Black River Action Team

3rd Annual Monitoring Report

December 2014

Contents

Introduction –

The Black River Action Team continued a volunteer water quality monitoring program in the summer of 2014 as a result of many elements dove-tailing: Tropical Storm Irene had blasted through the area in 2011, raising all sorts of concerns about the condition of the Black River; the BRAT welcomed member Bill Manner, who brings many years of experience with the Pennsylvania Department of Environmental Protection's Watershed Management Program; the Partnership Program with the La Rosa State Water Quality Laboratory accepted our application for inclusion; Endyne Laboratory in Lebanon, NH offered to donate dozens of E. coli tests to our cause; and volunteers began to step up and be willing to accept training and responsibility for the nine sites we chose to sample.

With the assistance of Marie Caduto, our region's Watershed Coordinator with the Agency of Natural Resources, the BRAT carefully selected eleven sites along the main stem of the Black River and three of her tributary streams to collect samples for monitoring.

Prior to monitoring for 2014 BRAT was able to enlist several new volunteers to assist with the sample collection. Lucy Georgeff, Chelsea Landry, Tammy Wright, Jess Curtis, and Rodger Capron assisted with sampling at regularly assigned sites after attending training with the BRAT Monitoring coordinator.

As part of the LaRosa Grant, we answered the following questions in our grant application and have listed our progress in the italicized text below.

What will be monitored?– Black River, Spoonerville Brook, Mile Brook and Great Brook will be monitored for E. Coliform, Nitrates, Phosphates, and Turbidity. The samples will be collected at a total of 11 sites, once a month for 5 months (May thru Sept.). *The Samples were collected on the May 28, June 25, July 30 August 27, and September 24, 2014.*

When will monitoring occur? – Beginning in late May /early June. A specific day will be determined and all sampling will need to be done on a designated day (like 3rd Monday of the month) at the same time of day. Samples will then be transported to the respective laboratories for analysis. *Monitoring was conducted as planned.*

How will samples be collected? – Volunteers will collect samples in the bottles provided by the laboratories, placed on ice and then be assembled for transport to laboratory. *Volunteers*

collected the samples; the bacteriological samples were driven to Ludlow, Vermont to meet the courier from Endyne Laboratory within four hours of collection; chemical samples were packaged on ice and shipped to LaRosa Labs via Green Mountain Courier. Training for the sample collectors was provided by the BRAT Monitoring Coordinator and at least once during the monitoring period the monitoring coordinator did site visits or reviewed monitoring procedures with the sample collectors.

Once the sample results are received from the laboratories, the results were entered into a data system, which will allow for the analysis of data, storage of data, and preparation of graphs and reports. *Sample results were entered into an Excel spreadsheet to allow analysis and graphing of the results.*

Our sites for 2014 were unchanged from the previous year and are listed below:

Site #1- BRAT.BR.1.6: Perley Gordon Road, dock at Stettner residence.

Convenient to access from a floating dock, this site is considered a "representation reach," as it is the closest to the Black River's confluence with the Connecticut River. It is the most downstream reach of the main stem, hosting a representation of all upstream impact. The river here is wide and flat, with a silty bed and a road on either bank. About 1/3 mile upstream is Gould Mill, a rocky waterfall that once hosted a mill; the waterfall offers a scenic view for users of the recreational trail on the bank above, as well as providing a mixing function for the river. Sampled by Kelly and Moira Stettner.

Site #2- BRAT.BR.2.4: Downstream of Springfield wastewater treatment facility. On the Black River -Sampled by Kelly and Moira Stettner.

Site #3- BRAT.BR.2.75: Upstream of Springfield wwtf.

This site goes hand-in-hand with Site #2; bracketing the outfall pipe for the wwtf should help the BRAT get a sense of any impact on the river from this outfall. Sampled by Kelly and Moira Stettner.

Site #4- BRAT.BR.3.6: Grout Park, behind Springfield Community Center.

This site is just below the last man-made dam on the Black River and below the main downtown industrial area of Springfield. Ducks and Canada geese are commonly seen here. Sampled by Kelly and Moira Stettner

Site #5 – BRAT.MB.0.0: Mile Brook

This site is just above the confluence of Mile Brook with the Black River in downtown Springfield samples by Lucy Georgeff.

Site #6 – BRAT.MB.0.2: Mile Brook Upstream

This site is located 0.2 miles above the confluence of Mile Brook with the Black River, just before Mile Brook is channeled underground under buildings and parking areas in downtown Springfield. Sampled by Lucy Georgeff

Site #7- BRAT.BR.5.1: Riverside Middle School.

A wide, flat, sandy-bottomed reach that is influenced by slow flow as the river enters a sharp bend downstream. The water here tends to be warmer, as there is no shading canopy of tree branches overhead to shield the river from the sun. Sampled by Chelsea Landry.

Site #8- BRAT.SB.0.1: Spoonerville Brook, North Springfield.

A small winding brook, the Spoonerville drains only about 5 square miles of watershed but runs very close to the site of a proposed biomass incinerator. The BRAT chose to sample Spoonerville Brook before the facility is approved and built, to generate baseline data that can be analyzed in the coming years. We hope to then be better able to recognize trends and notice changes, should the biomass incinerator be constructed. Sampled by Jess Curtis.

Site #9- BRAT.GB.0.3: Great Brook, North Springfield

Great Brook drains a much larger watershed than does the Spoonerville, coming into the Black River just 200’ upstream from the smaller brook. Great Brook runs along Main Street in North Springfield and may be impacted negatively by the truck traffic anticipated if the biomass incinerator is built. Again, we hope to build a solid database of information on Great Brook for future reference. Sampled by Jess Curtis.

Site #10 – BRAT.BR.8.6: Mill Rd, North Springfield

This reach is just downstream from the flood control dam managed by the Army Corps of Engineers, which holds back up to 16.7 billion gallons of water from the Black River main stem and the North Branch. Sampled by Tammy Wright.

Site #11 – BRAT.BR.12.3: Tolles Dam, Perkinsville.

This site is located just below the Tolles Dam, a popular swimming hole located of property controlled by the Army Corps of Engineers for the North Springfield Flood Control Reservoir. Sampled by Rodger Capron,

Samples were analyzed be Endyne Water Testing Laboratory and the LaRosa Analytical Laboratory through the Vermont Dept. of Environmental Conservation.

Methods

The sample collection protocol is spelled out in our QAPP document and this involves the following:

1. Bacteriological samples were collected by placing the sterilized bacteria bottles into the river and filling them to the top. These bottles then had the sample sheet completed, the samples placed on ice and transported to Endyne Laboratory within 6 hours of sample collection.
2. Nitrate samples required a plastic 50 ml centrifuge tube to be filled with the river sample to the 50 ml line. These samples also required that the sample tube be rinsed three times with river water before collecting the sample. These samples were then labeled with the pre-printed labels and placed on ice and shipped to the LaRosa Lab by courier.
3. Phosphate samples were collected using 60 ml glass vials, filled to the line marked on the vial. No rinsing of these vials was to be performed, and after collection they were labeled using the pre-printed labels, placed in ice and shipped to LaRosa Lab.
4. Turbidity samples were collected in 250 ml plastic bottles that were rinsed three times with river water prior to collecting the sample. These samples were then labeled using the pre-printed labels, placed on ice and shipped to LaRosa Lab.

Care must be taken during this sampling not to touch the inside or rim of the bottles, or the inside of the bottle caps, to prevent contamination. In addition to the samples collected, field blanks were collected using deionized water for Nitrates, and Turbidity, while duplicate samples were collected for Phosphates at each sample date for quality assurance.

Summary- It should be noted that all samples were collected on the dates indicated and represent a "snap-shot" of the water quality at the time of collection due to the dynamic nature of flowing waters, but can be relied upon to indicate basic water quality. This is the third year for the monitoring program initiated by BRAT and long term trends can be established after monitoring for several years. These results however, can indicate potential areas to explore further and refinement of monitoring locations may occur if problem areas are identified. For long term water quality evaluations, governmental organizations have been relying on data from macro invertebrates, as these organisms reside in the water and their presence/absence and population levels give reliable indications of water quality and are generally not impacted by short term variations in water quality. Variations in water quality were indicated in this year's results after the storm events, which significantly altered bacteriological and turbidity levels in the Black River for short periods of time.

Bacteriological

Sampling for E. Coli bacteria was performed at all sites for the time period May thru September 2014, with one interest being the safety of the water for full contact activities. The safe bacteria level for swimming as set by the Vermont Dept. Of Health is 235/100 ml. Most of the sample results obtained for the Black River fell below this level. However, the sample results from our May and July sampling greatly exceeded this level due to very heavy rain before the sampling

event. These rain events show the significance of runoff from lawns and fields on water quality. One site, BRAT.MB.0.0 had consistently high E. Coli counts exceeding the safe swimming levels, reflecting some old straight-pipe discharges into the brook between this site and the upstream site BRAT.MB.0.2. BRAT is currently working with the Town of Springfield to address this issue.

The weekly monitoring for E. Coli at Buttermilk Falls was conducted by Okemo Mountain Resort – all of those samples except June 18th were below 235/100 ml, indicating good water quality for swimming at this site throughout the season. The sample on June 18th followed a heavy rain event.

Greven Field in the Town of Cavendish was also monitored weekly for E. Coli by volunteers. These samples also indicated good water quality except for July 16th and 23rd when E. Coli levels were above 235/100 ml after rain events.

Nitrates -

Nitrate levels on the days sampled were all below 1 milligram per liter except for site BRAT.BR.2.4 on 9/24/14 that had a nitrate of 1.2 mg/l. These readings indicate that there is not any significant problem at this time from failing septic systems, sewage discharges, agricultural runoff, over fertilized lawns, or industrial discharges. Continued monitoring is desirable as in the future a Total Maximum Daily Load, or TMDL will be established by EPA for the Connecticut River to reduce the impact of nitrates on Long Island Sound. In addition monitoring for nitrates is desirable to determine if changes occur which could impact water quality.

Phosphates -

The level of phosphates on the days sampled ranged from a high of .00793 mg/l to a low of .0000766 mg/l. The levels found during the 2014 sampling of the Black River are below the levels recommended by EPA. EPA recommends maintaining phosphates below 0.5 mg/l for waters that discharge into lakes or reservoirs, and maintaining levels between .01 to 0.003 mg/l to reduce the impact of algal blooms.

Turbidity –

Turbidity levels found during the sampling of the Black River exhibited a range from a high of 315 NTU to a low of 0.057 NTU. The high readings were obtained after a major rainfall event on 7/30/14 and dropped to lower levels during dryer weather.

Next Steps –

The Black River Action Team is planning to continue sampling the Black River and selected tributaries in the future. We will apply for the LaRosa Laboratory grant for the 2015 season, if those grants are available and work with our partners at Endyne Labs to see if they can assist with our monitoring program in 2015. In the future we would like to expand our monitoring upstream to the Ludlow area and closer to the headwaters

In addition to the parameters and site locations monitored in 2014, we are attempting to expand the monitoring of the Black River swimming holes by partnering with local businesses who have been asked to "Adopt a Swimming Hole" and pay for weekly monitoring for bacteria. One swimming hole, Buttermilk Falls was adopted for 2014 by Okemo Mountain Resort. An Okemo staff member was trained by Bill Manner and monitored the area weekly from June to the end of August for E. Coli.

The BRAT team also expanded the scope of parameters monitored by adding pH and temperature at all monitoring sites. The Hach Mulitmeter probe was used for the pH Monitoring and thermometers for temperature.

Appendix 1

Site .	Date Sampled units	Nitrates mg/l	Phosphates ug/l	Turbidity NTU	E Coli CFU	pH
BRAT.BR.1.6	5/28/2014	0.35	32.7	8.65	550	8.12
BRAT.BR.2.4	5/28/2014	0.5	33.2	6.03	520	8
BRAT.BR.2.75	5/28/2014	0.31	29.5	6.57	730	8
BRAT.BR.3.6	5/28/2014	0.32	29.6	5.55	520	8.5
BRAT.MB.0.0	5/28/2014	0.6	793	315	>2400	7.86
BRAT.MB.0.2	5/28/2014	0.78	122	33	1700	7.9
BRAT.BR.5.1	5/28/2014	0.28	17.8	4.19	160	7.8
BRAT.SB.0.1	5/28/2014	0.27	26.5	5.53	260	7.9
BRAT.GB.0.3	5/28/2014	0.35	36.4	6.14	610	8
BRAT.BR.8.6	5/28/2014	0.27	17.9	5.85	100	8
BRAT.BR.12.3	5/28/2014	0.29	21.9	4.92	690	8.4
BRAT.FB	5/28/2014	<0.1	<5	<0.2		
BRAT.BR.8.6 Dup	5/28/2014	0.28	20.4	4.57		8
					NS=Not Sampled	
BRAT.BR.1.6	6/25/2014	0.54	16.1	1.89	120	7.9
BRAT.BR.2.4	6/25/2014	0.72	24.8	2.37	77	7.79
BRAT.BR.2.75	6/25/2014	0.43	16.8	2.35	72	7.83
BRAT.BR.3.6	6/25/2014	0.42	17	2.31	68	8
BRAT.MB.0.0	6/25/2014	0.44	35.1	2.35	2000	9
BRAT.MB.0.2	6/25/2014	0.42	20.4	2.14	59	8.95
BRAT.BR.5.1	6/25/2014	0.41	18	3.69	72	7.8
BRAT.SB.0.1	6/25/2014	0.52	15.6	0.81	70	8.8
BRAT.GB.0.3	6/25/2014	0.38	13.1	0.75	58	8.1
BRAT.BR.8.6	6/25/2014	0.38	16.3	2.55	56	7.9
BRAT.BR.12.3	6/25/2014	0.39	8.4	0.47	19	8.1
BRAT. FB	6/25/2014	<.1	<5	<0.2		
BRAT.BR.12.3 Dup	6/25/2014	0.37	7.66	NS		

BRAT.BR.1.6	7/30/2014	0.37	47.3	34.8	340	7.79
BRAT.BR.2.4	7/30/2014	0.43	46.6	33.8	520	7.68
BRAT.BR.2.75	7/30/2014	0.3	46.8	34.2	390	7.79
BRAT.BR.3.6	7/30/2014	0.3	46.9	34.8	460	7.94
BRAT.MB.0.0	7/30/2014	0.4	33	4.64	2000	7.9
BRAT.MB.0.2	7/30/2014	0.52	24	2.03	110	7.9
BRAT.BR.5.1	7/30/2014	0.28	42.7	30.5	820	7.9
BRAT.SB.0.1	7/30/2014	0.31	20	2.66	210	8.5
BRAT.GB.0.3	7/30/2014	0.41	28.9	4.02	320	8.2
BRAT.BR.8.6	7/30/2014	0.28	44.5	34.1	440	7.9
BRAT.BR.12.3	7/30/2014	0.25	18.5	3.58	98	8
BRAT. FB	7/30/2014	<0.1	<5	<0.2		
BRAT.BR.1.6 Dup	7/30/2014	0.32	47.2	33.2		
BRAT.BR.1.6	8/27/2014	0.36	14.8	1.74	72	7.74
BRAT.BR.2.4	8/27/2014	0.79	23.6	2.19	71	7.59
BRAT.BR.2.75	8/27/2014	0.29	11.8	2.1	88	7.65
BRAT.BR.3.6	8/27/2014	0.3	13.7	2.08	91	7.87
BRAT.MB.0.0	8/27/2014	0.39	21.2	1.24	2000	7.9
BRAT.MB.0.2	8/27/2014	0.45	20.8	0.57	250	8
BRAT.BR.5.1	8/27/2014	0.28	15.6	2.49	51	8.1
BRAT.SB.0.1	8/27/2014	0.35	12.3	1.11	24	8.1
BRAT.GB.0.3	8/27/2014	0.39	17.4	1.5	100	7.6
BRAT.BR.8.6	8/27/2014	0.25	14.5	2.7	20	7.8
BRAT.BR.12.3	8/27/2014	0.26	9.21	0.57	19	8.1
BRAT. FB	8/27/2014	<0.1	<5	<0.2		
BRAT.BR.2.4 Dup	8/27/2014	0.78	22.8	2.5		
BRAT.BR.1.6	9/24/2014	0.6	13.1	1.44	68	7.93
BRAT.BR.2.4	9/24/2014	1.2	19.1	1.81	41	7.5
BRAT.BR.2.75	9/24/2014	0.33	11.9	1.7	88	8.06
BRAT.BR.3.6	9/24/2014	0.33	12.4	2.48	63	7
BRAT.MB.0.0	9/24/2014	0.58	49.1	2.52	>2400	8.5
BRAT.MB.0.2	9/24/2014	0.39	38.3	5.79	70	8.49
BRAT.BR.5.1	9/24/2014	0.32	14.6	2.37	55	8.3
BRAT.SB.0.1	9/24/2014	0.5	12	0.74	28	7.95

BRAT.GB.0.3	9/24/2014	0.42	10.4	0.96	3	8
BRAT.BR.8.6	9/24/2014	0.26	11.7	2.39	10	8.3
BRAT.BR.12.3	9/24/2014	0.29	9.67	2.8	26	8.25
BRAT. FB	9/24/2014	<0.1	<5	<0.2		
Dup, BRAT.BR.2.75	9/24/2014	0.32	12	2.03		

Results from Buttermilk Falls monitoring conducted by Okemo Mountain

Buttermilk Falls	E. Coli Results 2014		
6/4/2014	63	cfu	
6/11/2014	55	cfu	
6/18/2014	390	cfu	heavy rain in past 24 hrs
6/25/2014	4	cfu	
7/2/2014	10	cfu	
7/9/2014	N/S	cfu	
7/16/2014	93	cfu	
7/23/2014	2	cfu	
7/30/2014	54	cfu	
8/6/2014	36	cfu	
8/13/2014	100	cfu	
8/20/2014	5	cfu	
8/27/2014	6	cfu	
9/3/2014	96	cfu	

Results from Greven Field monitoring

Greven Field			
5/28/2014		NS	cfu
6/4/2014		146	cfu
6/11/2014		60	cfu
6/18/2014		110	cfu
6/25/2014		66	cfu
7/2/2014		118	cfu
7/9/2014	N/S		cfu
7/16/2014		250	cfu
7/23/2014		360	cfu
7/30/2014		86	cfu
8/6/2014		72	cfu
8/13/2014		43	cfu
8/20/2014		NS	cfu
8/27/2014		44	cfu
9/3/2014		79	cfu

Appendix 2

Parameter Information

The following information is from the federal Environmental Protection Agency, Office of Water publication - Volunteer Stream Monitoring: A Methods Manual, EPA 841-B-97-003 November 1997 and provides information about the parameters and the significance of the parameters selected for monitoring to water quality.

Bacteriological

What are fecal bacteria and why are they important?

Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoan's that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff.

In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand. (Refer to the section on dissolved oxygen.)

Indicator bacteria types and what they can tell you

The most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, *Escherichia coli*, fecal streptococci, and enterococci. All but *E. coli* are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior; *E. coli* is a single species in the fecal coliform group.

Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. Thus, the usefulness of total coliforms as an indicator of fecal contamination depends on the extent to which the bacteria species found are fecal and human in origin. For recreational waters, total coliforms are no longer recommended as an indicator. For drinking water, total coliforms are still the standard test because their presence indicates contamination of a water supply by an outside source.

Fecal coliforms, a subset of total coliform bacteria, are more fecal-specific in origin. However, even this group contains a genus, *Klebsiella*, with species that are not necessarily fecal in origin. *Klebsiella* are commonly associated with textile and pulp and paper mill wastes. Therefore, if these sources discharge to your stream, you might wish to consider monitoring more fecal and human-specific bacteria. For recreational waters, this group was the primary bacteria indicator until relatively recently, when EPA began recommending *E. coli* and enterococci as better indicators of health risk from water contact. Fecal coliforms are still being used in many states as the indicator bacteria.

E. coli is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. EPA recommends E. coli as the best indicator of health risk from water contact in recreational waters; some states have changed their water quality standards and are monitoring accordingly.

Fecal streptococci generally occur in the digestive systems of humans and other warm-blooded animals. In the past, fecal streptococci were monitored together with fecal coliforms and a ratio of fecal coliforms

to streptococci was calculated. This ratio was used to determine whether the contamination was of human or nonhuman origin. However, this is no longer recommended as a reliable test.

Enterococci are a subgroup within the fecal streptococcus group. Enterococci are distinguished by their ability to survive in salt water, and in this respect they more closely mimic many pathogens than do the other indicators. Enterococci are typically more human-specific than the larger fecal streptococcus group. EPA recommends enterococci as the best indicator of health risk in salt water used for recreation and as a useful indicator in fresh water as well.

Which Bacteria Should You Monitor?

Which bacteria you test for depends on what you want to know. Do you want to know whether swimming in your stream poses a health risk? Do you want to know whether your stream is meeting state water quality standards?

Studies conducted by EPA to determine the correlation between different bacterial indicators and the occurrence of digestive system illness at swimming beaches suggest that the best indicators of health risk from recreational water contact in fresh water are *E. coli* and enterococci. For salt water, enterococci are the best. Interestingly, fecal coliforms as a group were determined to be a poor indicator of the risk of digestive system illness. However, many states continue to use fecal coliforms as their primary health risk indicator.

If your state is still using total or fecal coliforms as the indicator bacteria and you want to know whether the water meets state water quality standards, you should monitor fecal coliforms. However, if you want to know the health risk from recreational water contact, the results of EPA studies suggest that you should consider switching to the *E. coli* or enterococci method for testing fresh water. In any case, it is best to consult with the water quality division of your state's environmental agency, especially if you expect them to use your data.

According to the Vermont Department of Health, *E. coli* in water is measured as the number of bacteria found in 100 milliliters (mls) of water. In Vermont, when the test result at a public swimming area is 235 *E. coli*/100mls or less, it means that the water is considered suitable for swimming. A result greater than 235 E. coli/100 mls means

that the water is not considered suitable for swimming.

Nitrate

What are nitrates and why are they important?

Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L.

Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.

Sampling and equipment considerations

Nitrates from land sources end up in rivers and streams more quickly than other nutrients like phosphorus. This is because they dissolve in water more readily than phosphates, which have an attraction for soil particles. As a result, nitrates serve as a better indicator of the possibility of a source of sewage or manure pollution during dry weather.

Water that is polluted with nitrogen-rich organic matter might show low nitrates. Decomposition of the organic matter lowers the dissolved oxygen level, which in turn slows the rate at which ammonia is oxidized to nitrite (NO2) and then to nitrate (NO3). Under such

circumstances, it might be necessary to also monitor for nitrites or ammonia, which are considerably more toxic to aquatic life than nitrate. (See Standard Methods section 4500-NH3 and 4500-NO2 for appropriate nitrite methods; APHA, 1992)

Water samples to be tested for nitrate should be collected in glass or polyethylene containers that have been prepared by using Method B in the introduction.

Phosphate

Why is phosphorus important?

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

Forms of phosphorus

Phosphorus has a complicated story. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (PO_4). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate.

Both organic and inorganic phosphorus can either be dissolved in the

water or suspended (attached to particles in the water column).

The phosphorus cycle

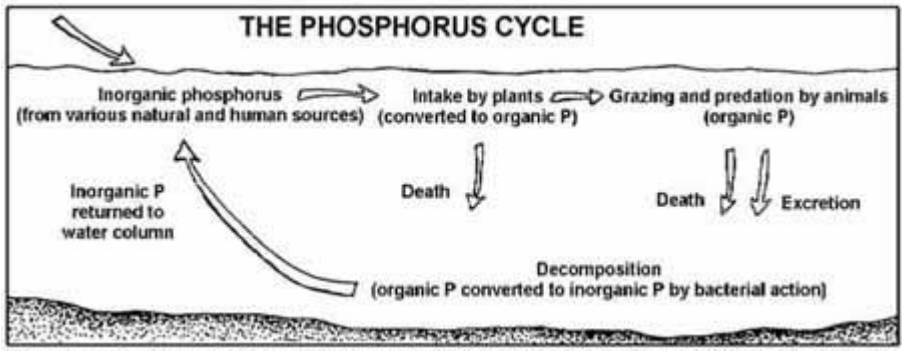

Figure 5.12

The phosphorus cycle
Phosphorus changes form as it cycles through the aquatic environment.

Phosphorus cycles through the environment, changing form as it does so (Fig. 5.12). Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Animals get the organic phosphorus they need by eating either aquatic plants, other animals, or decomposing plant and animal material.

As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again.

In a stream system, the phosphorus cycle tends to move phosphorus downstream as the current carries decomposing plant and animal tissue and dissolved phosphorus. It becomes stationary only when it is taken up by plants or is bound to particles that settle to the bottom of pools.

Turbidity

What is turbidity and why is it important?

Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macro invertebrates. Sources of turbidity include:

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth.

Sampling and equipment considerations

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of stormwater runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of streambanks and channels. Turbidity can

also rise sharply during dry weather if earth-disturbing activities are occurring in or near a stream without erosion control practices in place.

Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Comparisons of the change in turbidity over time, therefore, should be made at the same point at the same flow. Turbidity is not a measurement of the amount of suspended solids present or the rate of sedimentation of a steam since it measures only the amount of light that is scattered by suspended particles.