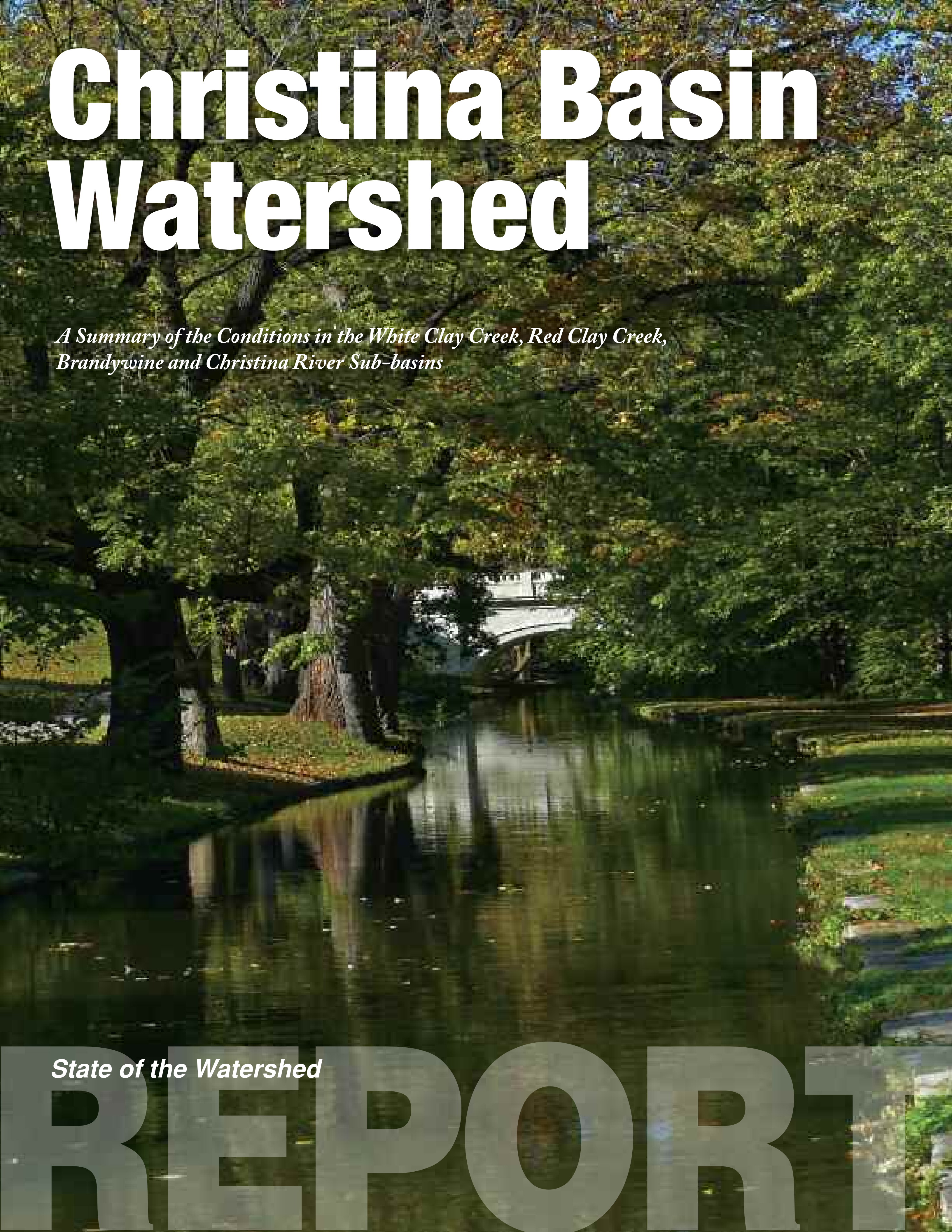
Christina Basin Watershed

A Summary of the Conditions in the White Clay Creek, Red Clay Creek, Brandywine and Christina River Sub-basins



State of the Watershed

REPORT

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Cover Photo: Mill Race along Brandywine Creek,
near Josephine Gardens, Wilmington, DE
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Photo by Rod Hampton

The State of the Christina Basin Watershed

Summary of Conditions in the White Clay Creek, Red Clay Creek, Brandywine Creek, and Christina River sub-basins

The Christina Basin covers 564 miles in Delaware, Pennsylvania, and Maryland and includes 4 sub-basins – the White Clay Creek, Red Clay Creek, Brandywine Creek, and Christina River. Technical Monitoring Volunteers of Delaware Stream Watch test water quality in the Delaware portion of the Basin and have collected monthly chemical data since the end of 1995.

Individual reports have been compiled for all four sub-basins and are available by contacting the Delaware Nature Society at (302) 239-2334 or visiting our website at www.delawarenaturesociety.org.

Results of Chemical Data Collected 2001 - 2005

Data for all four sub-basins indicate that water temperature, pH, alkalinity and conductivity are relatively consistent and meet state standards. In the previous 5 year study the greatest concerns for the watershed were low levels of dissolved oxygen during the summer and the amount of nitrogen that enters the waterway. With the addition of phosphate testing in 2002, it is easier to put the nitrogen levels into perspective. Overall, in the watershed, the dissolved oxygen levels are higher for the period between 2001 and 2005 then they were for the period between 1995 and 2000. The nitrate levels are lower during this time period. This is encouraging and it will be important to see if these trends continue.

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen available to aquatic organisms. Essential to the survival of aquatic life, DO is one of the most important indicators of water quality and is influenced by many biological and physical processes.

Oxygen from the atmosphere enters streams by the aerating action of the wind and by water flowing over rocks. In addition, algae and submerged aquatic plants help to increase DO levels during the day through photosynthesis. The respiration of aquatic plants and animals and the decomposition of organic matter remove DO from the water. DO is usually lowest in the pre-dawn hours when both plants and animals have been respiring all night and no oxygen has been produced by photosynthesis. These processes create a daily cycle of increasing and decreasing DO values.

In addition, DO is temperature-dependent, creating seasonal cycles of highs and lows. As the water temperature increases, oxygen is released from the water to the atmosphere. Cold water can therefore hold more DO. For this reason, streams that are shaded by trees can maintain cooler temperatures and higher DO values in the summer, supporting a greater diversity of macroinvertebrates and providing desirable habitat for cold water fish such as trout.

DO levels are the lowest of the year just before dawn during hot summer months. This is the result of several factors working to lower DO, including warmer water temperatures, respiration of many more aquatic plants and animals, and the movement of a greater volume of nutrients through the watershed during the growing season. Excess nutrients in the water can create an abundance of detrimental algae, which deplete DO through nightly respiration and through the decomposition of dead algae.

Low levels of dissolved oxygen can cause fish kills and can limit the biological diversity of the stream since aquatic organisms need the oxygen in the water just as we need the oxygen in the air. The DO standards set by the State of Delaware are a minimum of 4.0 mg/L and a seasonal average of greater than 5.5 mg/L in the months June to September. Our results indicate that the state standards for dissolved oxygen were generally met during the day, however, additional monitoring, especially during the night, may reveal that these standards are not being met.

From 2001-2005, the minimum state standards of DO were usually met at all sampling sites on the Red Clay and the White Clay Creek Watersheds. Four of 7 sites met state standards on the Brandywine River with the exception of single readings in the two main stem sites (Brandywine Zoo and Hagley Museum) and a single reading at the Husbands Run site. In the Christina River watershed, one of 9 sites had a single reading below the minimum state standard and another site had almost half its minimum DO readings fall below state standards (both are main stem sites – RT 141 Bridge and Noramco). Two of the Christina River tributary sites did not have enough summertime data to make a conclusion (Muddy Run and Belltown Run). The summer averages met the state standards for all sites. The average daytime DO levels for the entire duration of the study were equal to or greater than 5.5 mg/L in all sub-basins (with the single exception of the Christina River Noramco site with 4.7 mg/L average).

pH

Another important indicator of the health of a body of water is the pH. Any large increase or decrease in pH would harm the inhabitants of the stream. The pH of a stream is measured on a scale of 0 to 14. The term pH literally means potential of hydrogen. Water with more hydrogen ions (H+) than hydroxyl ions (OH-) is acidic and has a pH of less than 7, while water with more OH- ions than H+ ions is alkaline with a pH greater than 7. Water of pH 7 is neutral and has equal concentrations of the two ions. Since the pH scale is exponential, the differences between pH units represent magnitudes of the power of 10. Compared to the pH of 6, for example, a pH of 5 is ten times more acidic and a pH of 4 is one hundred times more acidic.

The pH of a stream affects the chemical processes that occur in the water. It can also affect the availability of nutrients to aquatic organisms by disrupting their metabolism. In fish, low values of pH can cause the softening of bones, interfere with reproduction, and cause gills to become clogged with mucus. Many people are aware of the effects of acidic materials, but alkaline materials can be just as harmful. Bleach is an example of an alkaline liquid.

The pH standard set by the State of Delaware is 6.5 to 8.5. Bacteria can tolerate a wide range of pH, while fish and the aquatic insects they feed on prefer a pH close to neutral. The largest diversity of aquatic organisms can be found in bodies of water with a pH of 6.5 to 7.5. Average pH levels in White Clay, Red Clay, and Brandywine sub-basins met state standards. The Christina River sub-watershed had two sites that did not meet the average state standard (both Muddy Run and Belltown Run had averages of between 6.0 and 6.5). In addition, two sites (Smalley's Dam Rd. and Rittenhouse Park) had a single sample outside of the standard range.

Alkalinity

Alkalinity is a measure of the acid neutralizing, or buffering, capacity of a solution. Natural waters contain ions that are dissolved from the soil and bedrock of the watershed. These ions may be acidic or alkaline. Higher values of alkalinity indicate that a greater number of alkaline ions are present. The presence of alkaline ions in the water gives it the ability to withstand some acidic input. The alkalinity of a stream can vary according to the amount of rainfall, the season, and the geology of the watershed. The alkalinity standard set by the State of Delaware is greater than 20 mg/L. Average alkalinity levels in each of the sub-basins met state standards. Only one site on the Christina River (Belltown Run) had individual readings below 20 mg/L on a regular basis (18% of the readings).

Excess Nutrients

Nitrogen makes up about 80% of the air we breathe. Inorganic nitrogen may exist as nitrates, nitrites, or ammonia; organic nitrogen is found in proteins and other compounds. Nitrates are the most common forms of nitrogen found in water. Excess nitrates enter aquatic systems from soil, fertilizer runoff and sewage treatment plants. While nutrients are necessary to support the aquatic food web, in abundance, nitrates become detrimental through a process called eutrophication. Eutrophication refers to the natural aging process of a water body that may be greatly accelerated by human activities, causing algal blooms and a corresponding decrease in dissolved oxygen.

The presence of excess nutrients such as nitrate-nitrogen is also a threat to the Christina Basin watershed. Excess nutrients impact wildlife indirectly by lowering dissolved oxygen levels and encouraging the proliferation of undesirable species of algae. The target level for total nitrogen (all forms of nitrogen combined) in Delaware freshwater is 1.0 to 3.0 mg/L.

Data show that the levels of nitrate-nitrogen have decreased overall when compared to the results from the time period of 1995-2000. Data collected by Technical Monitors show the average nitrate-nitrogen levels in all sub-basins of the Christina River are below the state standards for total nitrogen except at one site in the White Clay Creek (Pike Creek) and several sites on the main stem of the Red Clay Creek. Individual readings at most sites in all sub-basins occasionally exceeded state target levels, although most of the readings that were above 3.0 mg/L were recorded before mid 2003 except in the Red Clay and White Clay Creeks. Where the average nitrate-nitrogen values exceeded the desired range of total nitrogen, the readings were below 4.0 mg/L, showing an overall decline from the 1995-2000 time period. Nitrate-nitrogen levels at five out of eight Red Clay Creek sites had over 50% of the samples exceed the desired range of total nitrogen. None of the sites exceeded 3.0 mg/L every single time unlike the previous study (1995-2000) in which two of the sites recorded over 3.0 mg/L at every single reading.

The state phosphate target level is between 0.3 and 0.6 mg/L. At almost all sites the average orthophosphate level fell below the target levels and for the few sites that were within range their average levels were at the low end of the target range. There were several sites in the Christina and Brandywine sub-basins that had single individual recordings where the orthophosphate values were above range. Overall, phosphate is a limiting factor in this system as it is present in very low levels. The relatively high levels of nitrate present will not cause the problems associated with nutrient loading without higher levels of phosphate available.

Conductivity

Conductivity is a term used to describe how well electricity is transmitted, and in this case, is a measure of dissolved inorganic salts in a waterway. Water with a high concentration of dissolved salts transmits electricity and has a high value of conductivity. Conductivity values are generally consistent for a particular stream, reflecting the geologic characteristics of the watershed. Sudden, drastic changes in conductivity may indicate additional inputs into the stream system. The typical range of conductivity for Delaware piedmont streams is 120 to 400 ms. Average conductivity values in all sub-basins of non-tidal sites fell within this typical range, with the exception of two sites on the Red Clay Creek (Benge Rd. and Ashland Nature Center) and one on the Brandywine (Rocky Run).

Conclusions

Water quality regulations, beginning with the Clean Water Act, protect our local waterways from the drastic addition of pollutants. For this reason, water quality parameters such as pH, alkalinity, conductivity, and water temperature are within the acceptable ranges and tend not to differ between sites or over the time period included in this study. However, of more imminent concern is the addition of nutrients to our local waterways and the resulting decrease in dissolved oxygen.

Results indicate that if the suggested levels for total nitrogen are being exceeded in the Christina basin it is no longer due to nitrate-nitrogen. The average levels of nitrate-nitrogen at all but 4 sites (one in the White Clay and three in the Red Clay sub-basins) are below the state standard for total nitrogen. This is a significant change from the previous study period (1995-2000) where all 4 sub-basins nitrate-nitrogen levels exceeded the state standard for total nitrogen, even though they represent only one form of total nitrogen. Individual samples did exceed the state standard in most of the sites occasionally, but most were recorded before mid 2003. This suggests that the nitrate-nitrogen levels are improving over time.

While the amount of nitrogen in these waterways is still of concern, it may not be the nutrient that limits algae growth in this waterway. Algae growth is dependent on the availability of both nitrogen and phosphorus. Since the concentration of nitrogen is already beyond the desirable range, very small changes in the amount of phosphorus can create drastic increases in the amount of algae and bacteria in the stream. While algae and bacteria are part of natural ecosystems, in large quantities, these organisms may present a human health risk and can cause very low levels of dissolved oxygen in the summer.

The overall nutrient picture is even more encouraging when you include the phosphate data. Phosphate testing was added in 2002, and gives a more complete nutrient representation. Both phosphate and nitrate are needed for growth; a high level of one without a high level of the other will not produce the algae blooms that are the cause for concern.

Conductivity data collected was within the typical range for Delaware piedmont streams with two main exceptions; sites that were tidal and sites located near roads or pathways that are salted during winter months. In these cases, the results are not unexpected. Tidal sites will have higher conductivity levels than piedmont sites, reflecting the influence of the salts present in coastal plain stream sites. The higher conductivity levels in the second group of sites are probably due to salt on the roadways during the winter months washing into the waterways. There are however, two non-tidal sites on the Red Clay Creek which recorded high conductivity levels, presenting a concern. These results were obtained at all times of the year and do not reflect salting of the roads in winter and could be due to discharge from a wastewater treatment plant. Technical Monitoring volunteers have found higher levels of conductivity in the Red Clay Creek than in neighboring watersheds like the Brandywine. Both of the monitoring sites that exceeded the typical range are located on the mainstem downstream of the Kennett Square wastewater treatment facility. Dissolved ions such as chlorine, sodium, calcium and magnesium are typically released from wastewater treatment plants and are detected by measuring conductivity. The concentration of ions that was found in the Red Clay Creek probably does not affect wildlife and is low in comparison to seawater.

While the data collected through this program indicate that dissolved oxygen values in the watershed meet state standards during the day, this may provide a false sense of security because the daylight sampling performed by this program does not capture pre-dawn minimums that occur in most water bodies during the summer months. Even if daily averages meet the required standards, oxygen may fall to deadly levels for a few hours each day. This time is all that is required to diminish the diversity of organisms that can live in a given waterway and potentially cause fish kills.

What You Can Do

As the Technical Monitoring results have confirmed, the biggest threat to our waterways is not pollution from industry, but pollution from our yards, farms, roadways, and construction sites. This type of pollution, because it comes from so many sources, is called nonpoint source pollution. Contaminants from every community—sediments, sewage, pet waste, fertilizers, and pesticides—are carried into local streams and rivers when water runs over the land, picks up pollutants, and deposits them into nearby waterways. As residents of the watershed, we can all make a difference in local water quality by disposing of household chemicals responsibly, reducing or eliminating the use of chemical fertilizers and pesticides, protecting stream corridors with trees, creating backyard habitats, and volunteering for a Stream Watch program.

The Technical Monitoring Program

The Technical Monitoring Program was established in 1995 to provide reliable physical and chemical baseline data on the four sub-watersheds of the Christina River Basin in northern Delaware. The Program now includes 38 monitoring sites in the Greater Christina River Basin, chosen by DNREC to supplement information obtained through the state's monitoring efforts in other locations. Five sites located in the Mispillion River Basin were added in 2003 and five sites located in the Appoquinimink River Basin were added in 2007. Volunteers monitor assigned sites on a monthly basis, measuring temperature, dissolved oxygen, pH, nitrate nitrogen, orthophosphate, alkalinity, conductivity, and salinity (in tidal reaches). All volunteers attend two initial training sessions administered by the Stream Watch Coordinator. In addition, volunteers must participate in two annual quality control events coordinated by Delaware Nature Society staff, to ensure the data they collect is usable by the state. Volunteers submit data sheets for each sampling date that are reviewed by the Stream Watch Coordinator at Delaware Nature Society and then entered into the state's database.

Equipment used by Technical Monitoring Volunteers

Parameter	Equipment used
Dissolved oxygen	La Motte Dissolved Oxygen Field Kit (item # 7414/EDO)
pH	La Motte pH Field Kit (item # 2117/P-3100)
Alkalinity	La Motte Alkalinity Field Kit (item # 4491-DR)
Nitrate-nitrogen	La Motte Nitrate Field Kit (item # 3519/NCR-2)
Conductivity	Oakton Conductivity Meter (WD-35607-20 or TDSTestr 20)
Orthophosphate	Hach Orthophosphate Field Kit (MODEL # PO-19)
Temperature	La Motte Thermometer (item # 1066)
Salinity	Aquatic Ecosystems, Inc. Salinity Refractometer (item # SR3)

About the Delaware Nature Society

The Delaware Nature Society is a non-profit membership organization which fosters understanding, appreciation and enjoyment of the natural world through education and experience. DNS focuses on ecological preservation, stewardship and conservation of our area's natural resources. DNS maintains three main program and experiential sites: Ashland Nature Center and Coverdale Farm, in New Castle County and Abbott's Mill Nature Center in Sussex County. In addition the organization manages four nature preserves: Burrows Run and Flint Woods Preserves in New Castle County and Marvel Saltmarsh and Cedar Bog Preserves in Sussex County. The Society is also the Delaware affiliate of the National Wildlife Federation with input on national issues that concern citizens in our region.

Through its conservation and preservation programs the Society has become a major force in the protection of Delaware's natural heritage. By providing the leadership for a coalition of more than 300 organizations, the Society helped secure permanent revenue streams for the acquisition of open space and farmland. The organization manages over 1000 acres and protects more than 480 acres through conservation easements. Through its education programs it makes over 70,000 contacts annually with school students, members, and public group participants. The Society provides graduate courses for teachers through the University of Delaware and Wilmington College and develops environmental professionals through an Environmental Institution Management graduate course and Professional Leadership Institute.

The Society publishes books, videotapes, and materials on natural history topics, maintains a 4,000 volume library, and provides a clearinghouse for information on a wide variety of nature subjects and environmental issues. For more information;

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