THREATS TO WESTERN PENNSYLVANIA WATERWAYS

What is Water Pollution

Water pollution is an undesirable change in the physical, chemical, or biological characteristics of a body of water that can negatively affect the health, survival, or activities of humans and other living organisms. Water is valuable to us because it is necessary for so many things, but pollution limits its value and usefulness. Therefore, much attention has been given to studying sources of pollution, and finding ways to prevent and treat water pollution.

Often, pollution is classified into two categories: **point source** and **nonpoint source** pollution. Point source pollution is a single, identifiable source that **discharges** (empties) pollutants into the environment. Examples include a leaking waste storage container and a drainage pipe from a sewage treatment plant, industry, or off a city street. Nonpoint source pollution's source is more difficult to pinpoint because this pollution type can enter a stream with runoff from a widespread land area. Examples include farm fields, large construction sites, mining operations, lawns, and parking lots. To help distinguish the difference, think of point source pollution as pollution that could be stopped if a cap or seal was placed over the discharge source or small barrier around the source before entering the stream. However, to stop nonpoint source pollution, you would need to build a long cement barrier that would border beside the stream above and below ground and catch the runoff from the adjacent land.

Water Pollution Legislation

The Federal Water Pollution Control Act of 1972 renamed the Clean Water Act of 1977 (amended also in 1981, 1987, 1993) is the government legislation that seeks to protect the nation's vast water resources from pollution. The 1972 act changed outdated water pollution laws from 1899 and for the first time placed limitations on point source pollution discharges and created surface water quality standards. All factories, wastewater treatment plants, and other point sources were given limits and permits for the amount of conventional and toxic water pollutants they were allowed to discharge. In order to meet the act's goal of eliminating pollutant discharge into all navigable waters by 1985, industries were to implement the "best practicable" pollution control equipment by 1977 and more advanced equipment by 1983. All municipal treatment plants were supposed to have secondary treatment practices in place by 1977, and further improvements by 1983. Revisions to the act and deadline extensions have occurred with each of its amendments. However, the 1987 amendments called for state management programs for nonpoint sources, a pollution type generally overlooked previously. The Federal Government also enacted the Safe Drinking Water Act of 1974, requiring the EPA to establish national drinking water standards or maximum contaminant levels for all pollutants that "may" have adverse effects on human health.

Pennsylvania's water pollution control programs date back to 1905 (Purity of Waters Act), and the first comprehensive water pollution control state law, the "Clean Streams Law" was enacted in 1937. This law has been strengthened with amendments over time and addresses standards passed down by the Federal Government.

Sources of Western Pennsylvania Water Pollution

A 1994 Department of Environmental Protection assessment of water quality and biological conditions of waterways indicated 49,315 miles (91.4% of the 53,962 miles of

Pennsylvania streams) were meeting the Clean Water Acts “fishable/swimmable” goal; and 4,647 miles (8.6%) failed to meet the above criteria because of pollution problems (Arway, 1997).

Acid Mine Drainage - point and nonpoint source

Of the 8.6% of polluted streams, the biggest threat (56% or 2,596 miles) can be attributed to mineral resource extraction. **Acid mine drainage** (AMD) affects 2,404 miles of streams. “The influx of untreated acid mine drainage into streams can severely degrade both habitat and water quality often producing an environment devoid of most aquatic life and unfit for desired uses” (Kimmel, 1983). AMD is acidic water with a pH often below 4.5 (see pH information sheet for more information).

Coal is mined in two ways – underground mines with tunnels or surface/strip mining (removal of land from the surface to dig down to the coal seam). Acid mine drainage is often the product of water running through abandoned mining operations from the early 1900s, and to a lesser extent active mining. Soil and crushed rock removed from above coal seams underground is called overburden and can contain iron pyrite (FeS_2, fool’s gold). The disturbance of this rock and soil exposes the pyrite to air and water, creating a chemical reaction forming ferrous iron (Fe^{+3}), iron hydroxide ($Fe(OH)_3$) and sulfuric acid (H_2SO_4). The acid can dissolve other minerals and metals from surrounding rock, and can itself dissociate (break apart) yielding sulfate (SO_4^{-2}) and extra hydrogen ions (H^+) to the water (lowering the pH). Then the acid mine drainage finds its way into groundwater and surface water, adding acidity (lowering the pH). In a different process it is possible that neutral or alkaline mine drainage (NAMD) may be produced.

AMD releases toxic metals such as iron, aluminum, and manganese from surrounding rocks. When iron in the water comes in contact with dissolved or atmospheric oxygen, it oxidizes and precipitates out (drops out) and becomes the yellowish-orange stain on the bottom of the stream. These streams are often nicknamed “yellow boys”. This can also happen with the other metals – aluminum (white) and manganese (black). These metals can clog fish gills causing breathing complications or cause deformities to young fish. When they settle on the stream bottom, they fill in spaces between rocks where insects live or insect and fish eggs are laid, often smothering the eggs.

Acid mine drainage can and does have a myriad of negative effects upon the environment. In streams that are not well buffered by carbonate rocks, severe stress is placed upon all life within the stream because of the lowered pH levels (see pH information sheet for more information). Surface coal mining can be the source of much soil erosion to a stream because of the removal of vegetation and disturbance of the land surface.

There are ways of treating acid mine drainage. Since the late seventies, state and federal laws require that surface/strip mining companies restore the land to a state which is, as near as possible, to its original state. This includes the replanting and landscaping of the old site. AMD coming out of surface and underground mining operations can be treated either passively or actively.

Active treatment methods use strong alkaline chemicals (limestone, soda ash or sodium carbonate, caustic soda or sodium hydroxide, and ammonia) to neutralize the acid. In the process, metals precipitate out and have to be removed and securely stored. Active treatment is expensive to use over long periods of time, can be chemically dangerous, and is labor intensive.

Passive treatment methods generally employ channels, limestone, vegetation,

ponds and wetlands to mitigate the acidity problem. Limestone rids the extra hydrogen ions that make the water acidic. Wetland plants can take up, store, and process metals. And the natural process of metals reacting with oxygen and settling out of the water can be a useful solution. An example of a passive system for mitigation of acid mine drainage has been undertaken by one project participating school, Chartiers Valley High School.

The Scrubgrass Run Watershed Project attempts to treat the acid mine drainage problem in Scrubgrass Run, which eventually empties into Chartiers Creek and the Ohio River. Two ponds were set up trying to remove the metals from the water. The first induces the reaction of iron and oxygen to take place allowing the iron to precipitate in the form of rust. The water, which ideally is devoid of iron as well as oxygen, is then channeled into the second pond. Aeration is the main purpose of the second pond, adding oxygen to the water before sending it off to Scrubgrass Run. The treatment process is a challenging work in progress as Chartiers Valley seeks ways to keep oxidized iron in the first pond, and to better aerate the second pond. For more information on this project contact them at http://members.tripod.com/scrubgrass/. (photo from Scrubgrass website)

Oil and Gas Extraction – point source

Though less of a threat to streams as coal mining, this type of mineral extraction is still a problem in Western Pennsylvania. Oil and gas development includes the drilling, stimulation (fracturing of underground rock formations with pressure), and the production of oil and gas deposits buried underground. The geologic history of the region has created some rich reserves of gas and oil. Ever since Colonel Edwin Drake drilled America's first oil well in 1859 in Titusville, PA, the industry has grown to meet society's demand for fossil fuels.

Operating wells produce brine (salty water) with some toxics such as metals and phenols (organic hydroxy acid that is corrosive, smelly, and poisonous). Sometimes this brine enters streams untreated deliberately or illegally by an operator or through storage container leaks. Oil spills and broken pipes can also be a problem, adding crude oil to streams. In addition, forests are cleared for installing pumps and unpaved access roads are carved through the landscape, adding soil erosion and siltation threats to streams.

Agriculture – usually nonpoint source

Agriculture, the largest industry in Pennsylvania, is also the second major source of stream pollution (Arway, 1997). To keep land rich with nutrients, especially nitrates and phosphates, liquid and granular chemical fertilizers and animal manure are applied to farm fields. If applied in excess or during non-growing seasons, the fertilizers can be washed off the fields and into nearby streams, stimulating excessive plant growth (algae and aquatic weeds). This can turn a waterway into a green soupy mess and aquatic weeds can frustrate swimmers, fisherman, and boaters. When the vegetation dies, aerobic (oxygen using) bacteria decompose it and use oxygen from the water. The decline in oxygen can cause aquatic life to suffer or even die. This process is called

eutrophication. See the nitrates and phosphates information sheets for more information.

Wind and rain runoff sends soil into streams, creating turbid (cloudy) conditions. This soil settles out on the bottom of the stream (called sedimentation) and can destroy insect habitat, places for fish and insects to lay eggs, and even smother existing eggs. (See the turbidity information sheets with more information). Soil erosion can be caused by poor plowing techniques, such as failing to till fields with the contours of the land. There are no-till or conservation tillage methods that hold moisture better and prevent erosion. Failing to have crop cover during non-growing seasons or on unused fields is another source of soil erosion. Plant roots help keep soil in place, and maintaining a healthy riparian (streamside) vegetative zone can reduce the amount of soil erosion that reaches a stream. In addition, plants in riparian zones can soak up extra nutrients before they enter a stream.

Livestock is both a source of nutrients and soil erosion. Animal manure can add nutrients and harmful bacteria to a stream, especially if the livestock graze near or even in a stream. These animals can also erode banks and trample down vegetation that holds back erosion. Stream fencing and specially designed stream crossing areas can help keep livestock from damaging stream banks or adding waste directly to the stream.

Pesticides (herbicides and insecticides) are chemicals used by farmers that were developed to control plant and animal pests. If applied incorrectly to fields or in excess, these chemicals can enter a stream through wind and water erosion and can negatively affect all creatures – pest and non-pest. Pesticides can be toxic to aquatic animals at even low levels and can contaminate drinking water sources. By following the label specifications for the amount and season for pesticide applications, and by being careful with aerial applications, the amount of these chemicals entering streams can be reduced. In addition, there are non-chemical approaches to pest management (biological control) practices that can be used.

Irrigation systems that withdraw water from nearby streams can disrupt the stream system. Lowering the water level can increase the temperature of the waterway because shallower water warms faster than deeper water. Plus shallow water can disturb fish habitats and mussels that were normally underwater along stream edges can become exposed and vulnerable to death and predators.

<u>Deforestation</u> – nonpoint source

Pennsylvania is fortunate to have some very productive forests filled with trees (such as black cherry, pine, and oak) well sought after by timbering / lumber companies. Unsustainable forestry practices can harm streams in a number of ways. When trees are removed, especially if all trees are removed from an area (clearcutting), soil erosion will increase because there are no roots to hold soil in place and there is no leaf cover to lessen the impact of raindrops. Removing riparian zone trees intensifies soil erosion and eliminates an effective tool for catching uphill soil that washes toward the stream. The removal of streamside vegetation eliminates shade from the stream, thus increasing the temperature of the water (thermal pollution) (See the temperature information sheet for more information). Soil and silt can also be washed off the many unpaved logging roads that are constructed to reach remote parts of a forest.

Acid Rain – nonpoint source

Rain is naturally acidic (pH of 5.6) because of carbon dioxide in the air reacting with water to form carbonic acid, which can dissociate producing extra hydrogen ions. Due to human activity (atmospheric pollutants from fossil fuel burning, industrial processes, and automotive exhausts), we have increased the acidity of some precipitation. Sulfur dioxide (SO_2) and nitric oxide (NO_x) gases are sent into the atmosphere, are chemically changed, and return to the earth as wet deposition (rain, sleet, or snow) or dry deposition (dust particles).

The rain that falls in Pennsylvania averages a pH between 4.0 and 4.5. America's most acidic precipitation centers around Pennsylvania, Ohio, and New York. The Pennsylvania Fish and Boat Commission indicated that Pennsylvania receives more acid rain than any other U.S. state. Why is this? Pennsylvania is downwind of and is part of the industrial belt of the country – the big cities along the Great Lakes like Chicago, Detroit, Cleveland, and inland cities in Ohio, Illinois, Indiana, and Pennsylvania. Pittsburgh is also part of this industrial belt. These cities add air pollutants that create acid rain, and Pennsylvania is in the downwind weather patterns containing this rain.

Whether or not acid rain is a problem to streams depends on the geology of a region. Luckily, most of Western Pennsylvania rocks, bedrock, and soil contain calcium carbonate and magnesium carbonate, which can neutralize the acid (get rid of the extra hydrogen ions). Alkalinity represents the acid buffering capacity of the water (see the alkalinity information sheet later in the handbook). Acid rain does become a problem in Western Pennsylvania streams during major storm events, where surface runoff does not allow the acidic precipitation to come in contact with the buffering geology of the region. Quick acidic snowmelts can also cause these "acid spikes" to a stream. The stream's pH will recover eventually from these acid spikes. Acid rain can also add to the high acidity in acid mine drainage streams – streams that recover less successfully from their low pHs.

Sewage – point source

Sewage is the third worst Pennsylvania stream pollutant affecting 400 miles of streams (Arway, 1997). Even though wastewater treatment facilities are supposed to treat sewage before it is released to a waterway, some municipal plants in Western Pennsylvania are outdated. Some towns have storm drains connected to sewage lines. During storm events, the sewage treatment plant cannot handle the flood of water and sewage and may release untreated sewage to the stream. Some outdated treatment plants fail to remove all oxygen demanding organic solids through their treatment process, and some outdated plants are too small to meet the need of an increased community population. Great efforts have been taken to update facilities to meet government regulations. Rural homes use backyard septic systems to treat sewage, which can have failing processes or leaking storage components. This adds additional sewage to the groundwater and streams.

Sewage is harmful to a stream for a number of reasons. Sewage contains organic matter, which is broken down by bacteria in a stream. This aerobic (oxygen using) bacteria lowers oxygen levels in a stream (increased biological oxygen demand). There is a natural balance of organic substances in a stream (from dead plant and animal parts in and around a waterway) that need to be decomposed, but adding extra sewage organics can unbalance the system. Sewage is also rich in nutrients. As mentioned in the agriculture section, extra nutrients in a stream can also disrupt the stream ecosystem.

There are other problems with sewage additions. Turbidity (cloudiness) of the water can increase as sewage suspended solids are added. Untreated waste can also include chemicals, metals, and pesticides, possibly from industries connected to municipal systems. Pathogens (organisms that cause disease) exist in untreated sewage, and can be successfully killed with chlorination or ultraviolet light. However, chlorine can be toxic to a stream if used in excess during treatment. Wastewater can also be higher in temperature than the stream water, adding thermal pollution to the stream.

<u>Industry</u> – point source

Even though the Department of Environmental Protection Regional Offices regulate and control permits to reasonably limit industrial discharge, pollutants may still enter streams from various Western Pennsylvania industries. Below is a chart of industrial pollutants.

Power Plants	Heat, silt, chlorine
Steel Mills / Manufacturing	Heat, metals, acids, oil, cyanide, phenols (organic hydroxy acid that is corrosive, smelly, and poisonous)
Food Processing / Slaughterhouse	Organic matter (blood, fat, meat parts and juices), chlorine.
Paper Mill	Organic matter, acids, sulfites, metals, heat, chlorine.
Tannery	Organic matter, acids, metals
ALL of the above	Air pollution that can cause acid rain

<u>Urbanization / Suburban Areas</u> – point source and nonpoint source

Urban areas can place much stress on waterways because of the concentration of people and the alteration of land. Some of the problems previously discussed are associated with urbanization and suburban areas – industry, sewage disposal, and acid rain – but there are others worth mentioning.

Water withdrawal for municipal drinking water and industries is a problem that receives much attention especially during drought years. Lowering the water level can increase the temperature of the waterway because shallower water warms faster than deeper water. Plus shallow water can disturb fish habitats and mussels that were normally underwater along stream edges can be exposed.

Thermal pollution is a serious problem because shady streamside trees are often removed in urban areas, allowing sunlight to heat the water. Rainwater that flows over hot paved surfaces (roads and parking lots) is drained into a stream, possibly increasing its temperature. During the winter, road salt added to roads often washes into streams, increasing their salinity and total dissolved solids concentrations.

Cars driving on those paved streets add air pollutants to atmosphere that can create acid rain, and vehicles can add pollutants more directly to a stream when they leak oil or antifreeze onto roads and parking lots.

Homeowners can impact a stream. Improper disposal of car waste (oil and antifreeze) changed at home, as well as the improper disposal of other household wastes and toxins can add to water pollution. Some homeowners dump wastes into storm drains that empty directly into nearby creeks. Many homeowners take great pride in a perfectly manicured lawn. However, if lawn fertilizers and pesticides are used improperly or in excess, they can wash into nearby waterways during rain events.

As urban sprawl continues in Western Pennsylvania and more people move out of cities and into the suburban areas, the development of these areas can significantly degrade waterways. For instance, construction sites for homes, businesses, and roadways can cause soil erosion and siltation as vegetation is removed from the land.

<u>Recreation Areas</u> – point source

To escape the city or home for a while, many people head to the woods. The natural beauty of Pennsylvania draws millions of visitors to its forests and waterways. Pennsylvania's 4.5 million acres of public land include 116 state parks (one of the largest systems in the United States), and 2.1 million acres of state forests (one of the largest in Eastern United States). There are close to 54,000 miles of waterways, 2,500 lakes and ponds, and 5,000 miles of trails (Department of Conservation and Natural Resources, et. al., 1990's). Recreation use on public and private land can to detrimental to the waterways that many people come to enjoy.

Rural vacation homes and cabins can have faulty septic systems or none at all. All terrain vehicles (ATV's) can tear up land and cause soil erosion near streams. Illegal ATV riding in a creek can destroy fish, mussel, and insect habitats. Some hiking trails and "off roading" areas are being eroded. Litter from hikers, boaters, fisherman, and campers can also be an annoying problem.

Problem Streams of Western Pennsylvania

Based on a Pennsylvania Department of Environmental Protection (Resources) "1988 Pennsylvania Water Quality Assessment", a list of 20 waterways of most concern due to pollution was created. The following Western Pennsylvania waterways made that list - all are located in southwest corner of the state:

Waterway	**Miles Affected**	**Problems**
Allegheny River	14.5	Pesticides, industrial wastes, acid mine drainage
Monongahela River	12.2	Pesticides, industrial wastes, acid mine drainage
Ohio River	40.0	Metals, reduced oxygen levels, pesticides, acid mine drainage, industrial wastes, chemicals
Chartiers Creek (tributary to Ohio River)	35.0	Metals, reduced oxygen levels, acid mine drainage, pesticides, turbidity and suspended solids
Raccoon Creek (tributary to Ohio River)	78.0	Metals, reduced oxygen levels, acid mine drainage, turbidity and suspended solids, dissolved solids

Source: Cuff, D.J. et al., 1989. <u>The Atlas of Pennsylvania</u>