The Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation, Watershed Support Division, prepared this report. It is a project of the Citizens' Volunteer Monitoring Program. It follows the format of the previous ***Snapshot*** editions.

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Foreword

A Letter from the Secretary of Environmental Protection

I would like to extend a big "thank you" to all of you who participated in ***Snapshot of Water Quality 1999*** -– an Earth Day survey of Pennsylvania's surface water and watersheds.

Back in 1970, the original intention of Earth Day was to capture the attention of a nation and bring environmental issues to the forefront. Now, 30 years later we at DEP bring environmental issues and education to the forefront every day and are happy to continue participating in Earth Day – every day.

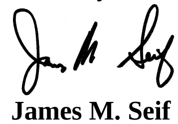
The citizen volunteer monitoring movement continues to capture the initial spirit of Earth Day and Pennsylvania's new 21st Century "Growing Greener" initiative. The ***Snapshot*** combines the efforts of citizens groups, older Pennsylvanians, schools and government organizations that collect water quality data at their own sampling stations at least once during the same week in April. Today, volunteer monitoring captures the interest of an environmentally aware public even more now than when we first worked on this project four years ago. Many new watershed associations and monitoring groups have formed. The first statewide summit of volunteer monitors was held. Local groups are piloting a handbook for volunteer water monitors. Our network continues to build stronger bonds as we all work together cooperatively.

Our new efforts to protect Pennsylvania's watersheds through the historic investment of nearly $650 million over the next five years in the Growing Greener Program validates the pioneering efforts of water monitors throughout the state.

I extend the invitation to all environmentally oriented groups and individuals to get involved in monitoring, especially in the lakes and streams of Pennsylvania. Of our more than 140 grassroots volunteer groups, only several are monitoring lakes, so there is a lot of room for monitoring efforts to increase in the years to come. The data collected from streams, rivers, ponds and lakes is an important key in determining the quality of our surface water and the health of watersheds across the Commonwealth.

Thank you, for all you do for our streams, rivers, lakes and watersheds. Let's keep our personal involvement in our environment growing.

Sincerely,



James M. Seif
Secretary

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The Big Picture

Volunteers willing to do water quality monitoring enthusiastically went into Pennsylvania's watersheds during Earth Week — April 17 – 26, 1999. They invested their time and expertise to gauge the quality of our water environment. We received an outstanding response to the participation packets we sent to individuals and organizations across the state. Data sheets were returned to DEP's Citizens' Volunteer Monitoring Program Coordinator and many positive experiences were achieved between the volunteers and our precious Pennsylvania environment.

No limitations were placed on how to choose the monitoring sites. In many cases, streams or lakes were chosen based simply upon their proximity and accessibility to participants. Data used in this report came from participants who submitted 366 data sheets. All the data was used to develop a "picture" of the overall water quality in Pennsylvania. The data collected helps us get a better picture of the ranges in results that we can expect to find, as well as determining trends and effects of physical influences upon water chemistry.

In The Beginning

DEP's ***Earthday Snapshot of Water Quality*** is a spin-off from Delaware River Basin Commission's *Water Snapshot*, which began in 1996. Both activities are big success stories. Over the years, dozens of additional adult organizations, schools, youth organizations, citizen and watershed groups, governmental agencies and private companies joined in the Earth Week project.

The purpose for the event is to work cooperatively to promote environmental awareness. Each year the plan and follow-up report focuses on another aspect of environmental assessment.

Last year we addressed habitat assessment for the first time. This year we focused on benthic macroinvertebrates, which are commonly called "water bugs" or aquatic insects, even though macroinvertebrates include more than just insects. We hope that each edition is complete in its own right and, at the same time, we hope that each edition complements the others. Readers are encouraged to use previous editions, as well as other references, as they continue to learn more about water quality monitoring, watersheds, and our environment.

EXTENT OF EFFORT

Numbers of submissions for the major basins were as follows:

Delaware River Basin - 201
Susquehanna River Basin - 90
Potomac River Basin - 3
Lake Erie Basin - 7
Ohio River Basin - 64

Table 1 shows the distribution of sites by counties within Pennsylvania and Table 2 shows the distribution of the four reports submitted from New York.

Students disturb the substrate with their feet and macroinvertebrates are captured in the kick-screen. The collection is then examined and identified.

PA County Distribution of Waters Sampled (Table 1)

County	# of Records
Adams	1
Allegheny	22
Bedford	1
Berks	10
Blair	1
Bradford	1
Bucks	24
Cambria	6
Carbon	2
Chester	23
Crawford	6
Cumberland	30
Dauphin	1
Delaware	12
Elk	1
Erie	7
Fayette	7
Franklin	1
Huntingdon	1
Indiana	12
Lackawanna	6

County	# of Records
Lancaster	18
Lebanon	6
Lehigh	8
Luzerne	2
Mifflin	1
Monroe	38
Montgomery	21
Montour	1
Northampton	24
Perry	2
Philadelphia	11
Pike	10
Potter	2
Schuylkill	4
Susquehanna	2
Washington	1
Wayne	2
Westmoreland	5
Wyoming	1
York	6

NY County Distribution Of Waters Sampled (Table 2)

County	# of Records
Allegany	3
Otsego	1

Water Quality Findings

The information gathered during ***Earthday Snapshot of Water Quality 1999*** helps us see the overall "picture" of water chemistry across the state, in major drainage areas, and in individual streams.

The data you submitted show that the statewide average water temperature was 10.8°C (51°), which is close to what could be expected. The temperature is about 3°F cooler than last year's average and the same as in 1997. It is very close to the daily average expected at this time of year for streams supporting trout: 11.1°C (52°F). Along with the return to cooler temperatures came the expected increase in dissolved oxygen. The overall average dissolved oxygen level of 11 mg/l is "normal" for the temperature, and it is well above the 6-7 mg/l required to support diverse aquatic life. Furthermore, the statewide pH average of 7.0 is quite acceptable, and a bit better than the 6.8 reported last year.

Overall, this year's reported conditions are very similar to those in 1997 and the vast majority of readings in all the various water quality factors, other than nutrients, are within established criteria. With just three years of data, we hesitate to say that trends are appearing. However, we are consistently meeting most water quality goals and criteria as well as getting a much clearer indication of the problems that do exist.

In most cases, where factors do not meet the criteria, the problem is known to come from abandoned mine drainage or agricultural practices and other sources of pollution linked to storm water runoff.

We are beginning to get a better picture of the ranges in results that we can expect, as well as determining trends and effects of weather, flow rates and other physical influences upon water chemistry. We are also gaining very valuable information on the kinds of tests that produce accurate results and sufficient precision to be of value. More detail on the various factors you looked at follows, and the ***FINDINGS*** for individual sites will be listed on DEP's website www.dep.state.ps.us (choose directLINK "snapshot").

Abby Hainley, Mark Saul, Michelle Auchenbach, Rachel Yohn and Melanni Leavy prepare to collect macroinvertebrates from a slow moving rural stream.

The Water Chemistry Factors

The water quality factors investigated this year are typically "in-stream" measurements. They are "standard factors" that can be measured with more-or-less commonly available water quality instruments. See last year's edition of Earthday ***Snapshot of Water Quality*** for a more detailed review of the general aspects of water chemistry.

Water Temperature

Ordinarily water below $0^{O}C$ ($32^{o}F$) is frozen and called ice. Water above 100 ^{O}C ($212^{o}F$) is usually boiling and steaming. In the normal and natural conditions of Pennsylvania, liquid water in streams, rivers and lakes seasonally ranges in temperature from 0 ^{O}C ($32^{o}F$) to about 32 ^{O}C ($90^{o}F$).

A lot of the physical, chemical and biological aspects of an aquatic ecosystem are directly affected by temperature. The amount of oxygen the water can hold goes hand in hand with the water temperature. Colder water can hold more oxygen than warmer water. Warmer water temperatures tend to increase the rate of aquatic plant growth and photosynthesis.

One of the most detrimental ways that humans influence the temperature of aquatic systems is by adding heat to the system, known as thermal pollution. Primary causes are heated water discharges of industries and storm-water running off heated urban surfaces.

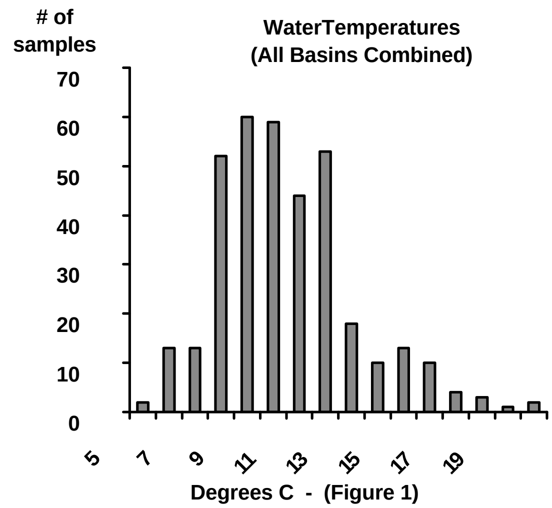
Waterbodies should have a wide vegetated border called a riparian zone. This is basically the floodplain or the land close enough to the stream to be influenced by the stream. Heavy vegetation in this area helps to moderate the water temperature, especially if tall trees overhang the stream and limit exposure of water to direct sunlight. The goal is to not exceed the prescribed temperature limits established for each water use.

Practically all forms of aquatic life prefer a relatively narrow and specific range of chemical and physical conditions. Not many organisms can tolerate extreme heat, cold, or extended periods of oxygen depletion. For example, brook trout don't live long in water above $70^{o}F$.

Temperature measurements should be taken directly in the stream with a simple waterproof thermometer or other thermistor-containing meter. Use the same instruments, whenever possible, to collect all the data that you wish to compare.

In order to make data comparisons from sampling event to sampling event, it is important to take the temperature at the same location in the stream each time and at the same time of day. It is also necessary to note weather conditions since water temperature is influenced by weather. Since temperature generally decreases with depth, it is a good idea to take the temperature at the same depth each time.

The graph (Figure 1) shows the water temperature of all the sites monitored during ***Earthday Snapshot of Water Quality 1999***.



As you can see from this graph, there is considerable range in temperatures among waterbodies — from $5.0^{o}C$ ($41^{o}F$) to $20^{o}C$ ($68^{o}F$), at the same time of year: April 17 – 26, 1999. The median (middle value from a ranked list) temperature for all data combined was $10.5^{o}C$ ($51^{o}F$). The average or mean (all numbers added together and divided by the number of entries) temperature of all sites monitored in ***Earthday Snapshot of Water Quality 1999*** was $10.8^{o}C$ ($51^{o}F$).

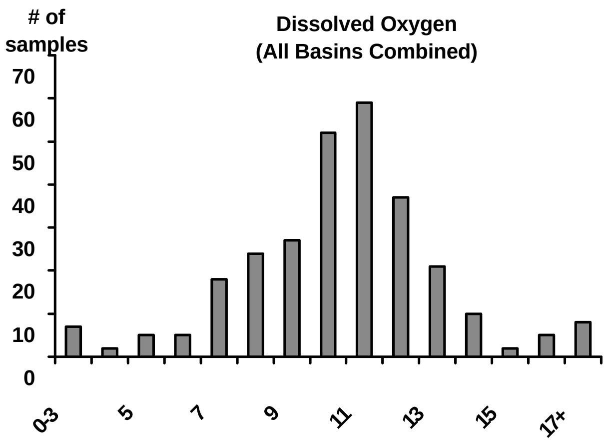
Dissolved Oxygen

You will usually see dissolved oxygen (D.O.) expressed as milligrams per liter (mg/l) or parts-per-million (ppm), both of which are interchangeable (1 mg/l = 1 ppm). Sometimes you will see "percent saturation." Cold streams should have 7 mg/l D.O. as a minimum, and lakes and ponds should have a minimum of 4 mg/l. Our waterbodies typically range from about 3 - 14 mg/l, but remember that higher amounts require colder temperatures.

Lots of oxygen is preferred by most life; therefore, low oxygen levels mean you will not have a very diverse, biological community. Most of the dissolved oxygen in water comes from the atmosphere. Waves on lakes and the tumbling water in fast-moving rivers help mix atmospheric oxygen with water. Additionally, algae and rooted aquatic plants add oxygen to the water through photosynthesis during the daytime.

The amount of oxygen able to be held by water decreases as pressure decreases, or as temperature increases. Dissolved oxygen is used in respiration (breathing) processes of plants and animals, and in the chemical reactions involved in their decomposition. Usually the organisms preferring cold water also require high levels of oxygen.

Both the mean and median dissolved oxygen value was 11 mg/l, an amount exceeding the requirement of any aquatic life. The hypothetical percent saturation for the whole study area, using the median temperature of 10.5°C (51°F) is about 96 percent. If you find individual sites with readings below 4 mg/l, it should raise curiosity as to the cause of the depletion. Out of more than 284 samples, seven monitors reported dissolved oxygen levels below 4 mg/l and only 18 were less than 7 mg/l — the generally accepted mark of good health for streams. The graph (Figure 2) shows the dissolved oxygen levels of all sites monitored during ***Earthday Snapshot of Water Quality 1999***.



mg/l or ppm - (Figure 2)

As you can see from the graph, there is a considerable range of dissolved oxygen among waterbodies at the same time of year, but ninety-four percent of the sites are in the healthy zone (7 mg/l or more). The extremes included two reports of near zero mg/l and four reports of >30 mg/l.

pH

pH is the concentration of hydrogen ions in solution. pH is most easily and accurately measured in-stream with a reliable meter. The scale goes from 0 to 14. Seven is neutral; less than seven is acidic; greater than seven is alkaline (pH greater than seven is sometimes called "basic"). You will rarely find water below 4 or above 9, in the normal and natural conditions of Pennsylvania. The pH of pure water is 7.00 at 25°C, while a pH of approximately 5.6 is considered "natural" for rainwater. Most aquatic life prefers water with a pH between 5 and 9.

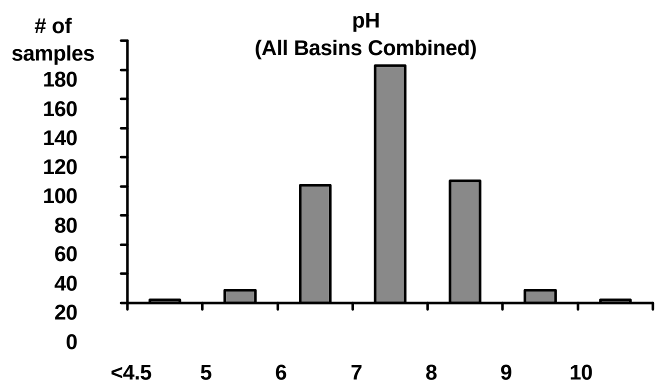
pH tests are conducted in nearly all aspects of water quality control and monitoring because pH affects the life within the stream and the chemistry of the stream. It can greatly influence the effects of aluminum, ammonia, carbon dioxide and alkalinity, and in turn their impact upon water quality and aquatic life.

Aquatic Macroinvertebrates and pH

pH values below 5 or above 9 decrease the number of different kinds of organisms able to live although some bacteria can survive down to a pH of 1 and some up to a pH of 13. Bacteria are adaptable, diverse pioneers of life who never say "die"!

Mine drainage and acid precipitation impact many Pennsylvania streams, and in those streams biodiversity suffers. There is not a lot of practical literature on tolerance of macroinvertebrates to the chemicals of acid precipitation and mine drainage, but generalizations are fairly easily made. It is known that the larvae of dobsonflies and fishflies (Corydalidae) are quite tolerant of wide ranges in pH. They are found in water with pH ranging from 4.4 - 8.8. Mayflies are known to be very sensitive to pollution - at least to organic pollution. They seldom live in waters below pH 5.5 or above pH 8.8. Stoneflies generally don't appear at pH less than 4.5, but they are not too sensitive to high pH.

As shown on the graph (Figure 3), only two of the more than 350 pH readings taken during this study had a pH less than 4.5 – about the point which causes taxa richness to become compromised. The graph shows the pH levels of all sites monitored during ***Earthday Snapshot of Water Quality 1999.***



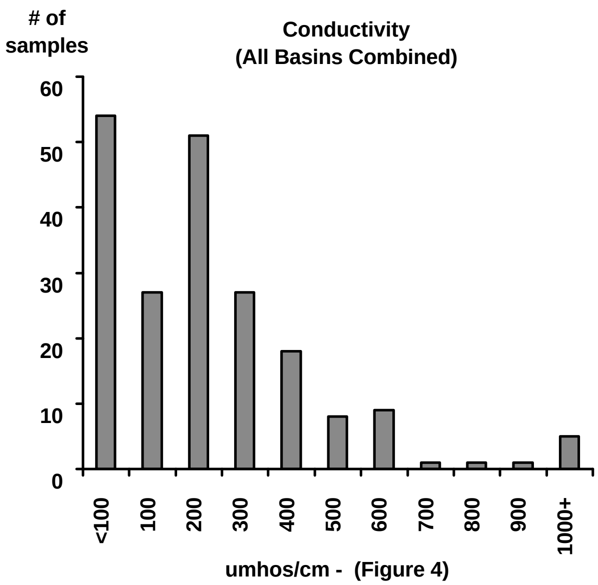
pH units - (Figure 3)

As you can see from this graph, among waterbodies the pH ranges from 4.0 to 10.0. The median, mode (the most frequently occurring) and the mean pH of all our sites combined were 7.0. Ninety-nine percent of the monitored sites have healthy pH! All submitted data is summarized.

Conductivity

Conductivity is determined "in-stream" with a conductivity meter. You could find conductivity perhaps as low as 0.5 micromhos per centimeter (umhos/cm) in distilled water or more than 10,000 micromhos per centimeter in tidal areas. In the normal and natural conditions of Pennsylvanian waterbodies, conductivity typically ranges from about 20 - 600 micromhos per centimeter.

Conductivity is a measure of the ability of water to conduct electric current. It does not measure any specific compounds present in the water sample. Rather, it gives a good indication of the amount of electricity conductors— salts, minerals, acids, and metals — dissolved in the water.



Conductivity reports ranged from several reports of less than 2 to a single high report of 17,000 umhos/cm (Figure 4). In 82 percent of the samples, conductivity readings were within the "common" range for Pennsylvania streams: 20 - 600 micromhos per centimeter. However, it is important to note that "normal" is specific to the stream and its geologic composition.

Conductivity is primarily related to the geologic composition of the streambed and the formations through which the ground water seeped prior to entering the stream. Many inorganic pollutants (chlorine, sulfates, metals and fertilizers) will increase conductivity.

Exactly how conductivity directly affects aquatic organisms is not well understood. It seems as though the influence upon living organisms is more from the associated changes in osmotic pressure rather than from the water's ability to carry an electrical current. Most bivalves (clams) enjoy relatively hard water, usually high in calcium and/or magnesium – and therefore high conductivity. The minerals are needed to form shells. Pennsylvania streams with high alkalinity (and almost always high pH) often produce a lot of algae and aquatic plants, as well as scuds, sow bugs and the whole cast of organisims which prefer high pH. Water with very low conductance seems to be favored by very few creatures or plants with the possible exception of mosses.

Alkalinity

Alkalinity is most frequently measured by titration tests. In order to meet water quality standards, streams *should* have a minimum alkalinity of 20 mg/l. However, it is not at all uncommon to find healthy streams with an alkalinity of only half this amount. Low alkalinity occurs naturally in areas where the rocks and minerals lack calcium. At the other end of the scale, limestone streams commonly have around 200 mg/l calcium carbonate ($CaCO_3$). If your alkalinity reading is over 75 mg/l, you should be able to verify that the geologic formations in the area contain significant amounts of carbonate materials.

In most natural water, calcium and magnesium carbonates and bicarbonates are the primary alkaline components (and both elements contribute to water hardness). Alkalinity (bicarbonate and carbonate) gives water its acid neutralizing ability, which is also called "buffering capacity." This allows the water to resist a change in pH when acid is added. In other words, alkalinity measures the water's ability to neutralize acids and keep the pH relatively constant. This is one way to determine the sensitivity of an aquatic system to acid input.

More than 50 alkalinity test results were submitted. They structured from 0 mg/l to 130 mg/l. Seventy-five percent were better than our minimum standard of 20 mg/l, however one in four samples were below that value. We know that more than 1,700 miles of Pennsylvania's streams have been polluted with acid mine drainage, and acid rain impacts a portion of our waterways. These problems tend to be greatest in streams having little natural defense in the form of alkalinity.

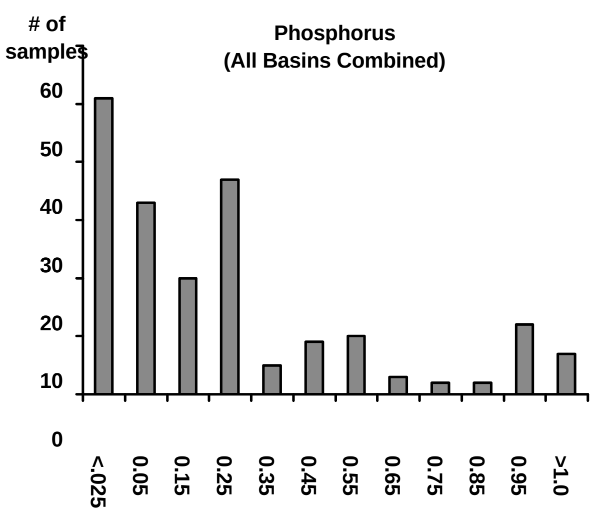
Phosphorus

In order to test for total phosphate, the water sample must undergo an acid heat digestion process. This process converts all the phosphate to dissolved orthophosphate. The prepared solution is analyzed using a colorimetric test. A standard is set for some Pennsylvania lakes at 0.1 mg/l. Phosphorus levels greater than 1 mg/l are seldom due to natural causes. Non-point source runoff boosts phosphate, especially in areas where excess crop fertilizer is used, or from urban runoff.

The major nutrients required by plants are phosphorus, nitrogen and potassium. In freshwater, phosphorus is often the nutrient in shortest supply and when it's depleted the plants must stop growing. As a rule of thumb, aquatic plants utilize about 10 parts of nitrogen for each part of phosphorus. If the ratio of nutrients available to the plants is more than 10 parts of nitrogen to one part of phosphorus, say 18:1, the extent of vegetative growth is limited by phosphorus. If the nitrogen to phosphorus ratio is less than 10:1, say 6:1; nitrogen is the limiting factor. Potassium is required in least amounts and is practically never a limiting factor in the aquatic environment.

Excess phosphorus leads to extensive algal and aquatic weed growth. Enrichment of lake-water with nutrients, usually phosphorus, affects several water quality issues, one being accelerated eutrophication – the aging and filling-in process of all lakes. In waters where accelerated eutrophication is taking place, the number of pollution sensitive species declines. Species that can tolerate lower dissolved oxygen levels replace the many different species that would exist in oligotrophic (nutrient poor) water. In areas with extra phosphates, bacterioplankton will sometimes flourish and compete with the phytoplankton. All this can lead to loss of recreational opportunities, fisheries and potential potable-water resources. Some blue-green algae cause illness in livestock and humans.

Phosphorus makes its way into streams and rivers from various sources, including wastewater treatment plants, manure, industrial wastes, fertilizers, detergents and land erosion. If fertilizers are used excessively, a lot of the phosphorus will eventually wind up running off the land and into streams and lakes. Therefore, two primary concerns are correcting runoff problems and using the proper amounts of fertilizer. Test your soil before adding fertilizer. Chemical fertilizer or manure application should be matched to the needs of the soil and crops. You will save money and prevent the potential threat to the environment by not over fertilizing fields, yards, or gardens. Keep your nutrients in the soil by keeping soil on the land – not in the water. Develop management systems that balance nutrient applications (input) with the amount removed by harvests (output).



mg/l - (Figure 5)

Phosphate ranged from zero (or below detection levels for the particular instrumentation in use) in many cases, to one high report of 13 mg/l (Figure 5). Fifty readings were less than 0.025 mg/l. As was the case last year, 50 percent of the tests indicated that phosphate was 0.1 mg/l or less. The spike that is indicated by the 0.25 bar also occurred last year. A possible correlation with agricultural or mining areas or detection limits of the instruments used is the probable explanation.

Maggie Barnes works on a chemical analysis of her water sample.

Nitrogen

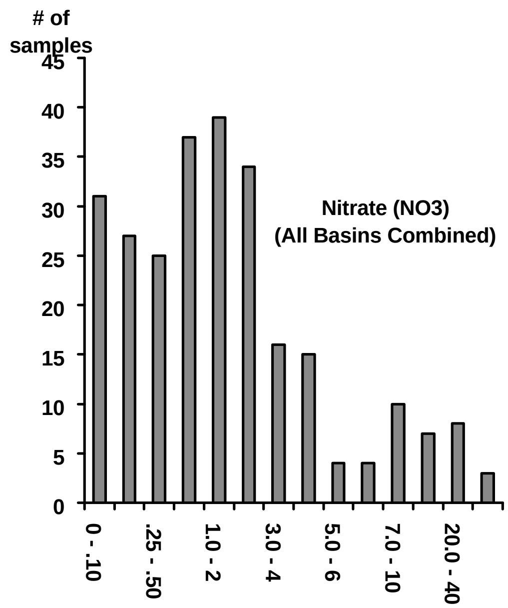
In order to meet the drinking water standards, water used for drinking should not exceed 10 mg/l nitrite + nitrate. Many aquatic biologists would also agree that the health of the aquatic system is better when nitrite + nitrate amounts do not exceed this amount. However, "nitrogen" occurs in several forms affecting the system in different ways. From the biological perspective no "total nitrogen" limit is established.

If the concentration of nitrate is greater than 20 mg/l, it may pose a health hazard to baby mammals by preventing hemoglobin from transporting oxygen. In humans, this is known as blue-baby syndrome. DEP has stated that nitrate levels should not exceed 10 mg/l in potable water supplies in order to avoid this potential health risk.

Nitrogen, like phosphorus, is a plant nutrient. The problems it causes are often similar to those discussed in the previous section on phosphorus. It can lead to excessive algae and plant growth that in turn degrades water quality, recreational opportunities, and can accelerate the aging of lakes. While nitrogen commonly limits plant growth in marine and terrestrial systems, it seldom does so in freshwater.

Nitrate levels of zero (or below detection levels for the particular instrumentation in use) were commonly reported. Several tests were as low as .02 mg/l and ranged to several extremely high values (over 40 mg/l) being reported.

As you can see from the graph (Figure 6), 46 percent, or 120 of the 260 reports, indicated that nitrate was less than 1 mg/l and 93 percent of the samples showed nitrates of less than 10 mg/l. Last year the percentages were 49 and 94 respectively. Fewer sites and some different sites were tested this year, so the difference may be insignificant. While the majority of sites meet water supply nitrite + nitrate standards there are several sites where the valves reported exceed the 10 mg/l water quality standard. As we move forward, we must continue to focus to correct acid rain, avoid excess fertilizer usage, minimize nutrient run-off and routinely remove nitrogen as part of the wastewater treatment process.



mg/l or ppm - (Figure 6)

You can help prevent pollution by making sure that the sewage system in your yard or community is functioning properly. Minimize the use of fertilizers on your lawn, and prevent runoff from yards and fields. Strategies that limit nitrogen loss to the water should be developed and employed throughout entire watersheds. Everyone is affected when water resources are degraded and everyone can contribute to correcting and preventing environmental problems.

Water samples can be analyzed for nitrate, nitrite or ammonia nitrogen using various colorimetric techniques. However, it has been our recent experience that colorimetric test kits can be very sensitive to user error. If you lack any confidence in your results, it is wise to have the sample analyzed by a professional laboratory.

Sulfate

Sulfate is derived from the weathering process of various common sulfur-containing sedimentary rocks and is a very common anion in water. Sulfate concentrations should normally range from 5 to 50 mg/l in natural waters. Sulfate should not exceed 250 mg/l in water used for drinking, mostly because it smells and tastes bad, and in sensitive individuals it can cause diarrhea.

Sulfuric acid is a major component of acid precipitation and serious biological impacts from sulfuric acid are possible, especially in poorly buffered streams. However, this is a bit complicated because representatives of all the major orders of aquatic insects have been found where sulfates were greater than 400 mg/l (see Table 3). The water's buffering capacity may be the key to whether or not the biological community is seriously impacted when sulfate levels are elevated.

Sulfate is one form of sulfur and is required by plants in trace amounts. Sulfate enters aquatic ecosystems primarily in three ways: acid precipitation, acid mine drainage and detritus breaking down and releasing hydrogen sulfide (H_2S).

Acid precipitation occurs when nitrogen and sulfur-containing fuels are burned, releasing sulfur dioxide (SO_2) gases into the air. Sulfur dioxide reacts with ozone and water droplets to make sulfuric acid (H_2SO_4), one of the acids of acid rain.

Acid mine drainage is also very prevalent in the Pennsylvania coal regions. During mining operations, pyrite (FeS_2), also called "fool's gold", was disturbed and made available to contaminate runoff. Both iron sulfate and sulfuric acid form during this oxidation process. Upon entering an aquatic ecosystem, the sulfuric acid has a detrimental impact on the ecosystem.

Decaying vegetation, in sediments lacking oxygen, slowly release sulfides which undergo other chemical reductions to form hydrogen sulfide and gaseous sulfur.

We did not ask ***Snapshot*** participants to measure sulfate; however, about 25 test results were submitted. They ranged from 0 mg/l (or not detectable) to 750 mg/l. Frequently sulfate is simply reported as "less than 50 mg/l" which is the detection limit for some tests and well below the applicable water quality standard of 250 mg/l.

Report Header Information

Station Identifier

The header information on the data sheets filled out by ***Snapshot*** participants gives us sufficient information to identify the site and location, date and time of survey, and the name and addresses of the investigators who volunteered. The stream's name is identified. The location of the station is described by using landmarks. This helps to identify the station for repeat visits and for comparisons of data from one year to the next.

Remember: You should always get the landowner's permission before entering upon private property.

The "river mile index" is the distance upstream from the mouth of the stream on which the survey site is located. The river mile index and latitude/longitude are specific locators for the site. To complete this part of the investigation, a photograph may be helpful in identifying station location and documenting habitat conditions. Stream width, the distance from bank to bank, is measured or estimated at a spot representative of the stream width in the reach being assessed. Additional observations should be reported in the extra space on the data sheets.

Maps are always very useful in understanding field survey work. You might want to use a U.S. Geologic Survey topographic map or simply use hand-drawn maps to illustrate major landmarks, features, orientation, vegetative zones or buildings that might help in data interpretation and future visitations to the site.

Weather Conditions

We observe the general weather conditions on the day of the survey as well as whether there was precipitation within two days prior to the day of the survey. This information helps us to interpret how precipitation, air temperature and intensity of sun may have affected the survey results.

Of course, it is important to clearly indicate units of measure on all readings. This is exceedingly important if you deviate from the units of measure being requested.

Keystone College participant titrates a water sample in an erlenmeyer flask.

Water Quality

We asked volunteers to measure and record values for each of the water quality factors indicated below. Some of these require using the appropriate, calibrated, instruments:

Water Depth: Surveyors are asked to estimate the vertical distance from the water surface to the stream bottom at a representative depth to obtain average depth.

Turbidity: Turbidity is most simply measured with a Secchi disc or if not measured directly, the observer can simply note the term which, based upon visual observation, best describes the amount of material suspended in the water column. Soil erosion contributes to warmer water temperatures by increasing the amount of suspended solids carried by the water, causing the water to be cloudy (turbid). Cloudy water absorbs the sun's rays and, as a result, the water temperature rises. Very turbid conditions reduce the efficiency of fish and insect gills, and reduces reproductive success in many kinds of aquatic life.

Sediment Odors: Participants may want to disturb sediment in a pool or any depositional area in the watercourse and note the odors associated with sediment. Odor can be a clue to pollution from petroleum or sewage, or simply that natural de-composition is taking place.

Some participants choose to turn over several rocks which are not too deeply embedded, sniff them to note any odors, and also observe and indicate whether the undersides are black. Black bottoms or sulfur odor can indicate low dissolved oxygen or anaerobic conditions.

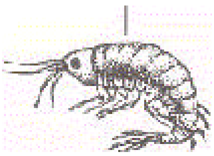
Aquatic Life Observed

The kinds and relative dominance of aquatic plants and animals are collectively an ecological assemblage that responds to all influences acting upon the environment. Aquatic and semi-aquatic vegetation provides refugia and food for aquatic and semi-aquatic life forms. Land animals and birds also utilize aquatic and wetland plants. By asking volunteers to list algae, rooted plants, fish, amphibians and invertebrates, we can get a better perspective of the health of the ecosystem. Participants also noted the type of instruments they used.

Here is a partial list of the aquatic life – or sometimes not-so-aquatic life - observed:

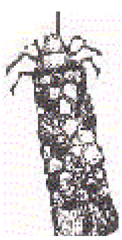
Alderfly

Algae on rocks
Amphibians
Amphipod

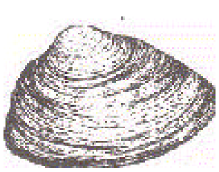


Annelids
Aquatic Worm
Asiatic Clams
Beetle Larvae
Benthic Algae
Birds
Blackfly

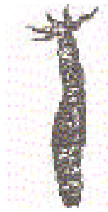
Bloodworm
Brown Trout
Buffalo and goat on side of hill
Caddisfly
Caddisfly Larvae



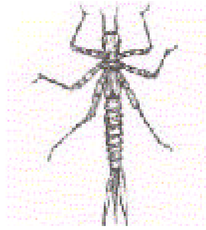
Canada Geese
Celadine (Rock Poppy) growing in sand pockets
Clams



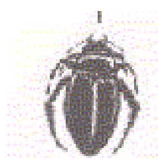
Cormorants
Cottonwood Trees
Cranefly
Cranefly Larvae



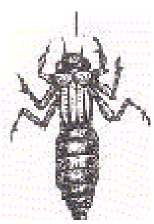
Crayfish
Damselfly Nymph



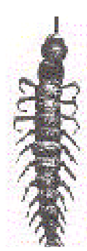
Damselfly
Dead Frog
Deer
Diatoms
Diving Beetles



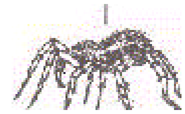
Dobsonfly
Dobsonfly Larva (Hellgrammite)
Dragonfly
Dragonfly Nymph



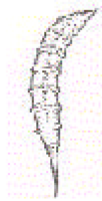
Duck
Duck Potato
Duckweed
Earthworm
Elodea
Fish
Fishfly Larva



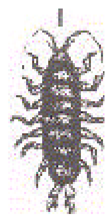
Fishing Spider



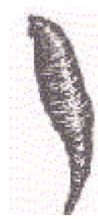
Flatworm
Geese
Gnats
Goose on Nest
Grasses
Herring Gulls
Hornwart
Horesefly Larva



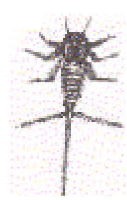
Isopod



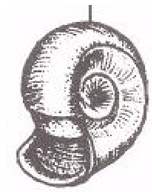
Jewelweed
Leeches



Mallard Ducks
Maple
Mayflies
Mayfly Nymphs



Midge Larva
Mink
Minnow
Moss
Newts
Orb Snail

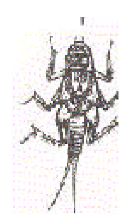


Pickerel weed
Planaria

Plants
Pouch Snail

Pyralid (moth)

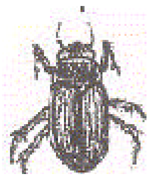
Raccoon
Red Worm
Rooted Aquatic vegetation
Salamander
Scuds
Severe Algae Bloom
Shrubs
Snail Eggs
Snails
Sowbug
Speedwell
Spatterdock
Stonefly
Stonefly Nymph



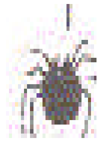
Sweet Flag
Threadworms

Tree Roots

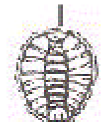
Turtlehead
Various Trees
Water Beetle



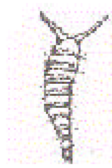
Water Lily
Water Mite



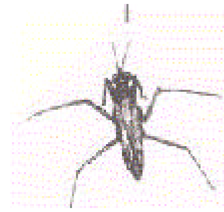
Water Penny



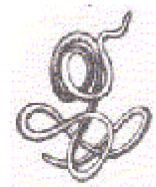
Water Snipe Fly



Water Striders



Water cress
Willows
Worms

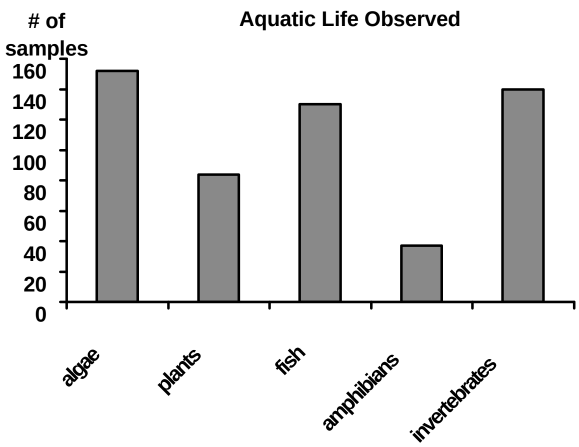


Volunteers were able to observe and identify a rather long list of creatures and plants. The list is especially rich in macroinvertebrates, including many aquatic insects. Much more information about the major orders of aquatic insects follows.

Mr. Griffin runs tests for dissolved oxygen and discusses the results with James Siene and Stephen Lengye (right) as classmates look on.

MAJOR GROUPS OF AQUATIC LIFE OBSERVED

Volunteers also noted the presence of algae, rooted plants, fish, amphibians and invertebrates at their sites (Figure 7). Of course, algae and invertebrates were most common. Although least frequent of the categories was amphibians, it was good to see that 37 respondents found them.



(Figure 7)

Habitat Assessment

Before entering any stream, think about your safety! Work only in small wadeable streams or in the wadeable shoreline of large streams and deep rivers. Never work alone. Sample with a partner onshore. Know your limits and don't exceed them; no one should enter fast moving water, ice cold water, or water more than 2 feet deep. Dress for the occasion and wear non-slip shoes or felt-soled boots. Wear a life-vest. It's not a sissy thing to do. There is a good reason why Fish Commission and U.S. Coast Guard personnel ALWAYS wear them when working in, upon, or near water! Have a bundled safety line or throwable buoy stationed downstream that can be tossed out by the partner in the event the person sampling falls and is carried downstream by the current. When in doubt, DON'T.

Habitat assessments can be accomplished by selecting key features and rating or scoring them. This information will provide evidence of their association with, or impact upon the whole stream system. Both physical characteristics and water chemistry should be considered when characterizing the stream.

Last year we introduced the ***Snapshot*** participants to visual habitat assessment. An understanding of the role of habitat will help you to find and understand problems in the aquatic ecosystem. The habitat assessment included a simplified version of several physical characterizations routinely used in professional biological surveys.

PROCEDURE FOR PERFORMING HABITAT ASSESSMENT

After selecting the reach to be assessed, the habitat assessment is performed on 100 yards (or meters) of stream. If you do both biological sampling and habitat assessment, both should be done in the same reach. It is best to perform the biological sampling first. Complete the **Habitat Assessment Sheet** by checking off the most applicable description in each category. Do this in teams of two or more investigators, if possible. This will help you to become more consistent in your determination, it is safer, and it improves quality assurance.

When we assessed the habitat we used a visual comparison of conditions and rated them as "Excellent", "Good", "Fair" or "Poor". Our method was loosely based on the one given in the **EPA Rapid Bioassessment Methods Manual**. Anyone interested in this topic should review this manual, which is available on EPA's website: http://www.epa.gov/owow/monitoring/rbp/

Learn the methods given there. This will give you a very good background, and you will find the methods are rather easily adapted and amended to cover special situations that you might encounter.

One requirement for all organisms is suitable habitat in which to live – to hide, rest, acquire food and reproduce. When we observe freshwater systems, we are usually concerned about the well-being of fish, amphibians, reptiles and insects, which spend at least some portion of their life in the water. Typically, we determine the quality of the habitat with a simple visual assessment of physical characteristics. We assigned an "overall" rating after looking at the following seven factors:

1. **Instream cover for fish, amphibians and aquatic bugs;**
2. **Fine particle sediments;**
3. **Flow patterns**
4. **Condition of banks;**
5. **Disruptive pressures to riparian zone;**
6. **Riparian zone vegetative width;**
7. **Litter.**

Instream cover for fish and aquatic bugs – This assessment factor focuses upon the cobble, large rocks, wood and undercut banks. These are the places where fish and bugs feed, live, hide and raise their young. The more kinds and amount of cover, the better, because this equates to an increase in habitat diversity. It is often easy to see that as cover increases, the diversity of life increases. Submerged logs and other pieces of wood are among the most productive habitat structure for fish, amphibians and aquatic insects.

Fine particle sediments such as sand, silt and mud – Here we are considering two very important conditions rolled into one: sediment deposition and embeddedness. **Embeddedness** refers to how much the potential cover is covered or surrounded by silt, sand or mud. Less is better in order to provide the maximum amount of cracks and crevices for macroinvertebrates and fish. We are also looking at **sediment deposition,** which measures the *amount* of sediment that has accumulated. When rocks are deeply stuck into fine sediments and the bottom is mostly sand, silt or mud there is a loss of habitat. Lots of silt and mud is also a good indication there may be erosion of banks or loss of topsoil in the watershed. Much sediment deposition and embeddedness are symptoms of an unstable environment that, in bad cases, will limit the variety and numbers of organisms living there.

Flow patterns - Patterns of velocity and depth are observed because they are features that further enhance habitat diversity. More patterns usually means the stream is a stable aquatic environment with better habitat diversity. Therefore, the best streams (as far as diverse habitat is concerned) will have all four patterns present: (1) slow deep; (2) slow shallow; (3) fast deep; and (4) fast shallow. There are some more-or-less technical guidelines to tell fast from slow, and shallow from deep; however, eyeballing the stream and making a judgement call works pretty well.

Condition of banks and coverage – With this factor we determine whether the stream banks are eroded or have the potential for erosion. Gently sloping banks are usually more stable than steep banks. Look for signs of erosion such as collapsing, guttered, crumbling or unvegetated banks and large areas of exposed tree roots, and exposed soil. Eroded banks lead to the previously mentioned sediment deposition. Also, look at the amount of plants growing on the bank and the near-stream portion of the riparian zone. The root systems of plants help hold soil in place and increase the ability of the bank to resist erosion and keep nutrients from washing into the stream. In the past, many aquatic biologists felt it was a good idea to score the worse of the two banks, applying the logic that a chain is as strong as its weakest link. However, now, looking at each bank, evaluating them separately, and reaching a consensus on the combined score for both right and left banks is gaining favor.

Disruptive pressures – The riparian area (roughly, the floodplain) and banks may be subjected to grazing, trails and paths, sidewalks, lawn, residential and urban development activities, et cetera. This is not good. When the growth of a *natural* plant community is lost, frequently the area becomes compacted, eroded and later "repaired" with riprap, concrete or boulders. The lack of canopy provides little shading, cooling or detritus to the stream. If you are good at plant identification, you should note if shrubs, trees and herbs are "exotics" or "native." Some exotics are invasive and tend to "take over," eliminating nearly all the native vegetation. Monocultures, often exotic vegetation such as purple loosestrife, reduce the diversity and quality of the habitat.

Riparian zone vegetative width – This factor measures the width of natural vegetation from the edge of the stream bank out through the vegetated "riparian" or "buffer" zone. The zone restricts runoff pollutants from entering the stream. The buffer zone also controls erosion, provides leaf-litter to the stream and habitat for many desirable species of amphibians, reptiles, mammals and birds. In some cases, wide riparian zones function as corridors for migrating and moving large and small animals. One could make the case that smaller streams can make do with narrower riparian zones, but we think wider is better in all cases. A width of 35 yards or more always allows the zone to function better in its varied roles than does a lesser width. When slopes are steeper, a greater width is needed to restrict pollutant runoff to the same extent. Therefore, we utilize the simple and effective means of determining quality based upon width and disruptive pressure. Again, it is gaining favor to evaluate each zone separately and arrive at a consensus for the score.

Litter - Looking for litter indicates, to some degree, human usage of the watercourse and local pride of the watershed. It can make us more aware of our presence in the watershed and how simple carelessness disrupts the natural beauty of an area. It also helps groups select areas for clean-up projects and lots of litter, tires, barrels or other items present may indicate illegal dumping or sources of pollution.

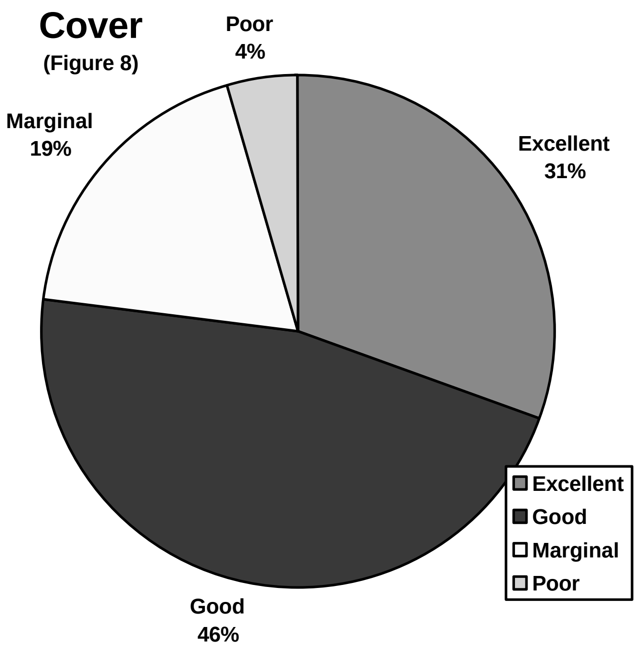
Overall – Simply determine the category that you think best describes the habitat in the area you studied. Think about the interaction of all the factors you looked at and measured. It is best if several people discuss their ideas and reach a consensus on the combined score after all things are considered. If you were a fish or bug who had to live here, how would you rate this place?

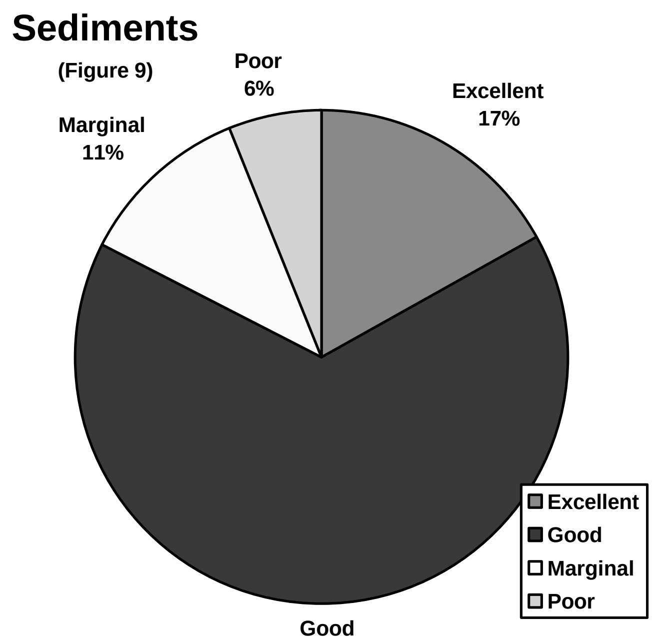
In addition to the above factors, sometimes it is desirable to include quantitative measurements as part of your habitat assessment. The idea is to form a mental picture of the condition of a stream system and to tie that in with the community of living organisms supported by those physical conditions.

Habitat Findings

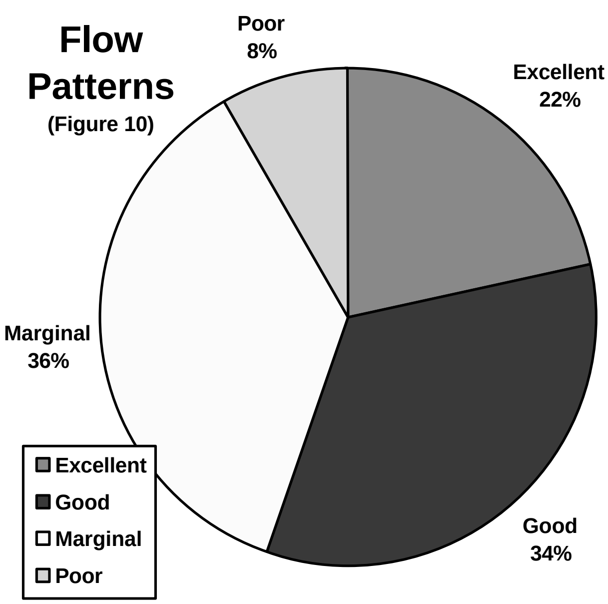
The assessment area we are primarily concerned with is restricted to the stream, its banks and floodplain or riparian area. Together, this is the area that primarily affects the life structure of the stream. The best news is that "overall" scores show 80 percent of the sites were assessed as ***good*** or ***excellent***. The worst news is that nearly 4 out of 10 sites have ***poor*** or ***marginal*** riparian zone widths. Also, scoring poorly was "Flow Patterns," however, this is less distressing because the limited patterns are often natural, due to the lay of the land (underlying rock formations), or even due to precipitation causing high or low flows. The results of your assessments were graphed and are shown on the following pages. The habitat assessment form we used simply combined the eight assessment factors used as the headings for the graphs.

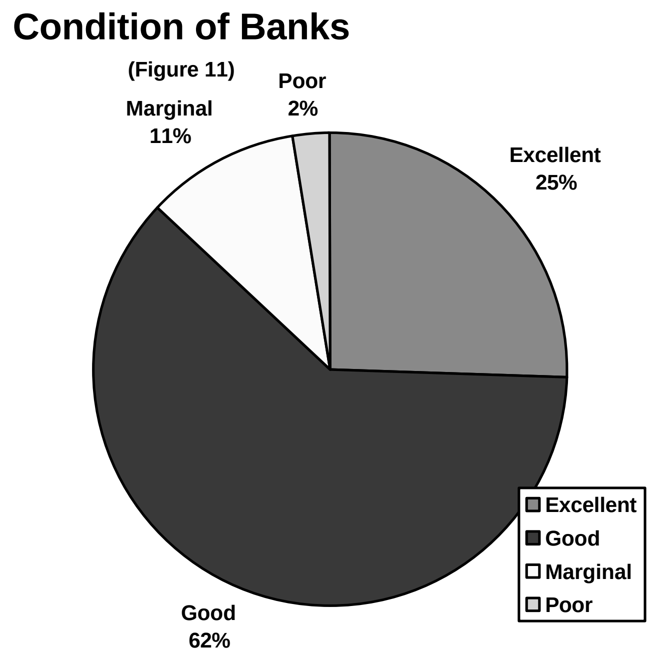
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
1. Instream cover (fish and aquatic bugs)	The stream contains lots of boulders (over 10"), cobble (2-10"), submerged logs, undercut banks or other stable habitat	There is adequate habitat of both rock and wood for maintenance of diverse populations of fish and bugs	Some rock and wood or other stable habitat but much less than desirable	Not much stable habitat; lack of habitat is obvious
2. Fine particle sediments: (sand, silt, mud)	The rocks in the stream are not surrounded by fine sediments; I see very little sand, silt, or mud on the bottom	Rocks are partly surrounded by fine sediments. I could easily flip over the rocks on the bottom	Rocks are more than half surrounded by fine sediments; rocks are firmly stuck into sediments	Rocks are deeply stuck into fine sediments; bottom is mostly sand, silt or mud





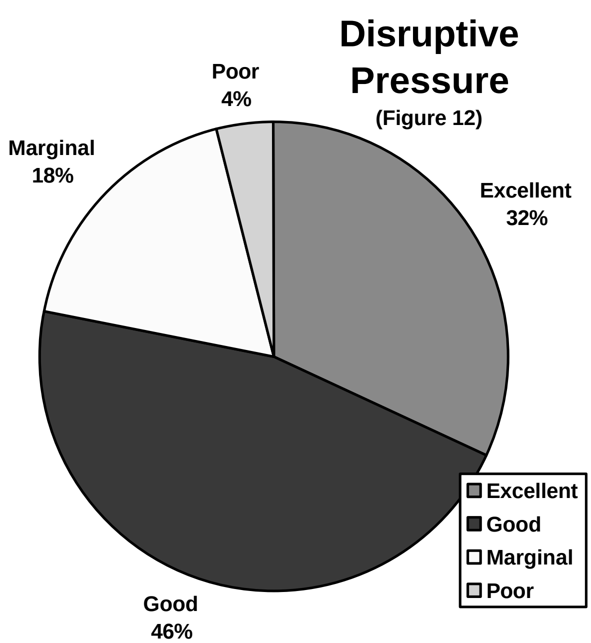
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
3. "Flow patterns": How many does the stream have....	All 4 of these velocity/depth patterns are present within 50 yards upstream or downstream of this site: **slow/deep, slow/shallow, fast/deep, fast/shallow**	Only 3 of 4 regimes (flow patterns) are present	Only 2 of the 4 regimes present	Dominated by 1 velocity/depth regime
4. Condition of banks and coverage?	The banks are stable; no evidence of erosion or bank failure; the whole bank is covered with vegetation or rock	Moderately stable; some small areas of erosion mostly healed over; most of the bank is covered by vegetation or rock	Largely unstable; almost half of the bank has areas of erosion or is NOT covered by vegetation or rock	Unstable; eroded areas; "raw" areas occur frequently; less than half of the bank is covered by vegetation or rock

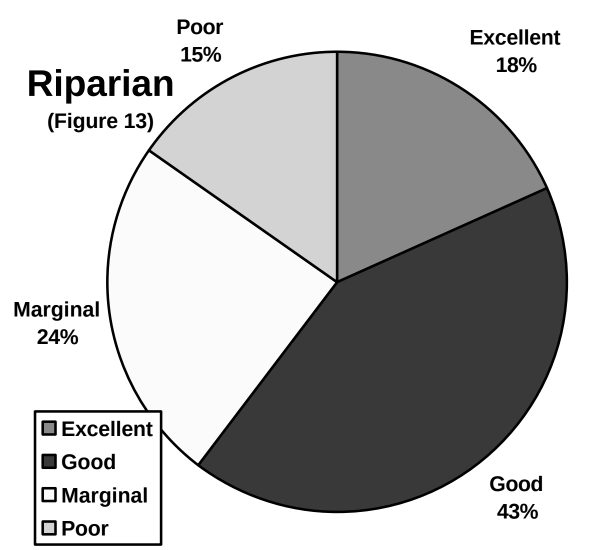




Lisa Clark, Hannelore Scharzenbacher, Ethan Crawford and Matt Hudson begin to identify organisms collected from Vandermark Creek. All four are members of the Delaware Valley High School Environmental Club.

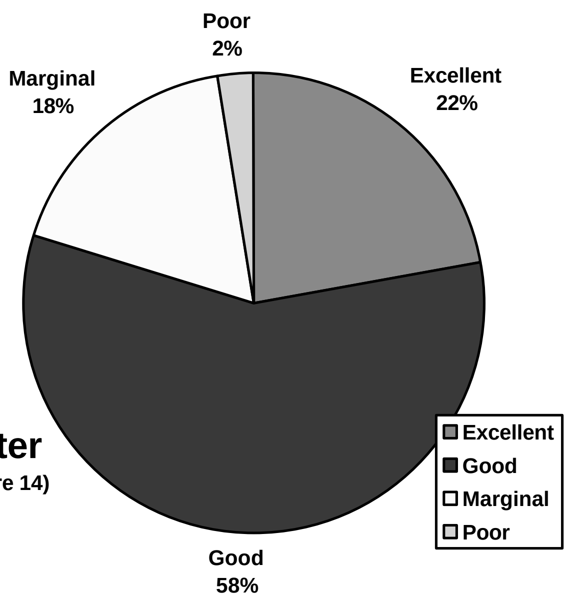
ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
5. Disruptive pressures to the "riparian" (land bordering stream banks) area?	Trees, shrubs or grasses have not been disturbed through forestry, grazing or mowing; almost all plants are growing naturally. Mature trees, understory and vegetation are present	Some disruption but not affecting full plant growth potential to any great extent; Trees, woody plants and soft green plants are dominant	Disruption is obvious; some patches of bare soil, cultivated fields or closely cropped vegetation are the norm	There is not much natural vegetation left or it has been removed to 3 inches or less in average stubble height
6. Riparian (land bordering stream banks) vegetative zone width	Riparian zone is more than 35 yards wide; human activities (parking lots, roads, clearcuts, lawns or crops) have not impacted zone	Riparian zone 12-35 yards wide; human activities have impacted zone only minimally	Width of riparian zone 6-12 yards; human activities impacting zone are commonly evident	Width of riparian zone is less than 6 yards; lots of nearby human activities



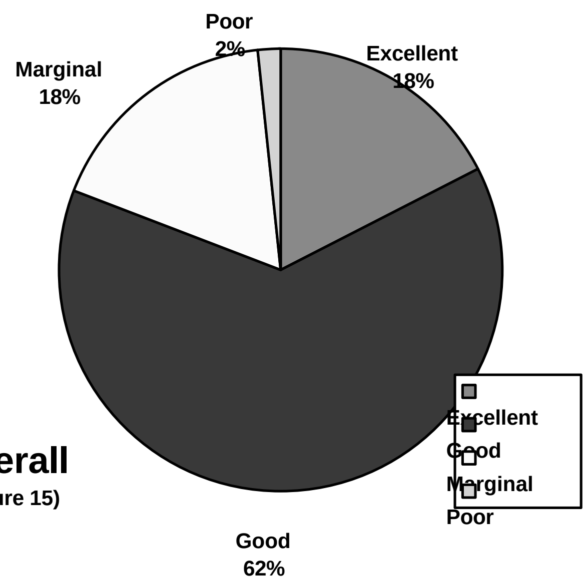


Han Wang, Andrea Walczak, Michael Mandel and LeeAnn Tran check nutrient amounts using colorimetric test kits.

ASSESSMENT FACTOR	EXCELLENT	GOOD	MARGINAL	POOR
7. Litter	There is no litter in the area	There is very little litter in the area; probably some degradable paper accidentally dropped by fishermen or hikers	Litter is fairly common and includes metal or plastic, obviously purposely dropped.	Area is a candidate for a clean-up project. Lots of litter, dumping, tires or barrels present
8. Overall I Rate the VISUAL ASSESSMENT of this site...	EXCELLENT	GOOD	MARGINAL	POOR



Litter
(Figure 14)



Overall
(Figure 15)

Matt Noorbakhoh, Shaheen Fakhar and Olivia Cheng used a D-frame net to capture aquatic insects as part of their stream assessment work.

The Bug Report

Water is required by all the organisms on earth. Clean water is crucial to achieving ultimate health for nearly every living thing, and you are one of them.

Congress passed the Federal Clean Water Act of 1972, to restore and/or maintain the good integrity of the water throughout the United States. Since then, there has been an accelerated interest in the ways developed and used to "score" the quality. It is very common to study the community of living things in the water as well as water chemistry. The idea simply being, if a certain kind of bug requires clean water and you find that kind of bug, the water must be clean. The presence of the bug indicates the kind of conditions that exist. Such an organism is called an indicator organism – when its presence indicates that the specific environmental conditions required for life of the organism are being met.

The number of pollution combinations that can occur is endless, and in many cases it is impossible to fully interpret and understand chemical composition. So, in addition to learning what we can about chemistry, we like to look at who lives in the water. Fish, amphibians, plants, algae and bugs and other life forms all have their stories to tell. The story most studied is that of a group called benthic macro-invertebrates – commonly referred to as "water bugs," although the group is much more than just bugs. It also includes worms, crayfish, and clams and the like. "Benthic" means under water and on the bottom. "Macro" means "large" and in this case "large" means big enough to be seen without a magnifying glass – sort of the opposite of "micro." "Invertebrate" means without a backbone. So, benthic macro-invertebrates are any form of animal life big enough to be seen, not having a backbone, and living at least part of its life on the bottom under water.

Picking and sorting macro-invertebrates for identification.

The primary actors are aquatic insects: mayflies, stoneflies and caddisflies usually get starring roles in biological assessments. These are the ones we will focus on in this edition of ***Earthday Snapshot of Water Quality***. Usually the supporting actors are still more insects: dragonflies; crane flies; fishflies and beetles. Cameo appearances go to true bugs, black flies and midges and other aquatic insects. Guest appearances and walk-on roles are handled by worms, leeches, crayfish, clams and whoever else comes up in the net. Hopefully we will be able to more fully discuss these groups in future editions of this report.

These so-called "bugs" have varying degrees of sensitivity to pollution. Some are very sensitive to their environment, making them very good indicators of water quality. Most spend at least several months exposed to the water: some spend a year or more in the immature stage before leaving the water as an adult, and still others never leave the water. Therefore, a period of time exists in their lives that they could not escape water pollution, if it occurred. The trick is in knowing who can tolerate what. For instance, mayflies would quickly give up the ghost in conditions that the leech family would consider "party-city." That's why most mayflies are called pollution *intolerant* and leeches are called pollution *tolerant.* Therefore, your stream scores better when you find mayflies.

A Word about Taxonomy

In order to use macroinvertebrates as indicators of water quality, you will need to identify them using an antiquated system known as "taxonomy" or "taxonomic nomenclature." This is a Latin naming system developed in the 1730's by Carl Linnaeus, and it has been jiggled around ever since. Nowadays most taxonomic texts begin by noting the specific scheme used by the author, as there is much disagreement as to which organisms belong where. The most frequent problems are usually at the genus level. Usually the disputes are about whether certain groups warrant their own genus name. Many biologists look forward to the day when a simpler system based on genetics will replace this system, which is based mostly on physical characteristics. But for now, this is all we have. The method breaks things down into more and more specifically defined categories: Kingdom; Phylum; Class; Order; Family; Genus; Species. Some people tack "Individual" on to the end, but for most work that is completely unnecessary. You can remember the ranking system by making up a mnemonic phrase such as, "Kind people, come over for ginger snaps." "Kind - K" for kingdom, "People – P" for phylum, "Come – C" for class, etc. The further you identify the organism the better results you can obtain by using the organism as an indicator of water quality. We aim to identify things to the genus level, but even the family level can be quite useful. Identification to family can usually be determined in the field by a skilled observer, without the aid of any special equipment beyond an inexpensive magnifying lens.

It is not a popular thing to say in certain circles, but many biologists feel your pain when it comes to taxonomy. Learning Latin names is not easy, and as more is learned and DNA analysis is done, we are learning that relationships are often far from what was previously thought. Through many hurdles we have yet to hurl. Still, when it comes to bugs, most don't have common names, so it might help to simply think of the Latin name

as the bug's common name. Until the whole naming system is overhauled – which will take decades – you'll see the family names and most of the genera used here

.

Pollution Tolerance

Stoneflies and mayflies are sensitive to many factors including alkalinity, chloride, hardness, iron and sulfate and therefore are good indicators of water quality. Beetles are not considered to be very significant as water quality indicators with the notable exception of Elmidae and related families.

Elmidae and related families are intolerant of water with pH below 4.5, and they are sensitive to high alkalinity, chloride, iron, sulfates and low dissolved oxygen. Chironomidae (midges) represent Diptera (the true flies) in most chemical extremes.

Some Chironomidae can tolerate pH below 4.5, and high iron (>5.0 mg/l), high sulfates (>400 mg/l) and low dissolved oxygen (<4 mg/l) situations. Chironomidae are therefore not usually useful indicators of acid precipitation impacts. Details of tolerances for many of the other true flies are poorly known. Table 3 lists a summary of what *may be* the extreme chemical tolerances for seven orders of aquatic insects, although admittedly it is very incomplete. A "Yes" means that the order has been collected under this condition frequently enough to suggest that the condition can be tolerated. This does not imply that these are preferred conditions. Remember, different families and genera in each order often have different abilities to tolerate chemicals or environmental conditions. Much work is still to be done in establishing tolerance limits of most organisms to specific chemicals, environmental conditions and thermal pollution.

Miranda Stewart measures stream depth.

TABLE 3

ORDER	PH <4.5	PH >8.5	Alkalinity >210	Chloride >1000	Iron >5.0	DO <4	Sulfate >400	Biochemical Oxygen Demand >10.0
Odonata (Dragonflies)	no	yes	yes	yes	no	yes	yes	yes
Ephemeroptera (Mayflies)	no	yes	yes	yes	no	yes	yes	yes
Plecoptera (Stoneflies)	no/yes*	yes	no	yes	no	no	yes	no
Megaloptera (Dobsonflies)	yes	yes	no	no	yes	yes	yes	no
Coleoptera (Beetles)	yes	yes	yes	yes	yes	yes	yes	no
Trichoptera (Caddisflies)	yes	yes	yes	yes	yes	yes	yes	no
Diptera (True Flies)	yes	yes	yes	yes	yes	yes	yes	yes

*Nemouridae and Leuctridae

Setting up a portable lab for streamside analysis of water samples.

The hard part, but also a fun part, is learning to identify a lot of creatures who you've never seen before in your life! Let me repeat that *this is the hard part* – but also a fun part! More and more simplified keys and aids are becoming available through this department, the Fish and Boat Commission, watershed organizations, environmental groups, universities and dozens of internet sites. It's good advice to use simplified keys at first, and learn from other people. Really, it isn't as hard as it seems at first. An orange, grapefruit, lemon, lime and tangerine look a lot alike and share many characteristics with one another. But, because you're familiar with them you have no trouble telling one from the other. It's like that with bugs or anything else. It's a matter of familiarity rather than a test of superhuman intelligence. Fly fishers are usually good aquatic entomologists – studiers of insects – and often are quite helpful with identification.

By learning to identify a few invertebrates now and a few later, you will soon amaze yourself and your friends and it will be all you can do to not show-off this new found ability! If you are enthusiastic about the topic of macroinvertebrates and want to hone your identification skills, consider owning the best professional keys you can find. Books such as Aquatic Insects of North America by R.W. Merrit and K.W. Cummins or Freshwater Macroinvertebrates of Northeastern North America by Barbara Peckarsky et.al., are practically necessary to identify the organisms to the genus level. At first they can be intimidating to use, but they are excellent professional texts. Go slow. Don't give up. Don't worry about making mistakes. Despite what you were led to believe in school, there is no jail sentence for getting the wrong answer.

In **Appendix F** of this booklet we've included a list of the macroinvertebrates that we've found in the streams and rivers (lotic systems) of Pennsylvania. The list can be used to help assure yourself that the "bug" you identified is one that occurs in the state. The list is not all-inclusive because we tend to work almost exclusively in the riffles of streams. If you sample ponds or lakes (lentic systems), or slow moving backwater areas of streams, chances are good that you will find macroinvertebrates not on the list.

An Introduction to Biological Indexes

Mayflies, stoneflies and caddisflies are the stars figuring most prominently as indicators of water quality. This is true partly because a biologist named W.L. Hilsenhoff developed a biological way of showing that most families of mayflies, stoneflies and caddisflies do not tolerate much organic pollution. Most require plenty of oxygen, too. In the **Hilsenhoff Biological Index**, each kind of critter is assigned a value from 0 to 10, according to how well it puts up with pollution. A "bug" gets a zero or one if it tolerates almost no organic pollution and a nine or ten if it can live in a nasty, polluted environment. Remember that this is like golf – lower scores are better than higher scores. "Zero" can be thought of as meaning zero tolerance for organic pollution.

To use the index, first you "simply" identify each of your bugs to its respective genus. Then look up the score for each genus (for this you need the listing of "bug scores", which is included as Appendix G of this booklet).

Now don't panic. Let's make up an example and see how it works. You can do this, despite the ridiculously hard looking formula.

The formula is this:

$$HBI = Sum\ x_i\ t_i / n.$$

The code to the formula is this:

HBI is an abbreviation for Hilsenhoff Biotic Index

"x_I" stands for the number of individual bugs you found within a genus.

"t_i" stands for the bug score value you looked up for each genus.

"/" means "divided by".

"n" stands for the total number of bugs you collected at this particular site.

"Sum" means add together all the numbers you get when you multiply each set of "x_I" and "t_i" together.

Follow the example and then try it by plugging in your own numbers.

Example:

So, suppose you netted and identified 102 bugs total. That means 102 is going to be the number that goes in where the "n" is. Let's say you've figured out that you have seven different kinds of bugs and you looked up all of Mr. Hilsenhoff's bug scores in ***Appendix G*** of this booklet. You found out that 22 bugs scored a "2", and 25 bugs scored a "3", and 15 bugs scored a "4", and 20 bugs scored a "5", and 10 bugs scored a "7", and 5 bugs scored an “8”, and 5 bugs scored a “9”. Those numbers are your scary “x_i” and “t_i” numbers that you must multiply together. So, you write:

(22x2)+(25x3)+(15x4)+(20x5)+(10x7)+(5x8)+(5x9)

Or,

44+75+60+100+70+40+45 = 434

Then you divide 434 by the total 102 bugs:

434/102 = 4.25!

Now you have something – your very own Hilsenhoff number! You can use it to compare this site to any other and you will be able to say which one probably is less polluted. The one with the lower score!

Believe me, interpreting the hints the bugs give to us is no easy task, but the next index is easier than the one we just did. The “**EPT Index**” is another famous “index” used to decipher what the bugs are trying to tell us about the water. The EPT Index got its name like this:

The Order of mayflies is called *Ephemeroptera*, sometimes shortened to “E”.

The Order of stoneflies is called *Plecoptera*, sometimes shortened to “P”.

The Order of caddisflies is called *Trichoptera*, sometimes shortened to “T”.

To use the EPT Index, identify all E’s, P’s and T’s to their family (or genus*). Then add up how many families you got. Higher scores indicate better quality than lower scores.… easy enough?

Just as simple as the EPT Index is one called **Richness**. This is simply the total number of families (or genera*) found at the site. Usually the total decreases with degradation, and usually more is better; but small infertile mountain streams are often low in taxa richness, even when nearly pristine. So, the rule doesn’t always hold true.

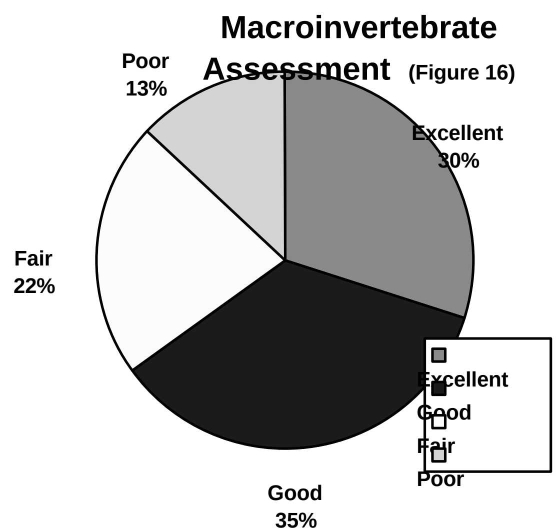
**Note: Working at the genus level may give better results, but more importantly, identify to the same taxonomic level for all streams you wish to compare!*

To figure out **Percent EPT**, simply count the number of bugs in your sample that are E’s, P’s, or T’s and divide by the total number of bugs in the sample. If you collected 133 bugs and 40 were EPT’s, divide 40 by 133 to get 30%. Usually the percent decreases with degradation. **Percent EPT** is another simple, yet very effective index for comparing/contrasting streams.

There are lots of other biological indexes and the more of them you test out the surer you will be about the quality of the water, as indicated by the community living in it. If this is the kind of thing you have an interest in knowing more about, one recommended source of information is EPA’s book called Rapid Bioassessment Protocols For Use In Streams And Rivers – Benthic Macroinvertebrates And Fish. This is available online through EPA’s website: http://www.epa.gov .

Macroinvertebrate Assessment Findings

Earthday Snapshot volunteers did macroinvertebrate assessments at seventy-seven sites. They used the simplified key to macroinvertebrates and scoring system supplied with the ***Earthday Snapshot*** packet. Macroinvertebrates indicate that the health conditions of the observed waterways were almost perfectly divided into thirds: 1/3 was Excellent, 1/3 was Good and 1/3 was less than desirable – only fair or poor. The results are shown in the following graph (Figure 16).



The Star Actors

The characteristic inability of the mayflies, stoneflies and caddisflies as a whole, to tolerate some types of pollution has led to their increasing use as pollution indicators in environmental quality assessments. In this edition of ***Earthday Snapshot of Water Quality***, we are emphasizing these three major orders.

Family descriptions are given for stoneflies and caddisflies. Most of the families of mayflies found in Pennsylvania are listed along with their preferred habitat. Other sources of information on them are easily found on the Internet and in published literature. This section is best used along with a good reference book with drawings. The previously mentioned books (Aquatic Insects of North America, by R.W. Merritt and K.W. Cummins or Freshwater Macroinvertebrates of Northeastern North America by Barbara Peckarsky) serve well, as do others. We strongly recommend tapping into as many resources as you can find. These and other books on the topic are available through many libraries, as are some professional entomological and freshwater biology journals. Several simplified keys to aquatic macroinvertebrates are available on the Internet, and local watershed groups or environmental organizations often have these resources available. A handy introduction to many of the benthic macroinvertebrates discussed in this report can be found at this website: http://osfl.gmu.edu/~avia/page1.htm . This site includes photographs and keys. It was constructed by Allyson Via-Norton, Amy Maher, and Diane Hoffman and all images are copyrighted - Jones & Bartlett Publishers. Another nice key to most families of mayflies and additional information on them can be found at this website: *An Identification Guide to the Nymphal Mayflies* by Karen M. Needham http://www.for.gov.bc.ca/ric/pubs/aquatic/mayfly . These Internet sites are not affiliated with DEP.

A student from LaSalle Academy checks water temperature using a simple waterproof thermometer.

Mayflies (Order Ephemeroptera)

Some people think mayflies are an extremely old group of insects, perhaps utilizing the cooler streams leading to the swamps and depressions wherein formed the coal deposits of Pennsylvania, as long as 350 million years ago! The aquatic nymphs are sometimes called naiads. Almost all mayfly nymphs (and adults) have three tails. But, a couple genera in the family *Baetidae*, as well as *Heptageniidae* and *Epeorus* have only two tails – more properly called caudal filaments. The nymphs don't have real wings, but they have bumps called wing-pads where you'd expect to see wings. They have three pairs of segmented legs on the middle part of the body – typical for an insect. Each leg ends with a single hook. The gills are on the abdomen, the rear 1/3 of the bug, and look a little bit like tiny feathers or leaves.

Most mayflies live in the water for close to a year as nymphs and two to 72 hours as adults. The main function of adults is simply to mate and die – and, of course, to excite trout anglers. Nymphs eat tiny algae and organic debris, but the adult's mouths don't work for taking in food, so they do not eat. Both nymphs and adults are an important food for fish. For this reason, trout anglers like to use artificial flies that look similar to the kind of mayfly that is most abundant in the water or hatching from it.

Many kinds of mayflies prefer the cooler, bubblier (highly oxygenated) streams. In such places they live among the cobble and under rocks. There are also some species that live in the mud and water column of ponds and temporary pools where they serve as a very nutritious food source for immature salamanders and other bigger bugs like diving beetles and water scorpions.

The gray shaded families in Table 4 have Hilsenhoff Scores of three or less and are therefore considered very sensitive to pollution. After looking at collections from several hundred riffle/run stations across the state, we find these families occur at the listed percent of stations.

Mayfly families: Table 4

Mayfly	Habitat	Percent Occurrence
Heptageniidae	Lotic & Lentic-Erosional	69%
Baetidae	Chiefly Running Water	59%
Ephemerellidae	Chiefly Running Water	42%
Isonychiidae	Riffles	36%
Leptophlebiidae	Fast-Flowing Waters	32%
Ephemeridae	Lotic & Lentic Burrowers	12%
Ameletidae	Stony Upland Streams	4%
Caenidae	Lotic-Deposit/Lentic Littoral	4%
Tricorythidae	Lotic-Deposit/Lentic Littoral	2%
Baetiscidae	Lotic-Deposit/Lentic Littoral	2%
Polymitarcyidae	Burrowers In Stream & River Beds	2%
Potamanthidae	Lotic-Depositional	1%
Siphlonuridae	Chiefly Running Water	1%
Neoephemeridae	Lotic-Depositional	<1%

A shaded riffle area provides good habitat for stonefly nymphs.

Stoneflies (Order Plecoptera)

There are at least 134 stonefly species known to inhabit Pennsylvania. All stonefly nymphs contain two stout tails. Like mayflies, they have three pairs of segmented legs on the middle part of the body, but on the end of each leg are two hooks forming a claw. Sometimes gills are not found, but if they are, they are usually located on both sides of the middle part of the body (the thorax) between the legs. Most stonefly nymphs live among the leaves and stones on the bottom of flowing streams. A few might be found in "quasi-lentic" environments. What? Well, not real flowing water (lentic) environments because they are confined to the wave swept shores of cold lakes. Why? Because most stoneflies breathe through their skin or with small gills, so getting enough oxygen is a problem in stagnant water. Since most nymphs live in the rocky substrate, mainly in riffles, they are particularly vulnerable to siltation. Other forms of pollution, such as runoff containing fertilizers, pesticides and other chemicals, are also a problem for stoneflies.

Their importance as fish food has made the stonefly nymphs very well known to anglers and aquatic ecologists. Stonefly nymphs can represent a major part of the community in clean streams. Many species inhabit only tumbling, bubbling, well-aerated streams, although several species are surprisingly tolerant of acidic conditions, sometimes found at a pH of 4!

The food menu at stonefly restaurants is varied. Some nymph customers are happy with a bowl of algae, others shred leaves searching for good nutritious detritus and bacteria, while others are predaceous. Some go for the blue-plate special every day. They aren't choosy about what they eat - being omnivorous – they eat just about anything.

A typical run-of-the-mill stonefly will live about a year, and all but a few days is spent in the water in one immature stage or another. Nymphs molt frequently; one to three times a month, as they grow. (Remember that there are exceptions to all these generalizations and many are discussed in more detail in the family sections.)

Adults are usually dirty-colored browns and charcoals, and most range in size from less than ¼ inch to about ¾ inch but the very biggest ones could be a tad over 2 inches. Adults are rather squat insects typically found on plants or structures overhanging streams or lakes. Most adults are said to be weak fliers. They are most common near the waters where they developed; however, some fly fairly well and with the assistance of a breeze they are easily dispersed more than a mile from home. If you live within a mile of running water you'll probably occasionally see a stonefly that has been attracted to the light, hanging on your screen door at night. Most adults, especially males, eat very little or nothing, although some feed on algae or other tiny plant material. Like mayflies, the primary role of adults is simply to mate and die – and the excitement they bring to trout fly-fishers is second only to that of the mayflies. Some stoneflies (see Capniidae, genus *Allocapnia*) are more active in the winter months than any other aquatic insects and the adults are found walking around on the ice and snow!

All of the families in Table 5 are shaded because they have Hilsenhoff Scores of three or less and are therefore considered very sensitive to pollution. After looking at several hundred riffle/run stations across the state, we find these families occurring at the listed percent of stations.

Stonefly families: Table 5

Stoneflies	Percent Occurrence
Perlidae	**60%**
Leuctridae	**29%**
Perlodidae	**21%**
Chloroperlidae	**17%**
Peltoperlidae	**16%**
Pteronarcyidae	**15%**
Nemouridae	**14%**
Capniidae	**13%**
Taeniopterygidae	**8%**
Lestidae	**<1%**

Meet the Stonefly Families

CAPNIIDAE: SMALL WINTER STONEFLIES

Nymphs are uniformly brown, with long slender bodies and no gills. Soon after hatching in early summer, the tiny young nymphs move deep beneath the stream bottom where they diapause (become couch potatoes and do nothing) until Autumn. In October, the nymphs resume activity and grow rapidly through the winter, despite near freezing temperatures. They feed on bacteria and fungi that cling to decaying leaves. Genus *Allocapnia* nymphs live in a variety of streams, from cool, mountain brooks to large, warm rivers.

Carrying kick screen full of macroinvertebrates out of the stream for identification.

Adults of the Capniidae family are short; about 1/4 - 3/8 inch (4mm to 10mm), black stoneflies with short wings and long tails. In this family and within Pennsylvania, the genus *Allocapnia* has the most species. Unlike most terrestrial insects, which hibernate during the winter and are active only during the warm months, adult *Allocapnia* come out of their watery homes, change into adults, feed, mate and lay their eggs during the coldest months of the year. Adults can come through cracks over air pockets in ice-covered streams. In February and March, you might see hundreds of these insects appearing like black spots moving on the snow. They are also easily seen on bridge railings or road signs near streams. After mating, males and females walk away from the stream to feed on blue-green algae or lichens growing on tree bark and old wooden fences, then soon, the females flutter back to the stream to lay two batches of eggs. The females must eat something before laying the eggs or the eggs will not hatch. Each batch contains 400 to 1000 eggs.

LEUCTRIDAE: ROLLED WINGED STONEFLIES

Leuctridae nymphs are active during the summer when Capniidae nymphs are settled into the detritus for a long, long, lazy spell – diapausing. These nymphs shred fallen leaves to smithereens as they feed upon them and the bacteria that grow on them. Leuctridae stoneflies are often in streams degraded by acid precipitation or with some mine drainage, as they can endure acid conditions that most other stoneflies or mayflies and many caddisflies simply can not tolerate.

The small, slender brown nymphs are so similar to nymphs of the Capniidae family that they are very difficult to tell apart. A rare genus, *Megaleuctra*, is twice as long as any other Leuctridae, reaching up to 3/4 inch (20mm). In this family, *Leuctra* is the commonest genus, and throughout Pennsylvania *Leuctra ferruginea* is the most common species. They live in a wide range of stream temperatures. It is one of the few stonefly species with a flexible life cycle. With them, it takes a year to go from egg to adult in warm water and up to two years in cold water. Cool water temperatures cause a delay in egg hatching and slow growth. The result is a series of overlapping generations with nymphs of differing ages present at one time. Because of the staggered ages, adults are emerging from late spring through fall.

Adult Leuctridae are black or dark gray and are not much different in size from adults of the Capniidae family. While resting, Leuctridae roll their wings around their bodies so that they resemble tiny Count Draculas or cigars. Adults are found from April through October, walking around on rocks that jut out of the water. They are also seen fluttering over streams, or wasting time in streamside trees or weeds. For some reason, Leuctridae are especially keen to hang out in hemlock trees.

NEMOURIDAE: SPRING STONEFLIES

Nemouridae nymphs are separated from the similar brown Leuctridae and Capniidae nymphs by their wide-spreading wing pads. Nymphs of most genera lack gills; however, several have branched gills on the underside of the neck. Nemouridae nymphs are found in a variety of streams, from cool headwater brooks to warm rivers, as well as springs and seeps. Some genera have a summer diapause (rest) in the egg stage with rapid nymphal growth from fall through spring; other nymphs hatch immediately and grow slowly throughout the year.

Nemouridae are small, stout stoneflies, about the same small size as those previously discussed – about 1/4 to 3/8 inch (4 -10 mm) in length. As adults, the wings are much longer than their bodies and frequently have dark blotches. The brown or gray adults show up from March through September. Males of this family are relatively easy to identify down to species level by looking very closely at their reproductive organs. As it happens, they have elaborately modified claspers. Along with the penis, claspers are part of the male reproductive structures and they are used to hang onto the female while mating. Unlike the mayflies, adults of both genders have mouths that allow them to eat, and they may live and feed for several months. As with other stonefly families, females must feed for proper development of their eggs.

Amphinemura, the most common and widespread genus in the family, is found in small streams throughout North America. They are more tolerant of siltation, acid precipitation and mine drainage than most other stoneflies. *Amphinemura*, along with *Leuctra*, are often the most abundant aquatic insects inhabiting acidic streams. Four species occur in Pennsylvania: *Amphinemura delosa* and *Amphinemura nigritta,* which emerge in the spring; *Amphinemura wui*, which emerges from summer through fall; and *Amphinemura linda*, which emerges in the fall. *Amphinemura wui* and *Amphinemura nigritta* often live in the same streams. All four species have an egg diapause lasting from four to seven months. Nymphs grow slowly during fall and winter and rapidly during the warmer months. The leaf/detritus -feeding nymphs are light brown to burnt orange, with two pairs of branched gills on their necks.

TAENIOPTERYGIDAE: WINTER STONEFLIES

Taeniopterygidae are about 1/4 to 5/8 inch (6 to 15 mm) long, with slender black or dark brown bodies. Adults emerge from winter through early spring and actively move around during the daytime, feeding on tree buds, foliage or blue-green algae that grows on trees and stones. The genus *Taeniopteryx* is the earliest to emerge and can often be seen walking on the snow along with adult Capniidae. *Taeniopteryx* and *Strophopteryx* have species that are abundant in remote, pristine trout streams as well as large urban rivers. One species, *Taeniopteryx maura*, is the most tolerant of all stoneflies of organic enrichment (sewage and barnyard waste). *Taeniopteryx* adults usually come out of the river a ton at a time. And although they are right as rain, like rain become nuisances to people who don't appreciate them. Sometimes on a warm, breezy day in March, numerous *Taeniopteryx* adults spread throughout downtown Harrisburg and land on people trying to enjoy a noontime walk along the Susquehanna River. Kids get a kick out of the event, but their less amused adult counterparts usually request the government to do something, like initiate an insecticide fogging program – which isn't done. The two other Pennsylvania genera, *Oemopteryx* and *Taenionema*, are rare and restricted to cool mountain streams.

Nymphs are generally brown, with wing pads diverging away from their bodies. Some species have a pale dorsal stripe extending the length of the body; others are mottled with brown and yellow. *Taeniopteryx* nymphs are unique among North American stoneflies in having a telescopic gill on the bottom segment of each leg. Nymphs of the other genera in this family do not have gills. Nymphs are not normally collected from their stream habitat from spring until fall. Stonefly hunters were puzzled for many years as to their whereabouts until diapausing (resting) nymphs were discovered burrowed deep in the stream bottom. All nymphal growth is rapidly completed during the three to four coldest months of the year. They feed on leaves and diatoms.

The earliest detailed studies of stonefly drumming behavior were conducted on European *Taeniopteryx* species by German researchers in the late 1960's. Since then, extensive laboratory studies have been conducted on the distinctive drumming sounds and behavior of North American adult *Taeniopteryx.* Males busily wander around, stopping from time to time to drum by tapping their abdomens on a twig, in the hopes of locating females. Females respond with a different drumming sound. Males and females continue to drum back and forth until they find each other. After mating, females will not respond to male drumming, but males will continue to drum, searching for other females.

CHLOROPERLIDAE: GREEN OR YELLOW STONEFLIES

Chloroperlidae are small - 1/4 to 5/8 inch (6 to 15 mm), delicate stoneflies that mind their own business and would probably be completely unnoticed if not for their bright yellow or green color. The family's scientific name is derived from a Greek word for yellow. Several genera have a black stripe down their backs. Adult emergence occurs in late spring and early summer. Most species are restricted to cool streams in remote, forested areas. They are able to live in mildly acidic streams. All Chloroperlidae nymphs are uniformly brown, with rather short, stiff tails and rounded wing pads. They are predaceous and were once believed to feed on salmon eggs and newly hatched fish (fry), but they actually scavenged on dead eggs and fry.

One species, *Haploperla brevis*, is more tolerant than other Chloroperlidae of warmer water, sediment and wastes from farms and fields. Not surprisingly, *Haploperla brevis* are more dominant in streams near human habitation. In early June, the pale yellow adults may be found on rocks drying their wings in the morning or fluttering near streamside vegetation later in the day. They are occasionally attracted to artificial lights. Putting up with warm summer stream temperatures is avoided by timing the egg-stage so they delay in hatching until temperatures cool down. Nymphs are active predators, feeding mainly on Chironomidae (midges) larvae.

Connellsville Area High School student grabs water samples.

PELTOPERLIDAEAE: ROACH-LIKE STONEFLIES

The common name for this family refers to the cockroach-like appearance of the nymphs, which have large, overlapping shields on the thorax. They are brown and range from 5/16 to 7/16 inch (8 - 11 mm) long. The nymphs have one or two slender gills near the base of each leg. All species are very similar, and prior to the taxonomic splitters going to work, were at one time considered to be the same genus. Presently, two genera are known to live in Pennsylvania: *Peltoperla* and *Tallaperla.* Nymphs are common dwellers of cool streams where they hide in the submerged leaf packs that accumulate near riffles. They eat a lot of decayed leaves and diatoms. In late May and June, the nymphs crawl out of the water onto bridge abutments and rocks to emerge from their skins. Adults, with brown or grayish bodies and wings, quickly retreat into streamside vegetation. There they are well camouflaged and rarely seen.

Tallaperla maria is a common Pennsylvania species found in forested, headwater streams. Fallen and sunk leaves are the major food source in these streams. *Tallaperla* nymphs play an important role in the cycling of stream nutrients by skeletonizing leaves and breaking them into smaller pieces, which become detritus for consumption by other insects and crustaceans. *Tallaperla* spend a long time in their stream habitat. They have a two-year life cycle, with a half year spent as an egg.

PERLIDAE: COMMON SUMMER STONEFLIES

Perlidae stoneflies are normally big: 1 – 1 1/2 inches (25 to 35 mm), long; a few genera, however, are only half as long. Adults can be brightly colored or dull, ranging from brown with tan wings to yellow with gray, white or black wings. The nymphs vary from dark brown to yellow-orange; many are brightly patterned. The robust nymphs have a pair of highly branched gills at the base of each leg. A few species also have anal gills. Remnants of the gills can be seen on the adults. Most Perlidae nymphs dwell in medium to large warm streams or rivers, but a few species within *Acroneuria* and *Perlesta* are quite cold hardy. Their branched gills are efficient at obtaining oxygen and help equip them to live in warmer streams with lower amounts of dissolved oxygen. Perlidae nymphs display a peculiar behavior when removed from a stream and placed in a pan of water. They move their bodies up and down, appearing to do “push-ups.” This generates a current and passes more oxygen over their gills. Perlidae nymphs are predators. They actively pursue their prey during the daytime and may compete with small predaceous fish for tiny zooplankton and littler bugs. Larger species in this family take two to three years to mature from egg to adult. Therefore, representatives of two or three age groups coexist year-round.

Acroneuria is the most widespread and the best-known genus of the Perlidae family. Fly fishers often refer to it as *Perla*, (which is actually a European genus). The adults are large: 7/16 to 1 – 3/16 inch (15 to 30 mm) long, and brown or burnt orange, with long brown wings. The male has a raised knob or hammer on the bottom of the last abdominal segment, which is used in drumming, as described in the Taeniopterygidae section. Unlike most other stoneflies, the females and nymphs are easier to identify to species than the males. Eight species are found in Pennsylvania. Usually, there is a succession of *Acroneuria* species from the headwaters to the downstream reaches of a stream system, with little species overlap. *Acroneuria carolinensis* is the most common species inhabiting Pennsylvania trout streams. Peak emergence for *Acroneuria* is early June, but may last up to three weeks. Adults are nocturnal and may be attracted to lights on warm summer nights. They are relatively good fliers and, if aided by the wind, may move several miles away from the stream they lived in as nymphs. This aids in species dispersal, but also may lead to egg deposition in streams that do not provide ideal conditions for nymphal development. Most species spend at least two years in the water, preying on midge larvae and other stoneflies. The nymphs and their dried, cast-off exuvia (skin) are much more easily collected than are the secretive, nocturnal adults.

Adults of the Perlidae genus *Agnetina* are 3/4 - 1 3/16 inch (20 to 30 mm), long and bright lemon yellow, with black markings and black wings. Males are distinguished from other Perlidaes by long oar-like claspers held over the top of the abdomen. The three North American species, *Agnetina flavescens*, *Agnetina annulipes* and *Agnetina capitata*, differ mainly in size and color pattern and were once considered one variable species, called *Phasganophora capitata*. Quite often, two species will live in the same stream and emerge into adults at the same time, from late May through June. Unlike most other Perlidae, adult *Agnetina* are diurnal (active in daytime) and often crawl around on bridges, stream banks or buildings. Females may be seen flying over the water with egg masses attached to their abdomens prior to ovipositing (laying eggs). Their diurnal nature and ability to live in fairly clean urban and suburban streams make them some of the more visible adult summer stoneflies.

Agnetina nymphs are dark brown with contrasting yellow markings. They have anal gills in addition to the thoracic gills. Nymphs live mainly in the swift current and rocky bottoms of medium to large streams. They are predators; their two years as nymphs are spent eating other stoneflies, caddisflies, mayflies and small fly larvae such as Chironomidae. When mature, they crawl far out of the water, dig their claws into rocky bridge pillars and emerge as adults. Hundreds of nymphal skins may remain stuck to bridges for months after the adults have disappeared.

PERLODIDAE: SECRETIVE SUMMER STONEFLIES

Adult Perlodidae stoneflies have yellow wings and whitish to tan bodies. They range from 3/8 to 1-3/16 inch (10 - 30 mm), in length. These are some of the most secretive adult stoneflies. They are so rarely encountered that taxonomists are often forced to rear nymphs in the laboratory to have enough individuals to study. Adults may occasionally be swept from streamside foliage with a beating sheet or lured into blacklights during warm summer evenings. Nine relatively similar genera have been collected in Pennsylvania. The nymphs are usually robust and brown with black or yellow markings. Most nymphs from the eastern United States do not have gills; however, a few have a single, tiny gill on each side of the neck. They most commonly live in small cool streams, although a few inhabit rivers. The large nymphs of the genus *Yugus* are the dominant predators in tiny Pennsylvania streams – streams that may be too small for fish to inhabit.

Isoperla is the most common genus in the family and the most diverse genus of stonefly in the United States, with over 60 species described to date. At 10 to 15 mm, *Isoperla* is smaller and thinner than other genera in the family. The yellow nymphs have dark patterns on their head and thorax and usually have dark longitudinal stripes or transverse bands on the abdomen. Nearly all adults, on the other hand, are uniformly yellow with tan or gray wings. Adults emerge from April through July and quickly hide in streamside vegetation. They have not been observed to feed. Life history studies have been completed on less than 15 of the *Isoperla* species so far and none of those species occur in Pennsylvania. Nymphs of some species actively feed and grow throughout the year while others diapause part of the year. Those resting beneath the stream substrate are able to endure in dried-up streambeds during summer droughts. Most nymphs are believed to be omnivorous, feeding on plant material when young, and on mayflies and fly larvae (blackflies and midges) as they mature.

PTERONARCIDAE: GIANT STONEFLIES

Pteronarcidae adults are large: 1 1/4 to 2 inches (35 to 50 mm), long. They are black-bodied stoneflies with clear, dark-veined wings. All six Pennsylvania species are in the genus *Pteronarcys.* Nymphs are common inhabitants of swift water where fallen leaves or debris accumulate at stream edges, above rocks, logs, bridge abutments or the trash racks at cooling water intakes of power plants. Some species are restricted to small cool streams, while others are found only in large rivers. Pteronarcidae have some of the longest life cycles of all the stoneflies, requiring from two to four years to develop from egg to adult. In May and early June, the nymphs climb far out of the water and dig their large claws into bridge bases, trees trunks or branches to emerge into adults. The secretive adults are rarely encountered; however, the cast-off nymphal skins can be collected from the emergence site long after the adults have disappeared.

Pteronarcys nymphs are large, dark brown insects with tufted gills on the bottom of each thoracic segment and the first two abdominal segments. Pointed extensions of the pronotum and wing pads make the nymphs look armored and menacing; however, they are very docile creatures, usually curling up into a ball when lifted out of the water. In spite of their size, they are not predaceous; they feed on leaves. The nymph's guts don't do a very good job at digesting leaves, and they actually get most of their nutrition from the diatoms and fungi attached to the leaves. Yes – some people like to study *Pteronarcys* feces! The nymphs play an important role in stream ecosystems. By shredding leaves into small pieces and releasing them partially decomposed in their feces, they make leaves more readily available as a food source for other insects living downstream.

Caddisflies (Order Trichoptera)

Larvae of the caddisflies vary quite a bit in size, but most are between 1/4 and one inch. They don't have wing pads like the mayfly and stonefly nymphs do, but rather, they look a bit like little caterpillars – to which they are related. They have no tails but they do have a hook at their rear end. Three pairs of segmented legs are found on the middle part of the body. Gills are filaments, if they are present, and usually found on the underside of the abdomen, but sometimes scattered high up on the body.

The Susquehanna River near Harrisburg supports a huge diversity of macroinvertebrates including more than 100 species of mayflies, stoneflies, and caddisflies combined.

Most breathing is done through the skin.

Two large groups of caddis larvae exist. One group builds cases consisting of small sticks, pebbles and other naturally occurring vegetation, or they spin silk cases around their bodies for protection. When you collect caddisflies it is a bonus to have the cases, as they can aid you in identification. For instance:

- *Hydropsychoidea & Polycentropodidae* spin silk nets
- *Dipseudopsidae* spin silk tubes
- *Limnephiloidea* make tubular stone or stick cases
- *Hydroptilidae* make stone purse cases
- *Glossosomatidae* make stone cases called saddles (or turtle shell cases)

The other group of caddis larvae is free-living, meaning they wander around on the bottom of the stream, looking something like a common caterpillar, without a case of any sort.

- *Rhyacophilidae* don't construct "houses" and are called "Free-Living".

As the larva gets older, it will eventually make a silken cocoon, like a caterpillar does. It will transform into a pupa and eventually into a young adult. When the time comes, it will cut its way out of the cocoon and move onto the surface of the water. There, most species will drift in the film until breaking free of the pupal skin and the adult flies away. Others crawl out of the water onto the pebbles or mud of the shoreline to emerge.

Studying cases, especially stone or stick cases can be a fascinating thing to do. There is no better single source of information on caddisfly larvae than Larvae of the North American Caddisfly Genera (Trichoptera) by Glenn B. Wiggins. However, knowing the caddisflies is quite a task because there are more than thirteen hundred species in North America and a lot remain undescribed! Three-hundred twelve species have been recorded in Pennsylvania. Fortunately, these all fall into 26 families – the same number as letters in the alphabet. So, it's a manageable number, although the names are much more cumbersome than the letters of the alphabet.

With very few exceptions, caddisfly larvae are aquatic. Most of them like well oxygenated, fast flowing streams, but some are residents of ponds and even temporary pools. Caddisflies are extremely diversified in many ways, with one kind or another being found worldwide in ice-cold mountain streams to warm, salty tidal pools! They are just as varied in their food preferences. Many enjoy grazing on algae while others order off the meat menu, preferring high-energy animal food – little bugs, zooplankton, or even little worms.

Caddisflies have four life stages: Egg – Larvae – Pupa – Adult. This is called complete metamorphosis. They molt (shed their skin) 5-7 times in their larval life. Their entire life which is typically one year. Each stage of the larvae, between molts, is called an instar. Most of life is spent as a larva. Transforming into an adult requires a two-week period as a pupa. The larva seals off the end of its "house" or, the ones that don't make "houses" will spin a silk case (cocoon) wherein the transformation takes place. The adult emerges from the case, which is usually fastened not very deep below the water surface. After adults mate, the female lays about ten batches of eggs – a couple dozen to a couple hundred per session. Some kinds of caddisflies lay their eggs on the water's surface, others on overhanging trees and weeds, and others in wet streamside soil.

Adults look a wee bit like moths. Like most aquatic insects, they don't live very long in this stage of life – typically about a month. Like the mayflies and stoneflies, the primary role of adults is to mate and die. All stages of caddisflies are important food for fish, especially larvae and the egg-laying females, which flutter on the water surface, often attracting the attention of trout, and bluegills and other fish.

The gray shaded caddisfly families in Table 6 have Hilsenhoff Scores of 3 or less and are therefore considered very sensitive to pollution. After looking at several hundred stations across the state, we find these families occur at the listed percent of stations.

Caddisfly families: Table 6

Caddisflies	Percent Occurence
Hydropsychidae	93%
Philopotamidae	61%
Rhyacophilidae	31%
Glossosomatidae	19%
Limnephilidae	15%
Polycentropodidae	15%
Uenoidae	7%
Brachycentridae	6%
Lepidostomatidae	4%
Odontoceridae	3%
Hydroptilidae	3%
Psychomyiidae	2%
Helicopsychidae	2%
Phryganeidae	1%
Leptoceridae	1%
Molannidae	<1%

Meet the Caddisfly Families!

BERAEIDAE

In Pennsylvania, in fact in all of North America, there is in this family only one, rare genus: *Beraea.* There are two species.

The larvae are small, about 1/4 inch (6 – 8 mm) and they make curved tube cases of sand. They have a dorsal (on their back) hump on the first segment behind their legs. Their head has a ridge along each side and they have tiny antenna near the front of the head, in line with the eyes. They live in small streams and springs where they gather and eat detritus.

BRACHYCENTRIDAE

In Pennsylvania, there are three genera: *Adicrophleps, Brachycentrus, and Micrasema.* There are 11 species. Brachycentridae are very sensitive to pollution, with a Hilsenhoff Score of one.

The larva are small, about 1/4 - 3/8 inch (6 – 12 mm) and they make tube cases. Depending on the genus, the case varies from a four-sided moss dwelling to a rounded, tapered one of plant material and silk and sometimes sand. But some sort of plant material is nearly always used. They have no dorsal or lateral humps like *Beraeidae* do. About half of the kinds have gills on their abdomen, but they are simple filaments and not numerous. In the other half, there are no gills and all oxygen is gotten through the skin.

Brachycentridae cling to the bottom and climb about in cold mountain streams and cool rivers. They like to hang out in moss, which they eat along with debris collected from the water by the fine combs of hair on their legs.

CALAMOCERATIDAE

Most of the members of this family live in the warmer parts of the world. In Pennsylvania there is only one genus: *Heteroplectron* – and in that genus there is only one species: *Heteroplectron americanum.*

The larva is 1 inch (25 mm) in length. Its case is fashioned by hollowing out a twig. The first and second segments behind the head – biologists call those segments the pronotum and mesonotum – have a covering of sclerotonin. The texture of sclerotonin is something like that of a fingernail. These “fingernails” are called “sclerotized plates” or “sclerites” if they are small. The third segment (metanotum) has a pair of these small sclerites on the sides just above the legs. The next segment back has a big dorsal hump.

Calamoceratidae (*Heteroplectron)* are found in slow running water and pools where detritus accumulates. They shred and eat leaves.

GLOSSOSOMATIDAE

In Pennsylvania, there are three genera: *Agapetus, Glossosoma and Protoptila* made up of eight species. Glossosomatidae are among the best indicators of nonpolluted water. They have a Hilsenhoff Score of zero, meaning they have nearly zero tolerance for organic pollution.

Glossosoma, Agapetus and Protoptila larvae are sort of papa bear, mama bear, and baby bear in size: 3/8 inch (9 mm), 1/4 inch (6 mm) and 1/8 inch (3 mm), respectively. They make a saddle case, looking something like a turtle shell. The pronotum …remember that word? …first segment behind the head – is almost entirely covered with sclerotized plates, and the mesonotum, …second segment behind the head, and metanotum, …third segment behind the head – of *Agapetus and Protoptila* have small sclerites. *Glossosoma* does not have these sclerites. All three sets of legs are about the same size. They have no gills.

Glossosomatidae like cold and well oxygenated water. The one exception to the rule in this family is *Protoptila*, which are found in rivers and slower, warmer waters. All can be found clinging to surfaces of submerged rocks where they scrape off meals of diatoms and algae.

Allegheny County Senior Environment Corps members analyze water samples from Deer Creek.

HELICOPSYCHIDAE

In all of North America, there is just one genus in this family: *Helicopsyche.* In Pennsylvania, there is just one species: *Helicopsyche borealis.* It is a good indicator organism, with a Hilsenhoff Score of three.

This guy is widespread and unforgettable, though not especially abundant. It is found at only about two out of every 100 survey sites. The larva’s coiled case is whirled, like you would picture an orb snail. The shell is covered over by sand. These are the toughest caddisflies in several ways. The coiled cases are only 1/4 inch in diameter, but they resist crushing and are sometimes found a foot deep into the substrate and in water up to ten feet deep. They are found in both streams and lakes and can tolerate long periods in icy cold water as well as water reaching 93°F. There is a structure just in front of the base of the front leg that looks like a horn jutting down and curved toward the jaw. It's called a "trochantin" and in *Helicopsyche* it is longer and more upturned than in most other caddisflies that have this structure.

Helicopsyche borealis clings to the rocky substrate and scrapes off diatoms, algae and detritus for lunch.

HYDROPSYCHIDAE

In Pennsylvania, this family is represented by seven genera and dozens of species. The genera are *Ceratopsyche, Cheumatopsyche, Diplectrona, Hydropsyche, Macrostemum, Parapsyche* and *Potamyia.* Hydropsychidae are not particularly important as indicators of water quality. Although the family likes high oxygen conditions, they are capable of living in somewhat degraded rivers. They have a Hilsenhoff Score of 5 – only fair.

The larvae of this family are mostly about 5/8 inch (15 mm) long and all of them have rather dense gills on the belly. They also have a tuft of hair at their very tail end (anal proleg). Hydropsychidae are known for their ability to spin nets of silk. The nets are used to strain food such as algae, detritus and zooplankton (tiny animals) from the water. They don't make portable "houses" but do build stationary retreats of sand, stone fragments, vegetation and silk. The forearms (actually, femora of the front legs) are modified to aid in scraping. Depending on the genus, Hydropsychidae are found from small, rapid, cold streams to large rivers or even lakeshores.

Amel Johnson measures stream width and calculates flow rate.

HYDROPTILIDAE

In Pennsylvania, there are ten genera and about 49 species. The genera are *Agraylea, Dibusa, Hydroptila, Ithytrichia, Leucotrichia, Mayatrichia, Neotrichia, Ochrotrichia, Oxyethira* and *Stactobiella.* Hydroptilidae, like most families capable of living in still water, are only "good", rather than excellent pollution indicators. The family has a Hilsenhoff Score of four.

Larval Hydroptilidae are the fat runts of the caddisfly order. Most are only 1/8 inch (3 mm) long although *Agraylea, Dibusa* and *Hydroptila* can be twice as big. Each stage of the larvae, between molts, is called an **instar**, and the first four instars are slender and caseless. But the fifth instar larvae have big, fat abdomens and live in attached or portable barrel-shaped cases of sand, silk or plant materials. They have no gills and exchange gasses through their skin. They live in both lotic (flowing water) and lentic (still water) conditions. Many are herbivores (plant eaters), enjoying the tossed filamentous and unicellular alga salad, with a dash of freshly scraped diatoms.

LEPIDOSTOMATIDAE

In Pennsylvania, this family has two genera and 16 species. The genera are *Lepidostoma,* having 15 of the species, and there is one species in *Theliopsyche*. Lepidostomatidae are very sensitive to pollution; with a Hilsenhoff Score of one, they are excellent indicator organisms.

The larvae of *Theliopsyche* are only about 1/4 inch (6 mm) long and those of *Lepidostoma* are about twice as big. The two genera don't build similar cases either. Most *Lepidostoma* use plant materials to build four-sided cases while *Theliopsyche* use tiny pieces of stone to build a slightly curved, tapered case. The larvae look a lot like Limnephilidae, except their tiny antennae are closer to the bottom of their eyes, and they don't have a humped back on the next segment back from their legs (first abdominal segment). Most have some single (unbranched) gills in rows along both sides of the back (dorsal) and belly (ventral) sides. Also, on the sides of the first abdominal segment there is a callused bump called a lateral tubercle. It helps the bug to stay correctly positioned within its case.

Lepidostomatidae reside in the clean gravel of springs and cooler streams where they shred detritus for food. Some people have reported seeing them feeding on dead fish.

LEPTOCERIDAE

The family contains eight genera. In Pennsylvania, there are seven genera and probably at least 44 species. The genera are *Ceraclea, Leptocerus, Mystacides, Nectopsyche, Oecetis, Setodes and Triaenodes.* The one genus missing from Pennsylvania is *Ylodes*, which is an insect of the American northwest. Like Hydroptilidae, this family is capable of living in still water. The family has a Hilsenhoff Score of four - good.

The larvae range from 1/4 - 5/8 inch (7 – 15 mm) in length, depending on the genus. They make tube cases of various materials and shapes. These caddisflies have really long hind legs, able to reach beyond their head. Their antennae are also very long, in contrast to most other caddisflies (but still short compared to the antennae of many of the more familiar bugs). They reach almost to the tip of the face. All of the species have seams below their eyes, called subocular sutures, but you'll have to look closely through a dissecting scope to see them. Leptoceridae live in all types of aquatic habitats and feed on all kinds of stuff from detritus to freshwater sponges and other invertebrates (animals without backbones). They obtain their food by collecting, gathering, filtering, and by predation.

LIMNEPHILIDAE

In Pennsylvania, there are 12 genera and 30 species. The genera are *Anabolia, Frenesia, Glyphopsyche, Hesperophylax, Hydatophylax, Ironoquia, Limnephilus, Nemotaulius, Platycentropus, Pseudostenophylax, Psychoglypha* and *Pycnopsyche*. This is yet another family with a Hilsenhoff Score of four – good.

This is a very big family, and they vary a lot in the way they look, act, and live. The larvae range from little more than 1/4 inch to as much as 1 1/4 inch (8 – 35 mm) in length, depending on the genus, but many are about 3/4 inch. All have short antennae that are always halfway between the eye and mandible (forward part of the mouth). They usually have a lot of hair (setae) on the first abdominal segment. They make cases of great variety, using stone, plant materials or both. They live in all types of aquatic habitats from wet meadow seeps to large lakes and rivers, although most have a fondness for the higher latitudes and altitudes. Most live in clean, cool, water where they feed on detritus, algae and even on vascular plants.

APATANIIDAE

"Lumpers" and old-timers still know the Apataniidae as part of the family Limnephilidae, but "splitters" removed Apataniidae from Limnephilidae. To us, it makes little difference as only one genus (*Apatania*) lives in Pennsylvania. The genus has three species. Like Limnephilidae, this family has a Hilsenhoff Score of four – good.

The larvae are 1/4 inch (7 mm) in length. Identifying this genus from other genera requires looking at the arrangement of tiny hairs (setae) and noting the absence of certain tiny hardened and seamed areas (sclerites) on the top of the third segment back, not counting the head – the segment with the hind legs. This segment is called the metanotal segment. Identification is not too easy. They make tube cases of rock pieces, slightly curved and tapered. They live in both flowing and still, cool water, and they like to eat diatoms and other small algae that they scrape from rocks.

GOERIDAE

Like the family Apataniidae, the family Goeridae was removed from the family Limnephilidae. These things happen for a variety of reasons ranging from divorce and arguments at caddisfly family reunions to arguments by entomologists at meetings. Only two genera live in Pennsylvania: *Goera* (3 species) and *Goerita* (1 species). Like Limnephilidae, this family has a Hilsenhoff Score of four – good.

Connellsville Area High School students pick macroinvertebrates from their kick screen.

These two genera are not too similar. The larvae are of different size, though both are small: *Goerita* is about 3/8 inch (5-6 mm) long and *Goera* is about twice that. *Goerita* builds a case of sand and tiny pieces of stone and *Goera* uses those materials but then about four big stones (comparatively big, that is) are fastened to the sides of the case. The "big" stones might help to keep the bug stable in the currents of streams where it lives and feeds on algae. *Goerita* lives in cold spring-fed runs and eats diatoms and detritus. Both genera have things that look like horns (trochantin) pointing forward from their shoulders. *Goerita* does not have gills, but *Goera* does.

UENOIDAE

In Pennsylvania, there is one genus: *Neophylax*, having 10 species.

Sometimes this genus is included in with Limnephilidae. Although broken out from Limnephilidae, this family is a bit more sensitive to pollution and has a Hilsenhoff Score of three – very good.

The larvae are 5/8 inch (15 mm) in length. They make short, thick cases of rock fragments with several larger stones along each side. The larvae have humps on the dorsal (top) and lateral (sides) of the first segment rearward of the legs – abdominal segment one. They are found in any size streams, often clinging onto stones, where they graze.

MOLANNIDAE

In Pennsylvania, there is only one genus: *Molanna* – and in that genus there are three species. Molannidae is an adaptable family and therefore not an especially good indicator organism. The family has a Hilsenhoff Score of six – fair to poor.

The larvae of this family are about 3/4 inch (19 mm) long. Their hind legs are quite a bit longer than other legs and their shins (tibia – fourth segment of the leg) are creased near the middle. They have a hump on their backs and sides on the next segment back from the legs. You'll have to look very closely with a good hand lens and dissecting scope at the butt-end of *Molanna flavicornis* to see a very tiny claw, shaped like a cat claw. It is toward the inner edge of the normal prolegs (anal hooks). If you can see it, you've made a sure identification to species, because no other caddisfly has this needle-like claw! The case is a flat tube of rock particles with a hood sticking out the front like an over-hanging roof, and to a lesser extent the overhang continues down the two sides. The *Molanna* are versatile, living in lakes, rivers, streams and springs, where they scrape, collect, prey upon and engulf any kind of food listed for any other family.

ODONTOCERIDAE

In Pennsylvania, there is only one genus: *Psilotreta* – and in that genus there are four species. They have a Hilsenhoff Score of zero. They are excellent indicator organisms with almost no tolerance for organic pollution.

The larvae of this family are about 5/8 inch (15 mm) long. The most notable thing about the genus is its case, which is a tube case, constructed of coarse rock pieces, tapered and slightly curved, ***without*** a silk lining internally. Instead, it is reinforced with small rock fragments and bands of silk, making it the most crush resistant of all caddisfly cases. The *Psilotreta* are burrowers in riffles and areas where detritus is deposited in streams of all sizes. They eat plant material including algae.

PHILOPOTAMIDAE

In Pennsylvania, there are three genera and six species. The genera are *Chimarra, Dolophilodes* and *Wormaldia*. Philopotamidae have a Hilsenhoff Score of three, meaning they are sensitive to organic pollution and very good indicator organisms.

The larvae are about 3/8 - 5/8 inch (12 - 17 mm) in length. They are silk net-spinners. The house is an elongated sack usually fastened on the underside of rocks. The same sack is used to filter the smallest organic particles from the water, which they use for food. The upper lip (labrum) has an extension that forms a "T". This looks like the critte, has a windshield ice-scraper for a nose and it helps in identifying the members of this family. The head and pronotum (segment with the front legs) are brownish orange, and the pronotum has a black margin along the rear edge. Philopotamidae live in running water of streams of all sizes. Adults of most species are active during spring and summer months, but some caddisfly adults in this family are active even in the winter. Eggs are laid under water.

Riffles provide good caddisfly habitat.

PHRYGANEIDAE

In Pennsylvania, there are five genera and 10 species. The genera are *Agrypnia, Banksiola, Oligostomis, Phryganea* and *Ptilostomis.* The family has a Hilsenhoff Score of four – good.

The larvae are mostly about 25 mm, but *Phryganea* is almost twice that size, and *Ptilostomis* is somewhere in between, about 35 mm. They all have a horn on their backs on the next segment rearward of the hind legs, and they all have nonbranched gills scattered over their body, but the first segment always has just two single gills on the ventral (bottom) side. The head and pronotum have two dark racing stripes on a light ochre-brown background. The ninth abdominal segment has a small, dorsal (topside) sclerite. All the genera make cylindrical tube cases of plant materials fastened together in rings or a spiral, and they are open at both ends. *Ptilostomis* likes the colder streams; the others seem to favor lentic (still) waters.

POLYCENTROPODIDAE

In Pennsylvania, there are four genera and probably at least two dozen species. The genera are *Cyrnellus, Neureclipsis, Paranyctiophylax (*or *Nyctiophylax) and Polycentropus.* The family Polycentropodidae has a Hilsenhoff Score of six – fair to poor.

The larvae of *Cyrnellus* and *Paranyctiophylax* are about 10 mm long. *Neureclipsis* and *Polycentropus* are twice as long. Their bodies are frequently strongly hooked into a "J-shape." Just above their front legs and pointing forward is a horn called a trochantin and they have a well-developed anal claw.

All are net-spinners making silken tube retreats of many shapes and sizes, which are fastened in depressions of rocks or wood. They filter zooplankton for food with the nets. The family can be found in running water, but they prefer slower moving areas of rivers or even water behind an impoundment.

DIPSEUDOPSIDAE

In Pennsylvania, there is one genus having two species. The genus is *Phylocentropus*. Sometimes this family/genus is included in with Polycentropodidae and like Polycentropodidae, it has a Hilsenhoff Score of six – fair to poor.

The larvae are 3/4 inch (20 mm) in length. They look as if they have a long skinny tongue sticking out, which is almost 1/2 as long as the head, but this is actually a tip of the labium. Their tarsi (last segment of legs) are flattened like boat oars and the claws of the middle and hind legs are short and stout. They make branching tubes of silk covered with sand. The tube is sunken into the sandy edges of streams and is used to capture diatoms and other bits of food.

PSYCHOMYIIDAE

In Pennsylvania, there are two genera having three species. The two genera are *Lype* and *Psychomyia*. Psychomyiidae have a Hilsenhoff Score of two. They are very good indicator organisms.

The larvae are 3/8 inch (8 or 9 mm) in length. They have a broad ax-head shaped trochantin, the labium is long (but not as long as Dipseudopsidae) and it is retractile. The pronotum (top surface of the first segment) is sclerotized (hardened and darkened), but not the mesonotum (top surface of the second segment) or metanotum (top surface of the third segment). The case is a silken tube (retreat) covered with sand and debris usually in cracks or crevices of rock and wood substrates. *Lype* like small cold streams, and *Psychomyia* are more likely to be found in bigger streams where they apparently eat a varied diet of algae, detritus and zooplankton.

RHYACOPHILIDAE

There are only two genera of Rhyacophilidae and only one of them occurs in Pennsylvania. What they lack in numbers of genera, they make up for in species. There are 18 species. The genus is *Rhyacophila*; with a Hilsenhoff Score of one, it is an excellent indicator of good water quality.

The larvae are 3/4 inch (20 mm) long and are free-living – meaning that they don't build cases. Some feed on moss and algae, and their bodies are bright green, but others are yellow-cream colored predators. However, the color/feed group relationship can not be relied upon. In other words, not all moss-eaters are green. The pronotum is the only sclerotized segment. All the legs are similar in size and shape. Some species have gills and some don't; but if they do, they are usually stiff and in dense tufts. The anal prolegs are strongly developed. They live in all size streams.

Betty Wheeler, Peggy Standish, Herman Hittner and Amel Johnson of Allegheny County Senior Environment Corps analyze water samples and record the results.

SERICOSTOMATIDAE

In Pennsylvania, there is one genus having one species. It is *Agarodes griseus*, with a Hilsenhoff Score of three – very good.

The larvae are 5/8 inch (15 mm) in length. They make tube cases of uniform sized pieces of rock and the rear opening is swirled about halfway closed with silk. At the top of each small anal proleg there are about 30 setae (hairs). They have humps on the dorsal (top) and lateral (sides) of the first segment rearward of the legs – abdominal segment one. You probably won't find this bug while doing normal stream survey work because it is often burrowed down in the sand and prefers small, cold streams and springs.

Your Volunteer Involvement

Freshwater benthic macroinvertebrates are ideally suited for water quality studies done by the non-specialist volunteer and professional biologist alike. They can be collected very easily from most aquatic systems with costs limited to inexpensive supplies, or homemade equipment, and a fishing license. Macroinvertebrates are used extensively for monitoring water quality by clubs, watershed groups, academia and government agencies. Many websites and conservation groups are devoted to helping volunteers learn more about macroinvertebrate identification, as well as biomonitoring in general. One example is Save Our Streams (SOS), sponsored by the Izaak Walton League of America (707 Conservation Lane, Gaithersburg, MD, 20878-2983). We encourage interested ***Snapshot*** volunteers to get involved in similar programs as well as studying on their own and with friends. As you are no doubt aware, water quality monitoring programs can become quite extensive. Unless your protocol is kept exceedingly simple, it will require a great deal of time, especially collecting and identifying specimens. Education, whether formal or through personal interests and efforts, is required. Help is available if you seek it, so don't get too discouraged. Your local watershed organization may be able to inform you about monitoring opportunities and biological investigations being done in your area. DEP's Citizens' Volunteer Monitoring Program (CVMP) has available a technical handbook for community-based monitoring called **Designing Your Monitoring Program**. To obtain a copy, contact CVMP at the address listed in the front of this booklet. Best of luck with your involvement with our natural resources. Your participation is encouraged and appreciated.

Appendix A
Participants - Delaware River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
Advanced Biology Class	Class		Easton	PA	18042
All Saints School 7th & 8th Grades	Rasor-Shellhamer,	Erin	Barnesville	PA	18214
Ancient Worlds & Waterways Team	Members		Bala Cynwyd	PA	19004
Avon Grove Elementary	Mick	Cameron	West Grove	PA	19390
Bernardine Center	McDermott, OSF	Sister Rose	Chester	PA	19013
Brandywine Valley Association	BVA Streamwatch		West Chester	PA	19382
Brodhead Watershed Association	Staffaroni	Felix A.	East Stroudsburg	PA	18301
Brodhead Watershed Association	Crane	Roger L.	East Stroudsburg	PA	18301
Brodhead Watershed Association	Cary	Kevin	Saylorsburg	PA	18353
Brodhead Watershed Association	Hartzler	Jim	Saylorsburg	PA	18353
Brodhead Watershed Association	Herczeg	Susan	Stroudsburg	PA	18360
Brodhead Watershed Association	Faulstick	Britt	Saylorsburg	PA	18353
C.F. Patton Middle School	Tang	Celia & Nora	Kennett Square	PA	19348
Charles Boehm M.S. Team 7B	Haring	LeeOra	Yardley	PA	19067
Conrad Weiser West Elementary School	Murdough	Cynthia	Womelsdorf	PA	19567
Cooks Creek Watershed Association	Oleksa	Lois	Durham	PA	18034
Cooks Creek Watershed Association	Ellis	Anke M.	Coopersburg	PA	18036
Crum/Ridley Volunteer Program	Bruce	Bob	Springfield	PA	19064
Crum/Ridley/Chester Volunteer Monitoring	Barrett	Lawrence	Glen Mills	PA	19342
Crum/Ridley/Chester Volunteer Monitoring	Weber	Peter	Swarthmore	PA	19081
Delaware Riverkeeper Network	Gusz	Fred	Morrisville	PA	19057
Delaware Riverkeeper Network	Volker	Herbert A.	Lansdale	PA	19446
Delaware Valley High School	Hodges	Sheila	Milford	PA	18337
Delaware Valley High School	Schanzenbacker	Hannelore	Milford	PA	18337
DRBC	Limbeck	R. L.		PA	
Earthright, UMAA, KARE	Wintz	M.	Huntingdon Valley	PA	19006
Earthright, UMAA, KARE	Proropiak	G.	Huntingdon Valley	PA	19006
EASI-SEC	Borden	Mary	Philadelphia	PA	19144
Ecology Class	Leonhardt, Advisor	Lance	Hellertown	PA	18055
Franciscans International - Delco Chapter	Walker	Jim	Chester	PA	19013
Friends of Poquessing Watershed	Remick	Donna	Bensalem	PA	19020
Friends of Tacony Creek Park	Maurer	Fred		PA	
Green Valleys Association	Hoekstra	Susan J.	Birchrunville	PA	19421
Green Valleys Association	Sheibley	Ronald & Don	Spring City	PA	19475
Hidden River Studio	Marinell & students	Suzanne	Plymouth Meeting	PA	19462
Hillendale Elementary	Sparre	Katie	West Chester	PA	19382
Historic Bartrams Garden	University City High		Philadelphia	PA	19143
Home School	Benkis	Maria	Kennett Square	PA	19348
Home School	Watson	Rachael	Kennett Square	PA	19348
Houston Elementary School	Miller	Diana	Philadelphia	PA	19119
Jacobsburg Environmental Education Center	House	Emil	Bushkill Township	PA	18064
Jim Thorpe Area High School	Skinner	LeRoy	Jim Thorpe	PA	18229
LaSalle Academy	Gallen	Meghan	Shillington	PA	19607
LaSalle Academy	Moyer	Andrew	Shillington	PA	19607
LaSalle Academy	Pezinzolkouski	Adam	Shillington	PA	19607
LaSalle Academy	Stahler	Mary Pat	Shillington	PA	19607
Lehigh River Watch Parkland H.S.	Miller	Robert D.	Orofield	PA	18069

Appendix A continued

Participants - Delaware River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
Little Schuylkill Conservation Club	Dougherty	Eugene J.	Delano	PA	18220
Lower Merion Conservancy	Caplan	Enid R.	Ardmore	PA	19003
Lower Merion Conservancy	Goldfine	Norah	Ardmore	PA	19003
Lower Merion Conservancy	Koch	R. H.	Ardmore	PA	19003
Montgomery County Health Department	Demarzio	Rachel	Norristown	PA	19401
Muhlenberg College	Marrone	Maria	Allentown	PA	18104
Neshaminy High School	Bernarsky	Michael S.	Langhorne	PA	19047
New Garden Elementary	Daman	Crystal	Landenburg	PA	19350
New Hope-Solebury Middle School	Echart &Students	Don	New Hope	PA	18938
North Penn Water Authority	Sandstrom	Bruce	Chalfont	PA	18914
Northampton Area Jr. H.S.	Fehnel	L. K.	Northampton	PA	18067
PA DEP	Garner	Eric	Bethlehem	PA	18017
PA DEP	Miller	M.	Bethlehem	PA	18017
PA DEP	Nawrocki	Leonard	Wilkes-Barre	PA	18711
Pen Argyl High School	Kopcho	Mr. Charles J.	Pen Argyl	PA	18072
Pennsylvania Fish & Boat Commission	Connor	M. G.	Pleasant Mount	PA	18453
Philadelphia Canoe Club	Members		Philadelphia	PA	19128
Philadelphia City Sail	Members			PA	19395
Philadelphia College of Textiles & Services	Students		Philadelphia	PA	19129
Philadelphia Suburban Water Company	Feuer	Robert C.	Bryn Mawr	PA	19010
Philadelphia Suburban Water Company	Kahley	Bob	Bryn Mawr	PA	19010
Philadelphia Suburban Water Company	Marleton	Craig	Bryn Mawr	PA	19010
Pocono Environmental Education Center	Chenderliny	Amy	Dingmans Ferry	PA	18328
Pocono Environmental Education Center	Polill	Barb	Dingmans Ferry	PA	18328
Radnor Middle School	Watershed Program		Wayne	PA	19087
SAVE Environmental Club	Reese	R.	Easton	PA	18045
Schuylkill Center for Environmental Educ.	Walker	Dana	Philadelphia	PA	19128
Schuylkill Riverkeeper	Marks	Eugene	East Greenville	PA	18041
Self	Drayer	Sandra	Gladwyne	PA	19035
Self	Gardiner	Bernice	Bethlehem	PA	18018
Self	Korb	Katherine	East Stroudsburg	PA	18301
Self	Mackenzie	Sharon	Simsbury	CT	06070
Self	McKinney	Robert	Quakertown	PA	18951
Self	Miller	Alyce	Cochranville	PA	19330
Self	Powers	Jan	Avondale	PA	19311
Self	Quinn	Marian	West Chester	PA	19380
Self	Swanson	Mark	West Grove	PA	19390
Self	Warrington	C.	Landenburg	PA	19350
Self	Williams	Kelsey	Oxford	PA	19363
Shafer Elementary	Krell	Susan	Nazareth	PA	18064
Shawnee Intermediate School Students	Bell, Advisor	Richard J.	Easton	PA	18042
Sierra Club - Coplay Creek Monitoring Project	Benson	Barbara	Coopersburg	PA	18036
St. Catherine Laboure School	Ellison	Sean	Harrisburg	PA	17111
Stedmonds Academy	Fromuth	Pat	Landenberg	PA	19350
Stroud Water Research Center	Williams	Vivian	Avondale	PA	19311
Telephone Pioneers	Youse	Arthur	Bethlehem	PA	15017
Tobyhanna Army Depot	Wildoner, Jr.	Thomas J.	Tobyhanna	PA	18466

Appendix A continued

Participants - Delaware River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
Lehigh Valley Pioneer Club	Williams	Carroll R.	Allentown	PA	18104
Tobyhanna Crk./Tunkhannock Crk.	Ayers	Clyde	Pocono Lake	PA	19347
Tobyhanna Crk./Tunkhannock Crk.	Beckhorn	Alice	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Ellis	Carol	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Hamilton	Bill	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Keller	Maryann	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Llewellyn	Jean	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Meyer	Debra	Pocono Lake	PA	19347
Tobyhanna Crk./Tunkhannock Crk.	Roth	Greg	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Snyder	Paul	Pocono Lake	PA	18347
Tobyhanna Crk./Tunkhannock Crk.	Whipple	John	Pocono Lake	PA	18347
Unionville School	MacLaughlin	Sean	Kennett Square	PA	19348
Upland Country Day School	Anderson	Carroll	Unionville	PA	17073
US EPA Region III (3CS10)	Kanetzki	Charles	Philadelphia	PA	19103
Wallingford Elementary School	Callahan	Joey	Wallingford	PA	19086
Wayne Elementary School	Richter & 4th Grade	Max	Wayne	PA	19087
Western Berks Water Authority	Rhoads	Gary D.	Sinking Spring	PA	19608
Westtown School	Boekell	Hanne	Coatesville	PA	19320
Westtown School	McLaughlin	Suzan	Westtown	PA	
Wildlands Conservancy	Cromer	Stacy	Emmaus	PA	18049
Wildlands Conservancy	Zellers	Heather	Emmaus	PA	18049
Wissahickon Valley Watershed Assoc.	Adams	Bob	Ambler	PA	19002
Women in Doctoral Sciences (WINS)	Fields	Rasheeta	Philadelphia	PA	19103
Women in Doctoral Sciences (WINS)	Pinkston	Jacqueline	Philadelphia	PA	19103

Appendix B

Participants - Lake Erie Basin

Organization	LAST Name	FIRST Name	City	State	Zip
Explorer Post 808	Wasiesky, Advisor	Steve T.	Erie	PA	16506
North East Middle School	Beavers	Alice	North East	PA	16441
Walnut Creek Middle School	Jobes	Judy	Fairview	PA	16415

Appendix C
Participants - Ohio River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
California University (PRWA)	Vargo	Dr. Bob	California	PA	15419
Cambridge Springs High School	Porter	Herb	Cambridge Springs	PA	16403
Connellsville Area Sr. High	Impact Class		Connellsville	PA	15425
Coudersport High School	Agricultural Science		Coudersport	PA	16915
Crooked Creek Watershed Assoc.	Vatter	C. LeeRoy	Indiana	PA	15701
EASI	Hamilton	Paul and	Meadville	PA	16335
EASI	Izbinski &		Meadville	PA	16335
EASI	Migdol	Bob	Cambridge Springs	PA	16403
EASI	Sayles et. al.	Bill	Pittsburgh	PA	15238
EASI Vintage	Brobst	John	Bradfordwoods	PA	15015
Greater Latrobe Senior High School	Roadman (AP	Glenn	Latrobe	PA	15650
Highland Sewer & Water Authority	Sewalk	Chester J.	Johnstown	PA	15904
Indiana S.H.	Palko	Phil	Indiana	PA	15701
Indiana University of PA	Simmons	Thomas W.	Indiana	PA	15705
Moon Area High School	Shadle	Christy	Moon Township	PA	15108
Mt. Lebanon High School	Amodie	Myra	Pittsburgh	PA	15228
Pittsburgh Voyager	Ruffennuch	Jamie	Pittsburgh	PA	15233
Pittsburgh Voyager	Staff		Pittsburgh	PA	15233
Powdermill Nature Reserve	Rohall	Theresa Gay	Rector	PA	15677
Self	Cole	Dick		PA	
Springdale High School	Class	7th Grade	Springdale	PA	15144
Vintage SEC	Hittner	Herman J.	Pittsburgh	PA	15206
Vintage SEC	Worrall	Tom	Pittsburgh	PA	15206
Vintage SEC	McCabe, Jr.	Earl A.	Pittsburgh	PA	15206
Warren Senior Environment Corps (EASI)	Neel	Charles and	Sheffield	PA	16347
Warren Senior Environment Corps (EASI)	Slattery (VISTA)	Gwen	Warren	PA	16365
Warren Senior Environment Corps (EASI)	Palmer	James J.	Warren	PA	16365
West Allegheny High School	Boustead	Diane	Imperial	PA	15126

Appendix D
Participants - Potomac River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
ALLARM	Gale	Anne W.	Chambersburg	PA	17201
Wilson College	Hill	Jessica	Chambersburg	PA	17201
Wilson College	Dentel	Michelle	Chambersburg	PA	17201
Wilson College	Thompson	Kim	Chambersburg	PA	17201

Appendix E

Participants - Susquehanna River Basin

Organization	LAST Name	FIRST Name	City	State	Zip
ALLARM	Hollinger	Darwin and	Mechanicsburg	PA	17055
ALLARM (Dickinson College)	Farley	George E.	Carlisle	PA	17013
Austin Area School District	Brewer	Angela L.	Austin	PA	16720
Bedford High School	Jackson	Laura	Bedford	PA	15522
Bellwood Antis High School	Goodman	Jon	Bellwood	PA	16617
CBF/Susquehanna Watershed Education	Friedman	Jeremy	Harrisburg	PA	17101
Conestoga Valley High School	Werts	Steve	Lancaster	PA	17601
DEP Snapshot Crew	Members			PA	
Donegal High School Advanced Biology Class	Baronak	Robert J.	Mount Joy	PA	17552
EASI/SEC	Kuchinski	Ed	Scranton	PA	18505
EASI/SEC	Marsico	Tony	Scranton	PA	18505
EASI/SEC	Martin	Les and	Scranton	PA	18505
EASI/SEC	Neary	Jack	Scranton	PA	18505
Environmental Geology Class	Brown	Suzanne E.	Mount Union	PA	17066
Envirothon Team	Warriors		Wellsvlle	PA	17365
Ephrata Borough Water Production Division	McFadden	Michael	Ephrata	PA	17522
Fairview Elementary School 5 Dist.	Zimmerman	Richard	Mountaintop	PA	18707
Forest Lake	Marckx	Joe	Endwell	NY	13760
Huntingdon Area Middle School	Hams Environmental		Huntingdon	PA	16652
Keystone College	Skinner	Dr. J.	LaPlume	PA	18440
LeTort Regional Authority	Fischbach	Brian	Carlisle	PA	17013
Northern High School	Knaub	Jessie	Lewisberry	PA	17339
NYSDEC Region 4	Streeter	Robert W.	Schenectady	NY	12306
Penn State Harrisburg	Dadhania	Dennis	Mechanicsburg	PA	17055
Penn State Harrisburg	Mastervich	Brian	Harrisburg	PA	17109
Penn State Harrisburg	Parsons	Dawn M.	Harrisburg	PA	17111
Penn State Harrisburg	Patel	Jay	Hershey	PA	17033
Penn State Harrisburg`	Daniecki	Katie	Monkton	MD	21111
Pine Creek Headwaters Protection Group	Stillerman	Paul	Wellsboro	PA	16901
Salt Spring State Park	Students	Salt Springs	Montrose	PA	18801
Self	Hodgson	Steve	Mechanicsburg	PA	17055
Self	Wood	Don	Benezette	PA	15821
Shippensburg Univ. (SRBC)	Van Fleet	Kim	Shippensburg	PA	17257
Stanley Cooper Senior Chapter Trout	Sedeski	John	Wilkes-Barre	PA	18702
SUNY College of Technology	Buckwalter	Prof. John	Alfred	NY	14802
Susquehanna River Basin Commission	Sitlinger	Darryl L.	Harrisburg	PA	17102
Susquehanna River Basin Commission	Takita	Charles S.	Harrisburg	PA	17102
Swatara Creek Watershed Association, Inc.	Embich	Tom	Lebanon	PA	17042
Swatara Creek Watershed Association, Inc.	Litz	JoEllen	Lebanon	PA	17042
Trout Unlimited	Simpson	Dean	Gettysburg	PA	17325
U.S. Geological Survey	Kline	Scott	Lemoyne	PA	17043
Warwick HS Students	Kafroth	Matt	Lititz	PA	17543
Williams Valley High School	Wytovich	Ed	Tower City	PA	17980
Yorktowne Senior Center	Tateosian	Lou	York	PA	17403

Appendix F *Pennsylvania Macroinvertebrate Taxa*

Over the past several years, DEP biologist Rod Kime has reviewed more than 5,000 macroinvertebrate taxa lists. They were collected from riffle/run sites across the State. This table shows:

- The macroinvertebrate taxa that were collected in the State
- The percent of times the taxon was found
- Gray shaded taxa are considered pollution sensitive, having a Hilsenhoff score of less than 3

You can use this list to help verify your identification as well as to help determine the quality of the water at your site.

Ed Molesky demonstrates deep water sampling techniques.

TAXON	Percent Occurrence Riffel/Run Stations
Hydropsychidae	93%
Chironomidae(other)	78%
Tipulidae	69%
Heptageniidae	69%
Elmidae	67%
Philopotamidae	61%
Perlidae	60%
Baetidae	59%
Cambaridae	58%
Psephenidae	49%
Nigronia	43%
Ephemerellidae	42%
Oligochaeta	41%
Isonychiidae	36%
Leptophlebiidae	32%
Simuliidae	31%
Rhyacophilidae	31%
Gomphidae	29%
Leuctridae	29%
Turbellaria	25%
Perlodidae	21%
Athericidae	20%
Sialidae	19%
Glossosomatidae	19%
Gammaridae	18%
Chironomidae (red)	18%
Chloroperlidae	17%
Peltoperlidae	16%
Asellidae	16%
Limnephilidae	15%
Polycentropodidae	15%
Pteronarcyidae	15%
Nemouridae	14%
Aeshnidae	14%
Capniidae	13%
Ephemeridae	12%
Physidae	12%
Sphaeriidae	10%
Corydalus	9%
Taeniopterygidae	8%
Amphipoda	7%
Annelida	7%

Appendix F continued *Pennsylvania Macroinvertebrate Taxa*

TAXON	Percent Occurrence Riffel/Run Stations
Tabanidae	7%
Uenoidae	7%
Hirudinea	7%
Ancylidae	6%
Brachycentridae	6%
Ceratopogonidae	6%
Dytiscidae	5%
Coenagrionidae	5%
Lepidostomatidae	4%
Ameletidae	4%
Other Worms	4%
Caenidae	4%
Corbiculidae	3%
Empididae	3%
Odontoceridae	3%
Calopterygidae	3%
Planorbidae	3%
Hydroptilidae	3%
Hydrophilidae	3%
Hydracarina	3%
Ptilodactylidae	2%
Cordulegastridae	2%
Corydalidae	2%
Gyrinidae	2%
Tricorythidae	2%
Tubificidae	2%
Baetiscidae	2%
Other Diptera	2%
Psychomyiidae	2%
Helicopsychidae	2%
Polymitarcyidae	2%
Lymnaeidae	1%
Pleuroceridae	1%
Potamanthidae	1%
Phryganeidae	1%

TAXON	Percent Occurrence Riffel/Run Stations
Siphlonuridae	1%
Leptoceridae	1%
Moths - Lepidoptera	1%
Unionidae	1%
Hydrobiidae	1%
Dixidae	1%
Dryopidae	<1%
Blephariceridae	<1%
Neoephemeridae	<1%
Dolichopodidae	<1%
Macromiinae	<1%
Crangonyctidae	<1%
Lestidae	<1%
Libellulidae	<1%
Viviparidae	<1%
Talitridae	<1%
Corduliidae	<1%
Molannidae	<1%
Psychodidae	<1%
Bryozoa	<1%
Valvatidae	<1%
Sisyridae	<1%

Keystone College students pose after a busy day in the field.

Appendix G *Hilsenhoff Scores for the top 99 Bugs Found in Pennsylvania!*

TAXA	Hils. #
1. Bryozoa (moss animals)	4
2. Hydracarina (water mites)	7
WORMS	
3. Annelida (segmented worms)	9
4. Oligochaeta (earthworms)	10
5. Tubificidae (tube worms)	10
6. Turbellaria (flatworms)	9
7. Other Worms	9
MOLLUSKS	
8. Hirudinea (leeches)	8
9. Ancylidae (limpets)	7
10. Hydrobiidae (snail)	8
11. Lymnaeidae (snail)	7
12. Physidae (snail)	8
13. Planorbidae (snail)	6
14. Pleuroceridae (snail)	7
15. Valvatidae (snail)	2
16. Viviparidae (snail)	8
17. Corbiculidae (Asian clam)	4
18. Sphaeriidae (fingernail clams)	8
19. Unionidae (large clams/mussels)	4
CRUSTACEANS	
20. Asellidae (pill bugs & sow bugs)	8
21. Amphipoda (scuds)	6
22. Crangonyctidae	4
23. Gammaridae	4
24. Talitridae	8
25. Cambaridae (crayfish)	6
MAYFLIES	
26. Ameletidae	0
27. Baetidae	6
28. Baetiscidae	3
29. Caenidae	7
30. Ephemerellidae	2

TAXA	Hils. #
31. Ephemeridae	4
32. Heptageniidae	3
33. Isonychiidae	3
34. Leptophlebiidae	4
35. Neoephemeridae	3
36. Polymitarcyidae	2
37. Potamanthidae	4
38. Siphlonuridae	7
39. Tricorythidae	4
DRAGONFLIES	
40. Aeshnidae	3
41. Cordulegastridae	3
42. Corduliidae	5
43. Macromiinae	3
44. Gomphidae	4
45. Libellulidae	9
46. Calopterygidae	5
47. Coenagrionidae	8
48. Lestidae	9
STONEFLIES	
49. Capniidae	3
50. Chloroperlidae	0
51. Leuctridae	0
52. Nemouridae	2
53. Peltoperlidae	2
54. Perlidae	3
55. Perlodidae	2
56. Pteronarcyidae	0
57. Taeniopterygidae	2
BEETLES	
58. Dryopidae	5
59. Dytiscidae (diving beetle)	5
60. Elmidae (riffle beetle)	5
61. Gyrinidae (whirligig)	4
62. Hydrophilidae	5
63. Psephenidae	4
64. Ptilodactylidae	5
MEGALOPTERA	
65. Corydalidae	3
66. Corydalus (dobsonfly)	4

TAXA	Hils. #
67. Nigronia (fishfly)	2
68. Sialidae (alderfly)	6
NEUROPTERA	
69. Sisyridae (spongillafly)	1
CADDISFLIES	
70. Brachycentridae	1
71. Glossosomatidae	0
72. Helicopsychidae	3
73. Hydropsychidae	5
74. Hydroptilidae	4
75. Lepidostomatidae	1
76. Leptoceridae	4
77. Limnephilidae	4
78. Molannidae	6
79. Odontoceridae	0
80. Philopotamidae	3
81. Phryganeidae	4
82. Polycentropodidae	6
83. Psychomyiidae	2
84. Rhyacophilidae	1
85. Uenoidae	3
LEPIDOPTERA	
86. (moths)	5
TRUE FLIES	
87. Athericidae	2
88. Blephariceridae	0
89. Ceratopogonidae	6
90. Chironomidae (bloodworms)	10
91. Chironomidae (other midges)	6
92. Dixidae	1
93. Dolichopodidae	4
94. Empididae	6
95. Psychodidae	10
96. Simuliidae (black fly)	6
97. Tabanidae	6
98. Tipulidae (crane fly)	4
99. Other Diptera (other flies)	6

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