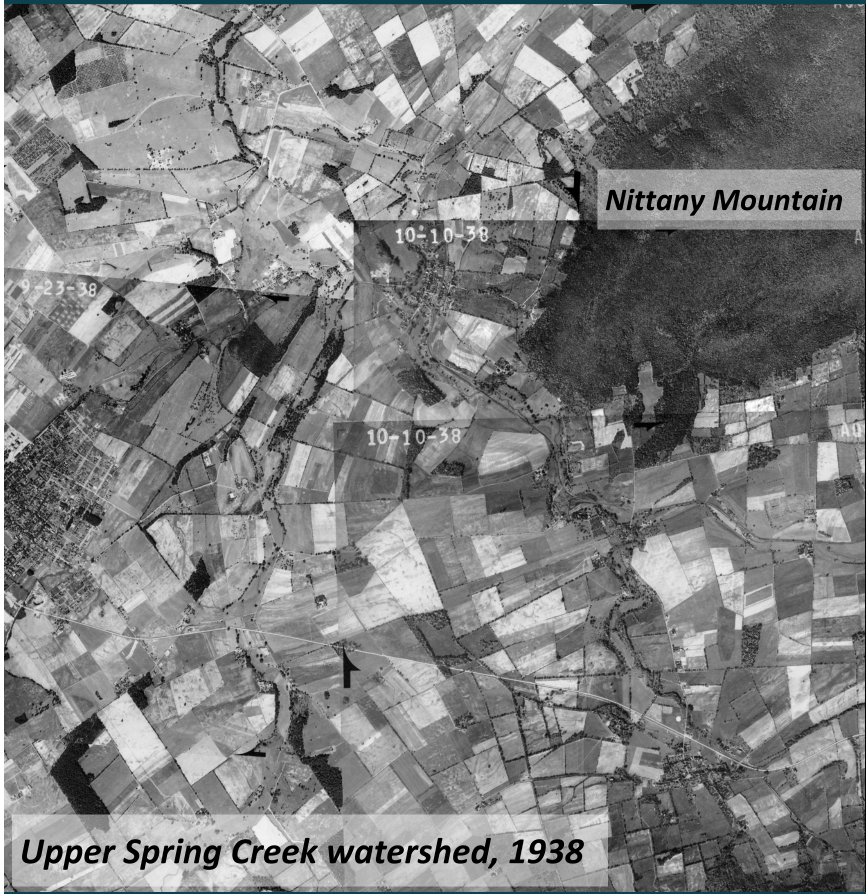
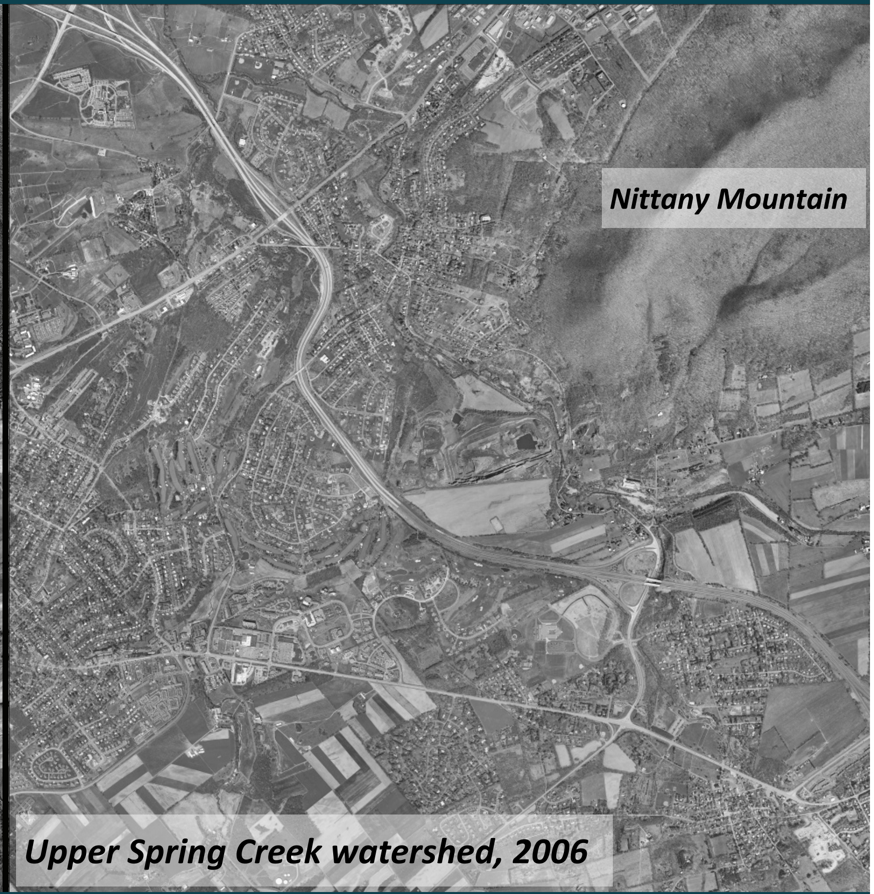
2010 State of the Water Resources Report





Spring Creek Watershed Association
Water Resources Monitoring Project

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__Cover Photographs__
Left: Aerial view over Oak Hall of the Spring Creek Watershed, 1938. Courtesy of Penn Pilot Photo Center and Pennsylvania Geological Survey. http://www.pennpilot.psu.edu/

Right: Aerial view over Oak Hall of the Spring Creek Watershed, 2006. Courtesy of PA MAP, Pennsylvania Department of Conservation and Natural Resources. http://www.dcnr.state.pa.us/topogeo/pamap/index.aspx

SPRING CREEK WATERSHED ASSOCIATION
A grassroots stakeholder initiative

From the Chair

Welcome to the 2010 edition of the Spring Creek Water Resources Monitoring Program (WRMP) annual report. In 2010 we achieved our mission of maintaining and collecting surface water and groundwater data necessary to assess long term trends in the health of our watershed. As is customary, the annual report provides a synopsis of the data collected in 2010 as compared to the previous eleven years of the program. Over the past few editions of the report we have provided an additional special topic based on interpretations of the data. For this year's report, the Water Resources Monitoring Committee decided to continue the tradition by including a hard copy of Pennsylvania Fish and Boat Commission Technical Report No. 1, *The Fishery of Spring Creek: A Watershed Under Siege* by R. F. Carline, et. al., 2011. This publication is both a superb example of the value of long-term monitoring and a comprehensive analysis of factors contributing to the health of our watershed. Data sets from the WRMP are referenced throughout the publication. Although released in the spring of 2011 and available online at http://fishandboat.com/water/streams/springck_fishery.pdf, hard copies of Technical Report No. 1 are essentially out-of-print. Special permission was obtained from the Pennsylvania Fish and Boat Commission to reproduce the publication for inclusion with this annual report.

As described in Technical Report No. 1, one of the major threats to our cold water fishery is the increase in the amount of impervious surface (roofs, roads, parking lots, and the like) that comes with urbanization. That's why the cover of this annual report gives comparative aerial views of our watershed from 1938 and 2006, which show the dramatic increase in impervious surface over time.

Also described within the publication are examples of programs that have been initiated by our community to help maintain the quality of the cold water fishery, including Penn State's land treatment of sewage effluent, the University Area Joint Authority's Beneficial Reuse program, stormwater management, and riparian buffer restoration.

A couple of the authors of Technical Report No. 1 are affiliated with the WRMP. Rebecca Dunlap is a past WRMP coordinator who served in that role from May 2004 to February 2007. Senior author Robert Carline is an original member of the Water Resources Monitoring Committee formed in 1999 and did an excellent job of serving as its Chair for many years, retiring from that duty in the fall of 2010. He continues to participate as an active and valuable member of the committee.

The day to day activities of the WRMP are described in this annual report. They include maintaining monitoring stations, collecting data from monitoring stations, replacing monitoring equipment when needed, and maintaining a computerized database. We provide output from our database upon request to municipal officials, consultants, planners, and researchers. In addition, we are continuously reassessing the scope of our program and looking for new ways to fulfill our mission. In that regard we are involved with the following current activities:

- Plans are being developed by our outreach subcommittee to inform a broader audience as to the value of the WRMP.
- The technical subcommittee is in the process of reassessing our discharge rating curves and we will be

From the Chair

implementing their recommendations starting in the fall of 2011.

- ❖ We are carefully considering the addition of periodic macroinvertebrate surveys as a function of the WRMP.
- ❖ We are assessing the role of the local USGS monitoring stations at Houserville, Axeman, and Milesburg in our program as on-going operation of these stations is under scrutiny due to budgetary constraints.

As a final note, I would like to take this opportunity to mention a change in the WRMP coordinator position at ClearWater Conservancy. Brianna Hutchison resigned in the fall of 2010 to take a position with the Susquehanna River Basin Commission. In early 2011, we were pleased to hire Nick Schipanski as our new coordinator. Nick is a trained aquatic biologist with experience working for watershed groups in the Finger Lakes region of New York State.

Thank you very much for your continued support of the WRMP. I am sure you will enjoy reading your copy of Technical Report No. 1, *The Fishery of Spring Creek: A Watershed Under Siege*. Please contact Nick or me if you have any questions concerning this annual report or the WRMP.

Rick Wardrop

Chair

Spring Creek at Oak Hall (credit: S. Knorr)

The Spring Creek Watershed Association, a grassroots stakeholder group composed of concerned citizens and professionals, initiated the Water Resources Monitoring Project (WRMP) in 1997 as part of its strategic plan for protecting the watershed. Their goal was to gather base-line information about the quantity and quality of water in the Spring Creek Watershed that could be used for the long-term protection of the resource as stress on the resource increased over time. A group of local environmental professionals formed the Water Resources Monitoring Committee (Table 1) in 1998 to develop and oversee the WRMP. The first surface water monitoring stations were established in late 1998/early 1999. Groundwater, stormwater, and spring monitoring stations were added as the project gained momentum (see Figure 1 for a timeline of events). Over the past 12 years, the WRMP has strived to:

A. Provide a description of the quantity and quality of the surface waters of Spring Creek and its tributaries, including springs.
B. Provide a description of the quality of storm-water runoff throughout the watershed.
C. Monitor ground-water levels in critical areas.
D. Provide the means to detect changes in quantity and quality of surface waters under both baseflow and storm-water runoff conditions, as well as ground-water reserves.
E. Provide sufficient measurement sensitivity through long-term monitoring to permit the assessment of the previously mentioned parameters.

The WRMP field stations and database are maintained primarily by the Water Resources Coordinator, a full-time staff position housed at ClearWater Conservancy, with the assistance of volunteers and ClearWater interns. A number of local partners provide funding to carry out WRMP data collection activities to support this one-of-a-kind project in 2010. Donors in support of the 2010 effort included:

- Bellefonte Borough
- Benner Township
- College Township
- College Township Water Authority
- Ferguson Township
- Halfmoon Township
- Harris Township
- Patton Township
- Pennsylvania State University Office of Physical Plant
- Spring Township
- Spring Township Water Authority
- State College Borough
- State College Borough Water Authority
- Spring Creek Chapter of Trout Unlimited
- University Area Joint Authority

Project Background

In addition to financial support, the WRMP received in-kind donations of professional services, laboratory analyses and supplies, technical assistance, and transportation from the following in 2010:

- Ground-water well owners
    - PA Department of Conservation and Natural Resources
    - Todd Giddings
    - Penn State University Office of Physical Plant
    - United States Geological Survey (USGS)
- Pennsylvania Department of Environmental Protection
- Pennsylvania Cooperative Fish and Wildlife Research Unit
- USGS
- University Area Joint Authority
- Volunteer field assistants
- Water Resources Monitoring Committee

Spring Creek at Spring Creek Park (credit: N. Schipanski)

WRMP Timeline

Figure 1. Timeline of major events associated with the Water Resources Monitoring Project.

Table 1. Water Resource Monitoring Committee Members for 2010.

WRMP Committee Member	Affiliation	WRMP Committee Member	Affiliation
Rick Wardrop, P.G. ***Committee Chair*** Hydrogeologist	Shaw Environmental & Infrastructure	**Todd Giddings, Ph.D., P.G.** Hydrogeologist	Todd Giddings and Associates, Inc.
Nick Schipanski Water Resources Coordinator	ClearWater Conservancy	**James Hamlett, Ph.D.** Associate Professor of Agricultural Engineering	Department of Agriculture and Biological Engineering, The Pennsylvania State University
Jason Brown Project Manager	University Area Joint Authority	**Bert Lavan** West Nile Virus Program Coordinator	Centre County Office of Planning and Community Development
Susan Buda Aquatic Ecologist	Citizen Volunteer	**Mark Ralston, P.G.** Hydrogeologist	Converse Consultants
Robert Carline, Ph.D. Aquatic Ecologist	Pennsylvania Cooperative Fish and Wildlife Research Unit, USGS—retired	**Kristen Saacke-Blunk** Director	Agriculture and Environmental Policy Center, The Pennsylvania State University
Hunter Carrick, Ph.D. Assistant Professor of Aquatic Ecology	School of Forest Resources The Pennsylvania State University	**Doug Weikel, P.E., C.S.I.** Service Group Manager	Herbert, Rowland, and Grubic, Inc.
Ann Donovan Watershed Specialist	Centre County Conservation District	**David Yoxtheimer, P.G.** Extension Associate	Marcellus Center for Outreach and Research, The Pennsylvania State University
Larry Fennessey, Ph.D., P.E. Utility Systems Engineer - Stormwater	Office of Physical Plant, The Pennsylvania State University		

The WRMP tracks quality and quantity of surface water and groundwater reserves at a number of sites throughout the Spring Creek Watershed.

Stream Monitoring Stations

The WRMP measures conditions at four sites along the mainstem of Spring Creek and 10 tributary sites located throughout the stream's five major sub-basins (Figure 2). Twelve of the 14 sites currently included in the WRMP have been monitored since 1998. The Water Resources Monitoring Committee chose the 12 original sites to be representative of land use practices across the watershed. Three of the original sites were chosen to coincide with existing USGS Gaging Stations. In 2004, a thirteenth site on an unnamed tributary to Buffalo Run was added in order to track potential impacts from acid drainage associated with pyritic rock uncovered during construction of I-99 northwest of State College. The fourteenth WRMP stream monitoring station, located on Slab Cabin Run downstream of Millbrook Marsh, was added in 2005 to assess the marsh's ability to control stormwater impacts from downtown State College and University Park.

Groundwater Monitoring Stations

The WRMP monitored water levels at three wells in 2010 (Figure 3). These wells were selected because they are not subject to frequent fluctuations caused by external factors such as high-yield pumping, stormwater, artificial groundwater recharge, or surface water discharges. In addition, the WRMP analyzes publicly available data from two USGS wells (Figure 3). When considered together, the five wells provide a picture of representative groundwater conditions across the Spring Creek Watershed.

Spring Monitoring Stations

Spring monitoring became part of the WRMP in 2005 with the addition of seven spring stations (Figure 3). Like the stream and groundwater sites, these springs were chosen to be representative of various land use, geologic, and hydrologic conditions encountered in the Spring Creek Watershed. For a detailed discussion of the watershed's springs and their importance to the region, please refer to the 2006 State of the Water Resources Report.

WRMP monitoring station at Slab Cabin Run at E. College Avenue (credit: B. Hutchison)

Monitoring stations

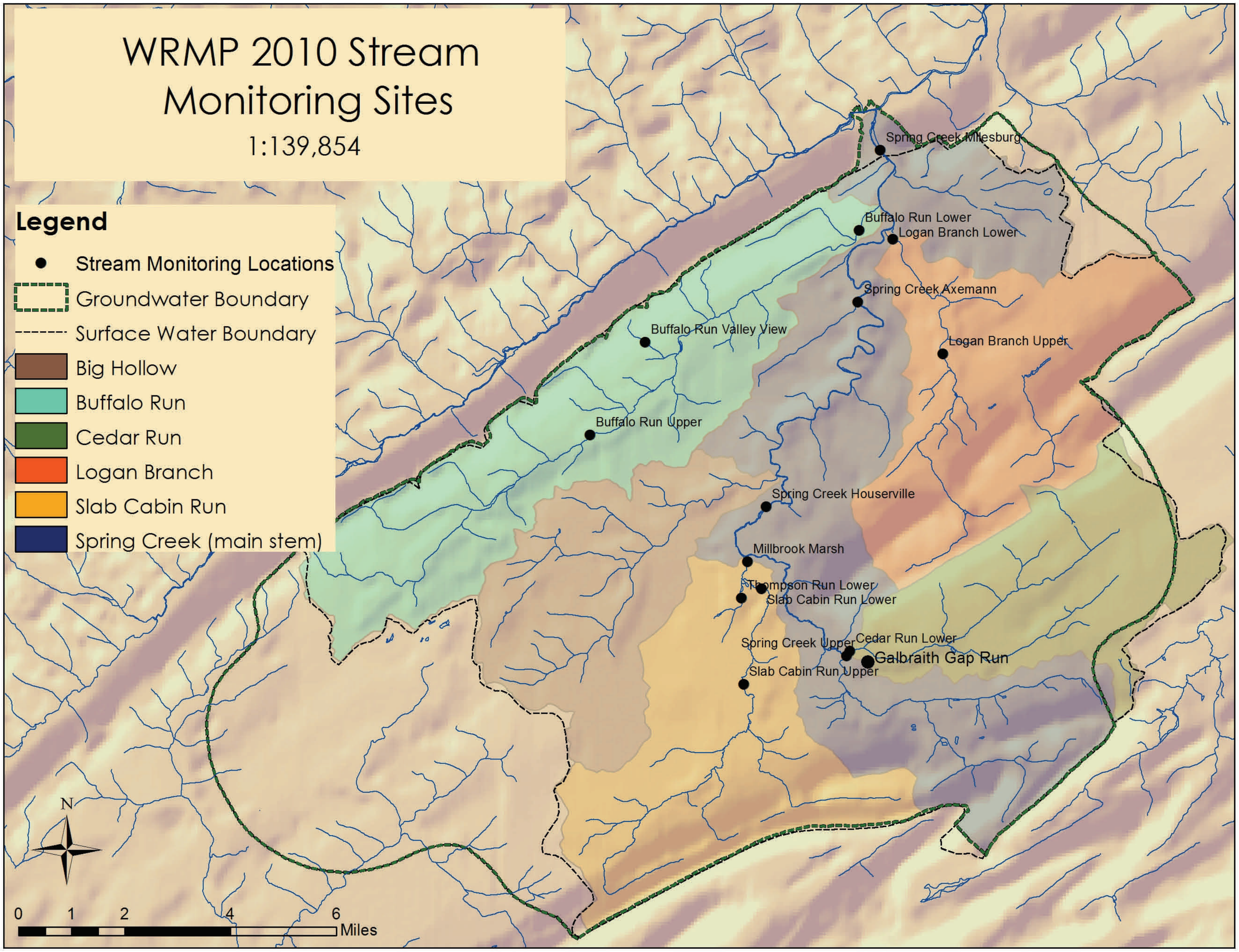

Figure 2: Stream sampling sites surveyed in 2010 as part of the Water Resources Monitoring Project.

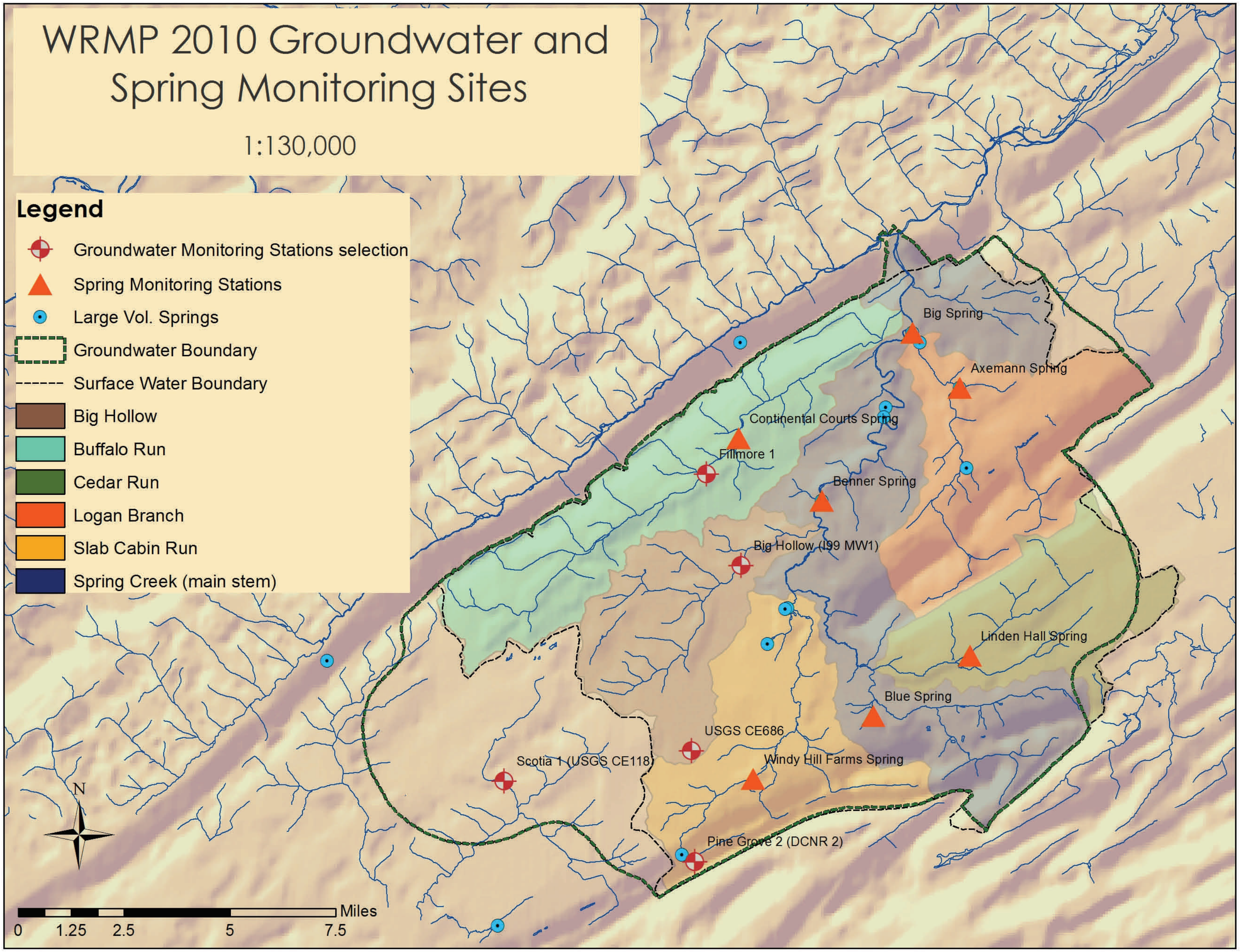

Figure 3: Groundwater and spring stations surveyed in 2010 as part of the Water Resources Monitoring Project.

Monitoring *methodologies*

To assure consistency and quality of data collected as part of the WRMP, the Water Resources Monitoring Committee developed a set of standardized procedures for data collection, sample processing, and database maintenance. A detailed description of these methods can be found in the Spring Creek Watershed Water Resources Monitoring Protocol. To review this document, please contact Nick Schipanski, ClearWater Conservancy's Water Resources Coordinator, at (814) 237-0400.

Water Quality Monitoring

WRMP staff and volunteers collected water samples from 14 stream sites and seven springs in 2010. Sampling took place on a quarterly basis (in March, June, November, and December) when streams were at baseflow conditions. The water samples were analyzed for chemical and nutrient content by the Pennsylvania Department of Environmental Protection Analytical Laboratories. Please see Appendix 1 for a list of parameters and Appendices 3 and 4 for the results of the water quality analyses.

Continuous Measurements

Thirteen stream stations were equipped with instruments to continuously monitor stream stage. Ten of these were maintained by the WRMP and outfitted with Design Analysis Associates, Inc. DH-21 pressure transducers, which measured stream stage every 30 minutes. The equipment at the other three stream stations was maintained by the USGS. Stream stage measurements were taken every 15 minutes at these stations.

Water temperature was measured hourly at 11 stream stations using Onset Computer Corporation Optic Stowaway TidbiT v2 data loggers. At the Thompson Run station, the temperature data logger was set to record temperature every 5 minutes instead of every hour. Readings were taken more frequently at this station because past data have shown that temperatures in Thompson Run often fluctuate widely in a short period of time during storm events.

Downloading data from TidbiT v2 temperature logger
(credit: N. Schipanski)

Water surface elevation was recorded at five wells comprising the groundwater monitoring network. WRMP staff and volunteers maintained the monitoring instruments at three of the five wells, which were equipped with InSitu miniTROLL pressure transducers that recorded water surface elevation every 3 hours . The other two wells, CE118 and CE686, were maintained by the USGS.

Discharge Measurements

In order to develop and calibrate the rating curves used to calculate stream flow from the DH-21 stage measurements, WRMP staff and volunteers took periodic instantaneous discharge measurements at each stream site using a Marsh-McBirney flow meter. These measurements were also used to detect any changes in stream channel dimensions due to sediment erosion or deposition.

WRMP monitoring station on Logan Branch near Pleasant Gap (credit: B. Hutchison)

Monitoring *results*

Water Quality

Water quality was assessed in March, June, November, and December 2010 during baseflow conditions at 14 stream and seven spring stations across the Spring Creek Watershed. WRMP water samples were evaluated for a number of common organic and inorganic pollutants (Appendix 1). A summary of water resource management issues for each municipality in the Spring Creek Watershed can be found in Appendix 2.

Trends in concentrations of the various parameters were similar to those observed for previous years' samples. Appendices 3 and 4 show median concentrations of all parameters analyzed at each of the stream and spring sites, respectively. Here are some generalizations:

- The concentration of nitrate nitrogen, a common pollutant of treated wastewater and agricultural runoff, was detected at relatively high levels across all stream sites in 2010, with the exception of two headwater stream sites at Buffalo Run Valley View and Galbraith Gap Run. Nitrate nitrogen concentrations were similar to those in previous years. Nitrate levels were high at the springs, particularly Axemann Spring, Benner Spring and Linden Hall Spring: groundwater may be a significant source of nitrates under baseflow conditions.
- Orthophosphorus, a pollutant commonly associated with agriculture, was present at low levels (near the detectable limit) at all of the stream sites. Orthophosphorus was also detected at low levels at Benner Spring, Blue Spring, and Windy Hill Farm Spring. The 2010 orthophosphate results were consistent with those from previous years.
- Chloride concentrations were similar to those observed over the history of the WRMP. When elevated, chloride indicates impacts from urbanization and water treatment processes. Consistent with an urban impact, the highest chloride concentrations were measured at two stream sites within State College- Slab Cabin Run at Millbrook Marsh and Thompson Run.
- Sulfates were detected at all sites except Galbraith Gap Run, Slab Cabin Run at South Atherton Street and Big Spring. In 2007, Buffalo Run suffered sulfate pollution from leaking pipes associated with pyritic rock cleanup at the Interstate 99 construction site. Sulfate concentrations were high in Buffalo Run in 2007 before dropping to levels only slightly elevated over pre-2007 levels in 2008 and 2009. In 2010, sulfate concentrations at both the upper and lower Buffalo Run sites were similar to the 2008 and 2009 findings.
- Total aluminum was detected at all sites in 2010 except Axemann Spring. Total aluminum concentrations were similar to historic levels at all sites except at Logan Branch near Pleasant Gap, which showed elevated levels compared to previous years. Dissolved aluminum concentrations were near or below the detection limit at all sites.
- Iron was detected at all stream sites and at low levels at Benner Spring, Blue Spring, Continental Courts Spring, and Windy Hill Farm Spring in 2010. Total iron concentrations were highest at Logan Branch near Pleasant Gap and Buffalo Run Valley View. The Logan Branch subwatershed has a long industrial history and the WRMP typically documents high iron levels at this site. Elevated dissolved iron concentrations at

Buffalo Run Valley View are also typical of this site and may be due to the pyritic rock cleanup at the Interstate 99 construction site.

- Total and dissolved manganese concentrations at all sites were low and similar to those observed during the WRMP period of record.
- Total cadmium was detected at a low concentration at Big Spring in only one of the four samples taken at this site in 2010. This metal, which has a number of agricultural, industrial, and urban sources, is not typically found at detectable concentrations in the Spring Creek Watershed.
- Fecal coliform bacteria were detected at all springs except Continental Courts Spring. Windy Hill Farm Spring had the highest concentration of fecal coliforms; however, none of the observed concentrations exceeded the Pennsylvania Department of Environmental Protections bathing standard (200 colonies/100 mL).

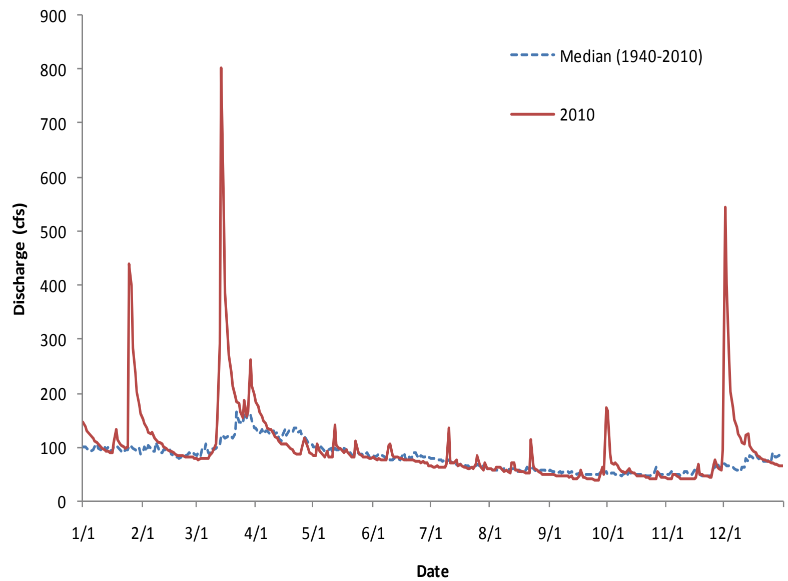

Figure 4. Average daily stream discharge at Axemann on Spring Creek in 2010 compared to median daily discharge for the period of record (1940-2010).

Stream Discharge

Stream discharge is defined as the volume of water in a stream passing a given point at a given moment in time. Larger streams have higher discharge rates than smaller ones; therefore, Spring Creek has a higher discharge than any of its tributaries. A stream's ability to move sediment and to dilute chemical pollutants is governed by discharge. Generally, the higher the discharge, the more effective a stream will be at moving sediment downstream and diluting pollutants. A stream's discharge determines the biological communities that will be found in its waters; therefore species that prefer to live in lakes or slow-moving rivers would not typically be found in a fast-flowing stream like Spring Creek. Stream discharge also fluctuates with the seasons and with storm events, making it a measurement of interest when studying the effects of runoff and flooding.

In general, the average daily discharge during baseflow of Spring Creek and its tributaries approximated the historic median records. The discharge of Spring Creek at Axemann in 2010 is a typical example (Figure 4). Sharp peaks in the graph represent storm or snow melt events. Average daily discharge in the mainstem of Spring Creek at Houserville also approximated historic median values while the discharge at Milesburg was slightly below the historic median values during the summer of 2010 but

Monitoring *results*

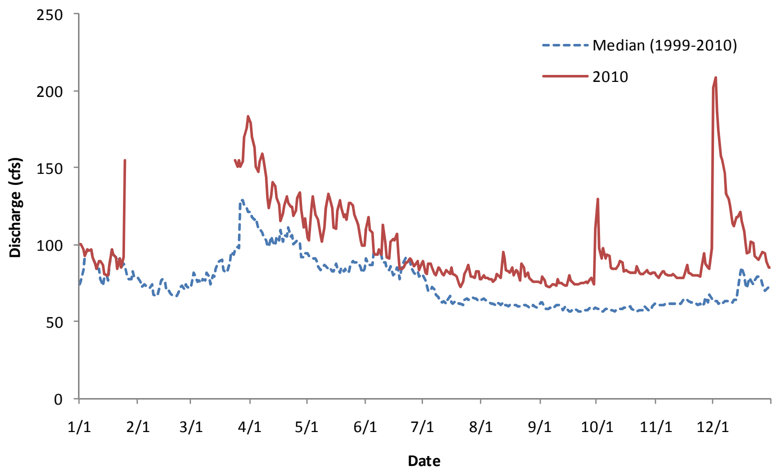

Figure 5. Average daily stream discharge on Logan Branch at Bellefonte in 2010 compared to median daily discharge for the period of record (1999-2010).

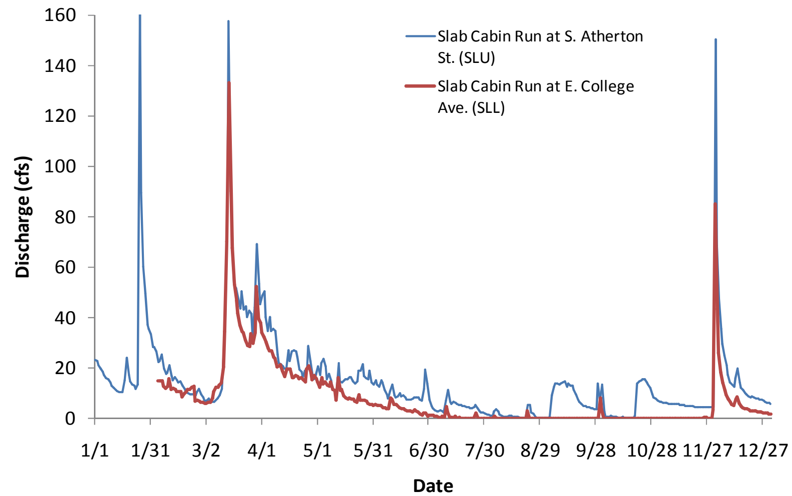

Figure 6. Average daily stream discharge on Slab Cabin Run at S. Atherton Street and at E. College Avenue in 2010.

approximated the historic flows during the rest of the year (http://waterdata.usgs.gov/nwis/uv?01546400 and http://waterdata.usgs.gov/pa/nwis/uv/site_no=01547100&PARAmeter_cd=00065,00060,00010).

Of the seven tributary sites monitored, the only site demonstrating an average daily stream discharge appreciably different from its historical median record was Logan Branch at Bellefonte, which was above the historic median value for most of 2010 (Figure 5). The average daily stream discharges at five tributary sites (Buffalo Run above Fillmore, Cedar Run, Slab Cabin Run at South Atherton Street, Slab Cabin Run at East College Avenue, and Thompson Run) approximated the historic median values for those sites (data not shown). Discharge data for Buffalo Run near Coleville during most of 2010 were unavailable due to equipment failure (this station has been repaired and 2011 data is expected).

In most streams, as drainage area increases in an upstream to downstream direction, stream discharge also increases. The East College Avenue site is downstream of the South Atherton Street site on Slab Cabin Run; however, discharge is typically higher at the upstream site (Figure 6). As is typical of most years, Slab Cabin Run at East College Avenue ran dry for periods in the summer and fall of 2010. This is because the downstream section of this stream is perched above the water table and loses water when the stream experiences low flows. The surface water, in this case, infiltrates the stream substrate to recharge the groundwater supply. This occurrence is common in karst, or carbonate rock, settings.

Stream Temperature

Temperature has a profound influence on aquatic life, governing nearly every process that occurs in streams, from solubility of oxygen and various chemicals to the

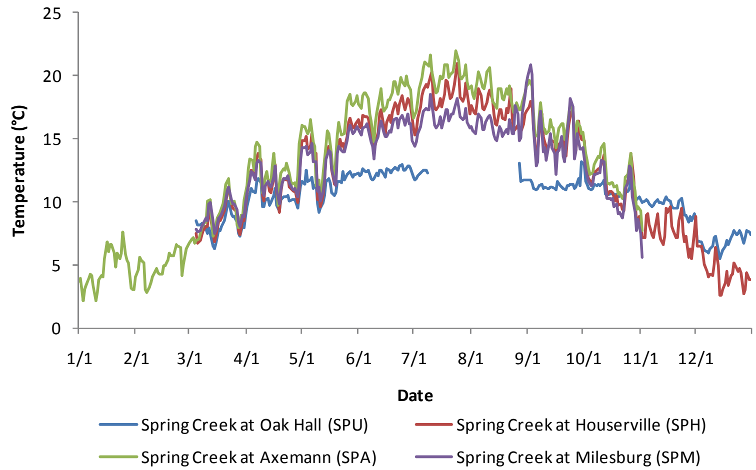

Figure 7. Average daily stream temperature at four sites on Spring Creek in 2010.

metabolic functions of fish and other organisms. Despite significant agricultural and urban impacts within the watershed, Spring Creek still manages to support a world-class brown trout fishery famous for its high densities of fish and large numbers of trophy-sized individuals. One of the primary reasons the stream remains so productive is that its waters are relatively cool even on the hottest days of summer. Except in times of extreme heat or drought, or during large storm events, inputs from groundwater maintain surface water temperatures in Spring Creek below the brown trout's lethal threshold of 24°C (76°F). When water temperatures rise above 24°C for extended periods of time, large-scale fish kills like the one that occurred in Slab Cabin Run in June 2005 can result.

Average daily stream temperatures in Spring Creek and its major tributaries remained below the lethal threshold for brown trout throughout 2010, ranging from about 0°

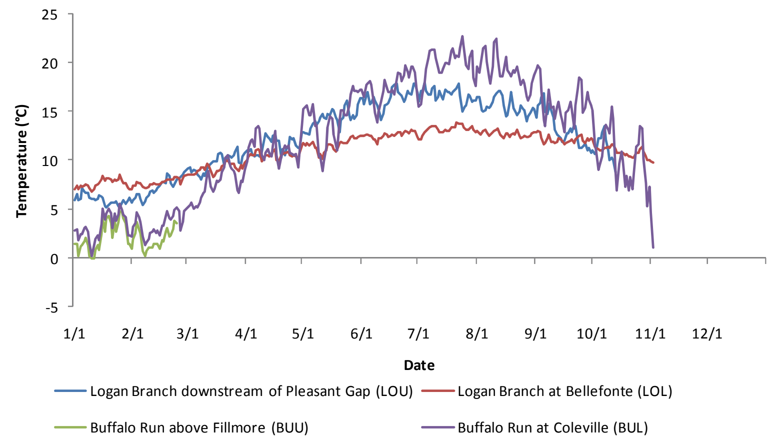

Figure 8. Average daily stream temperature at four sites on tributary streams to lower Spring Creek in 2010.

C in the winter to 23°C in the summer (Figures 7 to 9). Although the average daily temperature remained below 24°C , the maximum daily stream temperature exceeded this value several times at Slab Cabin Run at East College Avenue, Slab Cabin Run at South Atherton Street, and Buffalo Run at Coleville (Figure 10). It is typical for the

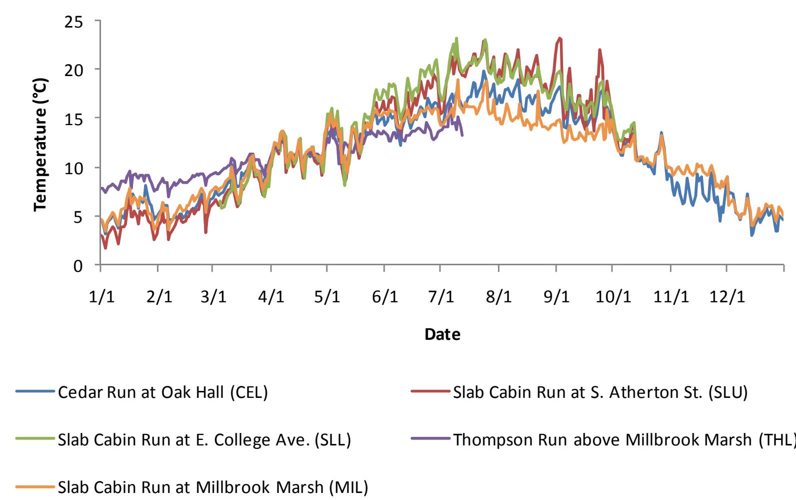

Figure 9. Average daily stream temperature at five sites on tributary streams to upper Spring Creek in 2010.

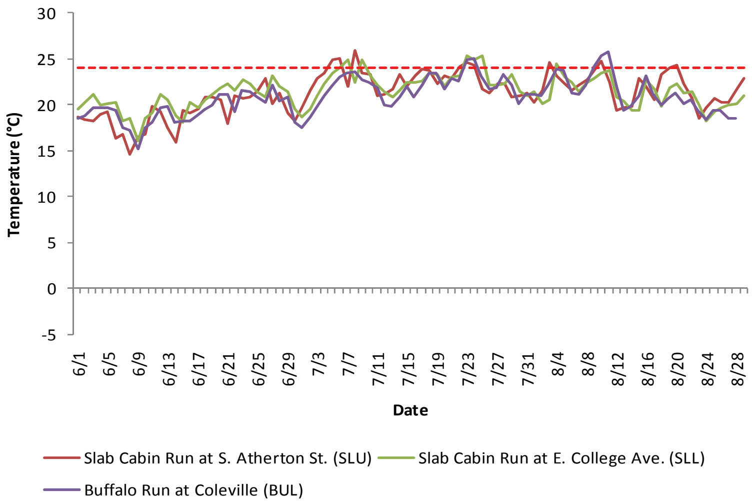

Figure 10. Maximum daily stream temperature in June, July and August for Slab Cabin Run at S. Atherton St., Slab Cabin Run at E. College Ave., and Buffalo Run at Coleville in 2010.

average daily temperature to exceed 24°C at sites on Slab Cabin Run and Buffalo Run for short periods of time during the summer. No trends in the occurrence or duration of these high temperature events is discernable in the WRMP record to date.

Groundwater

In addition to supplying streams with a constant influx of cold water that supports trout and other coldwater aquatic organisms, groundwater is also important to the human inhabitants of the Spring Creek Watershed. People living in the watershed draw nearly all of their potable water from the region's many high volume springs and productive well fields; therefore, it is important to monitor groundwater elevations throughout the watershed. In 2010, the WRMP collected groundwater elevation data from three monitoring wells and also assessed data from two additional wells maintained by the USGS.

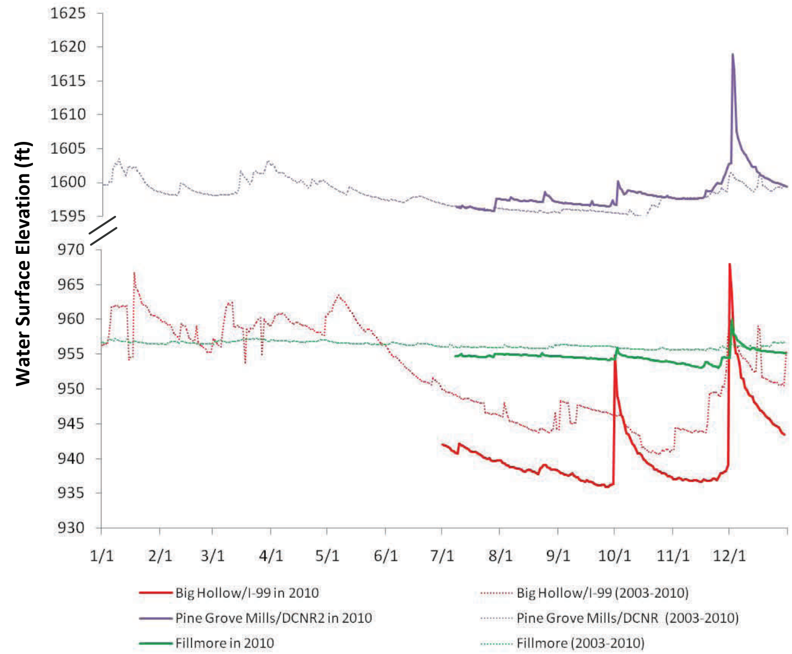

Figure 11. Median daily groundwater elevations at three WRMP monitoring wells in 2010 compared to median daily groundwater elevation for the period of record.

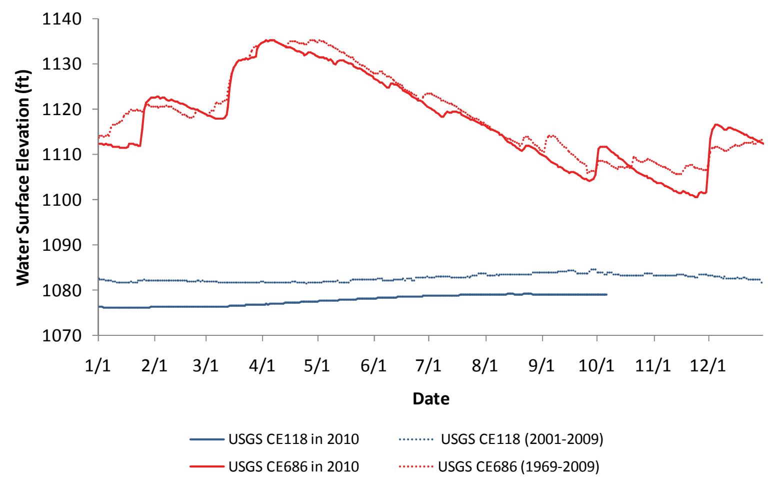

Figure 12. Median daily groundwater elevations at two USGS-operated wells in 2010 compared to median daily groundwater elevation for the period of record.

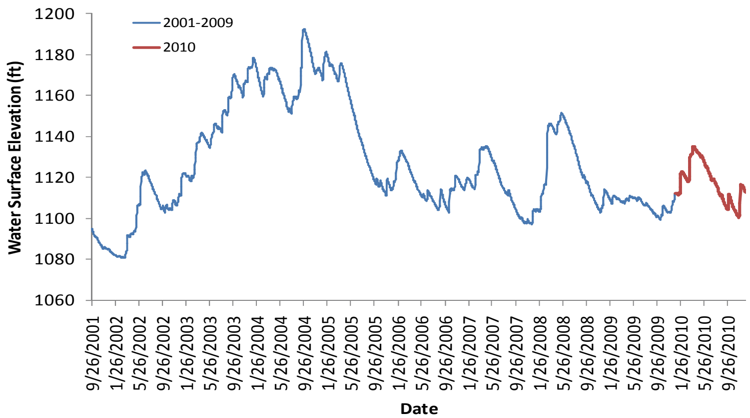

Figure 13. Daily mean groundwater elevation at USGS monitoring well CE686 throughout the period of record 2001-2010.

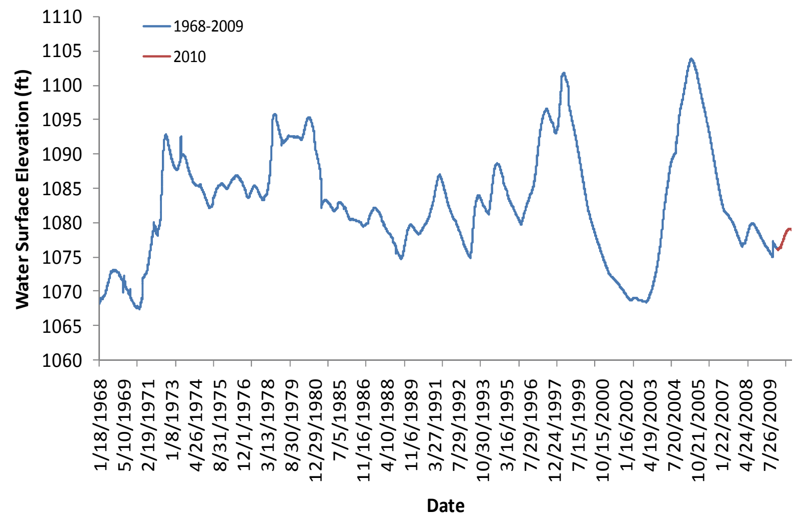

Figure 14. Daily mean groundwater elevation at USGS monitoring well CE118 throughout the period of record 1968-2010.

By the end of 2009, groundwater elevations were below the historical medians at the three WRMP wells after a steady decline in the second half of that year (see WRMP 2009 Annual Report). Groundwater elevations in 2010 exhibited typical fluctuations as a result of wet-dry periods but generally remained below historic values (Figures 11 and 12). Groundwater elevations were slightly below historic medians at Big Hollow and Fillmore, and slightly above the historic median level at Pine Grove Mills. Groundwater elevations at the USGS Centre County drought-monitoring well CE686 rebounded from lows observed during 2009 to levels similar to observations from 2006 through 2008 (Figure 13). The USGS monitoring well CE118 is located in the Scotia Barrens, an important recharge area for the watershed. Groundwater elevations at CE118 rose slightly from the lows experienced in 2009 but on average were over four and a half feet below historic levels through 2010 (Figures 12 and 14).

Fisherman on Spring Creek (credit: S. Knorr)

Closing

We hope that you found this year's report on the State of the Water Resources both interesting and informative. Residents of Spring Creek Watershed currently enjoy better water quality than the region has seen in nearly 100 years. Without quality long-term water level, discharge, and water chemistry data sets like those being maintained by the WRMP, it would be difficult to understand how our water resource is changing and why.

The Water Resources Monitoring Project, which has been in place for over 12 years, provides vital long-term data that can be used by local planning officials to make sound land use decisions. Your continued support will help this project maintain the ability to respond to new information needs and provide quality data to monitor changes within the watershed as our community continues to grow.

Buffalo Run near Coleville (credit: S. Knorr)

Appendix 1: Water Quality Parameters

Parameter	Description	Sources	Environmental Effects	Baseflow Monitoring	Spring Monitoring
Aluminum	The most abundant element on Earth	Urban runoff, industrial discharges, and natural sources	May adversely affect the nervous system in humans and animals	X	X
Cadmium	Natural element found in the Earth's crust	Industrial sources and urban sources including fertilizer, non- ferrous metals production, and the iron and steel industry	Toxic to humans and aquatic life	X	X
Chloride	The concentration of chloride salt ions dissolved in the water	Washes off roads where used as a deicing agent	Very high chloride concentrations can be toxic to macroinvertebrates and limit osmoregulatory capacity of fishes	X	X
Chromium	A trace element essential for animals in small quan- tities	Found in natural deposits of ores containing other ele- ments	Toxic to humans and aquatic life if present in excess	X	X
Conductivity	Measure of the water's ability to conduct electricity. Proportional to the amount of charged ions in the water	Sources of ions are both naturally occurring and anthro- pogenic in origin. Include soil, bedrock, human and animal waste, fertilizers, pesticides, herbicides, and road salt	Suspended solids clog fish gills and alter stream-bed habitat upon settling. Dissolved materials limit theos- moregulatory ability of aquatic animals	X	X
Copper	A heavy metal less common than lead and zinc in nature	Used in wiring, plumbing, and electronics. Also used to control algae, bacteria, and fungi	Toxic to humans and aquatic life. Solubility is ef- fected by water hardness	X	X
Dissolved Oxygen	The amount of oxygen gas dissolved in the water, saturation inversely related to temperature	Dissolved oxygen is depleted by respiration and micro- bial breakdown of wastes. It is restored by photosynthe- sis and physical aeration	Low levels of dissolved oxygen are harmful to aquatic animals. This is usually the result of organic pollution or elevated temperature	X	X
Coliform Bacteria	Common intestinal bacteria of warm and cold- blooded animals	Animal wastes and sewage contamination	Pathogenic to humans		X
Iron	Common element found in the Earth's crust	Urban runoff, industrial discharges, and natural sources	Toxic to humans and aquatic life	X	X
Lead	A heavy metal that occurs naturally as lead sulfide but may exist in other forms	Urban and industrial uses include gasoline, batteries, solder, pigments, and paint	Toxic to humans and aquatic life. Solubility is ef- fected by water hardness.	X	X
Manganese	Common element found in the Earth's crust	Urban runoff, industrial discharges, and natural sources	Toxic to humans and aquatic life	X	X
Nickel	A trace element essential for animals in small quan- tities	Industrial wastewaters	Toxic to humans and aquatic life if present in excess	X	X
Nitrate (NO3)	One of three forms of nitrogen found in water bod- ies, this form is used by plants. Organic nitrogen is converted to nitrate by bacteria	Any nitrogen-containing organic waste, including sewage from treatment plants and septic systems and runoff from fertilized lawns, farms, and livestock areas	High nitrate levels promote excessive plant growth and eutrophication. Excess nitrate in drinking water can cause illness or death in infants	X	X
Orthophosphate	The form of inorganic phosphorus required by plants. Often the limiting factor in plant growth	Rocks and minerals provide low natural levels. Human sources include commercial cleaning products, water treatment plants, and fertilized lawns and farmland	A small increase in orthophosphorus can cause eutro- phication, the loss of dissolved oxygen through the stimulation and decay of excessive plant growth	X	X
pH	A measure of the the acidity of water on a logarith- mic scale of 1 to 14 with 7 being neutral, below 7 acidic, and above 7 alkaline	Alkaline conditions can be a result of carbonate bedrock geology. Acidic conditions could be caused by acid deposition and pyritic reactions associated with acid mine drainage	Extreme acidity or alkalinity can inhibit growth and reproduction in aquatic organisms. Acidic waters also increase the solubility of metals from the sediment	X	X
Sodium	Soft metal commonly found in nature	Various salts of sodium occur in considerable concentra- tions in the Earth's crust	There is some evidence to suggest that these high levels of sodium are toxic to some plants	X	X
Total Suspended Solids	Any particles carried by the water including silt, plankton,organic stream matter, industrial waste, and sewage	Include urban runoff, wastewater treatment plants, soil erosion, and decaying plant and animal material	Suspended solids clog fish gills and alter stream-bed habitat when settled. Particles may carry bound toxic compounds or metals	X	X
Turbidity	A measure of water clarity expressed as the amount of light penetrating the water. It is relative to the amount of suspended material in the water	While in some cases high turbidity is natural, it is usually the result of earth-moving activities, urban runoff, and erosion	High turbidity blocks light from the water column, inhibiting productivity of aquatic plants and periphy- ton. These particles also absorb sunlight and increase temperature. Also, particles will eventually come out of suspension and cause sedimentation	X	X
Zinc	A heavy metal commonly found in rock-forming minerals	Urban runoff, industrial discharges, and natural sources	Somewhat toxic to humans and aquatic life. Solubility is affected by water hardness	X	X

Appendix 2: Summary of monitoring sites and management issues in their vicinity by municipality

Municipality	Monitoring sites with the municipality	Other sites influenced by activities within the municipality	Water resources management issues
Benner Township	Unnamed tributary to Buffalo Run (BVV) Continental Courts Spring (COS) Fillmore Well Benner Spring (BES) Spring Creek at Axemann (AXS)	Buffalo Run near Coleville (BUL) Spring Creek at Milesburg (SPM) Logan Branch near Pleasant Gap (LOU)	Agricultural practices (ground and surface water) Urbanization/ Suburbanization (storm-water and water sup-ply)
Boggs Township	Spring Creek at Milesburg (SPM)		
College Township	Spring Creek at Houserville (SPH) Slab Cabin Run at Millbrook Marsh (MIL) Slab Cabin Run at East College Avenue (SLL) Thompson Run (THL) Spring Creek at Oak Hall (SPU) Cedar Run at Oak Hall (SPU) Big Hollow/ I-99 Well Mount Nittany Well		Urbanization/ Suburbanization (storm-water and water sup-ply) Agricultural practices (upstream areas)
Ferguson Township	Windy Hill Farm Spring (WIS) DCNR/Pine Grove Mills Well USGS CE686 Monitoring Well USGS CE118 Monitoring Well	Thompson Run (THL)	Urbanization/ Suburbanization (storm-water and water sup-ply) Agricultural practices
Halfmoon Township		Buffalo Run near Fillmore (BUU) Big Spring (BIS)	Agricultural practices Suburban development
Harris Township	Blue Spring (BLS) Linden Hall Spring (LIS) Galbraith Gap Run (GGU)	Slab Cabin Run at South Atherton Street (SLU) Spring Creek at Oak Hall (SPU) Cedar Run at Oak Hall (CEL)	Agricultural practices (surface and ground water) Suburban development
Patton Township	Buffalo Run near Fillmore (BUU)		Agricultural practices/ suburbanization
Potter Township			Agricultrual practices
Spring Township	Logan Branch near Pleasant Gap (LOU) Axemann Spring (AXS) Buffalo Run near Coleville (BUL)	Logan Branch at Bellefonte (LOL) Spring Creek Milesburg (SPM)	Agricultural practices (surface and ground water) Suburban development Industrial water usage
Walker Township			Agricultural practices/ suburbanization
Bellefonte Borough	Logan Branch in Bellefonte (LOL) Big Spring (BIS)	Spring Creek at Milesburg (SPM)	Urbanization/ Suburbanization (storm-water)
Centre Hall Borough			Agricultural practices in surrounding areas
Milesburg Borough		Spring Creek at Milesburg (SPM)	Urbanization (storm-water)
State College Borough	Slab Cabin Run at South Atherton Street (SLU)	Thompson Run (THL) Slab Cabin Run at East College Avenue (SLL) Slab Cabin Run at Millbrook Marsh (MIL)	Urbanization/ Suburbanization (storm-water)

Appendix 3: Median Stream Water Quality Results (Metals) for 2010

		Aluminum (µg/L)		Cadmium (µg/L)		Chromium (µg/L)		Copper (µg/L)		Iron (µg/L)	
Site Name	**Abbrev**	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Galbraith Gap Run	GGU	7.6*	25.7	ND	ND	ND	ND	ND	ND	ND	27.5
Cedar Run - Lower	CEL	ND	58.5	ND	ND	ND	ND	ND	ND	ND	108.0
Slab Cabin Run - Upper	SLU	5.0*	40.6	ND	ND	ND	ND	ND	ND	ND	62.0*
Slab Cabin Run - Lower	SLL	ND	20.7*	ND	ND	ND	ND	ND	ND	ND	36.0
Slab Cabin Run - Millbrook	MIL	ND	25.7	ND	ND	ND	ND	ND	ND	ND	56.5
Thompson Run - Lower	THL	ND	21.1	ND	ND	ND	ND	ND	ND	ND	59.5
Buffalo Run - Upper	BUU	ND	72.8	ND	ND	ND	ND	ND	ND	10.0*	145.0
Buffalo Run - Valley View	BVV	ND	67.2	ND	ND	ND	ND	ND	ND	28.5	165.5
Buffalo Run - Lower	BUL	5.0*	66.2	ND	ND	ND	ND	ND	ND	10.0*	135.0
Logan Branch - Upper	LOU	5.0*	98.0	ND	ND	ND	ND	ND	ND	ND	159.0
Logan Branch - Lower	LOL	5.0*	52.3	ND	ND	ND	ND	ND	ND	10.0*	101.5
Spring Creek - Upper	SPU	5.0*	17.8	ND	ND	ND	ND	ND	ND	24.5*	39.0
Spring Creek - Houserville	SPH	ND	25.3*	ND	ND	ND	ND	ND	ND	10.0*	26.0*
Spring Creek - Axemann	SPA	ND	34.6	ND	ND	ND	ND	ND	ND	ND	59.5
Spring Creek - Milesburg	SPM	ND	72.6	ND	ND	ND	ND	ND	2.0*	ND	119.5

		Lead (µg/L)		Manganese (µg/L)		Nickel (µg/L)		Sodium (mg/L)		Zinc (µg/L)	
Site Name	**Abbrev**	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Galbraith Gap Run	GGU	ND	ND	1.0*	3.2	ND	ND	0.7	0.7	ND	5.0*
Cedar Run - Lower	CEL	ND	ND	1.6*	5.4*	ND	ND	6.9	7.1	ND	ND
Slab Cabin Run - Upper	SLU	ND	ND	2.5*	3.9*	ND	ND	12.2*	12.4*	ND	ND
Slab Cabin Run - Lower	SLL	ND	ND	2.8*	4.5*	ND	ND	22.3	22.5	ND	ND
Slab Cabin Run - Millbrook	MIL	ND	ND	4.4	6.1	ND	ND	28.5	28.5	ND	ND
Thompson Run - Lower	THL	ND	0.05*	2.3*	4.6	ND	ND	26.4	26.5	ND	ND
Buffalo Run - Upper	BUU	ND	ND	3.4	9.1	ND	2.0*	20.5	20.7	ND	ND
Buffalo Run - Valley View	BVV	ND	ND	14.8	28.4	ND	ND	13.2	13.9	ND	ND
Buffalo Run - Lower	BUL	ND	ND	3.5	7.8	ND	ND	10.0	10.6	ND	ND
Logan Branch - Upper	LOU	ND	0.50*	3.7	8.3	ND	ND	15.1	15.0	ND	ND
Logan Branch - Lower	LOL	ND	ND	1.6*	3.9	ND	ND	12.2	12.6	ND	ND
Spring Creek - Upper	SPU	ND	ND	1.0*	0.6	ND	ND	10.8	11.1	ND	ND
Spring Creek - Houserville	SPH	ND	ND	1.7*	2.9*	ND	ND	16.4	16.8	ND	ND
Spring Creek - Axemann	SPA	ND	ND	1.5*	4.0*	ND	ND	29.5	29.1	ND	ND
Spring Creek - Milesburg	SPM	ND	ND	2.5*	6.2	ND	ND	20.8	21.1	ND	ND

*	At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations
ND	All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 3: Median Stream Water Quality Results (Nutrients & Physicochemical) for 2010

Site Name	Abbrev	Calcium (mg/L) Total	Magnesium (mg/L) Total	Hardness (mg/L) Total	Chloride (mg/L) Total	Sulfate (mg/L) Total	Suspended Solids (mg/L) Total	Turbidity (NTU)
Galbraith Gap Run	GGU	3.1	1.6	14.0	1.3	ND	1*	ND
Cedar Run - Lower	CEL	75.3	23.4	285.0	17.2	19.8	4.5	1.96
Slab Cabin Run - Upper	SLU	42.1*	16.1	182.0	26.7*	ND	1.0*	1.29*
Slab Cabin Run - Lower	SLL	58.1	23.5	241.5	45.2	14.7*	1.0*	1.11*
Slab Cabin Run - Millbrook	MIL	63.9	27.0	271.0	65.3	19.1	1.0*	0.05*
Thompson Run - Lower	THL	67.1	29.2	290.5	64.0	17.4*	8.0*	0.05*
Buffalo Run - Upper	BUU	72.3	19.8	282.0	40.0	49.9	ND	3.61*
Buffalo Run - Valley View	BVV	33.5	4.4	102.0	21.0	13.0*	4.5*	1.70*
Buffalo Run - Lower	BUL	67.9	25.3	277.5	21.6	39.4	1.0*	2.72
Logan Branch - Upper	LOU	70.1	19.1	253.5	31.0	60.1	5.5*	6.42
Logan Branch - Lower	LOL	53.9	19.8	216.5	27.1	28.8	3.5*	2.31*
Spring Creek - Upper	SPU	54.6	18.4	211.5	23.4	20.4	6.0*	0.05
Spring Creek - Houserville	SPH	60.0*	19.7*	232.0	36.7*	17.0*	ND	0.53*
Spring Creek - Axemann	SPA	60.7	22.6	244.0	57.4	25.1	5.5*	1.26*
Spring Creek - Milesburg	SPM	56.6	21.0	227.0	41.1	26.4	4.5*	1.99*

Site Name	Abbrev	pH	Diss. Oxygen (mg/L)	Temperature (°C)	Conductivity (mS)	Nitrate-N (mg/L)	Orthophosphorus (mg/L) Total
Galbraith Gap Run	GGU	8.1	11.33	7.4	36.1	0.1	0.005*
Cedar Run - Lower	CEL	8.5	11.89	9.9	424.1	4.5	0.009*
Slab Cabin Run - Upper	SLU	8.3	13.39	10.2	257.1	2.9*	0.009*
Slab Cabin Run - Lower	SLL	8.4	12.10	10.4	439.5	2.6	0.009*
Slab Cabin Run - Millbrook	MIL	8.4	11.66	11.7	520.0	3.7*	0.010*
Thompson Run - Lower	THL	8.3	11.27	12.3	547.0	4.1	0.002
Buffalo Run - Upper	BUU	8.4	10.57	6.6	416.4	1.4	0.016
Buffalo Run - Valley View	BVV	8.4	10.72	7.7	184.2	0.3	0.021
Buffalo Run - Lower	BUL	8.7	10.24	12.3	405.5	1.8	0.012
Logan Branch - Upper	LOU	8.1	12.01	9.8	407.3	3.3	0.039
Logan Branch - Lower	LOL	8.2	11.14	9.9	333.9	3.3	0.017
Spring Creek - Upper	SPU	7.9	10.56	10.5	370.8	2.9	0.005*
Spring Creek - Houserville	SPH	8.6	13.17	10.1	358.7	2.9	0.005*
Spring Creek - Axemann	SPA	8.5	12.90	8.4	457.5	3.9	0.027
Spring Creek - Milesburg	SPM	8.3	11.78	9.0	369.8	3.3	0.021

*	At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations
ND	All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 4: Median Spring Water Quality Results (Metals) for 2010

		Aluminum (µg/L)		Cadmium (µg/L)		Chromium (µg/L)		Copper (µg/L)		Iron (µg/L)	
Site Name	**Abbrev**	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Axemann Spring	AXS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benner Spring	BES	5.0*	37.0	ND	ND	ND	ND	ND	ND	ND	59.0
Big Spring	BIS	5.0*	5.0*	ND	0.1*	ND	ND	ND	ND	ND	ND
Blue Spring	BLS	ND	62.0*	ND	ND	ND	ND	ND	ND	ND	70.0*
Continental Courts Spring	COS	ND	11.2*	ND	ND	ND	ND	ND	ND	ND	10.0*
Linden Hall Park Spring	LIS	ND	5.0*	ND	ND	ND	ND	ND	ND	ND	ND
Windy Hill Farm Spring	WIS	5.0*	25.6*	ND	ND	ND	2.0*	ND	ND	ND	35.0*

		Lead (µg/L)		Manganese (µg/L)		Nickel (µg/L)		Sodium (mg/L)		Zinc (µg/L)	
Site Name	**Abbrev**	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Axemann Spring	AXS	ND	ND	ND	ND	ND	ND	16.1	16.7	ND	ND
Benner Spring	BES	ND	ND	1.0*	4.0	ND	ND	25.9	27.6	ND	ND
Big Spring	BIS	ND	ND	ND	ND	ND	ND	9.5	9.9	ND	ND
Blue Spring	BLS	ND	ND	ND	1.0*	ND	ND	2.7*	2.6*	ND	ND
Continental Courts Spring	COS	ND	ND	ND	ND	ND	ND	8.5	8.6	ND	ND
Linden Hall Park Spring	LIS	ND	ND	ND	ND	ND	ND	3.2	3.0	ND	ND
Windy Hill Farm Spring	WIS	ND	ND	ND	1.0*	ND	ND	15.5	15.8	ND	ND

*	At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations
ND	All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 4: Median Spring Water Quality Results (Nutrients & Physicochemical) for 2010

Site Name	Abbrev	Calcium (mg/L) Total	Magnesium (mg/L) Total	Hardness (mg/L) Total	Chloride (mg/L) Total	Sulfate (mg/L) Total	Suspended Solids (mg/L) Total	Turbidity (NTU)
Axemann Spring	AXS	79.8	34.1	336.0	43.4	28.3	ND	ND
Benner Spring	BED	67.1	23.4	259.0	54.6	15.1	ND	1.25*
Big Spring	BIS	33.3*	16.7	152.0	20.2	ND	ND	ND
Blue Spring	BLS	30.9*	14.9*	140.5	4.9*	10.0*	ND	1.50*
Continental Courts Spring	COS	58.9	26.3	256.0	20.0	10.0	ND	ND
Linden Hall Park Spring	LIS	77.9	31.6	325.0	8.0	19.4	6.0*	ND
Windy Hill Farm Spring	WIS	51.5	24.3	234.0	26.0*	10.0*	1.0*	0.05*

Site Name	Abbrev	pH	Diss. Oxygen (mg/L)	Temperature (°C)	Conductivity (mS)	Nitrate-N (mg/L)	Orthophosphorus (mg/L) Total	Fecal Coliforms (#col/ 100mL)
Axemann Spring	AXS	7.5	8.79	10.3	516.0	6.4	ND	1.3
Benner Spring	BES	7.6	9.89	9.7	469.0	4.0	0.011*	7.7
Big Spring	BIS	8,23	10.30	10.3	240.0	1.9	ND	2.0
Blue Spring	BLS	7.8	7.33	9.1	247.4	1.5*	0.011*	1.3
Continental Courts Spring	COS	7.8	8.12	10.5	367.5	2.3	ND	0.0
Linden Hall Park Spring	LIS	7.4	8.22	10.0	435.0	4.9	ND	0.7
Windy Hill Farm Spring	WIS	7.7	8.97	9.2	422.9	3.4*	0.005*	9.3

*	At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations
ND	All concentrations for all sites were below detection limits so no value was assigned for concentrations
$	Values possibly affected by low flow or stagnant conditions due to drought