher's Guide*) to help demonstrate this concept.

Note: Depending on the students' comprehension, you may want to introduce the concept of an impermeable layer (confining layer) which stops the downward migration of the water and forms the base of the groundwater aquifer.

Surface and Ground Water Connections

Concepts:

Ground water and surface waters (including wetlands) are connected.

Objectives:

1. Students will participate in building a model of suface and groundwater.
2. Students will demonstrate awareness that surface and groundwaters are connected and that land use affects water quality.

Materials:

clear container approx. 4 " deep and at least 4" wide (glass bowls or plastic containers)
polished aquarium gravel
blue colored water
iced tea powder or unsweetened powdered drink mix (such as Kool-Aid)
cups
turkey baster

Preparation and Procedure:

Have students work in small groups. Each group will need a set of materials. Review what ground water is and how water is held by soil and moves through the soil, what an aquifer, water table, saturated zone and zone of aeration are.

1. Have students put approximately 2" of gravel in the clear containers. Have the demonstrator for each team create a depression in the gravel along one side of the container. The depression represents the cross section of any surface water (lake, stream, pond, etc.). For simplicity, call it a pond. The gravel represents the soil underlying the surface of the land and is used because it is easy to see the water travel through the pores and collect in the saturated zone. Point out that the depression and the pores surrounding it are filled with air.

2. Have the demonstrator slowly pour colored water into the container away from the "pond" and observe what happens. Water will flow downward around the gravel until it reaches an impermeable layer. After water collects on top of the impermeable layer, it spreads out, filling the pores between the gravel and eventually flowing into the pond.

3. Ask your students where the water in the pond came from. ("Gound water" discharged into the " pond". Depending on the time of year and the local geology, in New England ground water contributes anywhere from 40% - 90% of stream flow.) Ask what clues the model gives about the relation of the saturated zone under the ground and water bodies on the surface of the land. (The bottom of the pond is an area in which the ground is saturated and the water table intersects the surface of the land.) Ask your students if they know why ponds do not form everywhere. (Ponds form where the level of the water table is above or consistent with the pond elevation.)

4. Wetlands

Now that your students understand the connection between ponds and ground water, ask them what connection is likely between ground water and wetlands. Explain to your students that wetlands may be formed in areas where ground water is at or near the surface of the land for a portion of the year. Ask your students if they can "make a wetland" with their model. (Students must make a depression in the "land surface" which just intercepts the water table.)

NOTE: Wetlands may also be located in areas where a relatively small isolated impermeable layer of soil (often clay) or rock exists, thereby allowing water to collect and saturate the soil following storm events or snow melt. In this case, the water is not part of the underlying ground water system. These wetlands are often called "perched wetlands".

5. Water supplies

Many communities depend on large public wells for their drinking water. Often these wells are placed near wetlands and streams where ground water is readily available. Explain to your students that they will now investigate the connection between ponds, wetlands and wells. Using a pipette (or turkey baster), each demonstrator can "install a well" near the pond and wetland. Be sure the demonstrator squeezes the turkey baster before it is inserted to avoid pushing air into the system. Withdraw water through the well (placing the blue water into the empty cup provided). Observe what happens to the water table, pond and wetland. (The water table lowers, the level of the pond lowers, and the wetland dries up.) This demonstrates that an ecosystem with ponds, rivers, wetlands and wells may be closely connected and that activities affecting one resource may impact others.

6. Ask your students to suggest questions which communities should consider before installing a new well or increasing the volume of water pumped from their wells. When wells are located near ponds, rivers, and wetlands, it is important to determine the potential impacts of pumping on these other water resources. For this reason, many states regulate the amount of ground water which may be pumped by towns, industries, farmers, etc., for drinking water and irrigation purposes. When regulating water withdrawals, states typically determine the amount of water which may be withdrawn from a system after considering the amount of recharge entering the ground water system and determining the needs of any related surface water resources and the plants and animals that depend on them.

7. Ask your students to identify other factors which might impact the interrelationship between ground water, wetlands, surface water and wells. Natural processes such as drought and plant uptake also impact surface waters, wetlands, and ground waters. Plants, especially trees, may withdraw a large amount of water during the summer months. This means that less water is capable of recharging the ground water below and water table lowers, pond levels lower accordingly.

8. What happens if it rains and stormwater flows over the surface of the land and into a nearby stream? Ask your students to add water directly to the "pond" and observe what happens. Water which enters the stream or pond will travel through the underlying soil and flow into the ground water. When this happens a stream is called a *losing steam.* In cases where the ground water discharges to a stream it is called a *gaining stream.*

9. Water Contamination

The model may also be used to show the potential impact of ground water pollution on surface water. Tell your students that the powdered drink mix will be used to represent substances which when placed on the land may cause ground water contamination. You may wish to brainstorm with students to identify potential substances whch may contaminate ground water (e.g. fertilizers, pesticides, motor oil, antifreeze, and wastewater.)

10. Ask each demonstrator to place approximately 1 teaspoon of red powdered drink mix on the "land surface" in the clear container. What happens? (Some will dissolve if the gravel is wet, but the powdered drink mix will generally remain on the land surface.)

11. Tell your students that there is going to be rain and let it rain! Use droppers to drizzle water over the surface of the land including the "contaminant". What happens? (The powder dissolves in the water and is carried with the water through the pores of the gravel unitl it eventually reaches the ground water below.) Since this is a heavy storm, let it continue to rain and observe. (Over time the contaminated ground water is discharged into the pond.) Ask your students how the pond became contaminated? (Through contaminated ground water discharging into the pond.) This demonstrates how ground water is capable of contaminating surface waters.

Follow up

1. If a community discovers its surface waters are becoming polluted, what sources of contamination should it consider?

It should consider wastewater discharges and land activities which might contribute contaminants through both overland stormwater runoff and ground water discharge. Depending on the local geology of the area, the relative contribution of stormwater and ground water to nearby surface waters will vary.

To address surface water pollution, one must first understand how surface waters and ground water interrelate. Some communities members are unaware of the link between ground water and surface waters and focus all their efforts on storm water discharges.

Likewise, when investigating ground water contamination, one must consider whether or not surface water pollution is contributing to the contamination of ground water through losing streams and ponds.

2. Use the model to demonstrate how ground water in an unconfined aquifer generally flows downhill due to the force of gravity. Using the model, add water with the model lying flat on a table. Using a crayon, mark the water table level. Now slowly tip one end of the model and observe how the water table elevation changes. Ground water in the system will flow downhill and collect at the lowest point.

Adapted from University of Massachusett Cooperative Extension, *Watershed to Bay, A Raindrop Journey.*

Soil Filters

You may choose to have the students prepare and run this experiment, if so prepare the plastic bottles ahead of time as described below.

Concepts:

Soil acts as a filter, removing debris and some physical and chemical contaminants from water.

Objective:

To demonstrate that soil acts as a filter

Subjects:

Science (geology, hydrology)

Materials:

- One clear 2-liter plastic bottle (more if students are going to conduct the experiment themselves)
- Potting soil or sand
- "Dirty water" (e.g. pond water or other murky water)
- Shallow pan
- Copies of student lab sheets: Can Dirt Clean Dirty Water (optional)

Preparation:

1) Remove label from plastic bottle.
2) Cut top off plastic bottle.
3) Punch holes in the bottom of the bottle with knife or scissors so that water can drain out the bottom.
4) Fill bottle with sand or potting soil.
5) Place the plastic bottle in the shallow pan.

Procedure:

1) Explain the setup to the students.

2) Ask students to describe the "dirty water" (e.g. What color is it? Can you see through it?).

3) Have students predict what will happen as the "dirty water" filters through the soil. What will the water look like when it comes out the bottom? Will it be cleaner or dirtier? (Save some of the "dirty water" for comparison)

4) Slowly pour the water over the soil or sand and wait for it to filter through into the pan.

5) Pour the filtered water into a clear container for easier comparison with the "dirty water".

6) Observe the differences between the "dirty water" and the filtered water. What does the filtered water look like? Were the students' hypotheses correct?

7) Explain that this is what happens as water filters through the ground and moves down to the water table.

Can Dirt Clean Dirty Water?

Conduct the following experiment in groups of two or more.

Materials:

- One clear 2-liter plastic bottle (with top cut off, label removed and holes in the bottom)
- Potting soil or sand
- Container of "dirty water"
- Shallow pan
- Stirring rod, spoon, or similar object

Preparation:

(Check off each step as it is completed)

____ 1) Gather materials listed above.

____ 2) Fill the bottle approximately 3/4 full with soil or sand (be careful not to pack down the sand or soil).

____ 3) Place the bottle in the shallow pan.

Procedure:

____ 1) Describe the "dirty water". What color is it? Can you see through it easily? Are there things floating in it?

____ 2) What do you think the water will look like when it comes out the bottom of the bottle? Will it be cleaner or dirtier?

____ 3) Stir the "dirty water" and then slowly pour about half of the water over the soil in your bottle.

____ 4) When the water has filtered through the bottle and into the pan, carefully pour the water into a clear container.

____ 5) Describe the filtered water and compare it with the "dirty water".

____ 6) Was your prediction correct?

____ 7) As a group or class, discuss what might happen when polluted water enters the soil.

What's Around Our Water?

This activity may be done over two days.

Concepts:

Nonpoint source pollution (pollution from diffuse sources) comes from everyday activities like driving cars, farming, salting roadways in winter, walking pets, etc...and negatively impacts the surface water bodies within our watersheds.

Objective:

To help students develop a better understanding of nonpoint source pollution, where it comes from, and how our activities contribute to it.

Materials:

- Large map or 8 1/2 inch X 11 inch overhead of a section of your town, showing a water body and surrounding area (Note: if the water body is a river, focus on a section of the river that is familiar to the students)
- 8 1/2 x 11 copies of the same map (one for each student)
- Copies of student instruction sheet
- Markers, crayons, pencils, pens, chalk
- Poster paper, whiteboard, or chalkboard

Subjects:

Science (geology, geography), Social Studies (culture).

Procedure:

Day 1: Getting Started

1) Hang the map in an easily accessible place or use overhead. Ask the class if they recognize the area that the map is showing.

2) Together with the students, describe the area shown on the map, marking various landmarks on the large class map.

3) Give students the 8 1/2 inches x 11 inches copies of the map and have them write down the landmarks the class has identified. Depending on your class, you may want to hand the maps out before the class discussion so that the students are recording the landmarks as the class describes the area).

In the Field

4) Using the "What's Around Our Water" instruction sheet, have the students map what is around the water body. This can be done either as a class outing or as an assignment; either individually or in teams. (Note: If the area shown on the map is large, divide it into sections and assign a person or team to each section.)

A Challenge - For those students who want an extra challenge, ask them to guess which way the surface water would be flowing at various points around the water body. This challenge is stated on the student instruction sheet.

Day Two: After the Investigation

1) As a class, have the students compile a map showing all the features they have written down (Note: this will require a fair amount of help from you, as the students will most likely have the same features in slightly different locations).

2) Ask the students if any of the places on their map would have substances that could wash into the water body. List all these things on the white board, chalk board, or poster paper. Be sure to include sand, oil, etc... from driveways, streets and parking lots; bare soil with no vegetation to prevent erosion; pesticides and fertilizers from farms and gardens; animal waste; and trash from streets, alleys, and yards. (To ensure that everyone participates in this activity, you may decide to have small groups of students come up with a list and then take turns adding items to the class list.)

3) Review the term "nonpoint source pollution" (defined in the March edition of *The Salmon Times*). Remind students of the "watershed model" (October) and what happened when a spill occurred upstream.

4) Discuss other invisible, diffuse sources of pollution (e.g. car exhaust, smoke from industry, or acid rain).

5) Make a list of possible ways that some sources of pollution could be controlled or stopped. (Plant trees or shrubs to keep soil from washing away; reduce the use of fertilizers and pesticides on home yards and farms; use less salt on streets in winter.)

EXTENSION: Help the students come up with an activity that the class or the school could do to help reduce nonpoint source pollution. (Planting trees and scrubs around a nearby stream, cleanup an local beach, clean up the school grounds etc...).

Activity adapted from "Pollution Sleuths: Mapping the Sources" in *Waterways: Links to the Sea* by the Shore Stewards Partnership, Maine Coastal Program, June 1992.

Instructions:

Using the maps you worked on as a class, go to the assigned area and investigate!!
What do you see?
Where is it?
Can you locate it on your map?
All investigators take notes, so as you look around write down what you see. (Suggestion - use a pencil in case you need to adjust your map).

A few of the things you might see are:

trees
grass
shrubs/bushes
bare ground or sand (with no vegetation)
parking lots
driveways
roads
stores (make sure to write down what kind of store)
gas stations
houses
farms
gardens
factories (again be sure to write down what kind)
dams
trash piles
and many more...

An Extra Challenge: Pick several big features you have found and at each location decide whether you are uphill or downhill from the surface water body (stream, pond, river, lake etc...). When you have decided, draw an arrow pointing downhill. You just figured out where the surface water runoff is going to flow!

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