SPRING CREEK
WATERSHED COMMUNITY

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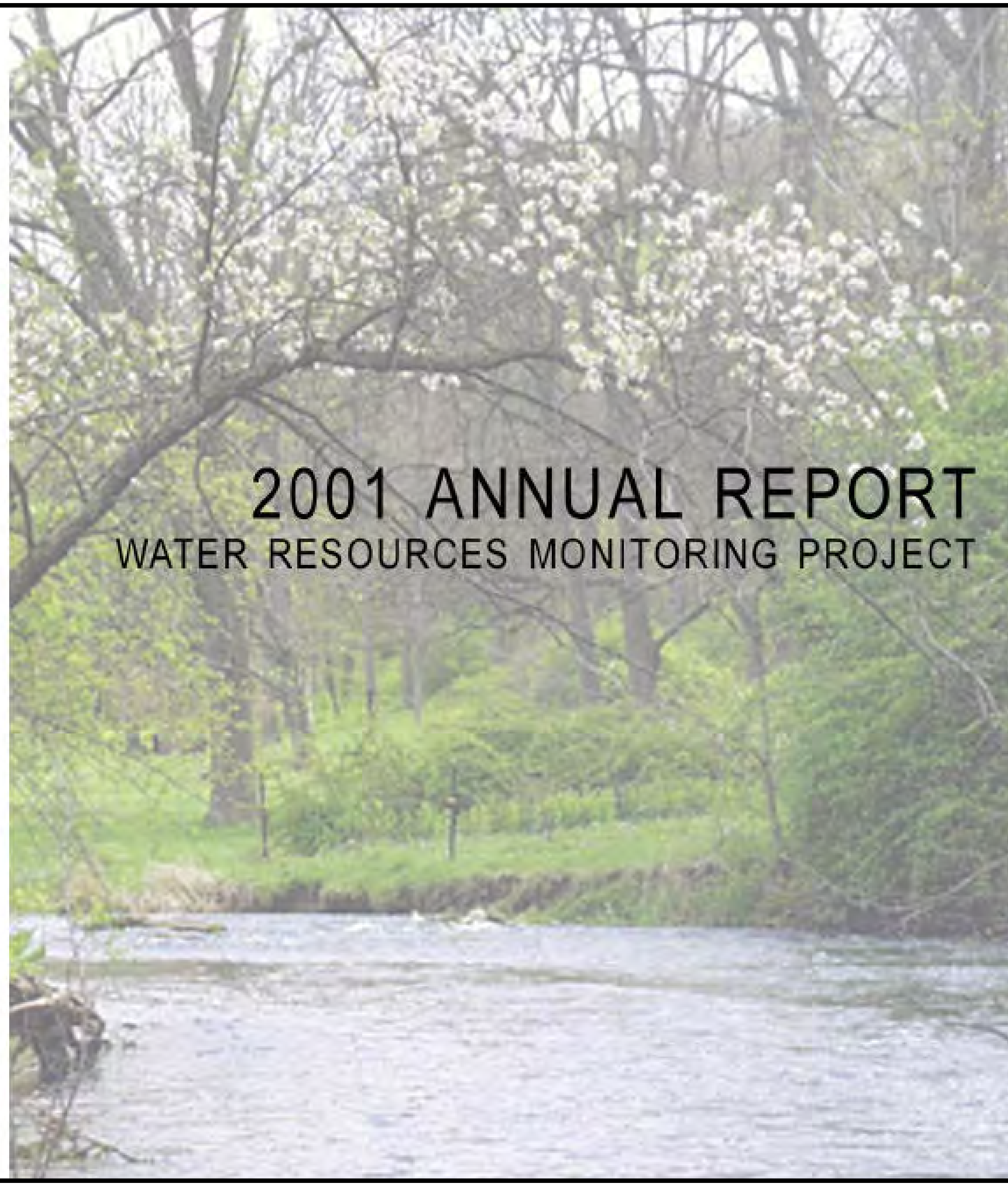

2001 ANNUAL REPORT
WATER RESOURCES MONITORING PROJECT

WINNER
2001 GOVERNOR'S AWARD FOR WATERSHED STEWARDSHIP
SPONSORED BY:
PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Pennsylvania is... Growing Greener

Contents

Copies of this report are available at the ClearWater Conservancy office:

2555 North Atherton Street
State College, PA 16803
(814) 237-0400

or on the Spring Creek Watershed Community's Web site www.springcreekwatershed.org.

All data collected by the Water Resources Monitoring Project are also available on our Web site.

Front Cover: Picture taken from the Logan Branch Upper stream monitoring station (Photographer: Becky Shirer).

Special thanks to the Centre County Board of Commissioners and the Spring Creek Watershed Commission for their continued support of the Spring Creek Watershed Community and its Water Resources Monitoring Project.

Thank you also to Joe Bishop, Jim McClure, Howard Nuernberger, and Dan Ombalski for their contributions to this report.

1.0 INTRODUCTION

THE SPRING CREEK WATERSHED COMMUNITY

The Spring Creek Watershed Community is a broad-based stakeholders project of the ClearWater Conservancy and is the largest organization in Centre County that is exclusively watershed-focused in its activities. The Community was created to be a public forum for discussion in which all viewpoints are welcomed. It comprises over 2,500 stakeholders living throughout the watershed, including private business and industry, municipalities, elected officials, government agencies, the farming community, land owners, developers, other non-profit organizations, and individual citizens who have a desire to preserve and protect the integrity of the Spring Creek Watershed. The Watershed Community works closely with its sponsoring organization, the ClearWater Conservancy, on numerous projects and activities in the watershed. Since the Spring Creek Watershed Community is not incorporated, ClearWater Conservancy administers grants on behalf of the Community and provides staffing for the organization. The Spring Creek Watershed Community also works closely with the Spring Creek Watershed Commission, an organization of government officials from the fourteen watershed municipalities and the Centre County Board of Commissioners.

THE WATER RESOURCES MONITORING PROJECT

The Water Resources Monitoring Project started in January 1998 as part of the strategic planning process of the Spring Creek Watershed Community to directly address one of our five strategic goals: Measure watershed quality and set goals for improvement. The project began by monitoring base flow conditions. With the award of two Pennsylvania Department of Environmental Protection (PA DEP) Growing Greener Grants in 2000, the project has expanded and now includes stormwater and groundwater monitoring components. Monitoring base flow will allow the assessment of the current relationship between stream flows and water quality. Stormwater monitoring will provide essential information regarding non-point source pollution and will provide the necessary data to evaluate the total load of pollutants being delivered to streams by stormwater runoff. Comparisons between base flow and stormwater data will allow a user to evaluate changes in water quality caused by urbanization and associated land use changes. Groundwater level monitoring will enable the assessment of groundwater storage within the watershed and will provide educational opportunities to the Spring Creek Watershed Community. Data will be collected for the purpose of evaluating the effects of groundwater withdrawals on groundwater levels, the connection between groundwater levels and stream flow, and how land use and zoning affect groundwater levels. The Water Resource Monitoring Project, comprised of base flow, stormwater, and groundwater monitoring, is a comprehensive monitoring network that will be used for the long-term protection of Spring Creek and its tributaries.

In 2001, the Water Resources Monitoring Project was awarded the 2001 Governor's Award for Watershed Stewardship in the Assessment and Planning Category. This award recognizes the efforts of the Water Resources Monitoring Committee, the comprehensive nature of the study design, and most importantly, the need for baseline data collection to proactively protect the water quality and quantity of Spring Creek and its tributaries.

THE WATERSHED

The Spring Creek Watershed occupies 175 square miles, and is home to 94,000 people, 14 municipalities, and The

Pennsylvania State University. The average daily flow from the Spring Creek Watershed is approximately 148 million gallons based on 34 years of record. This water leaves the watershed at Milesburg where it flows into Bald Eagle Creek. It continues to flow into the West Branch of the Susquehanna River and then into the Chesapeake Bay. Fifteen million gallons of groundwater are pumped every day from the limestone and dolomite aquifers located under the valley floor to meet the drinking water needs of the watershed.

An increase in urbanization coupled with changing land use patterns may adversely affect the overall health of Spring Creek and its tributaries by increasing groundwater withdrawal, decreasing the volume of groundwater recharge, and potentially increasing the volume of pollutants that enters the streams.

WATER QUALITY AND QUANTITY

This project is designed to establish baseline water quality and quantity data for Spring Creek and its tributaries. Baseline data are used to evaluate the present condition of an environmental resource, as well as to assess changes or trends. Baseline data are being collected for:

Base flow – Sustained stream flow that is not influenced by recent stormwater runoff.

Stormwater runoff – Water that runs off the land and into streams as a result of a storm event.

Groundwater – The water that is found underground in spaces between particles of soil and rock.

PROJECT OBJECTIVES

1. Provide a description of the quantity and quality of surface waters,
2. Provide a description of the quality of stormwater runoff,
3. Monitor groundwater levels,
4. Provide the means to detect changes in quantity and/or quality of base flow, stormwater, and groundwater, and
5. Provide sufficient measurement sensitivity to permit assessment of these changes.

THE WATER RESOURCES MONITORING COMMITTEE

The Water Resources Monitoring Committee is a volunteer group comprised of technical and environmental professionals who oversee and guide the activities of the Water Resources Monitoring Project (Table 1).

WINNER

2001 GOVERNOR'S AWARD FOR WATERSHED STEWARDSHIP

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Table 1. The 2001 Water Resources Monitoring Committee.

NAME	PROFESSION	AFFILIATION
Mark Ralston, P.G.*	Committee Chair, Hydrogeologist	Converse Consultants
Robert Carline, Ph.D.	Committee Vice-Chair, Adjunct Professor and Leader	Pennsylvania Cooperative Fish & Wildlife Research Unit, United States Geological Survey
Kristen Babcock	Project Technician	ClearWater Conservancy/Spring Creek Watershed Community
Andrew Cole, Ph.D.	Assistant Director	Center for Watershed Stewardship, Penn State University
Chris Finton, P.G.	Hydrogeologist	Danone Waters of North America
Steve Foard, P.E. **	Environmental/Safety Manager	Murata Electronics North America, Inc.
Bert Lavan	Senior Process Engineer	Corning Asahi Video Products
Todd Giddings, Ph.D., P.G.	Hydrogeologist	Todd Giddings and Associates, Inc.
Katie Ombalski	Watershed Coordinator/Project Manager	ClearWater Conservancy/Spring Creek Watershed Community
Gene Proch	Regulatory Affairs & Facilities Manager	Corning Asahi Video Products
John Sengle	Water Quality Specialist	PA Department of Environmental Protection
Becky Shirer	Project Technician	ClearWater Conservancy/Spring Creek Watershed Community
David Smith	Assistant Executive Director	University Area Joint Authority
Malcolm Taylor	Environmental Engineer	The Sear Brown Group
Shana Tritsch, P.G.	Senior Hydrogeologist	USFilter Groundwater Services
Rick Wardrop, P.G.	Hydrogeologist and Industrial Contamination Specialist	USFilter Groundwater Services

* Professional Geologist
** Professional Engineer

2.0 PROJECT FUNDING

Local financial support for the Water Resources Monitoring Project (WRMP) has come from a variety of watershed stakeholders including authorities, foundations, industries, institutions, municipalities, and organizations. To date, the Water Resources Monitoring Committee has raised $118,800 locally. These funds have paid for project start-up costs and operational expenses from 1998-2001. Fundraising efforts that occurred during summer 2001 secured the majority of project funding needs through 2003. The 2001-2003 funding cycle is anticipated to have an actual project value (including local funding, grants, and in-kind contributions) of $137,000 per year with a local cost share of $53,000 per year.

YEAR 2001 LOCAL FINANCIAL CONTRIBUTORS

Authorities

- State College Borough Water Authority
- University Area Joint Authority

Industry

- Corning Foundation
- Danone Waters of North America

Institutions

- Penn State University Office of Physical Plant

Municipalities

- Centre Region Council of Governments (College, Ferguson, Halfmoon, Harris, and Patton Townships, and State College Borough)
- Benner Township
- Bellefonte Borough
- Milesburg Borough
- Spring Township

Organizations

- Spring Creek Chapter of Trout Unlimited

GRANTS AWARDED

The Water Resources Monitoring Project has received grant funds totaling $83,615 from PA DEP's Growing Greener Program to conduct stormwater (2000-2002) and groundwater (2001-2003) monitoring. The project also received assistance from the Alliance for Aquatic Resource Monitoring and the United States Geological Survey (USGS) through a Technical Assistance Grant from PA DEP. The combined value of these grants contributed $24,160 to the Project in 2000, $6,933 in 2001, and an estimated $41,718 and $15,663 in 2002 and 2003, respectively.

IN-KIND CONTRIBUTORS

The Water Resources Monitoring Project received over $70,000 of in-kind contributions during the year 2001. These contributions included laboratory facilities and analyses, professional services, fundraising materials, groundwater monitoring wells, stilling well maintenance, technical assistance, chemical supplies, and transportation. In-kind contributors for 2001 include:

- Converse Consultants
- Corning Asahi Video Products
- Exygen Research
- Pennsylvania Cooperative Fish and Wildlife Research Unit, United States Geological Survey
- Pennsylvania Department of Environmental Protection
- Todd Giddings
- United States Geological Survey
- University Area Joint Authority
- USFilter Groundwater Services
- Volunteer field assistants and students
- Water Resources Monitoring Committee

3.0 PROJECT HISTORY

1998

- Developed a monitoring work plan
- Raised funds for startup and operating capital
- Began installation of monitoring equipment

1999

- Raised funds for operations
- Produced and distributed 1998 WRMP Annual Report
- Completed installation of base flow monitoring equipment
- Initiated base flow monitoring
- Completed and published the *Searchable Bibliographic Database*
- Completed and published the *Spring Creek Watershed Water Resources Monitoring Protocol*

2000

- Continued base flow data collection
- Produced and distributed 1999 WRMP Annual Report
- Awarded Stormwater Monitoring grant from PA DEP Growing Greener program
- Purchased and installed stormwater monitoring equipment
- Initiated stormwater monitoring
- Awarded Groundwater Monitoring grant from PA DEP Growing Greener program
- Completed the development of the water monitoring database
- Continued to calibrate and update stream flow rating curves for the nine non-USGS stream monitoring stations
- Participated in PA DEP's Watershed Snapshot

2001

- Received the 2001 Governor's Award for Watershed Stewardship in the Assessment and Planning Category
- Produced and distributed 2000 WRMP Annual Report
- Continued base flow data collection
- Completed the Stormwater Monitoring Protocol
- Continued stormwater monitoring
- Conducted geomorphological assessments at eight monitoring sites located on tributary streams of Spring Creek
- Began collecting groundwater level data from two monitoring wells
- Worked with municipalities, consultants, and industry to begin selection of the remaining five monitoring wells for the Ground-water Monitoring Project
- Received assistance from the Alliance for Aquatic Resource Monitoring and the United States Geological Survey through a Technical Assistance Grant from PA DEP
- Made project information, including a pilot version of our WRMP database, available through our Web site at www.springcreekwatershed.org
- Continued to calibrate and update stream flow rating curves for the nine non-USGS stream monitoring stations
- Participated in PA DEP's Watershed Snapshot
- Raised most of the funds needed to continue the project through 2003
- Assisted with the development of the RSVP/Centre County Senior Environmental Corps Volunteer Monitoring Program
- Continued to refine and update water monitoring database

4.0 MONITORING LOCATIONS

BASE FLOW AND STORMWATER

The rationale used to establish stream monitoring stations was to divide the watershed into smaller hydrologic units, called sub-watersheds or sub-basins, and to characterize the quantity and quality of water flowing from these sub-basins into the main stem of Spring Creek (Figure 1). The existence of three USGS gaging stations on the main stem of Spring Creek and three gaging stations maintained by the Pennsylvania Cooperative Fish and Wildlife Research Unit was also taken into account (Table 2).

When land use patterns were similar throughout a sub-basin, a single monitoring station was located at the point where flow from the sub-basin joined Spring Creek to describe water quantity and quality from the sub-basin (Figure 2). However, when land use patterns changed throughout a sub-basin, a monitoring station was located near the middle of the sub-basin and near its confluence with Spring Creek. Thus, data collected from the monitoring stations allow us to describe the amount of suspended and dissolved materials contributed from each sub-basin and describe how the quantity and quality of water in the main stem of Spring Creek changes as it travels from the upper part of the watershed near Boalsburg to its confluence with Bald Eagle Creek in Milesburg.

GROUNDWATER

The Water Resources Monitoring Committee (WRMC) is currently in the process of developing a groundwater level monitoring network for the Spring Creek Watershed. Data collected by this network will be used to assess the behavior of the groundwater reservoir in the Spring Creek Watershed. This network will be comprised of seven wells, two operated by USGS and five by the Spring Creek Watershed Community. The two USGS monitoring wells have already been instrumented by USGS. The first USGS well, CE 686, is located southwest of State College in the headwaters of the Spring Creek Watershed, near the boundary between the Big Hollow and Slab Cabin Run sub-basins. Real-time data from this well is available online at www.water.usgs.org/nwis/gw. The second USGS well is located in the Scotia Barrens, a vital recharge area for the Gatesburg Aquifer (source of the Bellefonte Big Spring). The remaining five wells will be instumented by the WRMC in 2002. In order to maximize the usefulness of groundwater level data, a number of screening criteria were used to develop a list of candidate groundwater level monitoring wells (Figure 3):

- A candidate well should reasonably represent groundwater level conditions over a large area, i.e., wells should represent broad “hydrogeologic environments”, such as carbonate valley, shale valley, mountain setting, etc.
- Candidate well locations should be geographically distributed across the Spring Creek Watershed.
- If possible, candidate wells should be located so as to give information about important groundwater features, such as the Gatesburg Aquifer and the Big Hollow drainage.
- Reasonably complete information should be available for well as-built characteristics, such as well yield, depth, casing, etc.
- Candidate wells should not be situated near a high-yield pumping well or wellfield, or in a location that is unduly influenced by stormwater or artificial groundwater recharge. In both of these cases, groundwater levels would be artificially controlled or influenced.
- Candidate wells should not be situated near a stream or groundwater discharge point. In these settings, groundwater level fluctuation would be subdued.
- Finally, the well owner must be willing to permit access to the well and publication of groundwater level data.

Table 2. Stream Monitoring Stations.

MONITORING STATION	LOCATION	OPERATOR
Spring Creek Milesburg (SPM)	Downstream of McCoy Dam in Milesburg	USGS
Buffalo Run Lower (BUL)	Upstream of the confluence with Spring Creek in Coleville	SCWC
Logan Branch Lower (LOL)	100 feet upstream of SR150 crossing in Bellefonte	SCWC
Spring Creek Axemann (SPA)	50 feet downstream of the bridge on Fisherman's Paradise Road	USGS
Logan Branch Upper (LOU)	Behind International Order of Odd Fellows building on SR144	SCWC
Spring Creek Houserville (SPH)	50 feet upstream of the intersection of Houserville, Trout, and Rock Roads	USGS
Slab Cabin Run Lower (SLL)	In Millbrook Marsh behind College Township Municipal Building	SCWC
Thompson Run Lower (THL)	In Millbrook Marsh behind the Millbrook Marsh Nature Center	SCWC
Slab Cabin Run Upper (SLU)	20 feet upstream of the bridge on South Atherton Street, near Branch Road	PCFWRU
Cedar Run Lower (CEL)	200 feet upstream of the intersection of Brush Valley & Linden Hall Roads	PCFWRU
Spring Creek Upper (SPU)	100 feet upstream from the Linden Hall Bridge in Oak Hall	PCFWRU
Buffalo Run Upper (BUU)	Off SR550, approximately 1000 feet upstream from the village of Fillmore	SCWC

USGS = United States Geological Survey, SCWC = Spring Creek Watershed Community
PCFWRU = Pennsylvania Cooperative Fish and Wildlife Research Unit

Photo by Mark Ralston

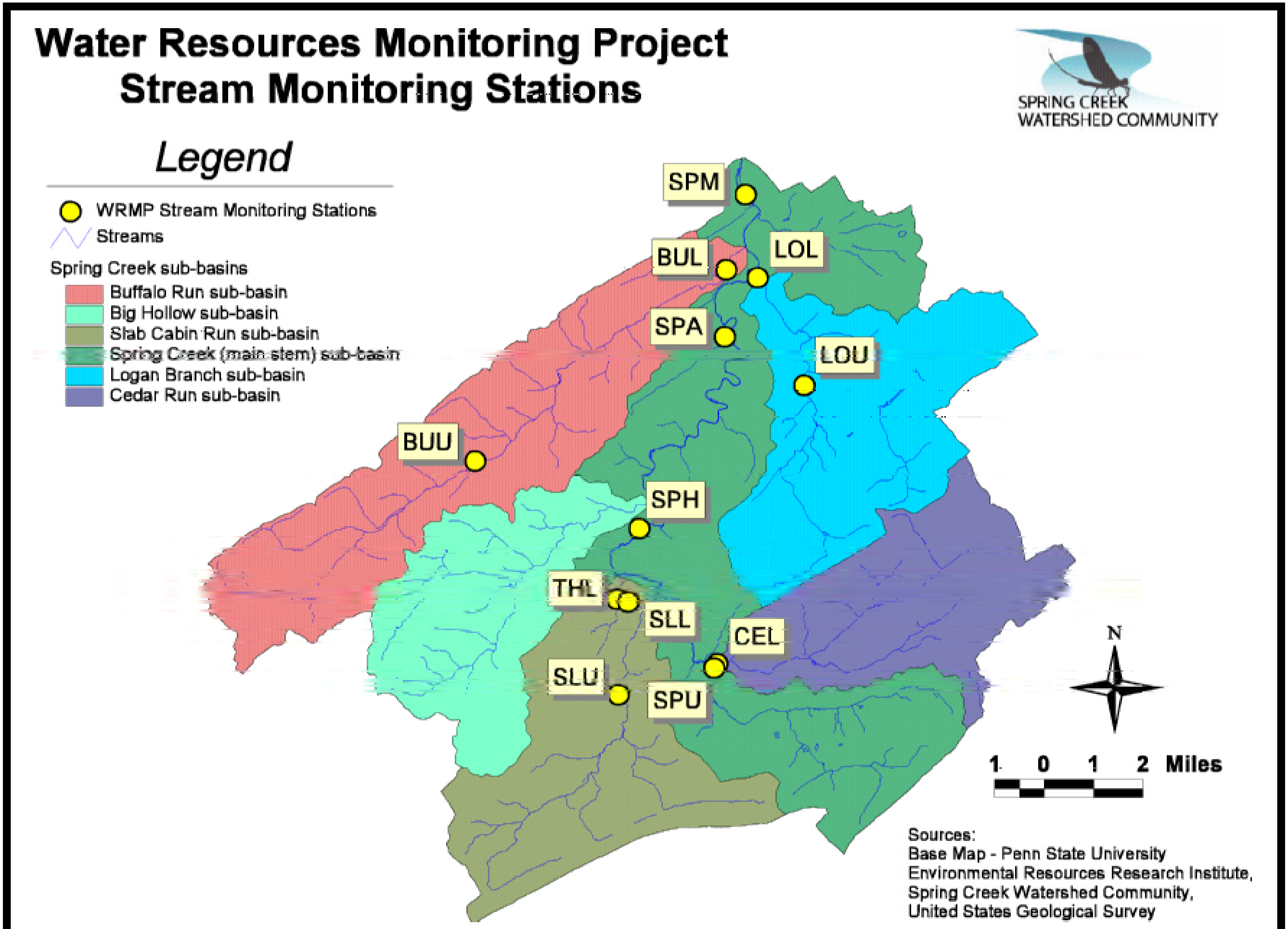

Figure 1. Water Resources Monitoring Project Stream Monitoring Stations.

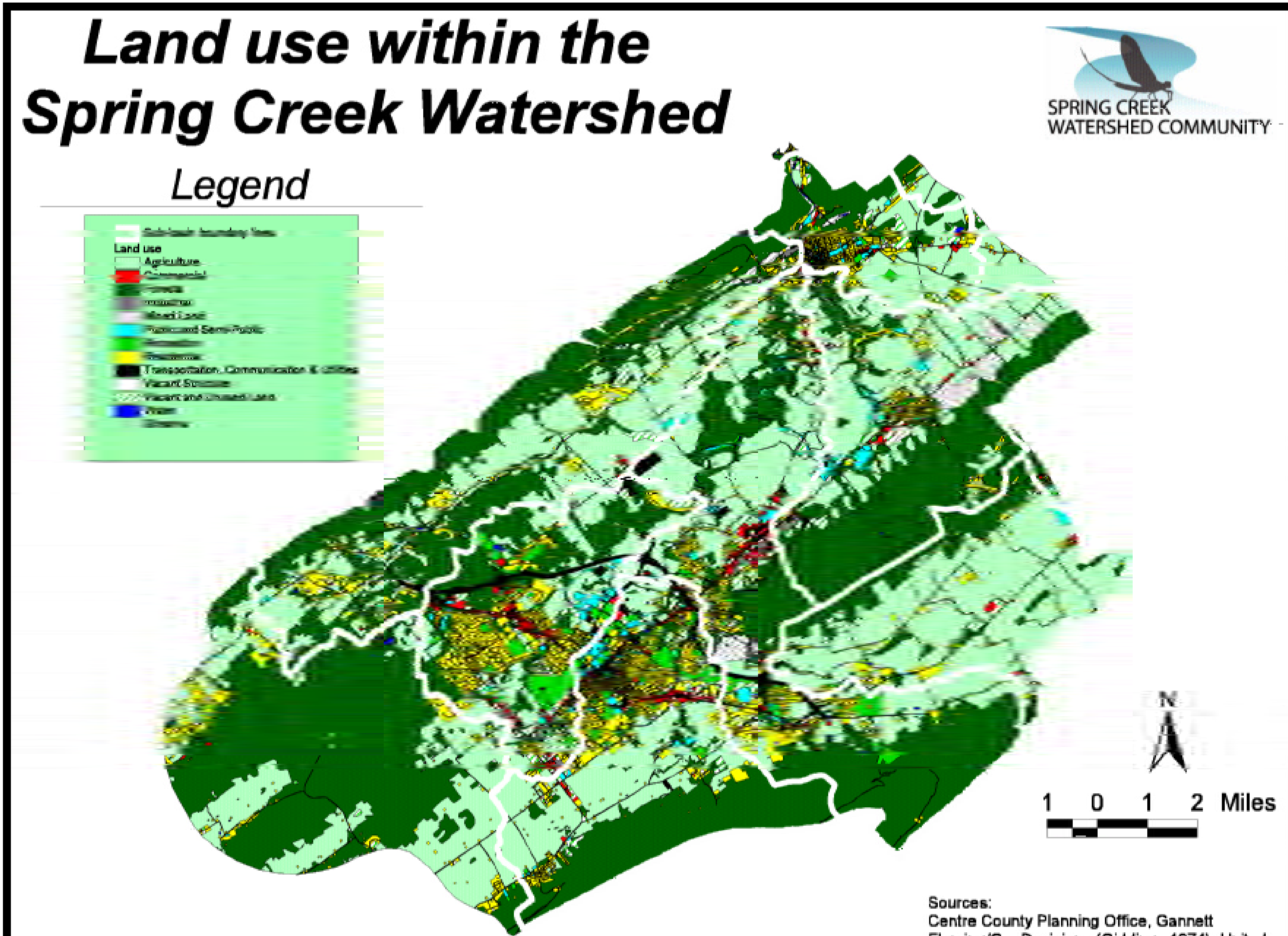

Figure 2. Land use with in the Spring Creek Watershed.

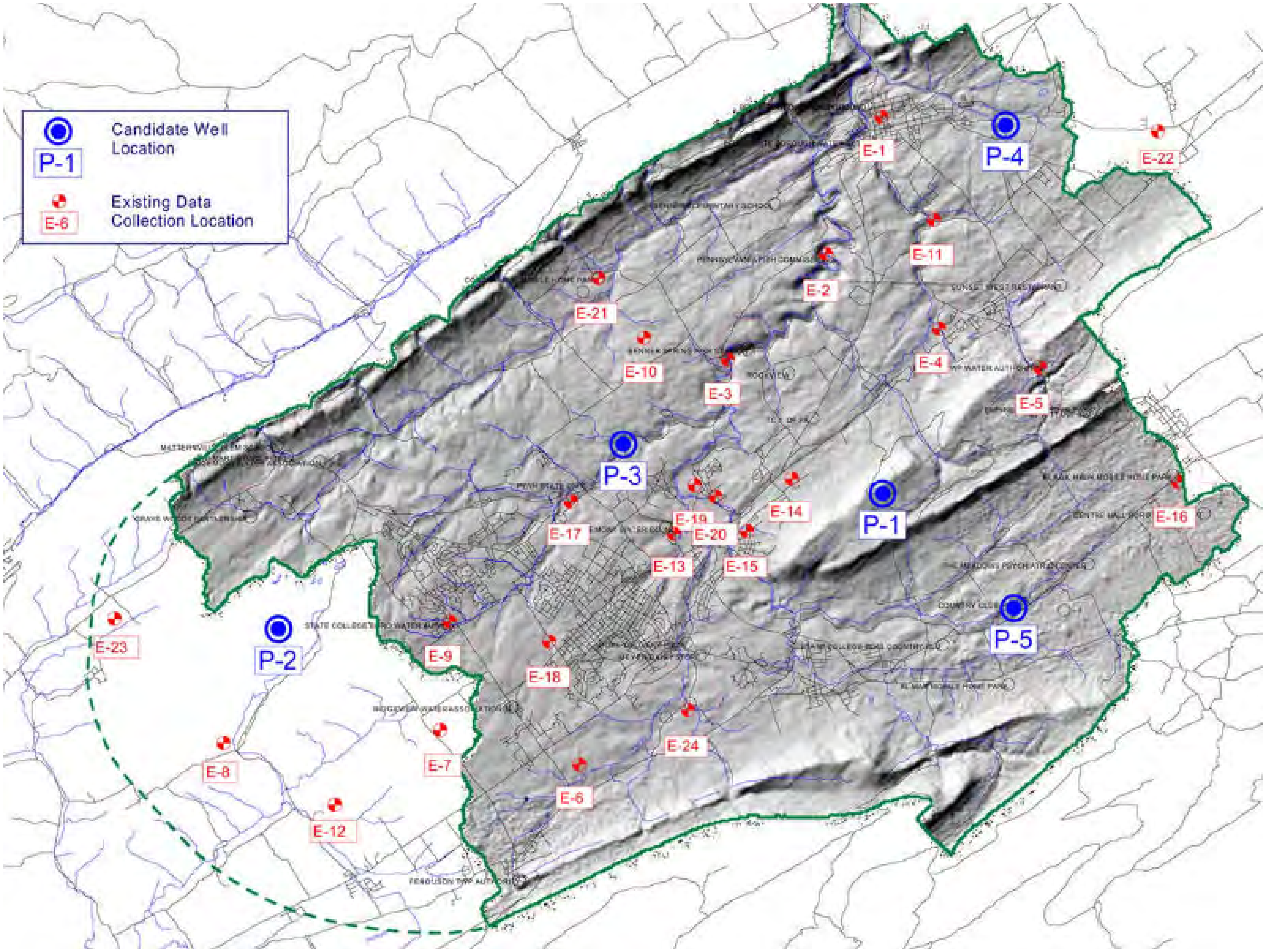

Figure 3. Proposed Groundwater Level Monitoring Wells.

5.0 METHODS

Base flow and stormwater monitoring are cooperative efforts between the Pennsylvania Cooperative Fish and Wildlife Research Unit (PACFWU), USGS, and the Spring Creek Watershed Community's Water Resources Monitoring Project. Standardized methods have been developed for data collection and sample processing to provide quality assurance for all data collected by the Water Resources Monitoring Project. Detailed methods for base flow and stormwater monitoring are documented in the *Spring Creek Watershed Water Resources Monitoring Protocol* and the *Spring Creek Watershed Stormwater Monitoring Protocol,* respectively. Both documents are available on our Web site (www.springcreekwatershed.org) or upon request. A protocol for groundwater monitoring will be created in 2002. The following is a brief description of the parameters measured for base flow, stormwater, and groundwater monitoring.

BASE FLOW MEASUREMENTS

Continuous Measurements

Stream flow - Stream flow is measured at all 12 monitoring stations for base flow and stormwater monitoring. Nine of the 12 monitoring stations are equipped with instruments that record water level every 30 minutes. The water level data are then converted to stream flow using station-specific rating curves (a rating curve relates water level to flow). Stream flow is recorded every fifteen minutes at the three USGS stations (Spring Creek Houserville, Spring Creek Axemann, and Spring Creek Milesburg).

Water temperature - Water temperature is measured at all 12 monitoring stations for base flow and stormwater monitoring. These instruments record data every hour.

Monthly Measurements

Every month water samples are taken during base flow conditions at each of the 12 monitoring stations using standardized procedures and sent to a laboratory for analysis. Samples are analyzed for 10 parameters. Monthly measurements also include dissolved oxygen and pH, which are measured in the field at each station when water quality samples are collected (Table 3).

STORM EVENT MEASUREMENTS

Stormwater runoff was monitored from June 2001 to May 2002 for storms that had greater than 0.25" of precipitation. Seven automatic samplers were located at each of the twelve monitoring stations on a rotating basis with the goal of capturing a minimum of one storm at each station per season. Once collected, samples from each station were combined based on flow data into three larger composite samples to represent the "beginning", "middle", and "end" of the stream's response to the stormwater runoff. These samples were analyzed for the parameters listed in Table 3 excluding dissolved oxygen and petroleum hydrocarbons. Stormwater measurements also included ammonia.

GROUNDWATER LEVEL MEASUREMENTS

In 2001, the Spring Creek Watershed groundwater level monitoring network was under development, therefore groundwater levels were only measured at the two USGS operated wells. Groundwater levels were measured every hour.

Table 3. Monthly water quality analyses.

PARAMETER	DESCRIPTION	SOURCES	ENVIRONMENTAL EFFECTS	PA DEP CRITERIA*
pH	A measure of the acidity of water on a logarithmic scale of 1 to 14. A pH below 7 is acidic, above 7 is basic or alkaline, and a pH of 7 is neutral.	The pH of Spring Creek is slightly alkaline because of the carbonate bedrock. pH can be lowered by acid mine drainage or acid rain.	Extreme pH can inhibit growth and reproduction in aquatic organisms. Acidic waters also release metals from the sediment, creating toxic conditions.	6-9
Dissolved Oxygen (DO)	Oxygen gas dissolved in the water is crucial to aquatic life. The amount of oxygen dissolved at saturation is inversely related to temperature.	DO is depleted by respiration and the microbial breakdown of organic wastes. It is restored by photosynthesis and physical aeration.	Low levels of dissolved oxygen are harmful to aquatic animals. This is usually the result of organic pollution or elevated temperatures.	>7.0 mg/L (HQCWF**) >5.0 mg/L (CWF**)
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 some clean rivers are naturally turbid, turbidity can be increased by earth-moving activities, urban runoff, and erosion from agricultural fields.	High turbidity blocks light from the water column and inhibits submerged aquatic plants. By absorbing sunlight, the particles also increase water temperature.	No criteria established.
Total Suspended Solids (TSS)	Any particles carried by the water. Includes silt, plankton, organic stream litter, industrial waste, and sewage.	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.	No criteria established.
Chloride	The concentration of chloride salt ions dissolved in the water.	Washes off of roads where it is applied as a deicing agent.	Very high chloride concentrations can be toxic to macroinvertebrates.	<150 mg/L HQ-CWF**
Ortho-phosphate	Orthophosphate is the form of inorganic phosphorous required by plants. Its availability is often the limiting factor in plant growth.	Rocks and minerals provide a low natural level. Human sources include commercial cleaning products, water treatment plants, and fertilized lawns and farmland.	A small increase in orthophosphate can cause eutrophication, the loss of dissolved oxygen through the stimulation and decay of excessive plant growth.	No criteria established.
Nitrate (NO_3)	One of three forms of nitrogen found in water bodies, nitrate is the form used by aquatic plants. Organic nitrogen (N) is converted to nitrate (NO3) by bacteria.	Any nitrogen-containing organic waste, including sewage from water treatment plants and septic systems, and runoff from fertilized lawns, farms, & livestock areas.	High nitrate levels promote excessive plant growth and eutrophication. Excess nitrate in drinking water can cause illness or death in infants.	<10 mg/L for Nitrate and Nitrite Combined
Total Petroleum Hydrocarbons	Molecules found in petroleum fuels. Indicates oil pollution and road runoff.	Runoff from roads, careless disposal, accidental spills, and natural deposits.	Varying degrees of toxicity to aquatic organisms and birds.	No criteria established.
Total Organic Carbon	A measure of the amount of carbon-containing compounds and thus the amount of organic material present.	Animal wastes, human wastes, plant material, agricultural chemicals, and petroleum compounds.	High carbon content in streams increases the growth of microorganisms, which depletes dissolved oxygen.	No criteria established.
Copper	A heavy metal less common than lead and zinc in nature.	Used in wiring, plumbing, and electronics, and to control algae, bacteria, and fungi.	Toxic to humans and aquatic life. Toxicity is affected by water hardness.	<12.7 ug/L***
Lead	A heavy metal that occurs naturally as lead sulfide but may exist in other forms.	Urban & industrial uses include gasoline, batteries, solder, pigments, and paint.	Toxic to humans and aquatic life. Toxicity is affected by water hardness.	<3.90 ug/L***
Zinc	A heavy metal commonly found in rock-forming minerals.	Urban runoff, industrial discharges and natural sources. Used in many alloys.	Somewhat toxic to humans and aquatic life. Toxicity is affected by water hardness.	<167 ug/L***

*PA DEP water quality criteria from Pennsylvania Code Title 25, Chapters 16 and 93
**HQ-CWF = High Quality Cold Water Fishery, CWF = Cold Water Fishery
***Assuming a water hardness of 150 mg/L.

6.0 BASE FLOW RESULTS & DISCUSSION

In response to requests and comments we received from the stakeholders of the Spring Creek Watershed Community in 2001, we have attempted to present the data in this report in a manner that we hope is more meaningful to all data users.

STREAM FLOW

Data Presentation

Two pie charts show the total volume of water that passed by the Spring Creek Milesburg station in 2000 and 2001 and the percent of that volume that was contributed by each tributary. A figure presenting stream flow over time, also called a hydrograph, is provided for 2001 at all stations other than Spring Creek Milesburg. The hydrograph for Spring Creek Milesburg is shown in a separate figure with the 34-year mean and minimum dialy flows.

Rating Curves

Flow rate is extracted from the stream level data using a station-specific rating curve. Rating curves are checked periodically, the frequency of which is dependent on the stability of the cross-section at each station. Based on these evaluations the existing rating curves were appropriate for all stations except Logan Branch Upper. A new rating curve was developed in 2002 for the Logan Branch Upper station and applied to all data after September 1, 2001 when an unexplained sudden change in stream level was recorded.

Data Completeness

During winter months, ice partially blocking flow or covering the streams can affect the flow rate determined by the rating curves. Effects of freezing were noted at the Slab Cabin Upper station during January through March, and therefore this data is qualified as estimated. Some portions of the 2001 flow data were lost from three stations due to technical problems. Data were lost from: Buffalo Run Upper (December 30-31) due to battery failure, Slab Cabin Run Upper (August 11– October 18) due to a leaking seal on a transducer, and Thompson Run Lower (July 2– August 8) due to an improper setting made during data download. All other stream flow records were complete and accurate.

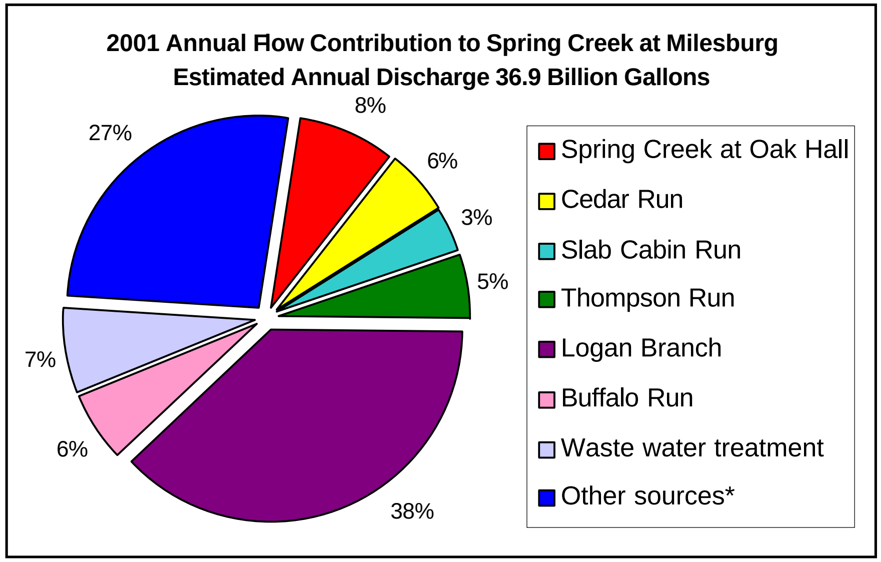

Figure 4. 2001 mean contribution of major sources to the annual flow at Spring Creek Milesburg. *Groundwater recharge, springs, and the fish hatcheries.

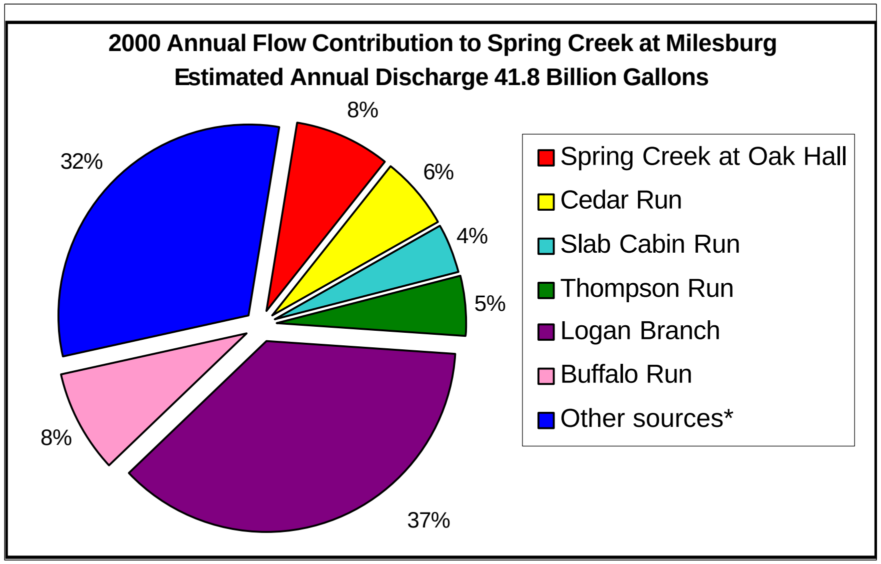

Figure 5. 2000 mean contribution of major sources to the annual flow at Spring Creek Milesburg. *Groundwater recharge, springs, and the fish hatcheries.

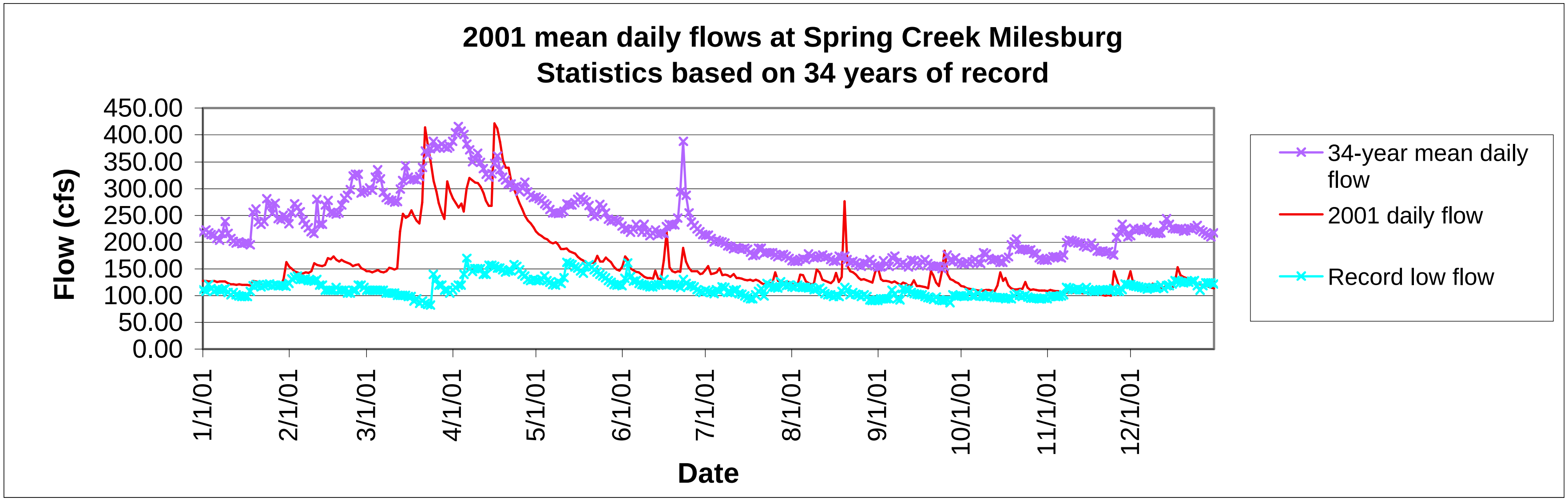

Figure 6. 2001 mean daily flows at Spring Creek Milesburg, with 34-year mean and minimum daily flows.

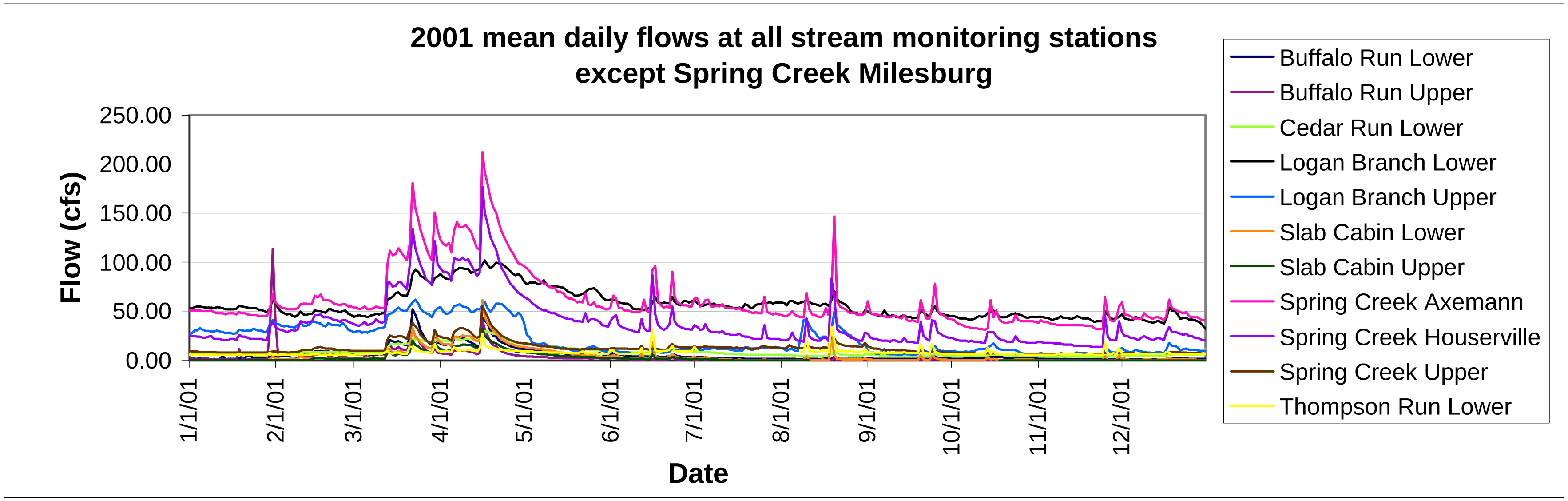

Figure 7. 2001 mean daily flows at all stream monitoring stations with the exception of Spring Creek Milesburg, which is shown in Figure 6.

Flow Volume and Contributions

The 2001 annual discharge of Spring Creek at Milesburg was approximated to be 36.9 billion gallons, with a mean daily discharge of 101 million gallons. The contributors of flow are indicated in Figure 4. Logan Branch was the largest single contributor in 2001, accounting for 38% of the total flow. The second largest contribution, 27%, includes groundwater recharge, springs (Big Spring and others) between Oak Hall and Milesburg, and the fish hatcheries (Benner Spring and Fisherman's Paradise). Of this 27%, nearly half is accounted for by the fish hatchery discharges. The remaining 35% of flow at Milesburg is from tributaries and the wastewater treatment plants (University Area Joint Authority and Bellefonte Waste Water Treatment Plant). Of note is that the wastewater treatment plants contributed more flow (7%) to Spring Creek at Milesburg than either Buffalo Run, Cedar Run, Slab Cabin Run, or Thompson Run.

These relative contributions to flow are similar to those reported during 2000 (Figure 5). The apparent percentage changes are due to the breakout of additional contributors (i.e. the wastewater treatment plants) during 2001, which for the 2000 analysis were included into the "Other sources" category. Additionally, the 2000 pie chart has been modified from that printed in the 2000 WRMP Annual Report which incorrectly stated the percentage of flow contributed by Buffalo Run.

Year in Review

The 2001 Spring Creek total discharge of 36.9 billion gallons is less than the relatively low 41.8 billion gallons reported during 2000. The flow decrease is related to the continued drought conditions experienced regionally and associated dropping groundwater levels. Total precipitation measured at the Penn State University Weather Station in State College during 2000 and 2001 was 18% and 21% below normal, respectively, with 2001 tying for the 6th driest year in 106 years of record. The cumulative effect of this precipitation deficit on groundwater levels is apparent in the continuing downward trend of the hydrograph of monitoring well CE 686 through 2000 and 2001 (Figure 41).

During year 2001, Spring Creek flow recorded at the Milesburg station was significantly below normal (generally 40-60%) for 10 months and set several daily records for low flow. Stream flows recorded at the Milesburg gage have been compared to the 34-year median and minimum flow recorded in Figure 6. Flow levels were so low that the median flow at Milesburg was only exceeded during four storm runoff events all year.

The low flows recorded at Milesburg are apparent in the flow levels at all of the stream monitoring stations (Figure 7). In addition, two tributaries were dry for the latter half of the year and into 2002: Buffalo Run Upper went dry on July 10th and Slab Cabin Run Upper went dry on July 16th. During this period, these stream segments flowed only during rain events.

STREAM TEMPERATURE

Data Presentation

A table shows the number of days that stream temperature reached or exceeded 68°F between 1999 and 2001. Additionally, five figures illustrate mean daily temperature from May 1999-December 2001 for all stations. Stations were grouped by physical location in the watershed to allow for more meaningful comparisons. Suggestions are also included for stream temperature management.

Temperature Variation

Water temperature of streams is related to several factors: proximity to springs, volume of nearby springs, and time of exposure to the atmosphere. Stations such as Spring Creek Upper and Thompson Run Lower are close to large spring sources; hence, winter temperatures are relatively high compared to other stations and summer temperatures are relatively low. Water temperatures at Slab Cabin Run Upper were coldest during winter and warmest during summer, closely approximating air temperatures, because spring flows into Slab Cabin Run are rather small and the springs are far removed from the monitoring station. In general, stream temperatures in the main stem of Spring Creek tend to increase during summer months as one moves downstream; when Big Spring, Logan Branch, and Buffalo Run enter Spring Creek, temperatures decline during summer. All temperature data collected from 1999 through 2001 is presented in Figures 8-12.

Summer Temperatures

Summer water temperatures are of most concern because they determine the suitability of the stream to support wild trout. One way to compare summer conditions among stations is to determine the number of days that stream temperatures equal or exceed 68°F (Table 4) because brown trout cannot grow, regardless of the food supply, when water temperature increases to 68°F. Among stations on tributaries, Slab Cabin Run had the most days $\geq$68°F and this total would have been greater if Slab Cabin Run

Table 4. Number of days that stream temperature reached or exceeded 68 ^{o}F.

MONITORING STATION	1999	2000	2001	AVERAGE RANK (WARMEST = 1)
Buffalo Run Lower	14	5	26	8
Buffalo Run Upper	43	22	76	5
Cedar Run Lower	91	13	64	4
Logan Branch Lower	43	16	52	6
Logan Branch Upper	No data	0	0	12
Slab Cabin Run Lower	65	79	82	3
Slab Cabin Run Upper	98	85	94	1
Spring Creek Axemann	94	58	100	2
Spring Creek Houserville	26	7	41	7
Spring Creek Milesburg	15	1	13	9
Spring Creek Upper	1	1	1	11
Thompson Run Lower	13	5	9	10

Upper had not been dry during much of the summer of 2000 and 2001. The next warmest tributary was Cedar Run, followed by Buffalo Run and Logan Branch.

The main stem of Spring Creek had rather cool summer temperatures at the Oak Hall station. As the water flowed downstream it warmed, such that the number of days $\geq$68^{o}F increased at Houserville and continued to increase at the Axemann Station, where it ranked second warmest among stations. After cool inputs of water in the Bellefonte region, the main stem of Spring Creek had few days when mean daily temperatures $\geq$68^{o}F.

Possible strategies to manage stream water temperatures include:

- protecting spring inflows,
- increasing riparian buffers, and
- minimizing inputs of warm stormwater, which typically originate from runoff of impervious surfaces.

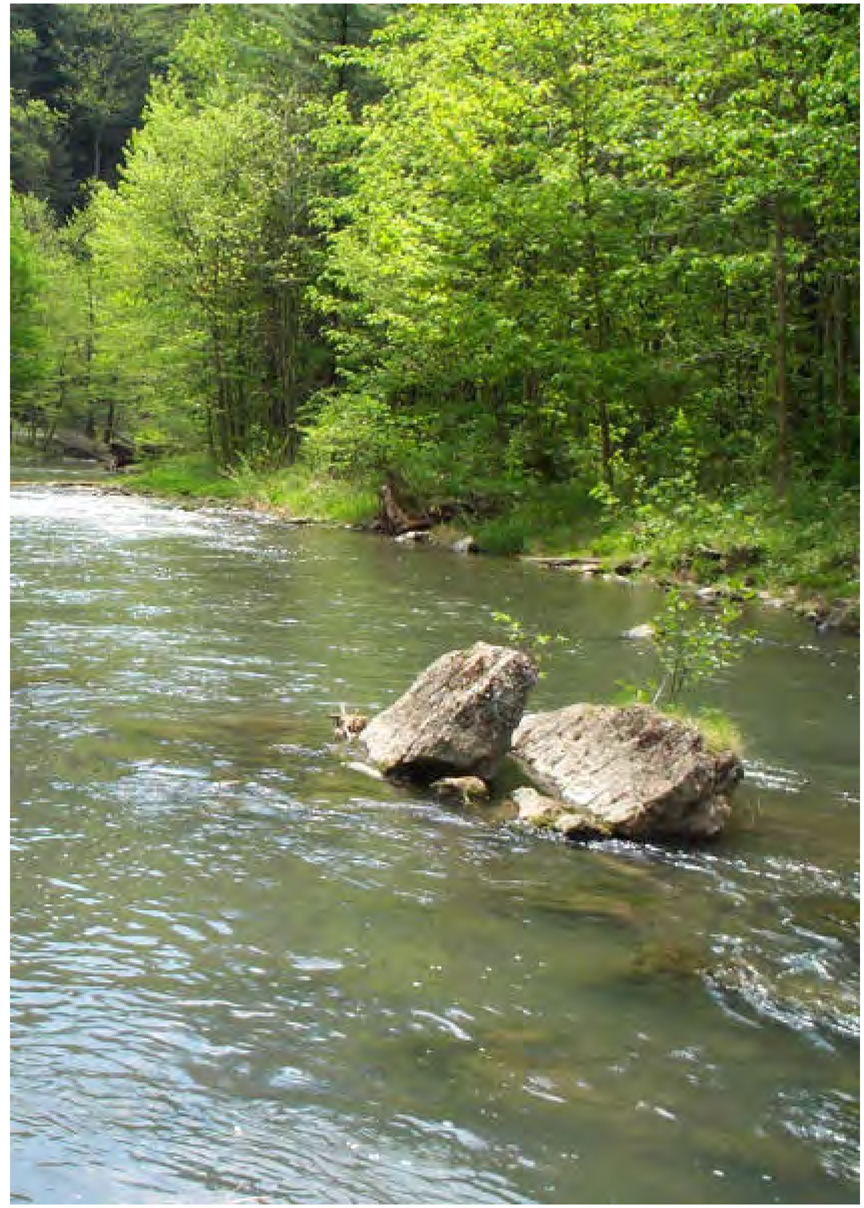

Photo by Mark Ralston

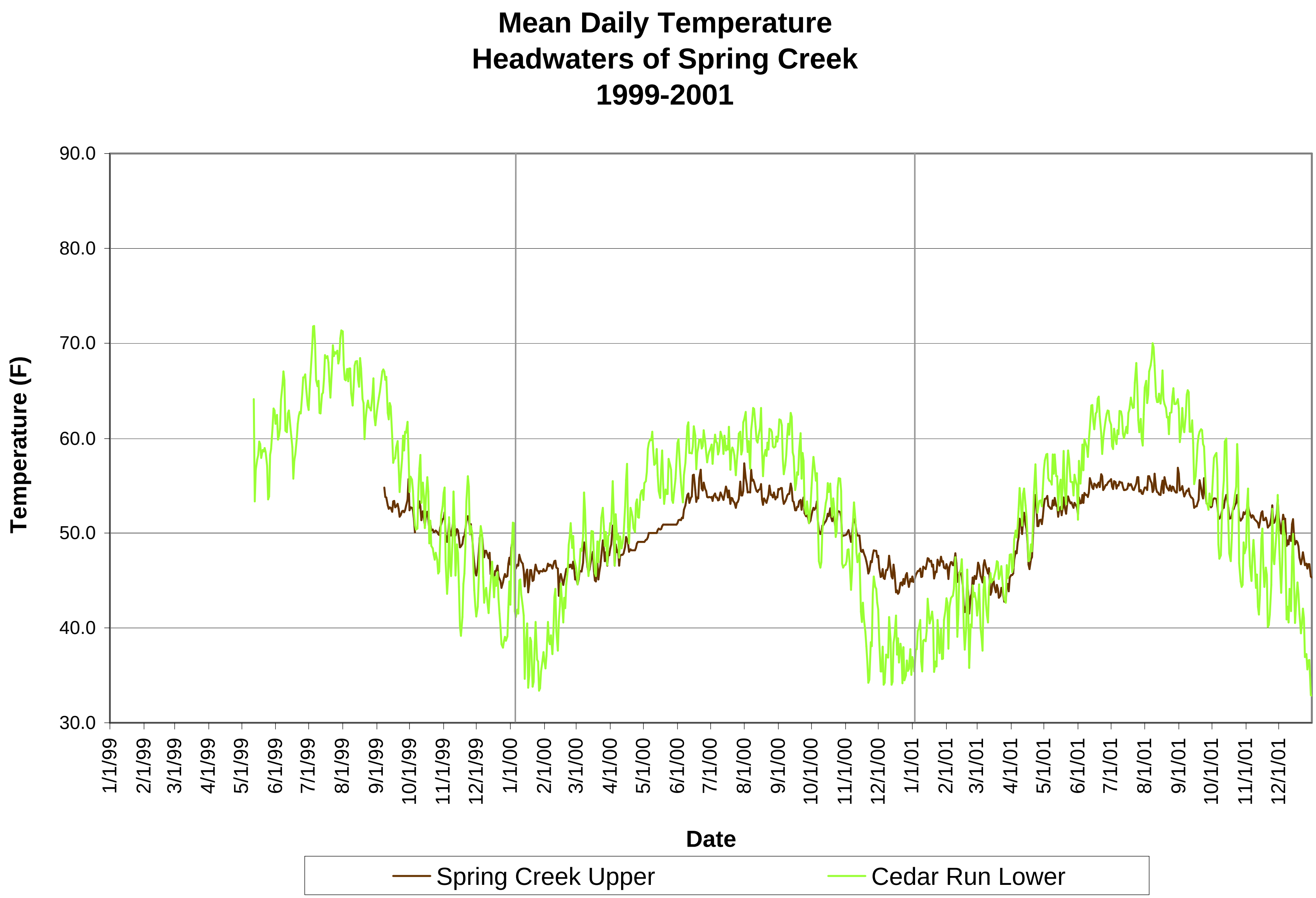

Figure 8. Mean temperature of the Spring Creek Headwaters from 1999 to 2001.

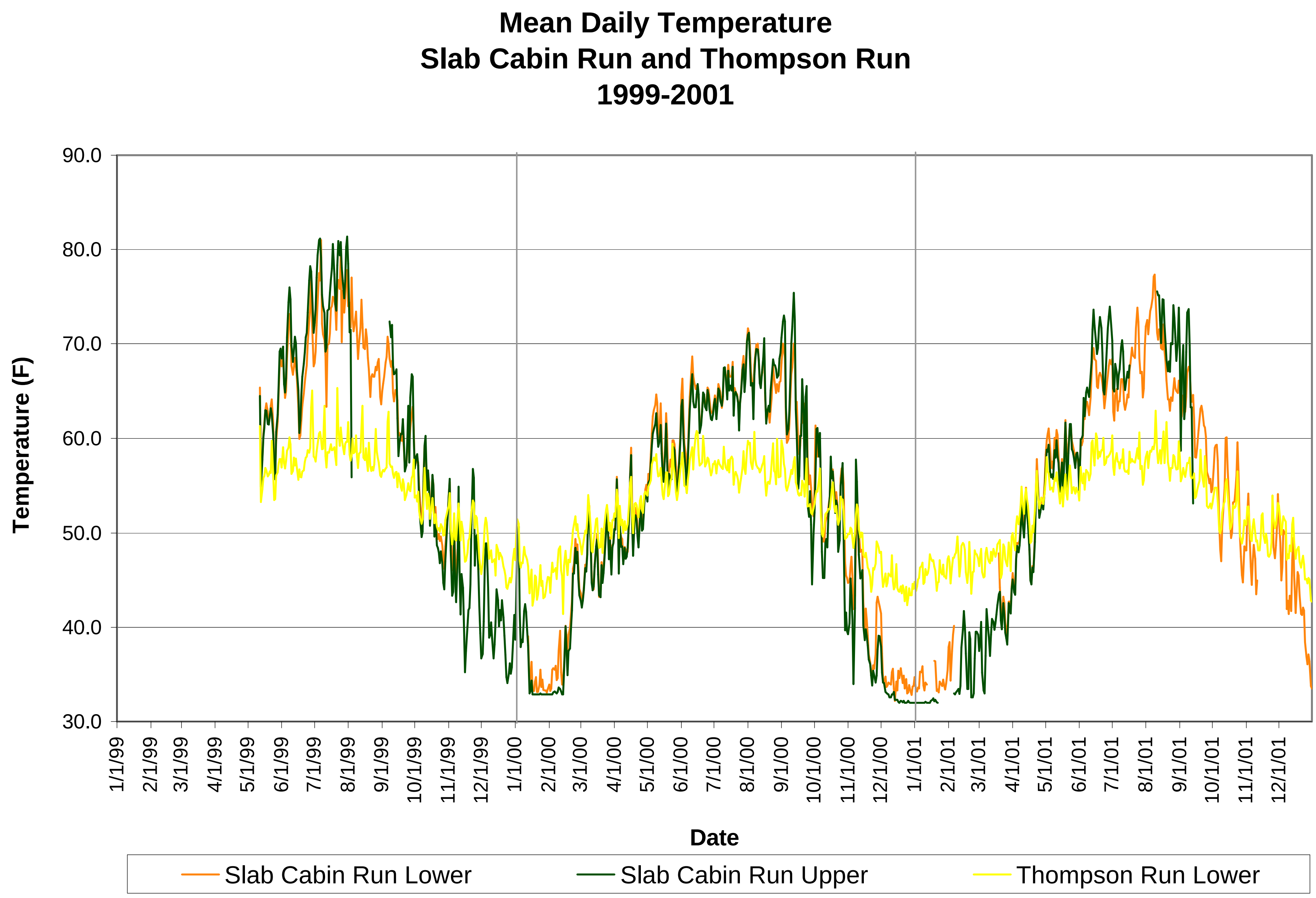

Figure 9. Mean temperature of Slab Cabin Run and Thompson Run from 1999 to 2001.

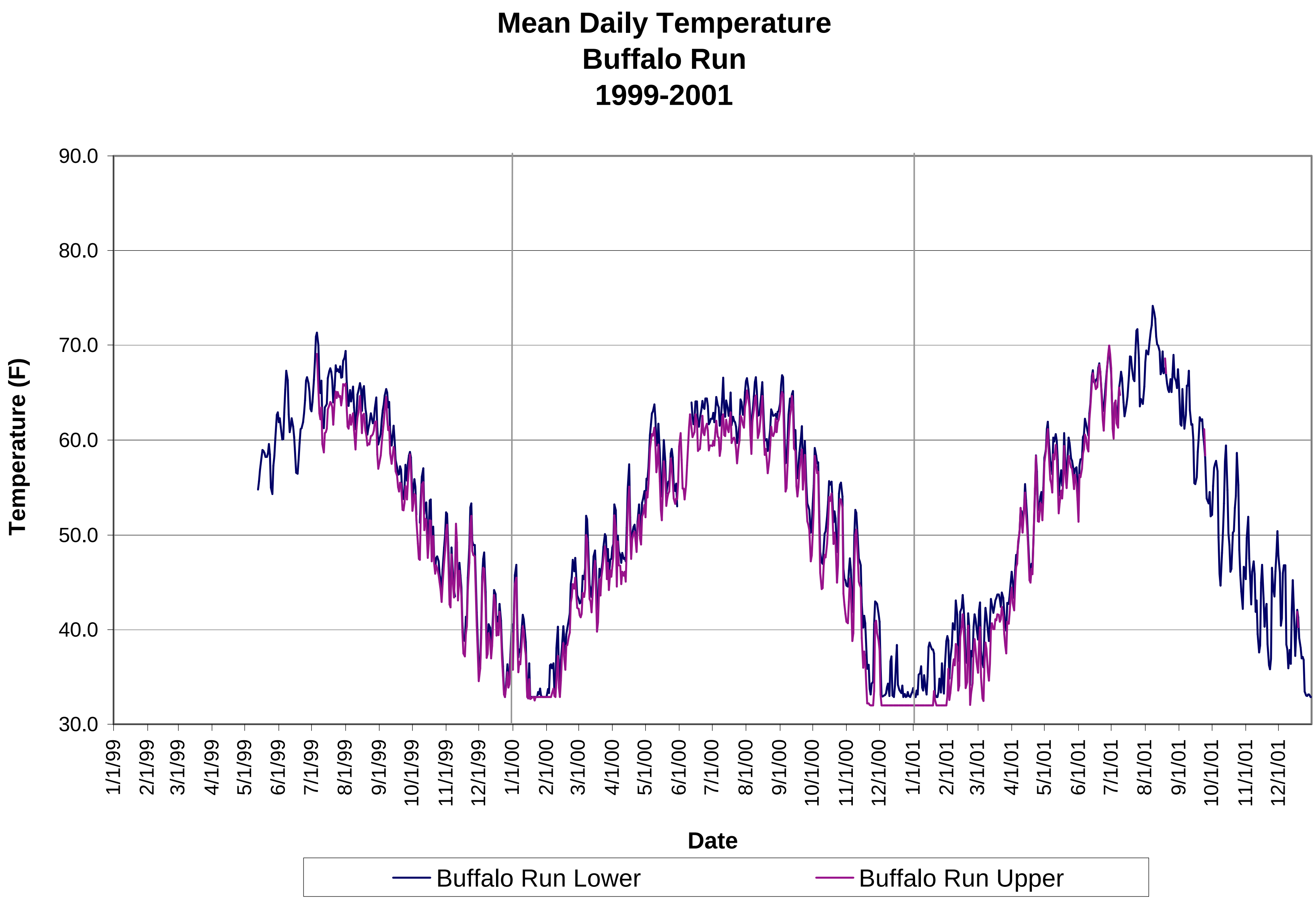

Figure 10. Mean temperature of Buffalo Run from 1999 to 2001.

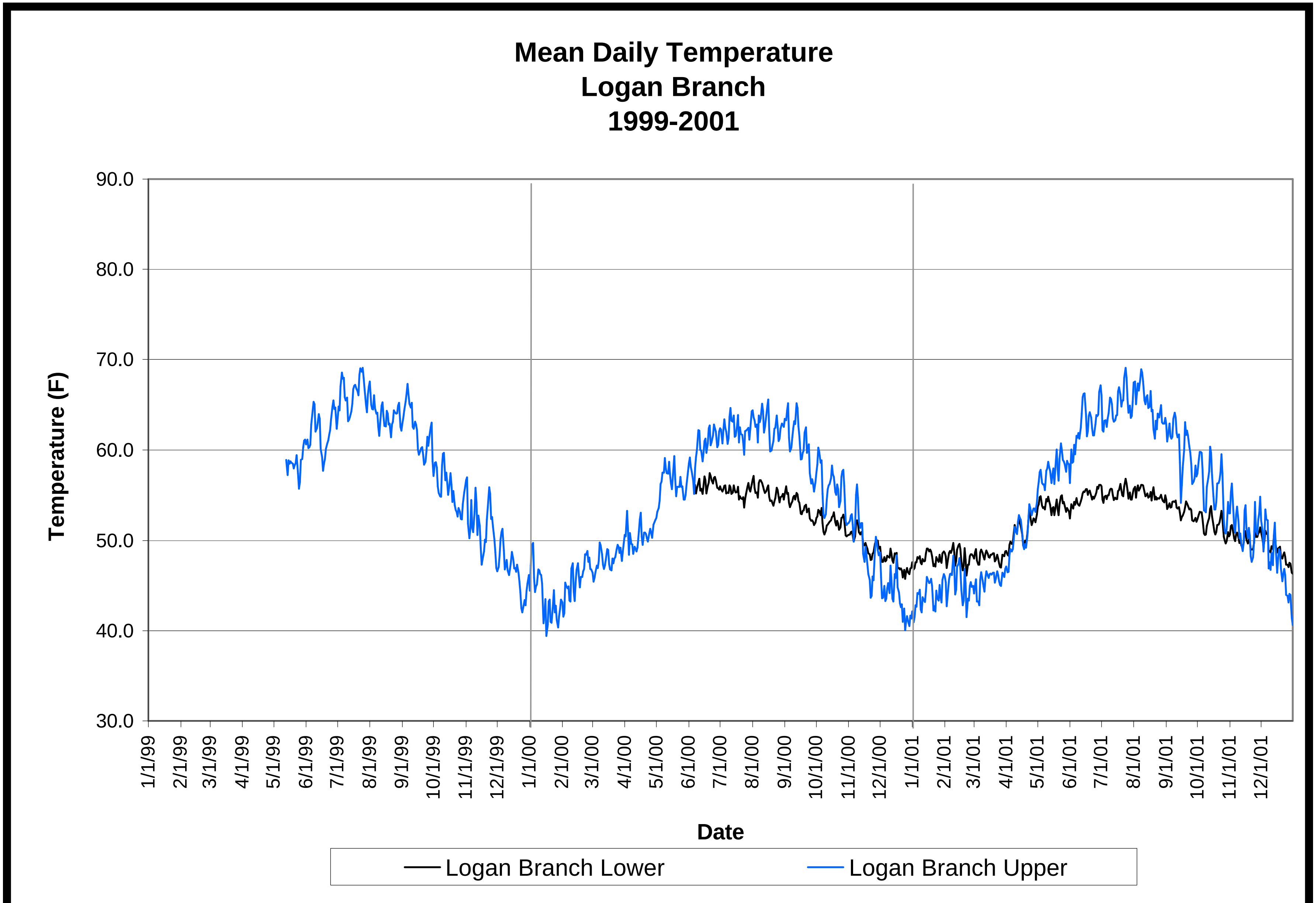

Figure 11. Mean temperature of Logan Branch from 1999 to 2001.

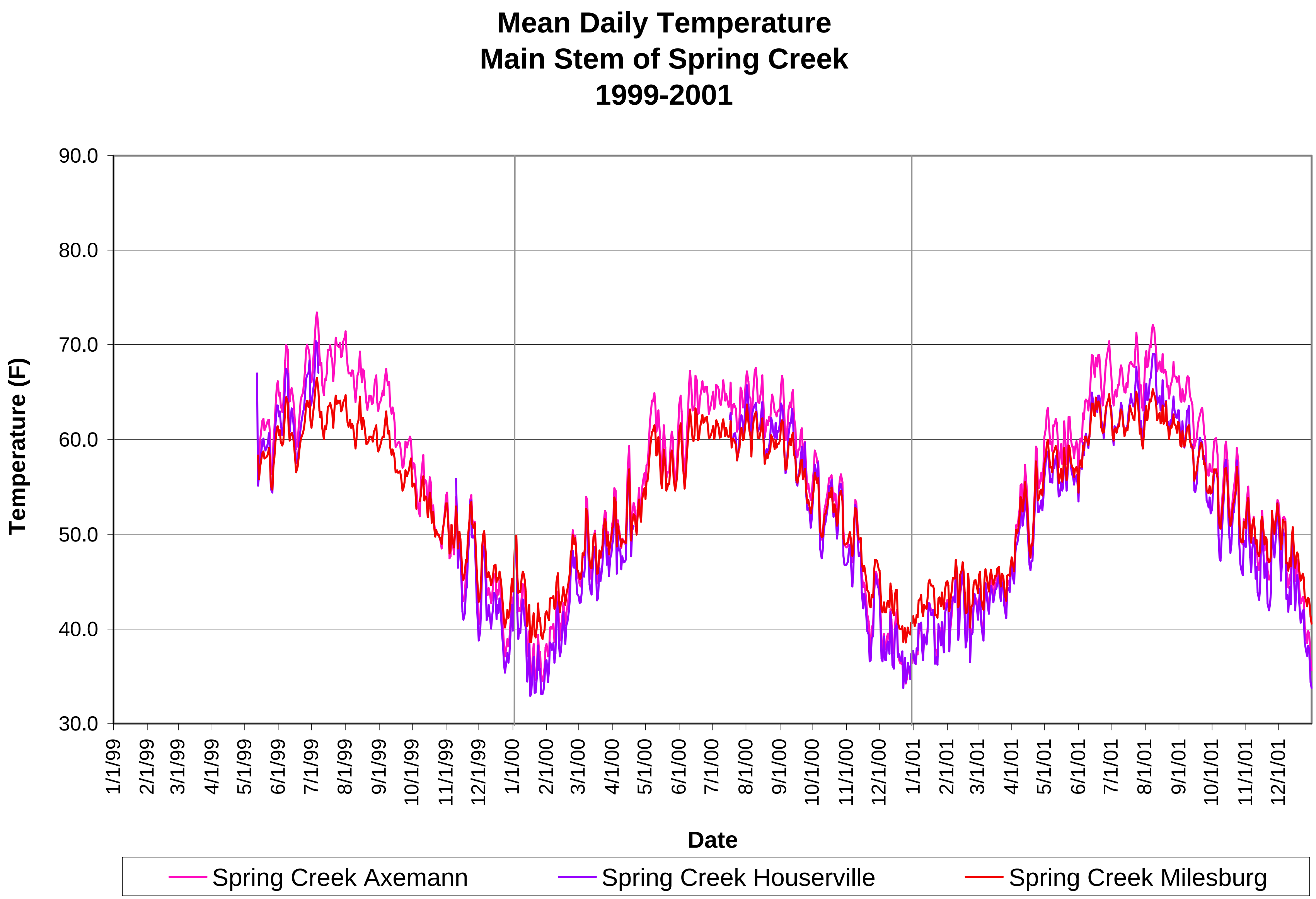

Figure 12. Mean temperature of the main stem of Spring Creek downstream of Oak Hall from 1999 to 2001.

MONTHLY MEASUREMENTS

Data Presentation

The data presented in this report are based on unfiltered water samples and represent the total concentrations of each parameter. Both filtered and unfiltered samples were analyzed, but for brevity's sake the dissolved concentrations are not presented. It is important to note that Slab Cabin Run Upper and Buffalo Run Upper experienced dry stream conditions for a significant portion of 2001. This should be taken into account when evaluating the data. Additionally, it is possible that data may be affected by unusual stream conditions surrounding the dry period.

Data for each water quality parameter are discussed briefly and include suggested strategies for improving or maintaining water quality. Discussion of each water quality parameter is accompanied by the following three figures:

1. a graph illustrating the 2001 annual maximum, minimum, and mean (i.e., average) concentrations at Spring Creek Milesburg from 1999-2001. We selected this station because it is located on the main stem of Spring Creek just upstream from the confluence with Bald Eagle Creek, and is therefore reflective of the water quality of the entire Spring Creek Watershed,
2. a table showing the mean annual concentration and the maximum and minimum concentrations detected at each monitoring station in 2001, and
3. a map that depicts the 2001 mean annual concentration using a graduated color scale to compare concentrations between monitoring stations and to the water quality criteria established by PA DEP (25 Pa. Code, Chapter 16 & 93). Note: PA DEP has not established water quality criteria for all water quality parameters.

In addition, results from Sengle (2002) are cited when relevant to each parameter. Sengle used the WRMP base flow data to determine the relationships between land use and water quality on the Spring Creek Watershed. The paper reports total loads (kg) and unit loads (kg/ha/yr) of selected pollutants on Spring Creek and its monitored sub-basins in the context of the relative proportions of major land uses (forest, agriculture, residential/commercial, transportation, and mining) occuring on those sub-basins. Collection of streamflow and water pollutant concentration (eg., mg/L) data enables the calculation of pollutant loads (kg) delivered from the monitored sub-basins and leaving the Spring Creek Watershed. Total pollutant load data is a powerful tool in determining major sources of pollutants and thus where pollution reduction efforts might be most effective.

At the end of the report, a table and figure illustrating the 2001 mean monthly values for flow and temperature and the 2001 measured monthly values for each water quality parameter are provided in Appendix A. All data collected by WRMP are available for viewing and downloading from our Web site (www.springcreekwatershed.org).

Total suspended solids

Suspended solids are all particles carried by the water including silt, plankton, organic stream litter, industrial waste, and sewage. This measurement is roughly proportional to turbidity, though turbidity is a more sensitive measure at low levels. Runoff from agricultural, industrial, urbanized, and construction areas can result in increased levels of total suspended solids, especially when riparian buffers are disturbed or removed. Other sources of total suspended solids (TSS) may include point discharges from industry or sewer treatment facilies.

Mean annual TSS concentrations were highest in 2001 at Spring Creek Axemann (20 mg/L) and Buffalo Run Upper (19 mg/L). The concentration at Spring Creek Axemann was over four times higher in 2001 than it was in 2000 (WRMC 2001), which might be attributable to construction that occurred near the monitoring station during summer 2001. Cedar Run Lower (CEL) had the highest monthly TSS concentration (66 mg/L) in 2001. CEL also experienced considerably higher mean annual TSS concentrations in 2001 (17 mg/L) than in 2000 (8 mg/L). It is notable that the highest mean annual TSS concentrations occured in sub-basins that are largely agricultural. The lowest mean annual TSS concentration was observed at Slab Cabin Run Lower (6 mg/L) (Table 5 and Figure 14). Maximum TSS concentrations varied significantly at Spring Creek Milesburg between 1999 and 2001 (Figure 13).

Possible strategies to reduce TSS concentrations could include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek,
- avoiding disturbances or development in, or adjacent to, riparian areas,
- decreasing access of livestock to the riparian zones,
- ensuring that siltation fencing is properly installed and maintained on construction sites, and
- allowing runoff to infiltrate instead of routing it directly into streams.

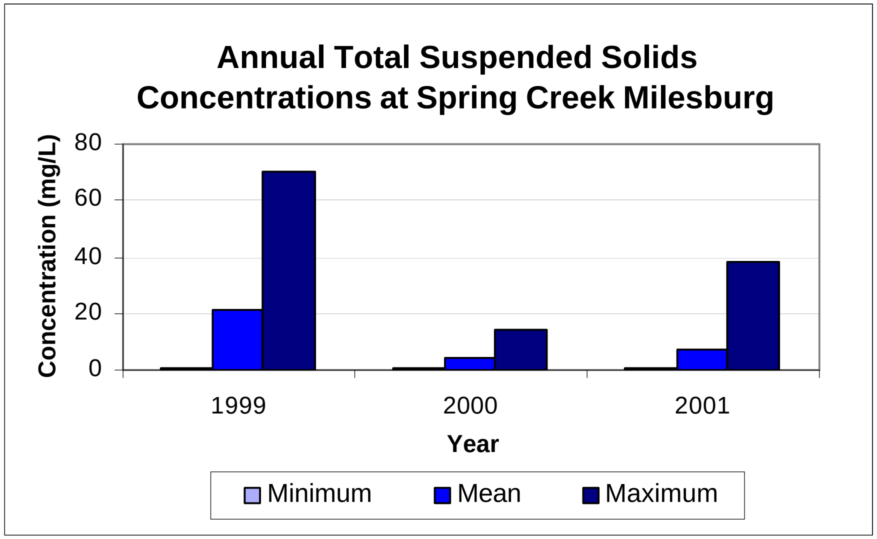

Figure 13. Annual minimum, mean, and maximum total suspended solids concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 5. 2001 Total Suspended Solids Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	13	1	24
Buffalo Run Upper**	19	1	58
Cedar Run Lower	17	1	66
Logan Branch Lower	9	1	48
Logan Branch Upper	8	1	40
Slab Cabin Run Lower	6	1	20
Slab Cabin Run Upper**	15	4	38
Spring Creek Axemann	20	1	62
Spring Creek Houserville	8	1	20
Spring Creek Milesburg	7	1	38
Spring Creek Upper	8	1	32
Thompson Run Lower	8	1	16

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 2 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

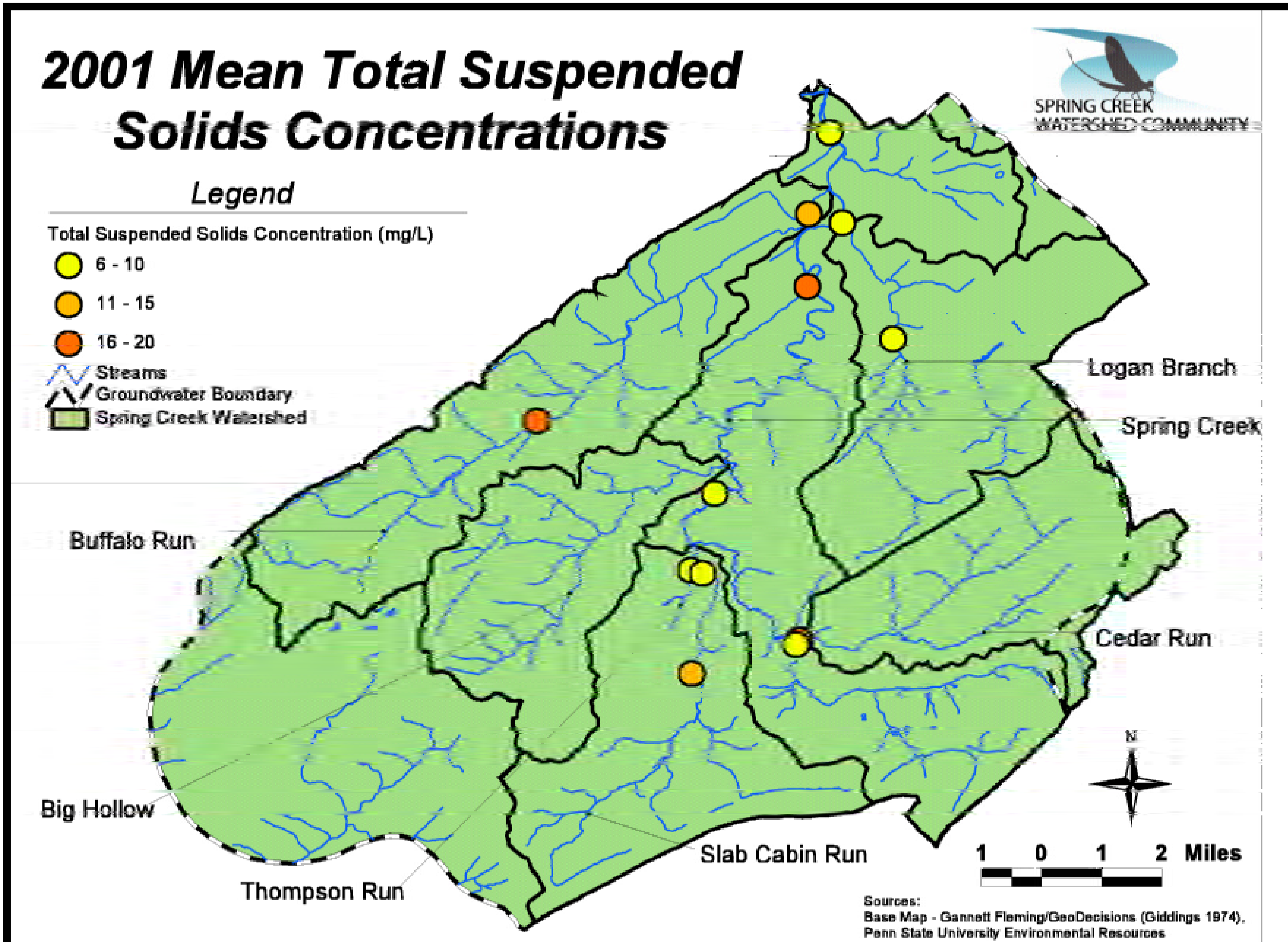

Figure 14. 2001 Mean Total Suspended Solids Concentrations at WRMP Monitoring Stations.

Turbidity

This water quality variable is a measure of how well light passes through a sample of water, such that low turbidity values mean excellent transmission of light. Turbidity is relative to the amount of suspended material in the water and is measured in Nephelometric Turbidity Units (NTUs). Water samples taken during base flow conditions in the Spring Creek Watershed are typically below 40 NTUs. Runoff from agricultural, industrial, urbanized, and construction areas can result in increased turbidity levels, especially when riparian buffers are disturbed or removed.

Mean annual turbidity levels were low at all monitoring stations in 2001 with the highest levels at Slab Cabin Run Upper (5.14 NTU) and Buffalo Run Lower (4.82 NTU). Cedar Run Lower had the highest monthly value (13.80 NTU) (Table 6 and Figure 16). All stations had elevated values in March, which correspond to an increase in steam flow (Appendix A.1 and A.4). Mean annual turbidity levels at Spring Creek Milesburg from 1999-2001 were below 4.00 NTU (Figure 15).

Possible strategies to reduce turbidity levels could include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek,
- avoiding disturbances or development in, or adjacent to, riparian areas,
- decreasing access of livestock to the riparian zones,
- ensuring that siltation fencing is properly installed and maintained on construction sites, and
- allowing runoff to infiltrate instead of routing it directly into streams.

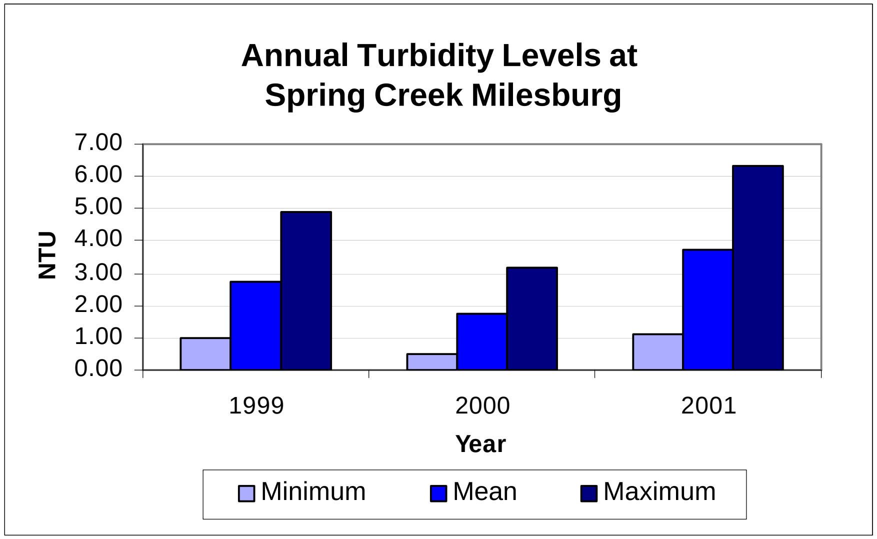

Figure 15. Annual minimum, mean, and maximum turbidity levels as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 6. 2001 Turbidity Levels.

MONITORING STATION	MEAN* (NTU)	MINIMUM (NTU)	MAXIMUM (NTU)
Buffalo Run Lower	4.82	0.50	10.90
Buffalo Run Upper**	4.75	2.09	10.70
Cedar Run Lower	4.64	1.14	13.80
Logan Branch Lower	1.76	0.50	5.23
Logan Branch Upper	3.86	1.50	8.60
Slab Cabin Run Lower	2.52	0.50	7.25
Slab Cabin Run Upper**	5.14	2.85	10.90
Spring Creek Axemann	4.54	0.50	9.03
Spring Creek Houserville	3.08	1.10	8.14
Spring Creek Milesburg	3.73	1.11	6.34
Spring Creek Upper	1.93	0.50	4.90
Thompson Run Lower	2.35	1.06	4.49

*Mean values were calculated by summing all detected values and half the detection limit (detection limit = 1.00 NTU) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

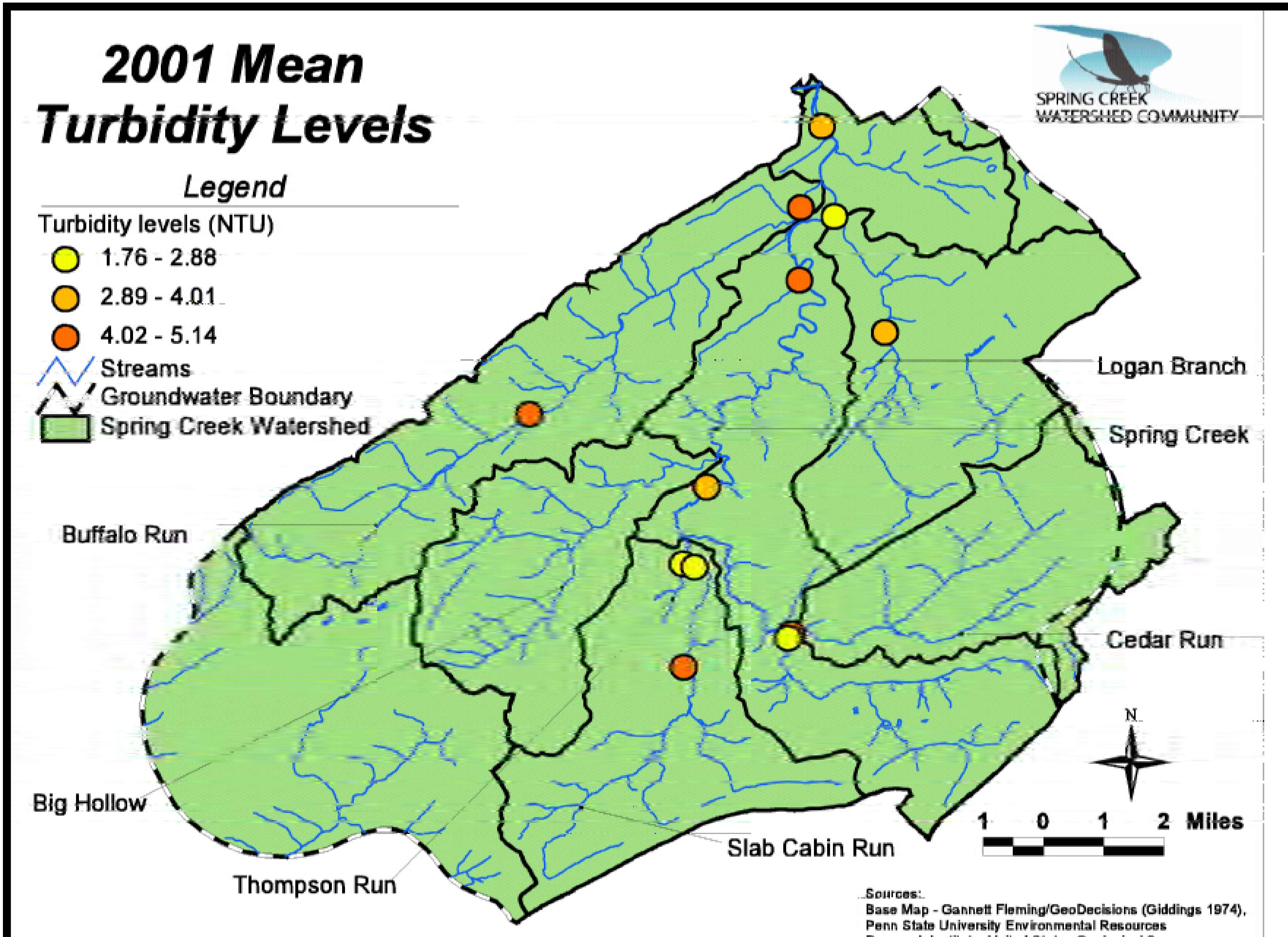

Figure 16. 2001 Mean Turbidity Levels at WRMP Monitoring Stations.

Dissolved Oxygen

Sources of dissolved oxygen (DO) in streams are atmospheric oxygen and plant photosynthesis. Streams lose DO to chemical or biological demand, such as the microbial metabolism of organic matter. In the absence of DO demand, percent oxygen saturation in water is a function of temperature; cold water may hold up to approximately 13.0 mg/L of DO, while warmer water may hold approximately 7.0 mg/L of DO. Groundwater may be relatively low in DO, although aeration will restore DO to groundwater upon discharge from springs or seeps to surface water bodies. Small streams often exhibit natural, measurable daily variation in DO due to plant output of oxygen during daylight hours versus plant uptake of oxygen at night.

Mean annual DO concentrations in 2001 met the PA DEP water quality criteria of 5.0 mg/L for Cold Water Fisheries (CWF) and 7.0 mg/L for High Quality Cold Water Fisheries (HQ-CWF) (25 Pa. Code, Chapter 93.7), ranging from 10.1 mg/L at Spring Creek Upper to 13.0 mg/L at Spring Creek Houserville. The lowest monthly concentration occured at Buffalo Run Upper (7.0 mg/L) in January, just meeting the criteria for HQ-CWF, and the highest monthly concentration occured at Slab Cabin Run Lower (16.1 mg/L) in February (Table 7 and Figure 18). Yearly mean DO concentrations from 1999 to 2001 at Spring Creek Milesburg were consistent between years and well above the criteria of 5.0 mg/L for CWF (Figure 17).

Possible strategies to ensure that Spring Creek continues to have healthy DO concentrations include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek to decrease stream temperatures through shading,
- reducing the potential for thermal pollution by allowing runoff to infiltrate instead of routing it directly into streams, and
- minimizing loading of organic matter entering the stream from point and nonpoint sources.

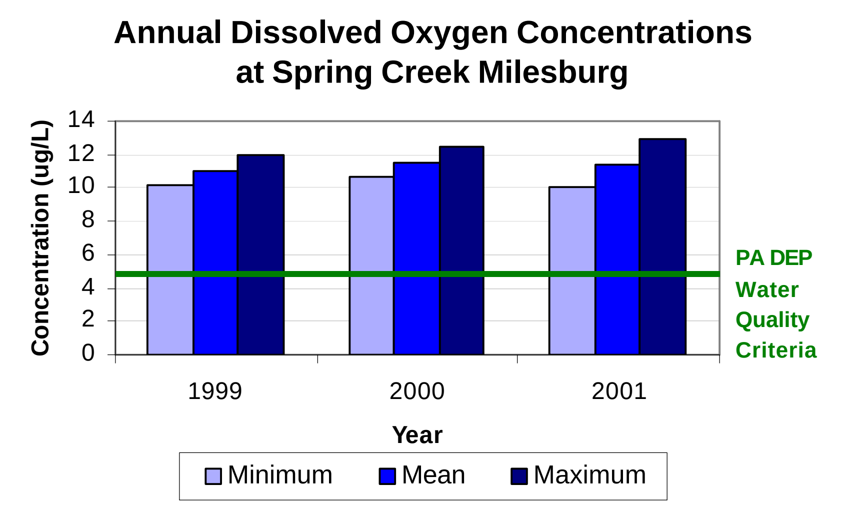

Figure 17. Annual minimum, mean, and maximum dissolved oxygen concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 7. 2001 Dissolved Oxygen Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	11.7	8.4	13.9
Buffalo Run Upper**	11.3	7.0	14.8
Cedar Run Lower	12.2	10.8	14.9
Logan Branch Lower	11.1	10.1	12.5
Logan Branch Upper	10.6	8.6	13.6
Slab Cabin Run Lower	12.2	9.8	16.1
Slab Cabin Run Upper**	11.0	7.7	12.8
Spring Creek Axemann	11.9	9.4	13.7
Spring Creek Houserville	13.0	11.0	14.6
Spring Creek Milesburg	11.3	10.1	12.9
Spring Creek Upper	10.1	8.5	11.3
Thompson Run Lower	12.1	10.0	13.4

*Average concentration was calculated using twleve monthly measurements.
**At Upper Buffalo Run and Slab Cabin Run, six and seven samples were taken respectively due to dry stream conditions.

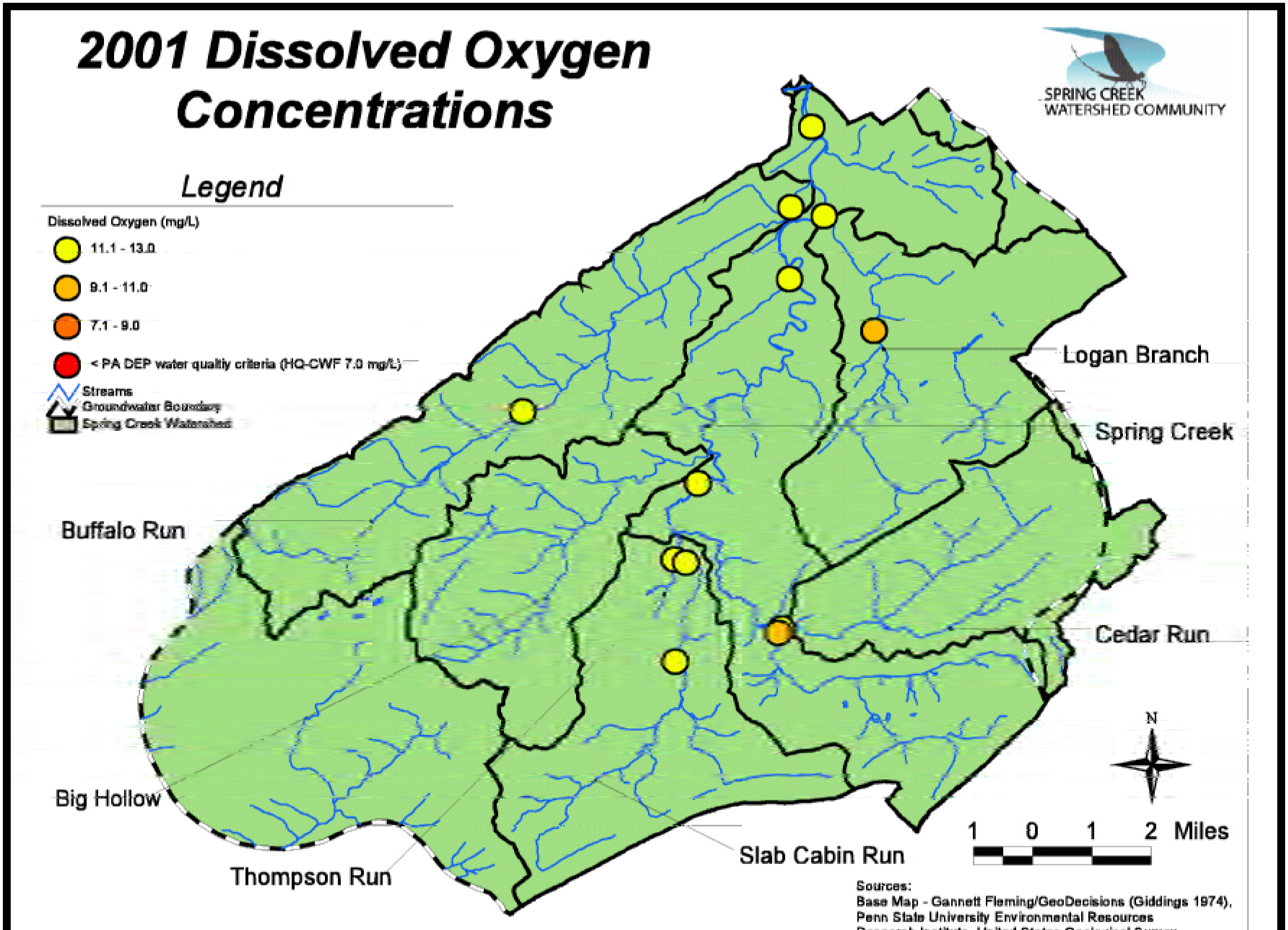

Figure 18. 2001 Mean Dissolved Oxygen concentrations at WRMP Monitoring Stations.

STREAM pH

pH is a measure of the acidity of water. Pure water has a pH of 7.0, whereas acid rain may have a pH of approximately 4.0 or lower, and alkaline water (from carbonate bedrock areas) will tend to have a pH greater than 7.5. In our area, the pH of surface water is generally low in most of the tributaries and mountain streams (such as Roaring Run). Groundwater in the valleys acquires dissolved carbonates from bedrock, which raises the pH of both groundwater and of the valley streams. The pH of streams may decrease during storm events due to the dominance of low pH precipitation. The carbonate chemistry of our valley streams is a fundamental aspect of the aquatic ecosystems of Spring Creek, Logan Branch, Buffalo Run, Cedar Run, etc.

Mean annual pH values in 2001 ranged from 7.2 at Slab Cabin Run Upper to 8.1 at Spring Creek Milesburg. Spring Creek Upper and Thompson Run Lower had the lowest monthly pH measurements of 6.9. Buffalo Run Lower and Spring Creek Milesburg had the highest monthly pH measurements of 8.6 (Table 8 and Figure 20). The mean annual pH at Spring Creek Milesburg has remained consistent from 1999 to 2001, however the range in pH values in 2001 is larger than in the previous years (Figure 19). It should be noted that pH was not measured in the field in September and October 2001. A water sample was collected at each station during monitoring and pH was measured within 36 hours of collection.

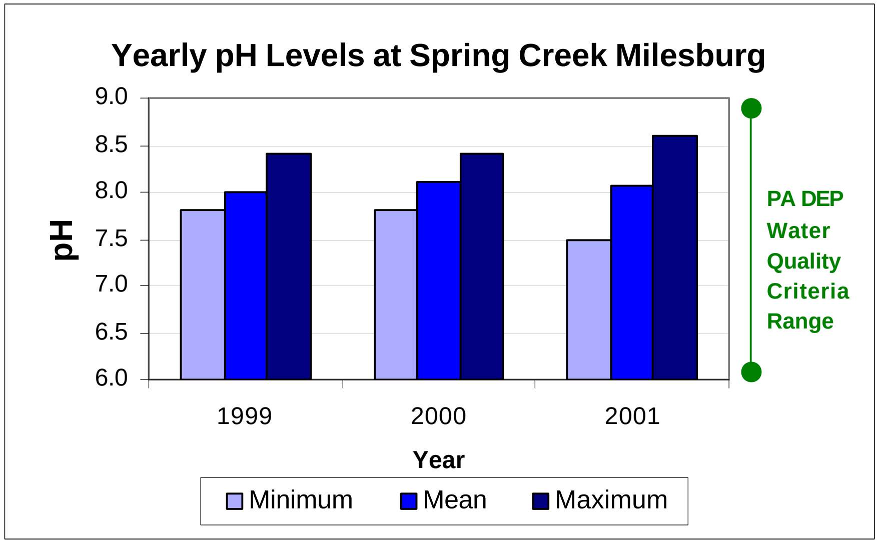

Figure 19. Annual minimum, mean, and maximum stream pH as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 8. 2001 Stream pH.

MONITORING STATION	MEAN* pH	MINIMUM pH	MAXIMUM pH
Buffalo Run Lower	8.0	7.4	8.6
Buffalo Run Upper**	7.6	7.1	8.3
Cedar Run Lower	7.9	7.1	8.3
Logan Branch Lower	7.7	7.1	8.3
Logan Branch Upper	7.7	7.3	8.2
Slab Cabin Run Lower	7.8	7.2	8.3
Slab Cabin Run Upper**	7.2	7.1	7.5
Spring Creek Axemann	7.8	7.3	8.4
Spring Creek Houserville	7.9	7.1	8.4
Spring Creek Milesburg	8.1	7.5	8.6
Spring Creek Upper	7.3	6.9	7.7
Thompson Run Lower	7.8	6.9	8.4

*Mean value was calculated using twleve monthly measurements.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

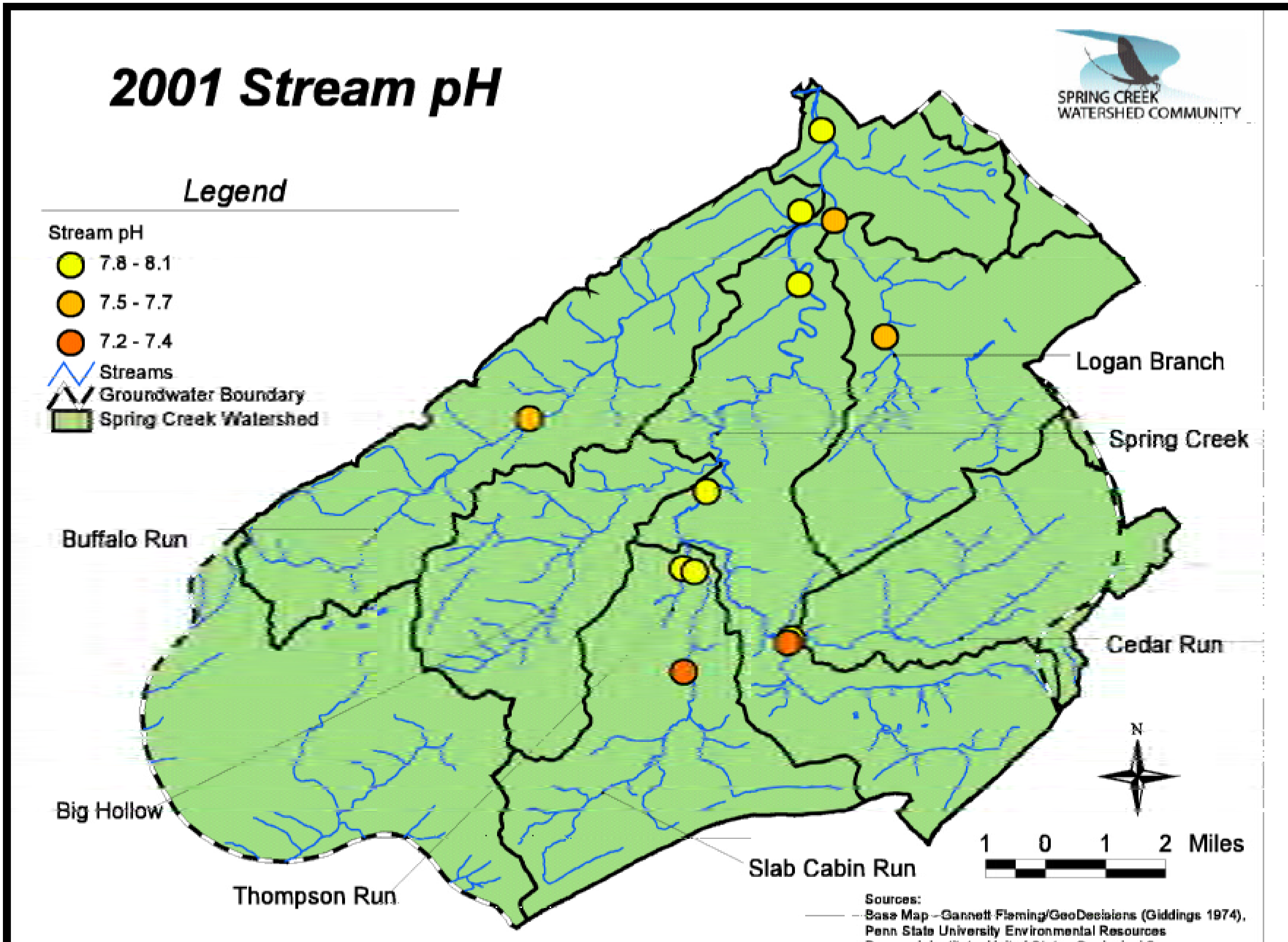

Figure 20. 2001 Mean Stream pH at WRMP Monitoring Stations.

Chloride

This common chemical is typically associated with runoff from roadways, where it is applied for deicing in the form of calcium chloride or sometimes sodium chloride. It is not toxic to most aquatic organisms except at exceptionally high concentrations, but it is a good surrogate measure of runoff from paved surfaces.

PA DEP water quality criteria for chlorides are different for cold water fisheries (250 mg/L) than they are for high quality cold water fisheries (150 mg/L) (25 Pa. Code, Chapter 93.7). Mean annual chloride concentrations in 2001 did not exceed criteria at any monitoring station. Mean annual chloride concentrations were highest at Slab Cabin Run Lower (71 mg/L) and Thompson Run Lower (57 mg/L), which are both located in urbanized sub-basins (Table 9 and Figure 22). Mean annual chloride concentrations between 1999 and 2001 at Spring Creek Milesburg remained relatively consistent (Figure 21).

Sengle (2002) reported that the unit load (kg/ha/yr) of chloride was strongly related to the proportion of residential and transportation land uses on the monitored sub-basins of Spring Creek. As the proportion of residential and transportation land uses increased, the unit load (kg/ha/yr) of chloride also increased. These results suggest that base flow water quality on the monitored sub-basins of Spring Creek is sensitive to the types of land uses occuring on those sub-basins.

Possible strategies to ensure that Spring Creek continues to have healthy chloride concentrations include:

- covering salt stockpiles and
- minimizing application of deicing materials to road surfaces.

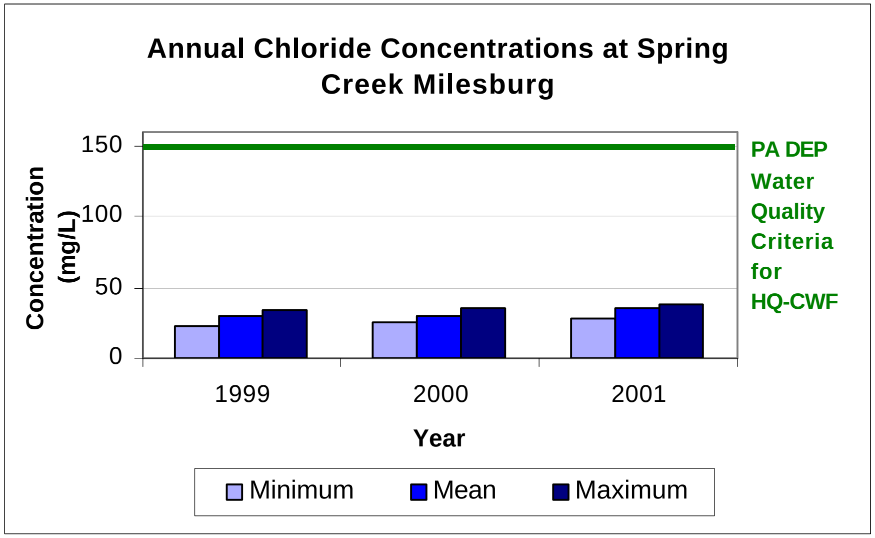

Figure 21. Annual minimum, mean, and maximum chloride concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 9. 2001 Chloride Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	17	14	22
Buffalo Run Upper**	27	21	40
Cedar Run Lower	16	13	20
Logan Branch Lower	22	19	26
Logan Branch Upper	34	21	48
Slab Cabin Run Lower	71	33	114
Slab Cabin Run Upper**	34	25	49
Spring Creek Axemann	49	40	56
Spring Creek Houserville	35	28	42
Spring Creek Milesburg	35	29	38
Spring Creek Upper	16	11	19
Thompson Run Lower	57	48	68

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 1 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

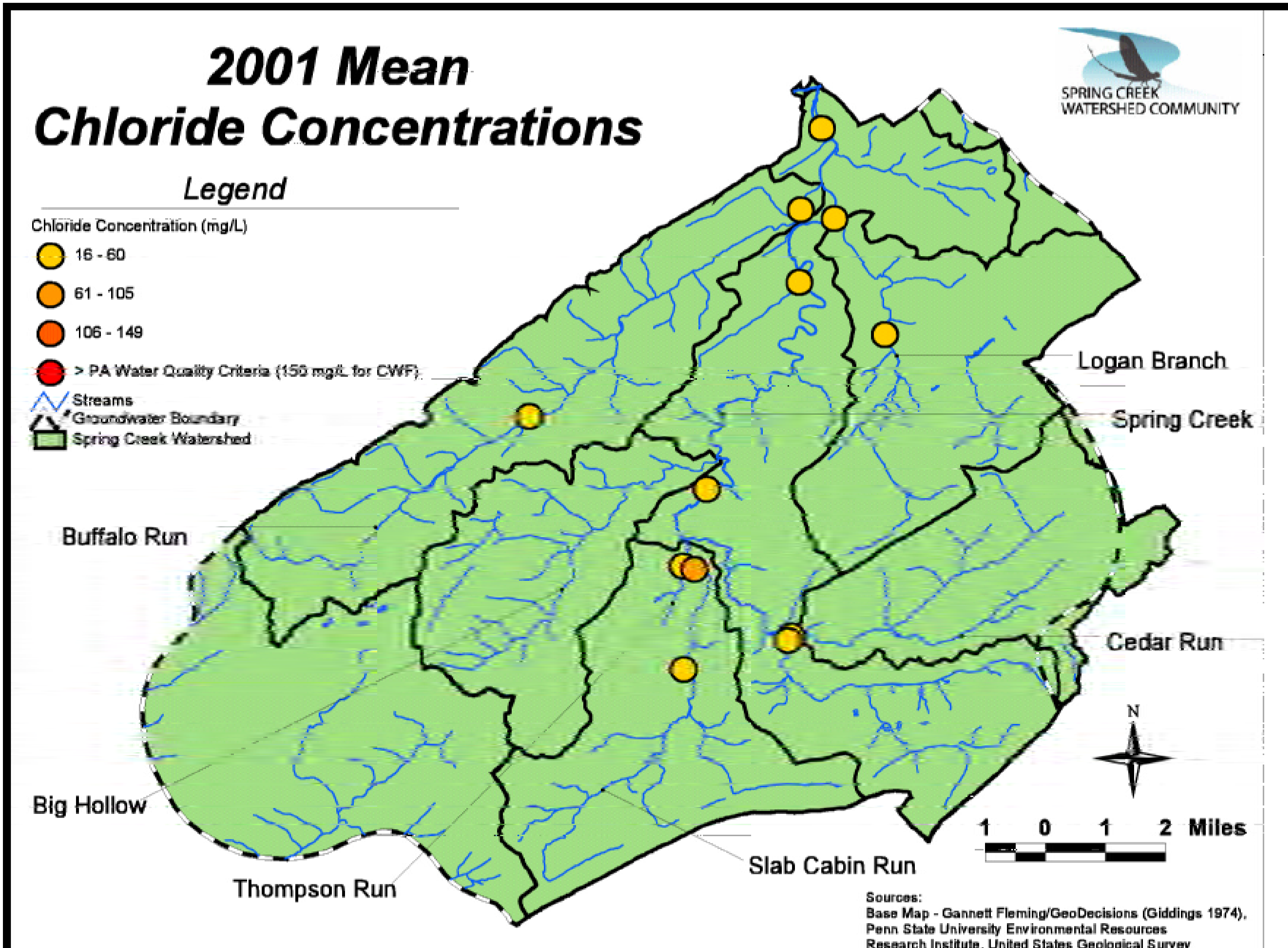

Figure 22. 2001 Mean Chloride Concentrations at WRMP Monitoring Stations.

Lead

This heavy metal is toxic to humans and aquatic life. Common sources of lead include urban runoff and industrial discharges.

Over most of the watershed, concentrations of lead were low in 2001, with 50% of all mean annual lead concentrations below detectable limits (Table 10 and Figure 24). Annual mean lead concentrations for 2001 did not exceed the PA DEP water quality criteria (3.90 µg/L, assuming 150 mg/L hardness) (25 Pa. Code, Chapter 16), however monthly concentrations did exceed the criteria once at Spring Creek Axemann (8.1 µg/L) and five times at Logan Branch Upper. Lead was consistently detected in Logan Branch throughout 2001 (Appendix A.8). Maximum detected values of lead have increased at Spring Creek Milesburg from 1999 through 2001 (Figure 23).

Sengle (2002) found a strong relationship between the percent of samples that exceeded detection limits for metals and the proportion of industrial and mining land use.

Possible strategies to reduce lead concentrations could include:

- preventing nonpoint sources from directly entering streams,
- working with landowners and businesses to have old storage tanks removed, and
- encouraging industries to reduce the concentrations of lead in their discharges.

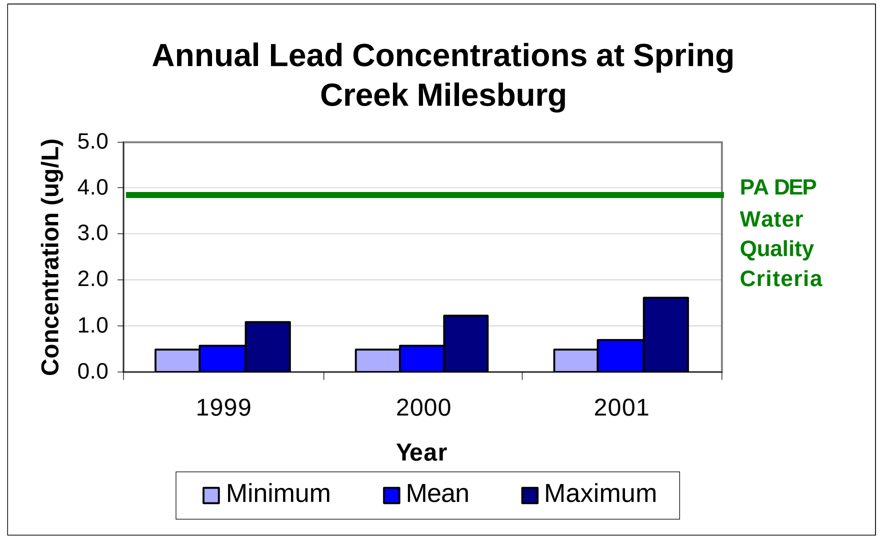

Figure 23. Annual minimum, mean, and maximum lead concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 10. 2001 Lead Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (UG/L)	MINIMUM CONCENTRATION (UG/L)	MAXIMUM CONCENTRATION (UG/L)
Buffalo Run Lower	0.5	0.5	0.5
Buffalo Run Upper**	0.5	0.5	0.5
Cedar Run Lower	0.5	0.5	0.5
Logan Branch Lower	1.2	0.5	1.8
Logan Branch Upper	3.5	1.8	4.7
Slab Cabin Run Lower	0.6	0.5	1.1
Slab Cabin Run Upper**	0.5	0.5	0.5
Spring Creek Axemann	1.2	0.5	8.1
Spring Creek Houserville	0.6	0.5	1.6
Spring Creek Milesburg	0.7	0.5	1.6
Spring Creek Upper	0.5	0.5	0.5
Thompson Run Lower	0.5	0.5	0.5

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 1.0 ug/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

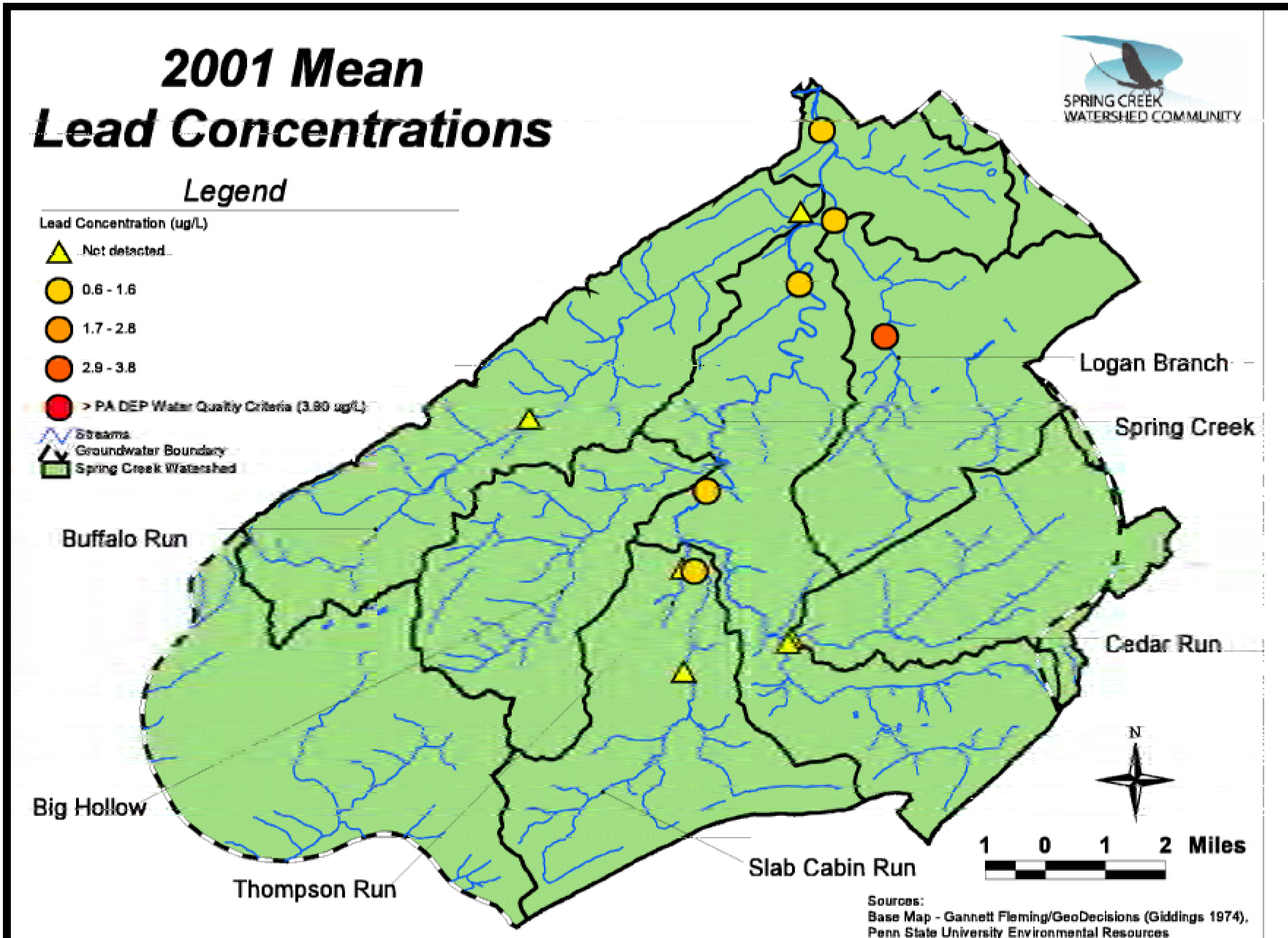

Figure 24. 2001 Mean Lead Concentrations at WRMP Monitoring Stations.

Copper

Like lead, copper is toxic to humans and aquatic life. Sources of copper include industrial discharges and agents used to control algae, bacteria, and fungi.

Mean annual copper concentrations in 2001 did not exceed the PA DEP water quality criteria (12.66 µg/L, assuming water hardness of 150 mg/L) (25 Pa. Code, Chapter 16). The highest mean annual concentration (3.7 µg/L) and highest monthly concentration (6.6 µg/L) of copper were both found in Logan Branch Lower, which is in a largely industrialized sub-basin. Copper was not detected at any other monitoring station in 2001 (Table 11 and Figure 26). Mean annual copper concentrations at Spring Creek Milesburg varied slightly between 1999, 2000, and 2001 (Figure 25). It is important to note that the detection limit for copper changed from 10.0 µg/L to 4.0 µg/L in March 2000. This should be taken into account when comparing copper concentrations.

Possible strategies to reduce copper concentrations could include:

- discouraging homeowners from using chemical agents that contain copper,
- preventing nonpoint sources from directly entering streams, and
- encouraging industries to reduce the concentrations of copper in their discharges.

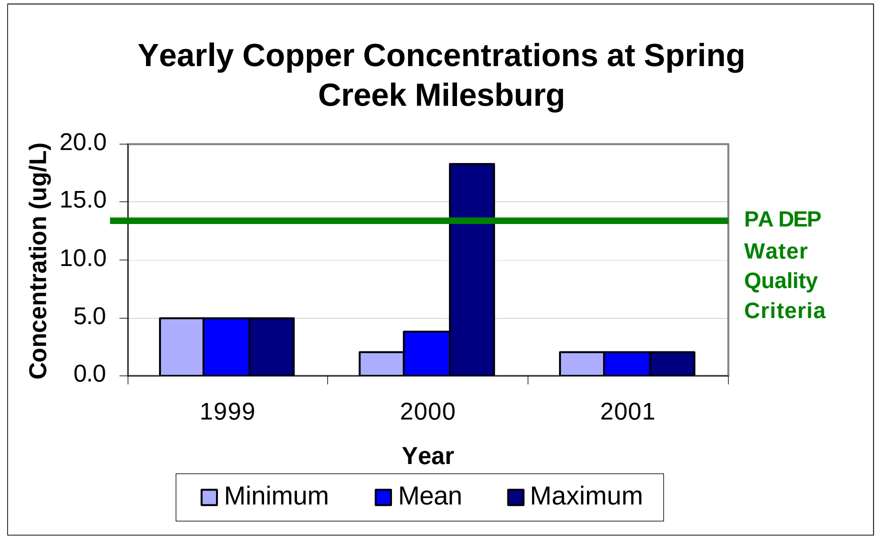

Figure 25. Annual minimum, mean, and maximum copper concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only. *Note that the detection limit for copper changed in March 2000 from 10.0 ug/L to 4.0 ug/L.

Table 11. 2001 Copper Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (UG/L)	MINIMUM CONCENTRATION (UG/L)	MAXIMUM CONCENTRATION (UG/L)
Buffalo Run Lower	2.0	2.0	2.0
Buffalo Run Upper**	2.0	2.0	2.0
Cedar Run Lower	2.0	2.0	2.0
Logan Branch Lower	3.7	2.0	6.6
Logan Branch Upper	2.0	2.0	2.0
Slab Cabin Run Lower	2.0	2.0	2.0
Slab Cabin Run Upper**	2.0	2.0	2.0
Spring Creek Axemann	2.0	2.0	2.0
Spring Creek Houserville	2.0	2.0	2.0
Spring Creek Milesburg	2.0	2.0	2.0
Spring Creek Upper	2.0	2.0	2.0
Thompson Run Lower	2.0	2.0	2.0

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 4.0 ug/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

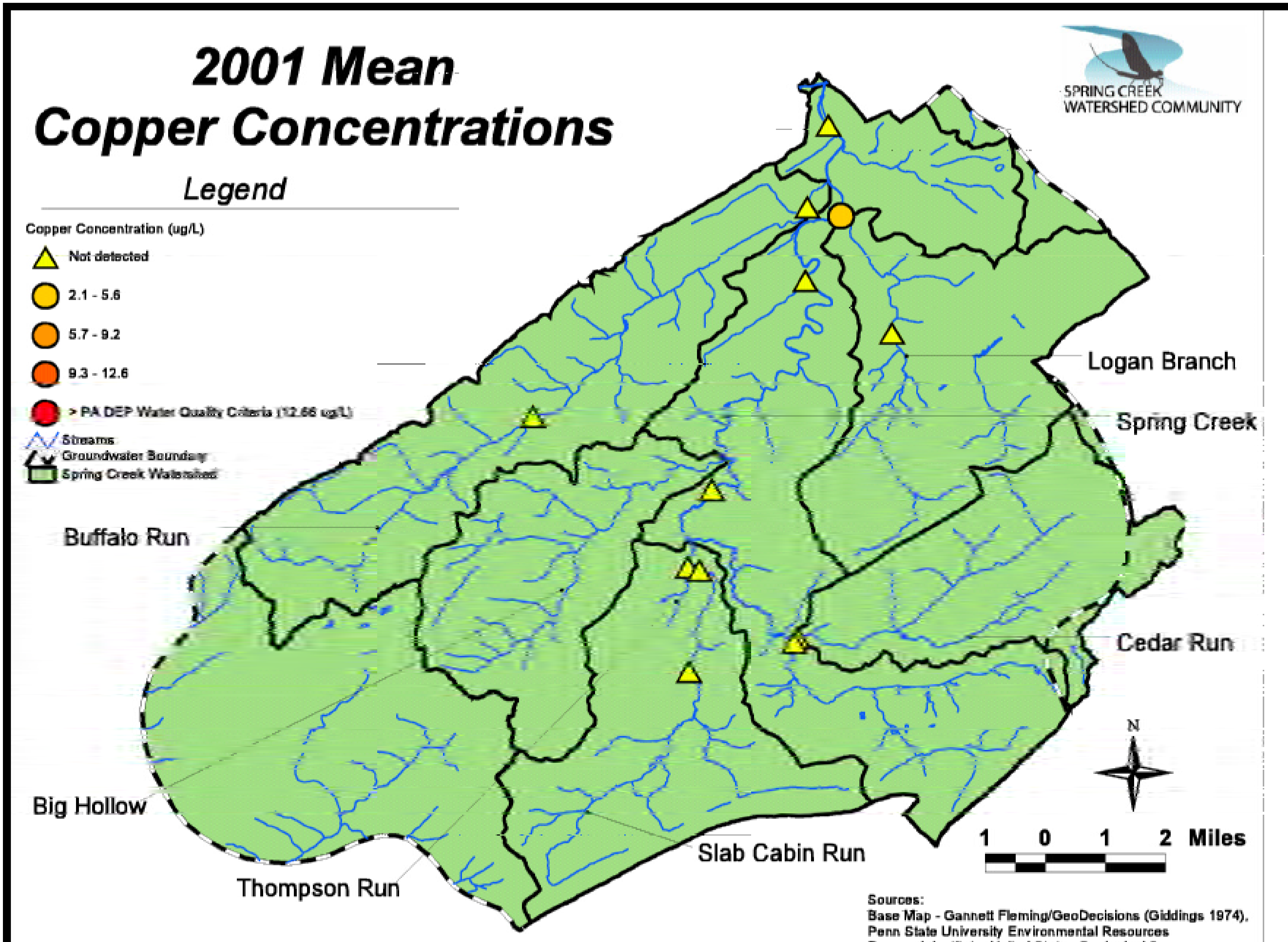

Figure 26. 2001 Mean Copper Concentrations at WRMP Monitoring Stations.

Zinc

This heavy metal is somewhat toxic to humans and aquatic life. It is typically found in concentrations substantially higher than copper or lead because it is a common element in rock-forming minerals.

Mean annual zinc concentrations in 2001 did not exceed the PA DEP water quality criteria (167 µg/L, assuming water quality hardness of 150 mg/L) (25 Pa. Code, Chapter 16). Logan Branch Lower had the highest mean annual concentration (25 µg/L) and the highest monthly concentration (49 µg/L) (Table 12 and Figure 28), which were similar to its concentrations in 2000 (WRMC 2001). Spring Creek Axemann experienced a significant increase in zinc concentration in May (46 µg/L) (Appendix A.10). Mean annual zinc concentrations at Spring Creek Milesburg have not exceeded the PA DEP water quality criteria from 1999 through 2001. However in 1999, Spring Creek Milesburg had a maximum monthly value that did exceed the criteria by nearly 300% (Figure 27).

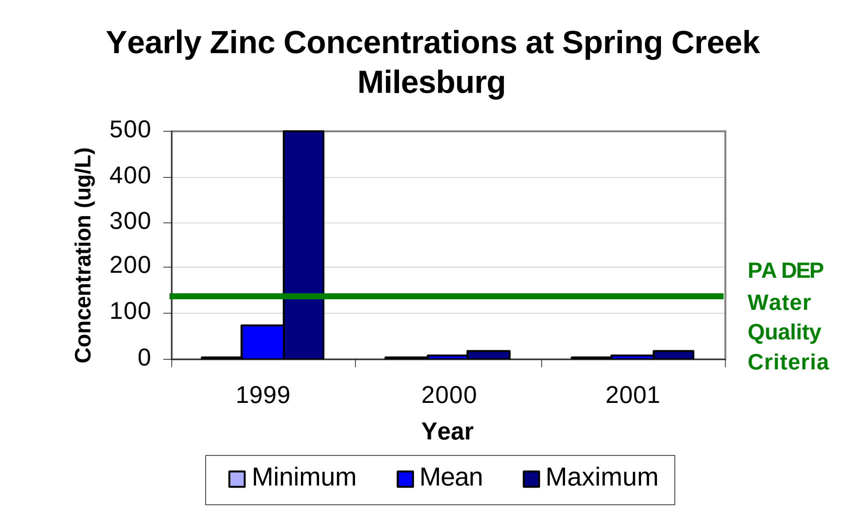

Figure 27. Annual minimum, mean, and maximum zinc concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 12. 2001 Zinc Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (UG/L)	MINIMUM CONCENTRATION (UG/L)	MAXIMUM CONCENTRATION (UG/L)
Buffalo Run Lower	6	5	20
Buffalo Run Upper**	5	5	5
Cedar Run Lower	6	5	11
Logan Branch Lower	25	14	49
Logan Branch Upper	6	5	11
Slab Cabin Run Lower	6	5	12
Slab Cabin Run Upper**	6	5	10
Spring Creek Axemann	10	5	46
Spring Creek Houserville	6	5	11
Spring Creek Milesburg	9	5	18
Spring Creek Upper	6	5	12
Thompson Run Lower	7	5	14

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 10 ug/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

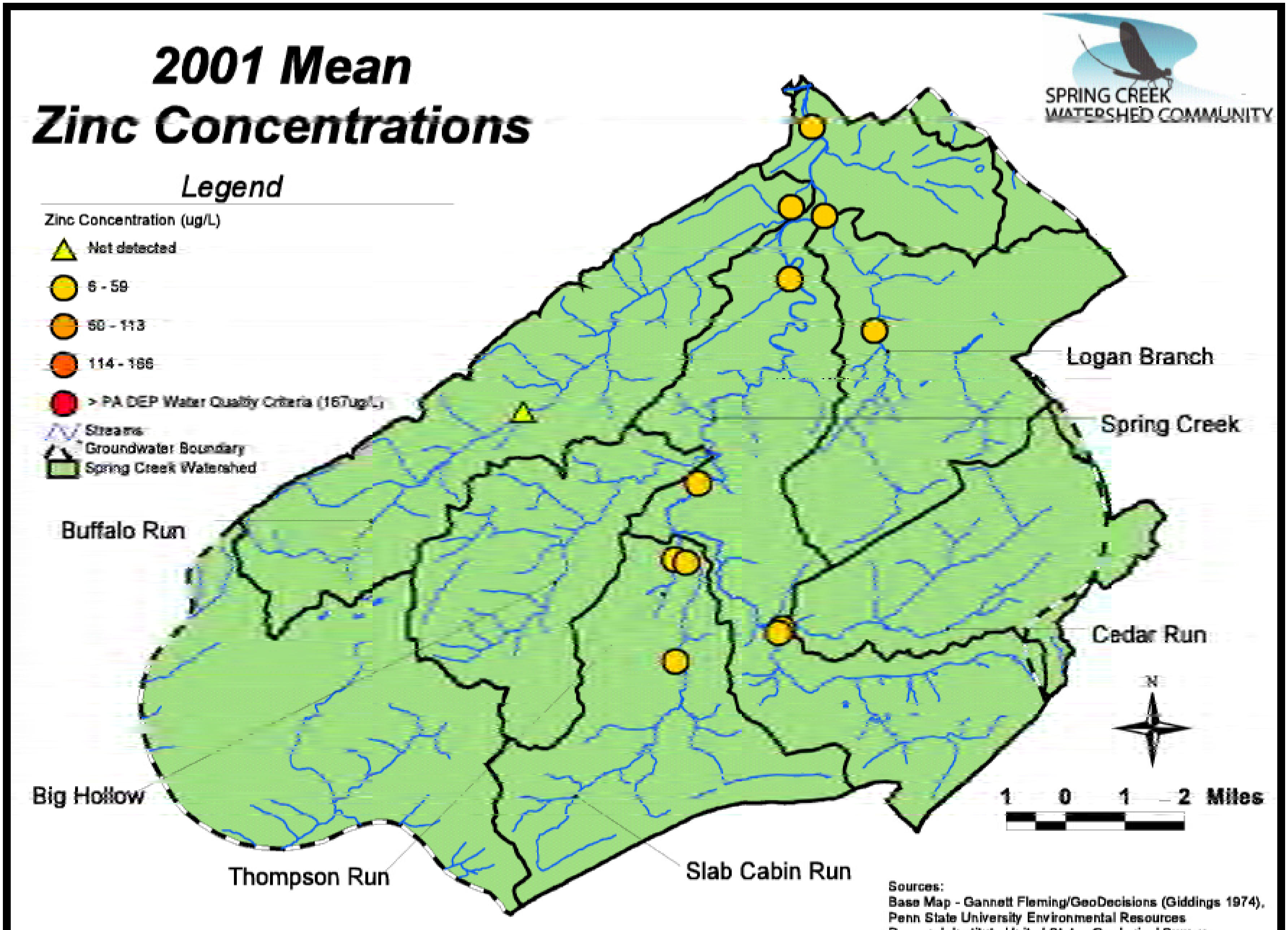

Figure 28. 2001 Mean Zinc Concentrations at WRMP Monitoring Stations.

Nitrate

This nutrient can be derived from a number of different sources including agricultural runoff, wastewater treatment plants, fish hatcheries, and urban runoff. Nitrates are not toxic to aquatic life at typical concentrations, though they can contribute to excessive growth of aquatic plants and nuisance algae. When this excess vegetation decomposes it depletes dissolved oxygen (DO) and may limit the types of organisms that can inhabit the stream. Nitrate concentrations that exceed 10 mg/L in drinking water can cause methemoglobinemia, or "blue baby" syndrome, a condition which causes an infant's skin to develop a peculiar blue-gray color. The condition can progress rapidly to cause coma and death if it is not recognized and treated appropriately.

Mean nitrate concentrations in 2001 were well below the PA DEP water quality criteria of 10 mg/L (25 Pa. Code, Chapter 93.7) at all stations and did not exceed 10 mg/L in any month. Mean annual nitrate concentrations were highest at Spring Creek Axemann (4.89 mg/L), Cedar Run Lower (4.37 mg/L), and Thompson Run Lower (4.05). Spring Creek Axemann had the highest monthly nitrate concentration (7.35 mg/L). Mean annual nitrate concentration was lowest at Buffalo Run Upper (1.36 mg/L) (Table 13 and Figure 30). Maximum nitrate concentrations steadily increased at Spring Creek Milesburg between 1999 and 2001 (Figure 29).

Sengle (2002) found that as forested land increased in a sub-basin, nitrate concentrations decreased during periods of base flow.

Possible strategies to reduce nitrate concentrations could include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek,
- decreasing use of fertilizers in residential and agricultural areas,
- decreasing access of livestock to the riparian zone, and
- evaluating effluent from the three fish hatcheries, and if needed, encouraging the implementation of nitrogen-reducing procedures.

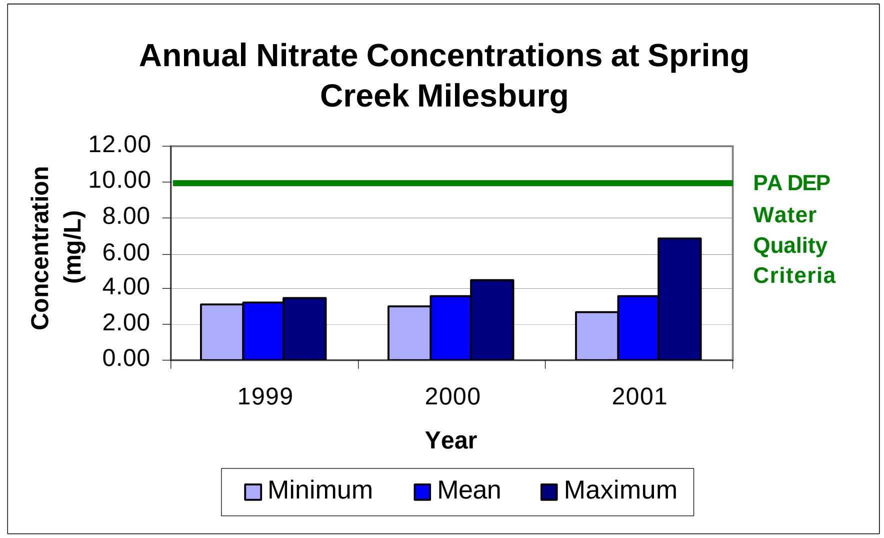

Figure 29. Annual minimum, mean, and maximum nitrate concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 13. 2001 Nitrate Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	1.71	1.44	2.17
Buffalo Run Upper**	1.36	1.04	1.69
Cedar Run Lower	4.37	3.63	5.08
Logan Branch Lower	2.96	2.55	3.58
Logan Branch Upper	2.70	2.11	3.45
Slab Cabin Run Lower	1.68	0.39	2.37
Slab Cabin Run Upper**	2.39	1.53	2.99
Spring Creek Axemann	4.89	3.65	7.35
Spring Creek Houserville	3.05	2.46	3.74
Spring Creek Milesburg	3.56	2.72	6.8
Spring Creek Upper	2.41	1.38	3.61
Thompson Run Lower	4.05	3.37	4.49

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 0.04 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

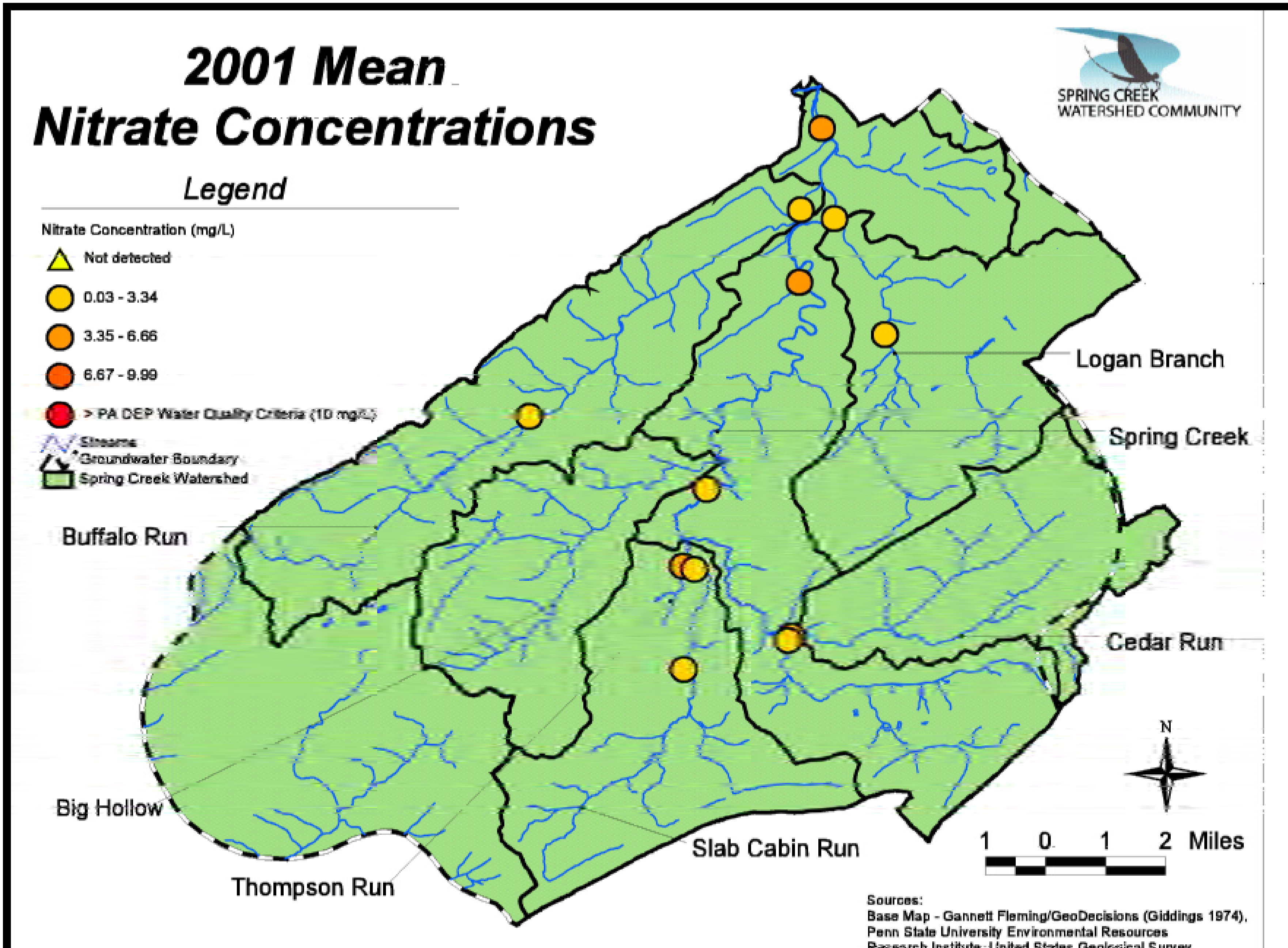

Figure 30. 2001 Mean Nitrate Concentrations at WRMP Monitoring Stations.

Orthophosphate

Orthophosphate represents the concentration of available or "reactive" phosphorus present in stream water and does not include phosphorus present in organic matter or bound to sediments and particles. Orthophosphate readily binds to organic and mineral particles and, as a result, in-stream concentrations are expected to be low.

Sources of orthophosphate are similar to nitrate and include agricultural runoff, wastewater treatment plants, fish hatcheries, and urban runoff. Elevated levels of this nutrient also stimulate increased aquatic plant growth and nuisance levels of algae. When this excess vegetation decomposes it depletes dissolved oxygen (DO) and may limit the types of organisms that can inhabit the stream.

The highest mean annual orthophosphate concentrations in 2001 occurred at Slab Cabin Run Upper (0.075 mg/L) and Logan Branch Upper (0.046 mg/L) with Logan Branch Upper also having the highest monthly concentration (0.085 mg/L). The lowest mean annual orthophosphate concentration occurred at Spring Creek Upper (0.009 mg/L) (Table 14 and Figure 32). Orthophosphate concentrations at Spring Creek Milesburg have been consistent between 1999 and 2001 (Figure 31).

Sengle (2002) found that the major point sources in the Spring Creek Watershed discharge significantly more orthophosphate (174%) than leaves the basin at Milesburg. These results suggest that orthophosphate is used rapidly by aquatic plants and becomes bound to organic and mineral sediments.

Possible strategies to reduce orthophosphate concentrations could include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek,
- decreasing the use of fertilizers in residential and agricultural areas, and
- evaluating effluent from the three fish hatcheries and, if needed, encouraging the implementation of nutrient reducing procedures.

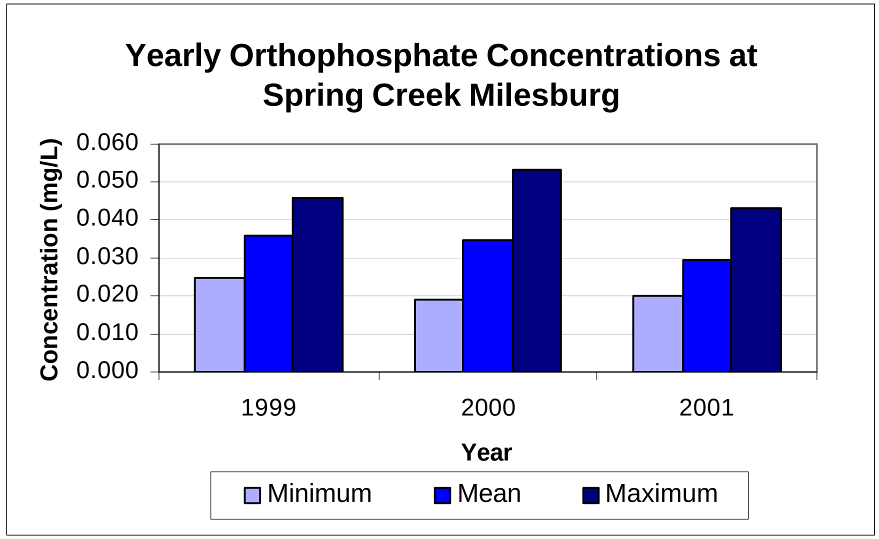

Figure 31. Annual minimum, mean, and maximum orthophosphate concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 14. 2001 Orthophosphate Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	0.014	0.005	0.028
Buffalo Run Upper**	0.017	0.005	0.029
Cedar Run Lower	0.015	0.005	0.022
Logan Branch Lower	0.014	0.010	0.018
Logan Branch Upper	0.046	0.016	0.085
Slab Cabin Run Lower	0.016	0.005	0.061
Slab Cabin Run Upper**	0.075	0.019	0.120
Spring Creek Axemann	0.031	0.017	0.057
Spring Creek Houserville	0.013	0.005	0.022
Spring Creek Milesburg	0.029	0.020	0.043
Spring Creek Upper	0.009	0.005	0.017
Thompson Run Lower	0.020	0.005	0.036

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 0.010 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

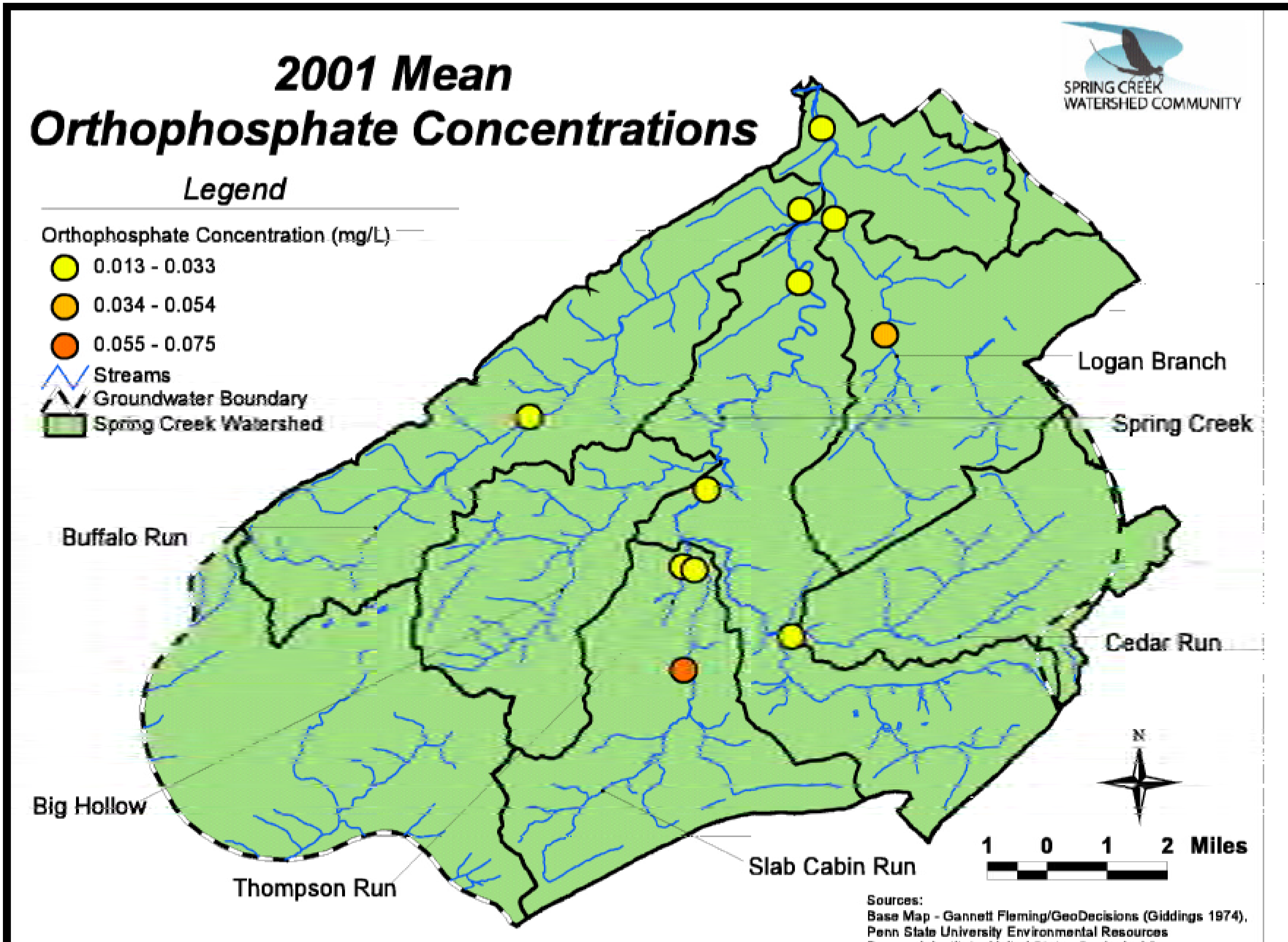

Figure 32. 2001 Mean Orthophosphate Concentrations at WRMP Monitoring Stations.

Total organic carbon

Animal wastes, human wastes, plant material, petroleum compounds, insecticides, herbicides, and other agricultural chemicals account for large amounts of total organic carbon (TOC). These compounds are consumed by microorganisms in streams and can result in reductions of dissolved oxygen. Low concentrations of dissolved oxygen are harmful to all aquatic life.

The highest annual mean concentrations occurred at Slab Cabin Run Upper (2.4 mg/L) which also had the highest monthly concentration in 2001 (3.6 mg/L). The lowest concentrations occurred at Logan Branch Lower (0.5 mg/L) (Table 15 and Figure 34) where TOC was not detected in 2001. The annual maximum TOC concentrations at Spring Creek Milesburg were lower in 2000 and 2001 than in 1999. As a result, the mean annual concentrations in these years were slightly reduced (Figure 33).

Possible strategies to reduce total organic carbon concentrations could include:

- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek,
- decreasing access of livestock to the riparian zone,
- decreasing use of insecticides and herbicides in residential and agricultural areas, and
- preventing nonpoint sources from directly entering the streams.

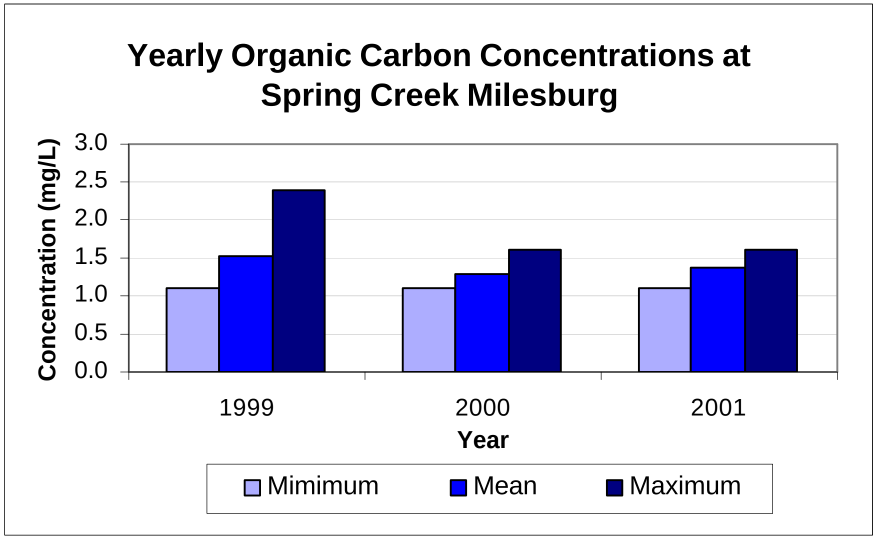

Figure 33. Annual minimum, mean, and maximum total organic carbon concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 15. 2001 Total Organic Carbon Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	1.4	1.0	1.9
Buffalo Run Upper**	1.5	1.2	1.7
Cedar Run Lower	1.1	0.5	1.4
Logan Branch Lower	0.5	0.5	0.5
Logan Branch Upper	2.0	1.4	2.5
Slab Cabin Run Lower	1.8	1.4	2.4
Slab Cabin Run Upper**	2.4	1.6	3.6
Spring Creek Axemann	2.0	1.6	2.5
Spring Creek Houserville	1.1	0.5	1.4
Spring Creek Milesburg	1.4	1.1	1.6
Spring Creek Upper	0.6	0.5	1.0
Thompson Run Lower	0.8	0.5	1.3

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 1.0 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

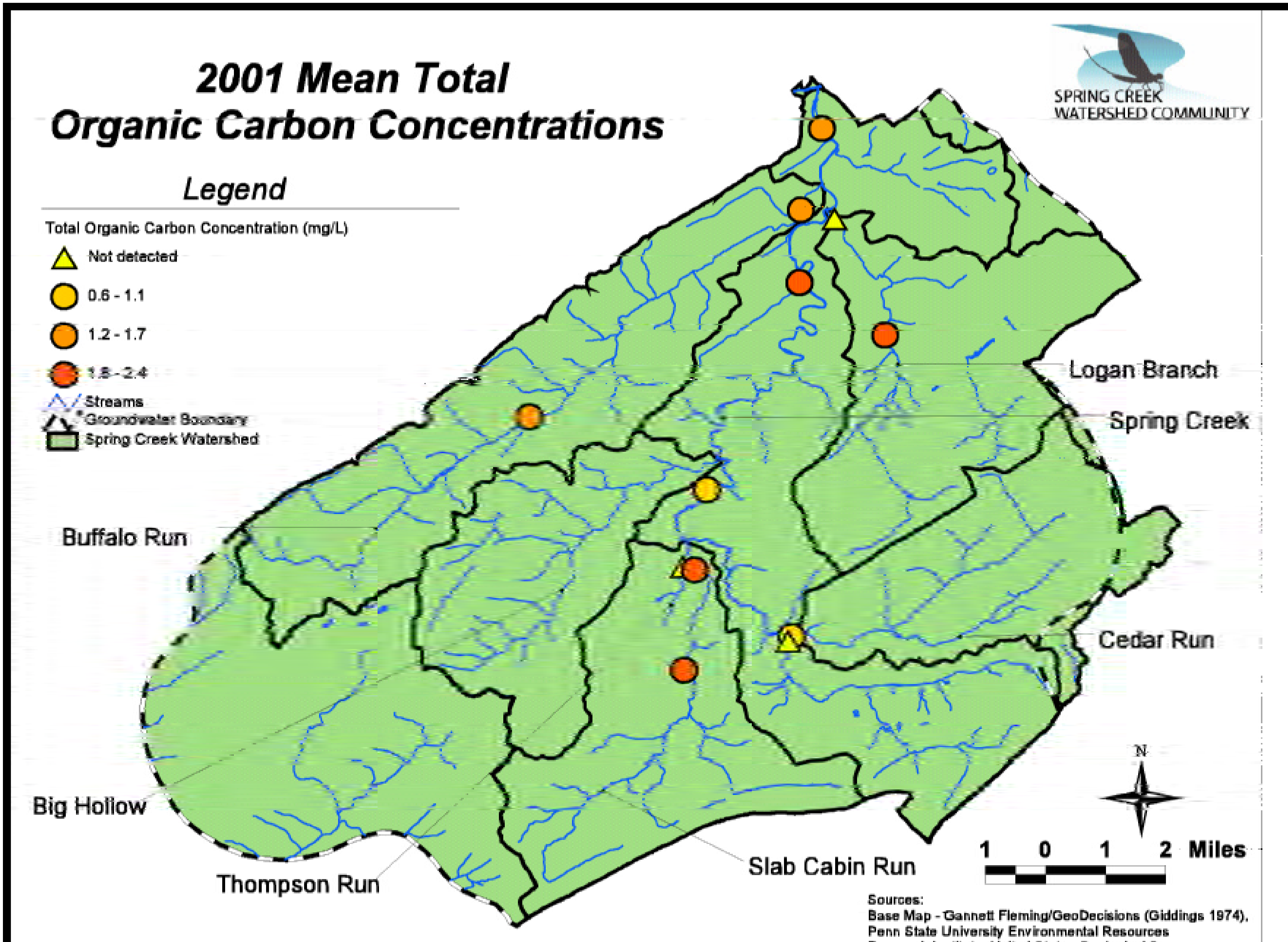

Figure 34. 2001 Mean Total Organic Carbon Concentrations at WRMP Monitoring Stations.

Petroleum hydrocarbons

Petroleum hydrocarbons largely originate from vehicle fuels and lubricants. Concentrations of these compounds generally reflect the intensity of vehicular traffic and the associated pollution that runs off of paved surfaces. These compounds are moderately toxic to aquatic life and birds.

Petroleum hydrocarbons were detected once each at three of the twelve monitoring stations in 2001: Slab Cabin Run Lower (5.0 mg/L), Spring Creek Milesburg (5.2 mg/L), and Logan Branch Upper (5.5 mg/L) (Table 16 and Figure 36). This resulted in low annual means at these stations. Mean and maximum concentrations at Spring Creek Milesburg were higher in 1999 than in 2000 and 2001. Petroleum hydrocarbons were not detected at this station in 2000, but were detected once in 2001, resulting in a slight increase in the annual mean (Figure 35).

Possible strategies to reduce total organic carbon concentrations could include:

- encouraging alternative modes of transportation (public transportation, biking, walking),
- increasing the total area of riparian buffers along all tributaries and the main stem of Spring Creek, and
- preventing nonpoint sources from directly entering the streams.

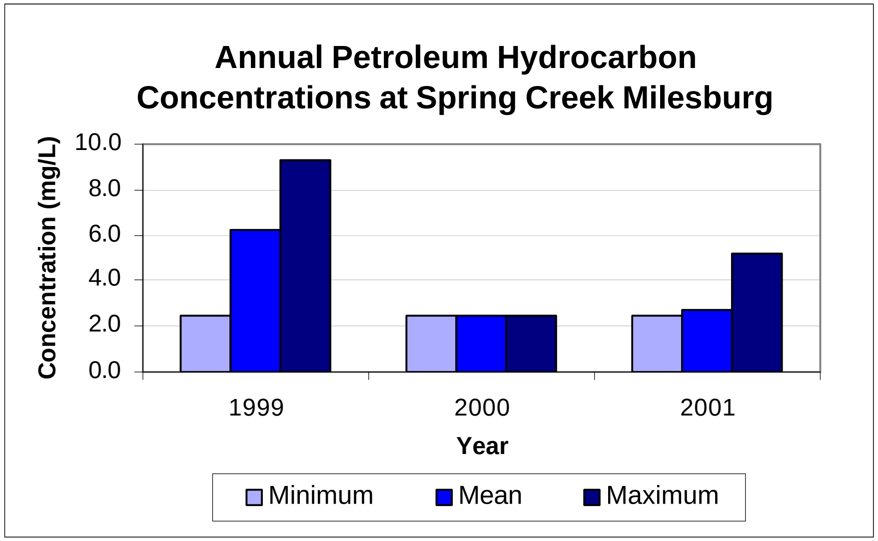

Figure 35. Annual minimum, mean, and maximum petroleum hydrocarbon concentrations as measured monthly at Spring Creek Milesburg. Data collected in 1999 from May-December only.

Table 16. 2001 Petroleum Hydrocarbon Concentrations.

MONITORING STATION	MEAN* CONCENTRATION (MG/L)	MINIMUM CONCENTRATION (MG/L)	MAXIMUM CONCENTRATION (MG/L)
Buffalo Run Lower	2.5	2.5	2.5
Buffalo Run Upper**	2.5	2.5	2.5
Cedar Run Lower	2.5	2.5	2.5
Logan Branch Lower	2.5	2.5	2.5
Logan Branch Upper	2.8	2.5	5.5
Slab Cabin Run Lower	2.7	2.5	5.0
Slab Cabin Run Upper**	2.5	2.5	2.5
Spring Creek Axemann	2.5	2.5	2.5
Spring Creek Houserville	2.5	2.5	2.5
Spring Creek Milesburg	2.7	2.5	5.2
Spring Creek Upper	2.5	2.5	2.5
Thompson Run Lower	2.5	2.5	2.5

*Mean concentration was calculated by summing all detected values and half the detection limit (detection limit = 5.0 mg/L) when variable was not detected. This value was then divided by the total number of samples taken.
**Only six samples at Slab Cabin Run Upper and seven at Buffalo Run Upper were able to be collected due to dry stream conditions.

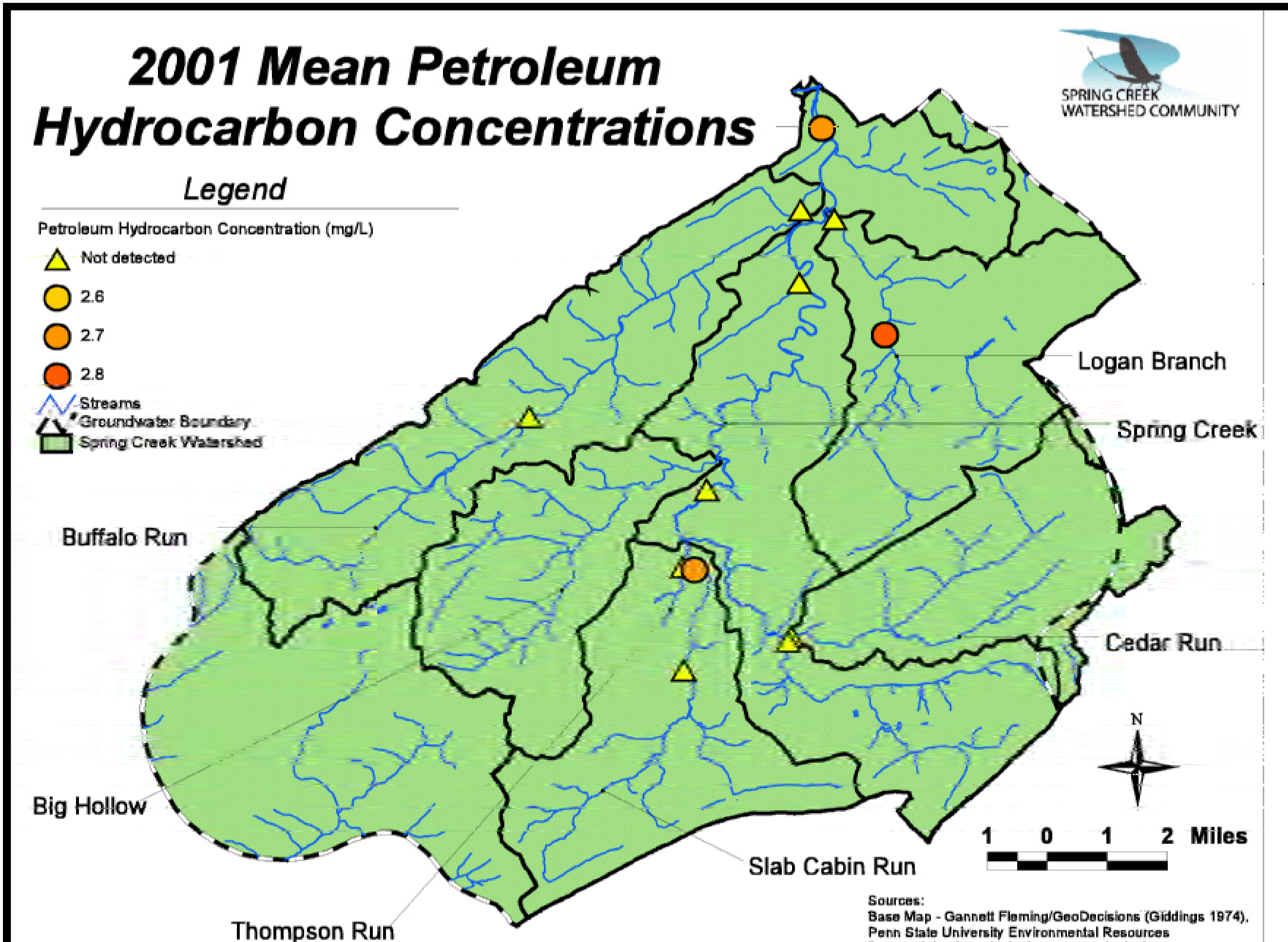

Figure 36. 2001 Mean Petroleum Hydrocarbon Concentrations at WRMP Monitoring Stations.

7.0 STORM EVENT RESULTS & DISCUSSION

Data Presentation

From January 2001 to May 2002, a total of 18 storms were sampled at the WRMP stream monitoring stations. Between one and seven stations were sampled during each storm.

This report includes an example of one monitored storm that began on October 14, 2001. Discussion of the stormwater data is accompanied by:

1. A storm hydrograph for each station. These hydrographs illustrate base flow immediately preceding the storm, the storm peak, and the return to base flow conditions. Vertical lines indicate the time intervals used to create three composite samples which represent the "beginning", "middle", and "end" of the storm,
2. Figures illustrating comparisons of the load of selected parameters at each of the four stations. The loading is shown for each of the composites indicated on the hydrographs.

October 14, 2001 Storm event monitoring

Monitoring began at 19:00 (7:00 p.m.) on October 14, 2001. A total of 0.82" of precipitation was measured at the Penn State Weather Station, located at Walker Building, University Park Campus, Pennsylvania State University. It should be noted that precipitation amounts vary widely across the Spring Creek Watershed. The last significant precipitation (>0.1") occurred 20 days prior to this storm. This storm was monitored at Spring Creek Upper, Buffalo Run Lower, Logan Branch Lower, and Spring Creek Milesburg.

A storm hydrograph for each of these stations is shown in Figure 37. The shape and magnitude of each storm peak is determined by several factors including the amount of precipitation, basin size, stream channel shape, point discharges, and land use. Peak stream flows were 14.46 cfs (cubic feet per second) at Spring Creek Upper, 6.45 cfs at Buffalo Run Lower, and 62.37 cfs at Logan Branch Lower. Double storm peaks, with values of 182.49 and 213.05 cfs, were recorded at Spring Creek Milesburg. These peaks represent more than 100% increase from base flow at Spring Creek Upper and Buffalo Run Lower, a 38% increase at Logan Branch Lower, and a 65% and 94% increase at Spring Creek Milesburg.

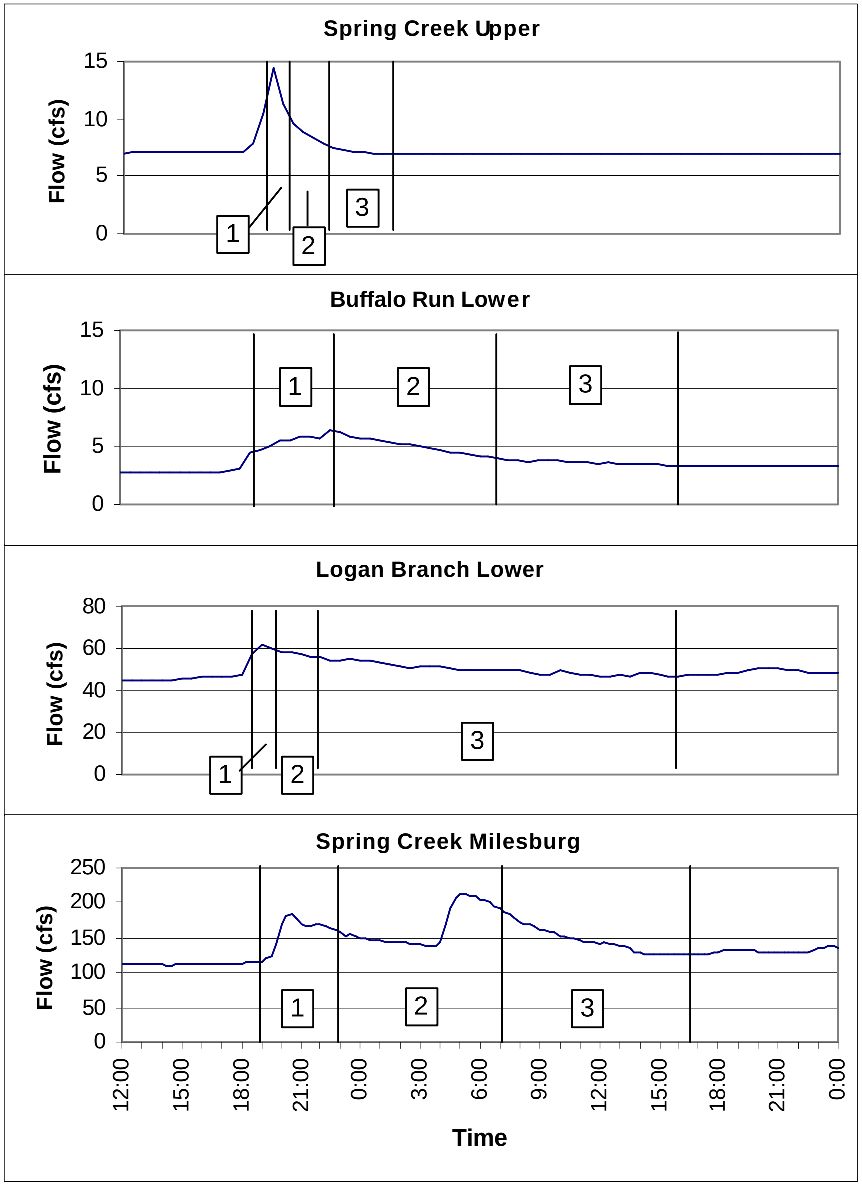

Figure 37. Half-hourly flow for the storm. Vertical lines indicate the intervals used for creating composite water samples.

The quality of stormwater runoff is dependent on the surrounding land use. The three figures to the right illustrate the effect of stormwater runoff on the stream load of three parameters: total suspended solids (TSS), nitrate, and lead. In general, larger streams such as Spring Creek Milesburg will have higher loads as a result of their greater volume of water. However, when there is a significant input of materials such as sediment, nutrients, or metals, it is possible for smaller streams to exceed the loads of larger streams.

Solids such as clay or soil can be transported into streams by stormwater that runs over agricultural, industrial, urbanized, and construction areas when proper preventive measures are not taken. In this storm, three of the four monitored streams showed an increase in total suspended solid loads in the course of the storm (Figure 38). Loads in Spring Creek Upper and Logan Branch Lower rose in the period directly after the peak flow, whereas in Spring Creek Milesburg the increase in load occurred during the stream's return to base flow (Figure 36). The total suspended solid load in Buffalo Run Upper was highest during the rise of flow and decreased through the remaining course of the storm.

Nitrate loads from stormwater runoff are commonly higher in residential and agricultural areas where runoff can wash nutrient fertilizers and livestock wastes into the streams. Spring Creek Upper showed an increase in nitrate load at the peak of the storm in comparison to the annual mean base flow load (Sengle 2002) (Figure 39). Nitrate load in Logan Branch Lower rose above the annual mean base flow load in the period directly after the peak flow. The highest nitrate load in Spring Creek Milesburg, which occurred after the second storm peak, was also higher than the annual mean base flow load. Nitrate load in Buffalo Run showed little response to stormwater runoff.

Sources of lead in stormwater runoff are typically industrial in nature. However, lead was commonly used as a fuel additive in the past, so it may be detected near old fuel storage facilities. Lead was not detected at Spring Creek Upper or Buffalo Run Upper during base flow monitoring in 2001 (Figure 24) but was detected in the monitoring of the October 14th storm (Figure 40). Logan Branch Lower experienced a significant increase in lead load as the stream levels began to recede, while lead load at Spring Creek Milesburg was highest during the first storm peak.

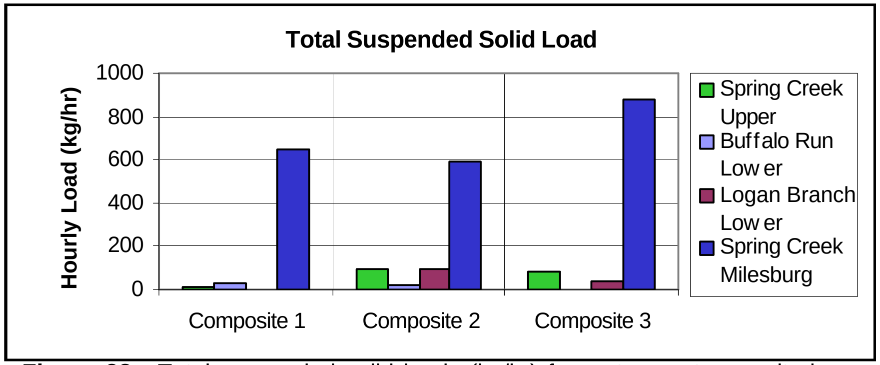

Figure 38. Total suspended solid loads (kg/hr) from stormwater monitoring that occurred on October 14th, 2001. Composite sample numbers correspond to those indicated on the hydrographs in Figure 37.

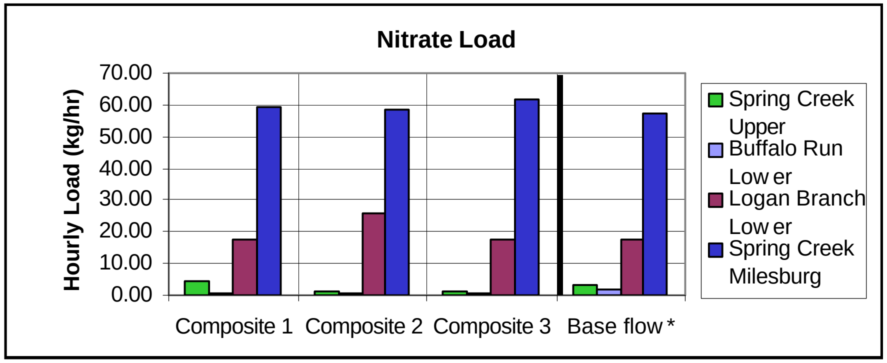

Figure 39. Nitrate loads (kg/hr) from stormwater monitoring that occurred on October 14th, 2001. Composite sample numbers correspond to those indicated on the hydrographs in Figure 37. * Sengle 2002.

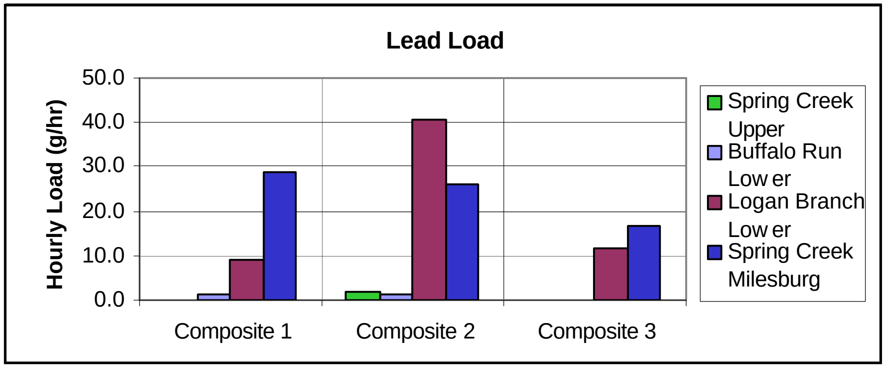

Figure 40. Lead loads (g/hr) from stormwater monitoring that occurred on October 14th, 2001. Composite sample numbers correspond to those indicated on the hydrographs in Figure 37.

8.0 GROUNDWATER RESULTS & DISCUSSION

Data Presentation

Prior to 2001, Centre County was one of a few counties in Pennsylvania that did not have a groundwater level monitoring well as part of the PA DEP/ USGS groundwater level monitoring network. In 2001 a Centre County well was added to the statewide monitoring network. Todd Giddings donated this well that is now part of Pennsylvania's Water Resources Monitoring Network and part of the Spring Creek Watershed's Water Resources Monitoring Project.

This report presents a plot of groundwater level data and some observations on the gradual onset of the "invisible drought" that actually began in 1998 and has resulted in declared drought conditions over the past three years. In 2002 the WRMP will be instrumenting five additional groundwater level monitoring wells in Centre County.

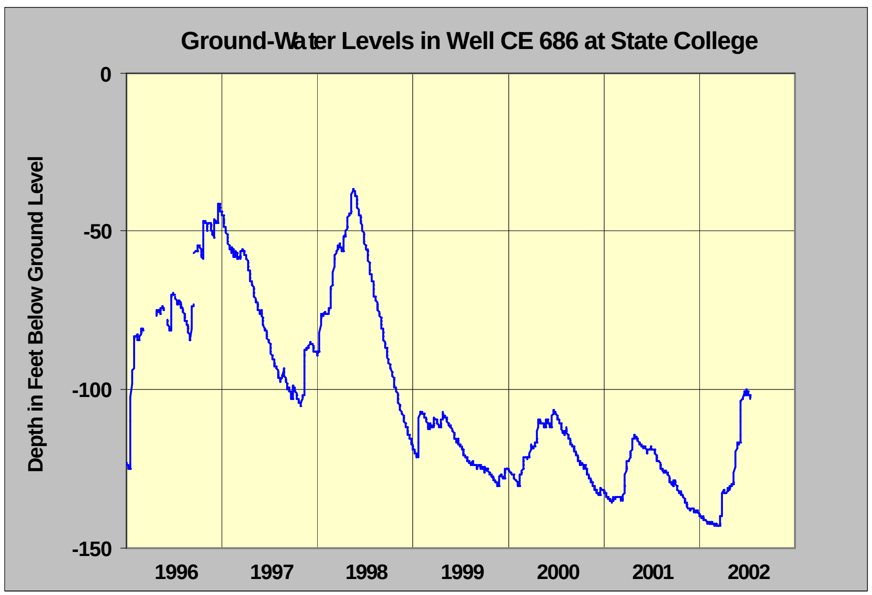

Figure 41. 1996-2002 groundwater levels measured at CE 686 (feet below ground level).

Groundwater Monitoring

Monitoring well CE 686 is located between State College and Pine Grove Mills near the boundary between the Slab Cabin Run and Big Hollow sub-basins. The hydrograph of this well shows that water table levels in the headwaters area of the Spring Creek Watershed reached new lows at the end of 2001 (Figure 41). The only visible signs of the groundwater drought in the watershed were the dry stream channels of Slab Cabin Run and Buffalo Run, and hence the ground-water drought was called an "invisible drought".

The "invisible" or groundwater drought began in the fall of 1998, when there was below-normal precipitation and negligible groundwater recharge. In 1999 there was a nearly state-wide drought emergency and groundwater levels continued to decline. Total precipitation for 2000 was 18% below normal, and total precipitation for 2001 was 21% below normal (Penn State University Weather Station). The cumulative impact of this precipitation deficit is apparent in the continuing downward trend of the hydrograph of drought monitoring well CE 686 throughout 2000 and 2001 (Figure 41).

Spring Creek set several new 34-year record low flows on various dates in 2001 due to the low amount of groundwater reaching all streams. The dry stream channels of Slab Cabin Run and Buffalo Run were caused by the decline of groundwater levels under those channels to elevations below the streambeds. This caused the streams to lose water through their streambeds into the ground below.

9.0 CONTEMPORARY ISSUES AFFECTING THE SPRING CREEK WATERSHED

PA DEP STREAM ASSESSMENTS

Pursuant to the requirements of Section 303 of the federal Clean Water Act, the PA Department of Environmental Protection (PA DEP) is required to asses the condition of all streams in Pennsylvania and determine if surface waters are attaining their designated use. Work by PA DEP to complete a statewide assessment of all surface waters is ongoing and in 2001 included work on the Spring Creek Watershed.

In 2001, benthic macroinvertebrates and water quality samples were collected at 17 locations along the main stem of Spring Creek for an aquatic biological investigation by PA DEP. The collection locations spanned the entire reach of the Spring Creek basin, from the headwaters reach east of Boalsburg to the mouth near Milesburg. In 2002, a draft report and analysis of the aquatic survey data was released by PA DEP. The draft report recommended four separate reaches of Spring Creek for inclusion on PA DEP's list of waters not attaining their designated uses, commonly referred to as the 303(d) list.

The PA DEP report identified a combination of point and non-point source discharges as suspected causes of stream impairment resulting from siltation, thermal modification, and organic enrichment of Spring Creek. The DEP report identified a total of 6.6 miles of the approximately 21 total miles of the main stem of Spring Creek as not attaining its designated use.

The base flow and stormwater data that are currently being collected by the Spring Creek Water Resources Monitoring Project on Spring Creek and its tributaries will provide essential information for developing viable plans to abate some of the sources of impairment to Spring Creek.

NEW GROUNDWATER MONITORING WELL

A new monitoring well for Centre County was instrumented by the United States Geological Survey in September 2001. Real-time data for this well is reported on their Web site at http://water.usgs.gov/nwis/gw. Designated CE 686, the well is located two miles southwest of State College in the headwaters area of the Spring Creek Watershed. The well, which is now part of Pennsylvania's Water Resources Monitoring Network and the Spring Creek Watershed Community's Water Resources Monitoring Project, was donated by Todd Giddings. David Hess, Secretary of the Pennsylvania Department of Environmental Protection, attended the well dedication ceremony.

NEW LEGISLATION

New water resources legislation is currently under consideration by the Pennsylvania House of Representatives and Senate. The Water Resources Conservation and Protection Act has been proposed because water is a critical economic and environmental resource for which the quantity and demand are poorly understood. This legislation will require an update to the State Water Plan, identification of Critical Water Planning Areas, creation of a Water Conservation Program, and establishment of residential well construction standards. The Spring Creek Watershed is a candidate to be designated a Critical Water Planning Area because of the region's rapid population growth and heavy reliance on groundwater for drinking water.

10.0 SOURCES OF ADDITIONAL INFORMATION

WEB SITES

All data collected by the Water Resources Monitoring Project are available to the public free of charge and can be accessed at the ClearWater Conservancy office and on the Spring Creek Watershed Community's Web site at www.springcreekwatershed.org. Real-time stream flow data for USGS's Pennsylvania stream monitoring stations can be viewed at http://waterdata.usgs.gov/pa/nwis/rt. Real-time groundwater level data for USGS well CE 686 can be viewed at www.water.usgs.org/nwis/gw.

PUBLICATIONS

Searchable Bibliographic Database (1999) – is a compilation of all studies of Spring Creek and its tributaries. The database has 267 citations that include conference proceedings, dissertations, journal articles, maps, reports, video recordings, and Web pages that are searchable by author, journal, title, type of document, and a list of keywords. This document is available online on the Spring Creek Watershed Community's Web site www.springcreekwatershed.org. Hard copies are also available at the ClearWater Conservancy office for $10, which covers publication costs incurred by the Conservancy.

Spring Creek Watershed Water Resources Monitoring Protocol (v2001) – this document was designed to provide quality assurance for water monitoring data. It provides standardized methods for sample collection and processing for volunteers, interns, and staff who perform monthly sampling procedures. It also includes a checklist of sampling materials and instructions for calibrating equipment and downloading data.

Spring Creek Watershed Stormwater Monitoring Protocol (2001) – this document was designed to provide quality assurance for stormwater monitoring data. It provides standardized methods for sample collection and processing for volunteers, interns and staff who perform storm sampling procedures. It also includes a checklist of sampling materials and instuctions for downloading data.

1998 WRMP Annual Report – is available at the ClearWater Conservancy office and on the Spring Creek Watershed Community's Web site.

1999 WRMP Annual Report – is available at the ClearWater Conservancy office and on the Spring Creek Watershed Community's Web site.

2000 WRMP Annual Report– is available at the ClearWater Conservancy office and on the Spring Creek Watershed Community's Web site.

11.0 PLANS FOR THE YEAR 2002

The goals for the year 2002 for the Water Resources Monitoring Project, as established by the Water Resources Monitoring Committee, are as follows:

- Continue monthly sampling and laboratory analysis of surface water at all 12 monitoring stations
- Continue collecting flow and temperature data at all 12 monitoring stations
- Continue to refine the station rating curves
- Continue to maintain the Water Resources Monitoring Project online database, including base flow, stormwater, and groundwater data
- Update the Spring Creek Searchable Bibliographic Database
- Complete stormwater monitoring as outlined in the PA DEP Growing Greener Grant. Provide a snapshot of the data in the 2001 WRMP Annual Report. Summarize stormwater data in the final project report to PA DEP.
- Partner with USGS to initiate groundwater level monitoring
- Develop a protocol for groundwater level monitoring
- Write the 2001 WRMP Annual Report

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Sengle, John. 2002. Controls on base flow hydrology/chemistry in a mixed land-use karst basin. School of Forest Resources, Pennsylvania State University, Masters of Science Paper, unpublished.

Water Resources Monitoring Committee. 2001. The 2000 WRMP Annual Report. Spring Creek Watershed Community, unpublished.

Photo by PSU College of Agriculture (Howard Nuernburger)

APPENDIX A: 2001 MONTHLY DATA

Table A.1. 2001 WRMP Mean monthly stream flow in cubic feet per second (cfs).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.28	7.12	16.93	20.60	7.71	4.63	2.21	1.62	1.85	2.50	1.31	1.51	5.86	2.50
Buffalo Run Upper	6.13	5.29	9.86	10.99	2.68	1.31	0.20	0.10	0.08	Dry	Dry	0.03	3.06	1.31
Cedar Run Lower	6.03	8.35	14.47	22.03	12.94	8.69	6.72	5.21	5.07	4.84	4.01	5.62	8.67	6.72
Logan Branch Lower	53.44	49.05	64.54	91.95	72.61	57.77	56.45	56.77	46.73	44.92	43.03	41.96	56.60	56.45
Logan Branch Upper	30.29	35.80	43.32	52.30	14.43	8.67	11.85	24.12	8.27	10.02	7.38	10.23	21.39	14.43
Slab Cabin Run Lower	0.34	2.09	10.05	23.68	7.86	3.65	1.11	1.68	1.01	0.78	0.47	0.88	4.46	1.68
Slab Cabin Run Upper	0.50	1.23	6.77	14.63	4.82	2.07	0.39	0.02	NO data	Dry	0.04	Dry	2.77	0.86
Spring Creek Axemann	48.94	57.39	95.58	132.77	69.00	58.67	53.39	52.52	46.90	38.90	38.53	46.03	61.55	53.39
Spring Creek Houserville	23.71	38.18	69.84	99.33	46.23	37.20	26.97	26.94	23.43	20.81	18.60	24.45	37.97	26.97
Spring Creek Milesburg	124.26	155.46	229.71	298.60	179.32	150.07	133.06	136.58	128.37	114.61	108.77	122.29	156.76	136.58
Spring Creek Upper	8.30	10.45	19.38	28.13	12.99	12.36	13.16	14.60	9.89	7.05	6.83	7.40	12.54	12.36
Thompson Run Lower	5.73	5.85	8.18	11.24	7.85	9.49	11.52	11.17	8.16	6.57	6.64	6.47	8.24	8.16

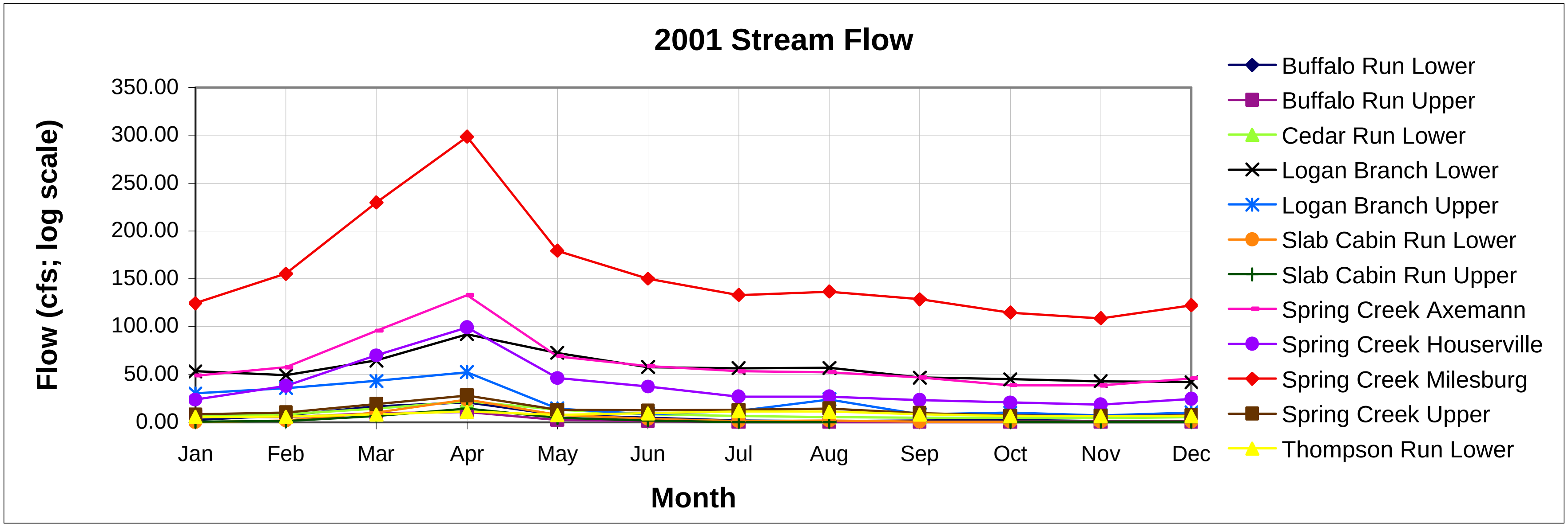

Figure A.1. 2001 WRMP mean monthly stream flow (cfs).

Table A.2. 2001 WRMP Mean monthly stream temperature (ºF).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	35.0	39.5	41.6	50.7	58.1	63.9	65.6	68.6	60.2	51.2	43.6	39.4	51.5	51.0
Buffalo Run Upper	32.1	36.4	39.0	49.9	56.7	63.1	63.5	69.2	60.4	Dry	Dry	36.6	50.4	49.9
Cedar Run Lower	38.8	42.6	44.1	51.4	56.0	60.4	61.9	64.8	59.4	52.4	46.9	42.5	51.8	51.9
Logan Branch Lower	48.0	48.2	48.2	50.9	54.0	54.8	55.2	55.2	53.4	51.8	50.3	48.9	51.6	51.3
Logan Branch Upper	43.8	45.3	45.5	50.9	57.8	62.6	64.8	65.1	60.3	55.9	51.6	47.5	54.3	53.8
Slab Cabin Run Lower	34.2	37.8	42.2	50.5	58.7	64.8	66.5	69.4	61.7	53.3	48.8	43.0	52.6	51.9
Slab Cabin Run Upper	32.0	36.0	39.8	49.9	57.8	67.5	67.2	71.6	66.5	Dry	No data	Dry	53.9	54.3
Spring Creek Axemann	39.5	42.3	43.8	52.9	60.1	65.5	66.4	67.9	62.2	54.9	49.9	45.2	54.2	53.9
Spring Creek Houserville	39.3	42.1	43.2	50.7	56.5	61.5	62.6	64.4	58.4	52.1	47.6	43.4	51.8	51.4
Spring Creek Milesburg	42.8	44.3	45.0	52.0	57.6	61.4	61.8	62.6	58.3	53.5	50.2	46.9	53.0	52.7
Spring Creek Upper	46.3	45.1	44.8	49.6	53.0	54.6	55.0	54.9	54.0	52.6	51.7	48.8	50.9	52.1
Thompson Run Lower	45.78	47.1	47.5	52.3	55.0	57.6	57.5	58.3	55.7	52.4	50.2	48.0	52.3	52.3

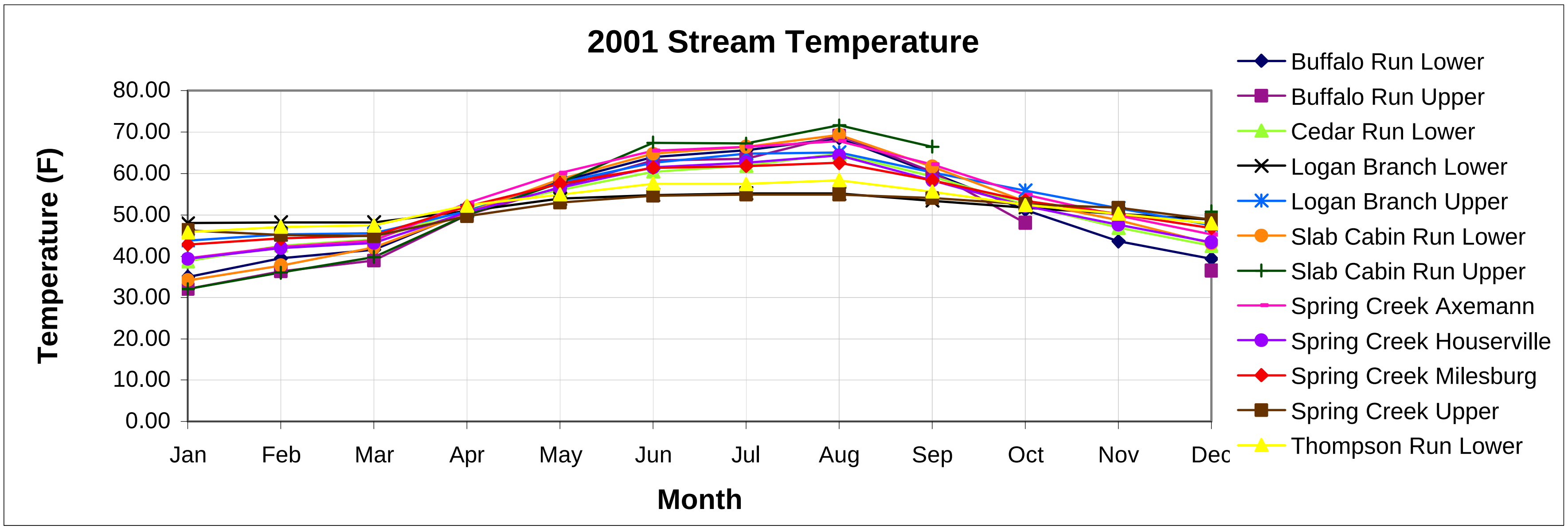

Figure A.2. 2001 WRMP mean monthly stream temperature (ºF).

Table A.3. 2001 WRMP Total Suspended Solids Concentrations* (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	4	28	20	24	14	18	22	6	1	12	4	1	13	13
Buffalo Run Upper	1	58	6	4	46	8	12	Dry	Dry	Dry	Dry	Dry	19	8
Cedar Run Lower	6	1	30	10	12	66	30	1	28	1	4	10	17	10
Logan Branch Lower	1	48	14	1	12	4	1	22	1	6	1	2	9	3
Logan Branch Upper	1	40	2	18	1	1	18	8	1	6	4	1	8	3
Slab Cabin Run Lower	1	1	1	6	1	8	1	1	18	1	20	16	6	1
Slab Cabin Run Upper	Dry	4	16	4	8	38	22	Dry	Dry	Dry	Dry	Dry	15	12
Spring Creek Axemann	1	62	36	1	36	18	18	20	1	14	20	8	20	18
Spring Creek Houserville	1	1	20	16	1	16	1	1	14	1	14	10	8	6
Spring Creek Milesburg	1	38	1	14	8	1	6	10	1	1	1	4	7	3
Spring Creek Upper	1	1	8	10	6	32	10	1	14	1	1	12	8	7
Thompson Run Lower	8	8	8	6	16	14	6	1	8	1	6	8	8	8

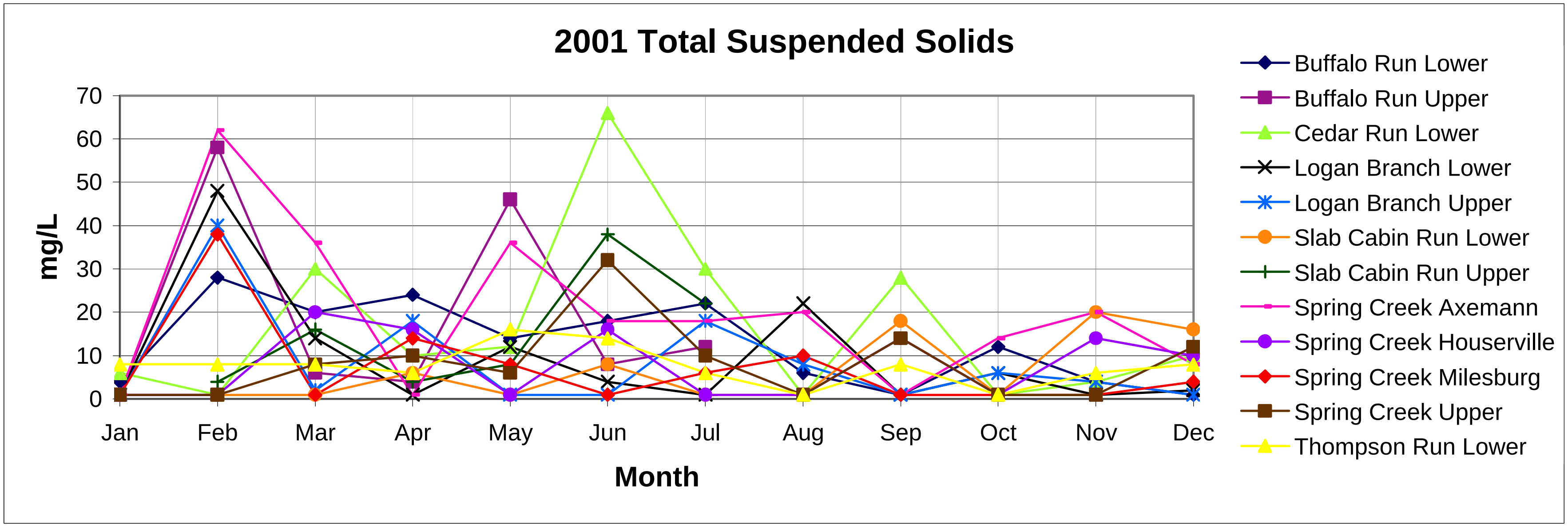

Figure A.3. 2001 WRMP Total Suspended Solids Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 2 mg/L.

Table A.4. 2001 WRMP Turbidity Levels* (NTU).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	1.76	1.78	10.90	8.29	3.92	3.45	8.94	7.24	4.60	3.86	0.50	2.63	4.82	3.89
Buffalo Run Upper	2.09	2.80	10.70	5.50	2.47	3.39	6.28	Dry	Dry	Dry	Dry	Dry	4.75	3.39
Cedar Run Lower	1.14	1.53	13.80	7.48	2.61	4.59	5.15	4.70	5.02	2.61	3.47	3.60	4.64	4.10
Logan Branch Lower	0.50	0.50	5.23	5.20	1.81	0.50	0.50	1.43	1.82	2.66	0.50	0.50	1.76	0.97
Logan Branch Upper	2.05	1.50	8.60	6.81	2.34	1.80	2.92	3.94	3.90	5.86	4.16	2.43	3.86	3.41
Slab Cabin Run Lower	0.50	0.50	7.25	5.01	2.14	2.28	1.51	4.16	1.86	1.06	2.52	1.41	2.52	2.00
Slab Cabin Run Upper	Dry	3.08	10.90	7.24	2.85	3.06	3.72	Dry	Dry	Dry	Dry	Dry	5.14	3.40
Spring Creek Axemann	0.50	1.90	8.10	9.03	4.23	3.80	8.88	5.69	3.55	3.34	2.50	2.95	4.54	3.68
Spring Creek Houserville	1.10	1.17	8.14	4.98	2.04	3.70	3.00	3.52	3.39	2.09	1.61	2.19	3.08	2.60
Spring Creek Milesburg	1.11	1.26	6.34	6.16	4.62	2.12	5.16	3.23	6.22	2.58	3.26	2.67	3.73	3.25
Spring Creek Upper	1.31	0.50	4.90	2.97	1.63	2.04	2.81	2.31	2.04	0.50	0.50	1.68	1.93	1.86
Thompson Run Lower	2.68	1.36	4.00	4.49	1.52	1.90	1.75	1.79	3.21	1.06	1.81	2.58	2.35	1.86

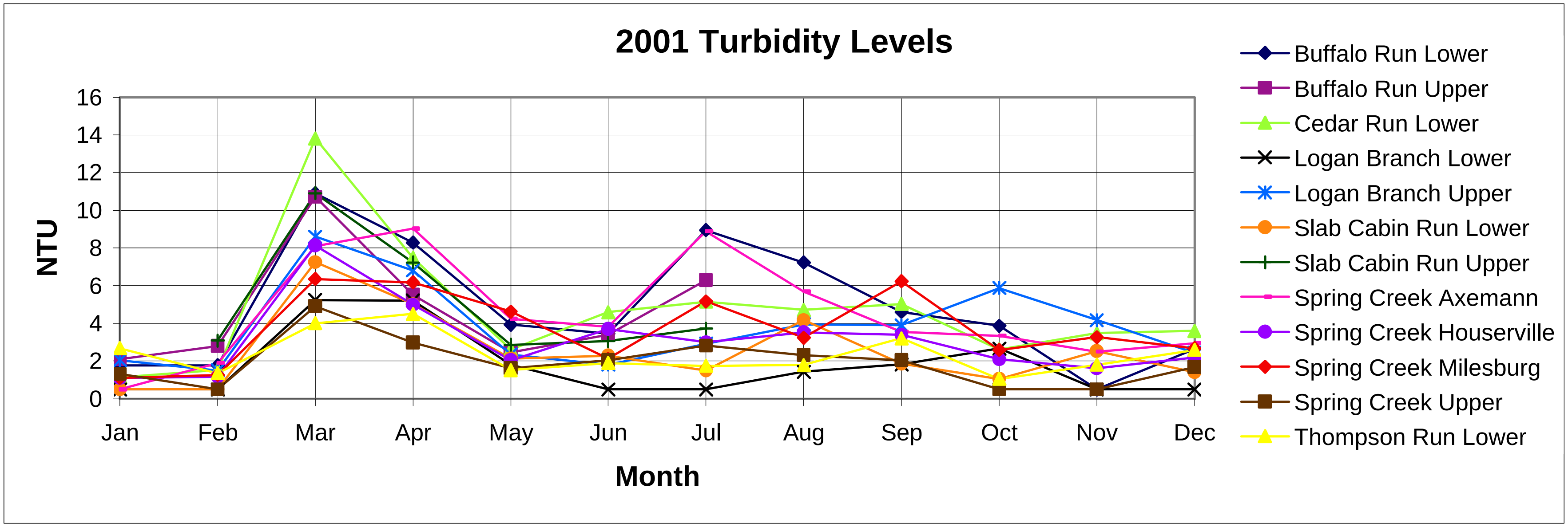

Figure A.4. 2001 WRMP Turbidity Levels (NTU). *Non-detected values shown at one-half detection limit which is 1 NTU.

Table A.5. 2001 WRMP Dissolved Oxygen Concentrations (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	13.7	13.9	13.8	12.7	10.2	10.1	9.3	8.4	10.6	12.3	13.2	12.0	11.7	12.2
Buffalo Run Upper	7.0	12.8	13.9	14.8	11.5	9.9	9.2	Dry	Dry	Dry	Dry	Dry	11.3	11.5
Cedar Run Lower	14.9	13.4	11.8	11.8	11.5	11.9	11.0	11.3	10.8	12.5	12.4	12.5	12.2	11.9
Logan Branch Lower	10.1	11.1	12.5	11.8	10.7	10.7	11.2	10.4	11.8	10.7	11.5	11.1	11.1	11.1
Logan Branch Upper	10.3	10.9	13.6	12.9	12.2	10.2	10.6	9.5	9.6	9.7	8.6	8.8	10.6	10.3
Slab Cabin Run Lower	15.1	16.1	13.3	12.4	13.0	10.7	10.3	9.8	12.0	11.5	11.6	10.8	12.2	11.8
Slab Cabin Run Upper	Dry	11.9	12.8	11.3	12.0	10.2	7.7	Dry	Dry	Dry	Dry	Dry	11.0	11.6
Spring Creek Axemann	12.7	13.4	13.7	13.7	10.7	11.3	11.4	9.4	12.9	11.5	12.1	10.5	11.9	11.8
Spring Creek Houserville	14.6	14.5	13.5	12.6	13.9	13.3	11.3	12.4	12.3	11.0	13.7	12.8	13.0	13.1
Spring Creek Milesburg	11.3	11.6	12.9	12.3	10.1	10.6	10.4	10.2	11.4	11.8	12.1	11.3	11.3	11.4
Spring Creek Upper	10.6	10.7	11.3	11.1	11.2	10.6	9.2	9.9	8.9	9.4	8.5	9.7	10.1	10.3
Thompson Run Lower	13.4	12.2	11.2	11.4	13.4	10.7	10.0	12.6	13.1	13.1	13.2	10.8	12.1	12.4

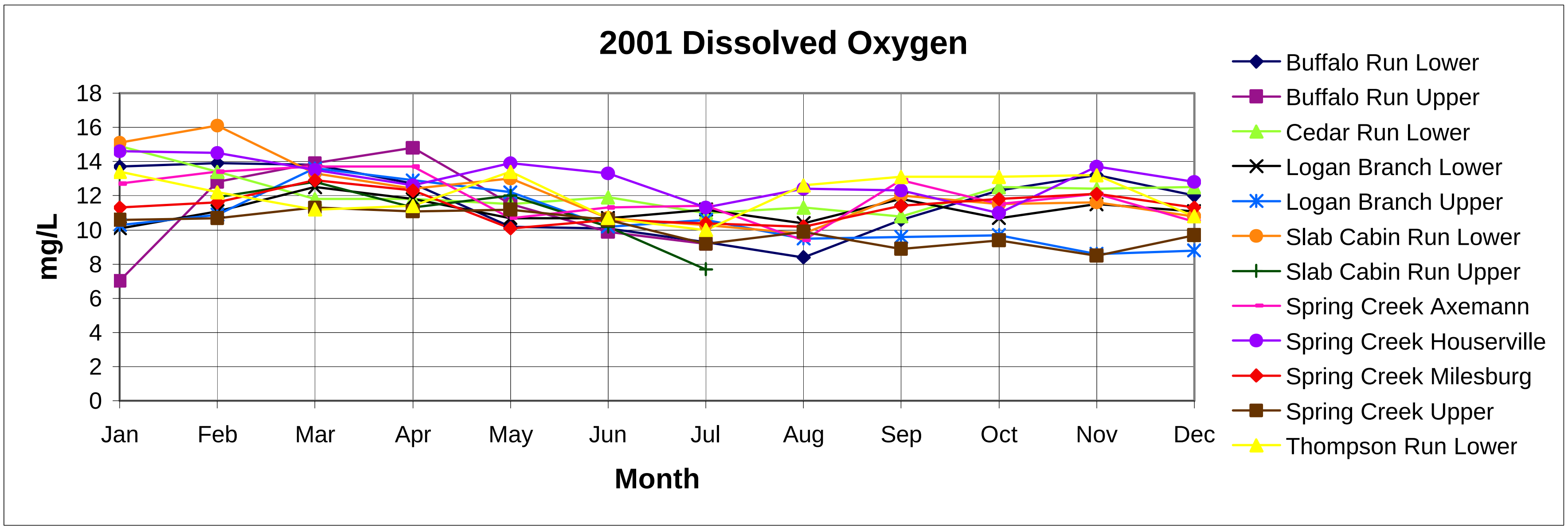

Figure A.5. 2001 WRMP Dissolved Oxygen Concentrations (mg/L).

Table A.6. 2001 WRMP stream pH (Standard Units)														
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP***	**OCT***	**NOV**	**DEC**	**MEAN**	**MEDIAN**
Buffalo Run Lower	8.1	8.0	7.4	7.5	7.7	7.5	8.1	7.9	8.44	8.17	8.2	8.6	8.0	8.1
Buffalo Run Upper	7.5	7.6	7.2	7.7	7.5	7.1	8.3	Dry	Dry	Dry	Dry	Dry	7.6	7.5
Cedar Run Lower	7.8	8.2	7.7	7.1	7.9	7.6	7.6	7.8	8.24	8.17	8.3	8.3	7.9	7.9
Logan Branch Lower	7.7	7.7	7.3	7.3	7.5	7.1	7.7	7.6	8.29	8.00	7.9	8.0	7.7	7.7
Logan Branch Upper	7.3	7.8	7.6	7.3	7.7	7.4	7.8	8.2	8.14	8.04	7.7	8.0	7.7	7.8
Slab Cabin Run Lower	7.8	8.0	7.5	7.2	8.2	7.5	7.4	7.4	8.28	8.22	8.1	8.0	7.8	7.9
Slab Cabin Run Upper	Dry	7.1	7.3	7.1	7.5	7.1	7.1	Dry	Dry	Dry	Dry	Dry	7.2	7.1
Spring Creek Axemann	7.7	8.0	7.4	7.5	7.3	7.5	8.0	7.6	8.38	8.23	8.1	8.0	7.8	7.9
Spring Creek Houserville	8.0	8.2	7.4	7.1	7.9	7.9	7.7	8.0	8.29	8.00	8.4	8.2	7.9	8.0
Spring Creek Milesburg	8.0	8.1	7.8	7.5	7.9	7.6	8.1	8.1	8.54	8.23	8.3	8.6	8.1	8.1
Spring Creek Upper	7.1	7.1	7.2	7.1	7.3	6.9	7.1	7.2	No data	7.68	7.5	7.6	7.3	7.2
Thompson Run Lower	7.8	7.8	7.4	6.9	8.0	7.8	7.3	7.8	8.30	8.24	8.4	8.0	7.8	7.8

*pH measured from water samples collected in field within 36 hours of collection.

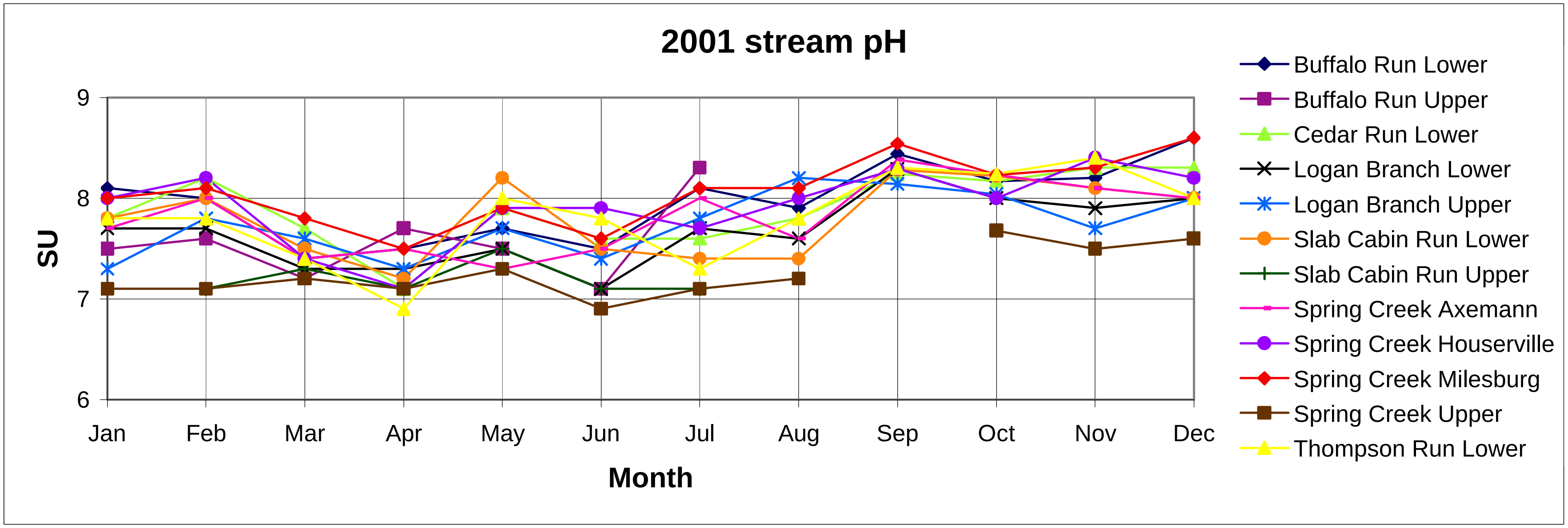

Figure A.6. 2001 WRMP stream pH (Standard Units).

Table A.7. 2001 WRMP Chloride Concentrations* (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	14	21	22	19	17	18	16	15	15	14	15	14	17	16
Buffalo Run Upper	21	40	27	23	22	27	28	Dry	Dry	Dry	Dry	Dry	27	27
Cedar Run Lower	13	19	20	18	14	15	16	14	14	14	15	17	16	15
Logan Branch Lower	21	23	26	23	21	22	22	22	21	19	19	21	22	22
Logan Branch Upper	36	39	26	21	31	31	34	37	48	35	34	30	34	34
Slab Cabin Run Lower	100	114	59	41	33	47	60	92	82	71	79	73	71	72
Slab Cabin Run Upper	Dry	49	36	27	25	32	37	Dry	Dry	Dry	Dry	Dry	34	34
Spring Creek Axemann	51	54	48	40	41	50	44	48	56	54	56	48	49	49
Spring Creek Houserville	35	42	37	29	28	33	34	33	36	38	39	34	35	35
Spring Creek Milesburg	36	37	38	33	29	35	33	34	37	33	35	37	35	35
Spring Creek Upper	11	18	14	14	14	18	18	17	17	19	18	14	16	17
Thompson Run Lower	66	59	66	68	58	53	48	49	60	54	54	54	57	56

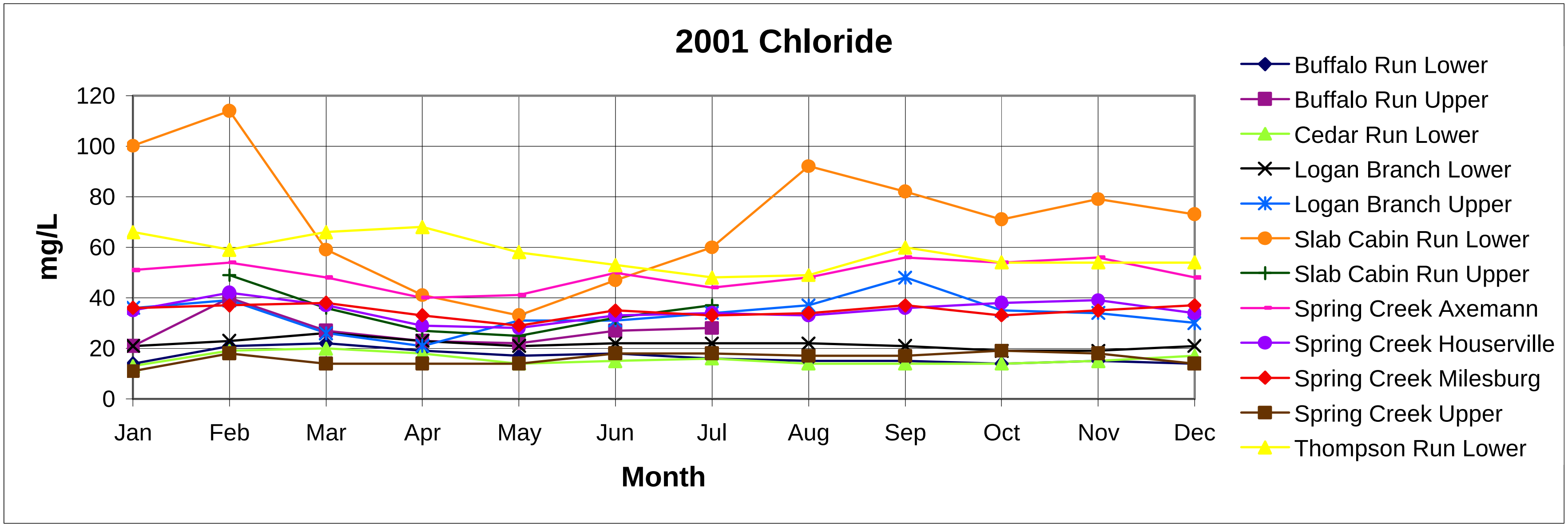

Figure A.7. 2001 WRMP Chloride Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 1 mg/L.

Table A.8. 2001 WRMP Lead Concentrations* (ug/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Buffalo Run Upper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Dry	Dry	Dry	Dry	Dry	0.5	0.5
Cedar Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Logan Branch Lower	0.5	0.5	1.8	1.6	1.6	1.4	1.6	1.3	0.5	1.3	0.5	1.3	1.2	1.3
Logan Branch Upper	4.1	1.8	4.7	2.9	2.6	4.0	4.0	3.7	3.5	3.9	3.2	3.1	3.5	3.6
Slab Cabin Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.1	0.5	0.6	0.5
Slab Cabin Run Upper	Dry	0.5	0.5	0.5	0.5	0.5	0.5	Dry	Dry	Dry	Dry	Dry	0.5	0.5
Spring Creek Axemann	0.5	0.5	0.5	0.5	0.5	1.0	8.1	0.5	0.5	0.5	0.5	0.5	1.2	0.5
Spring Creek Houserville	0.5	0.5	0.5	0.5	0.5	0.5	1.6	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Spring Creek Milesburg	0.5	0.5	0.5	0.5	1.6	0.5	1.2	0.5	1.2	0.5	0.5	0.5	0.7	0.5
Spring Creek Upper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thompson Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

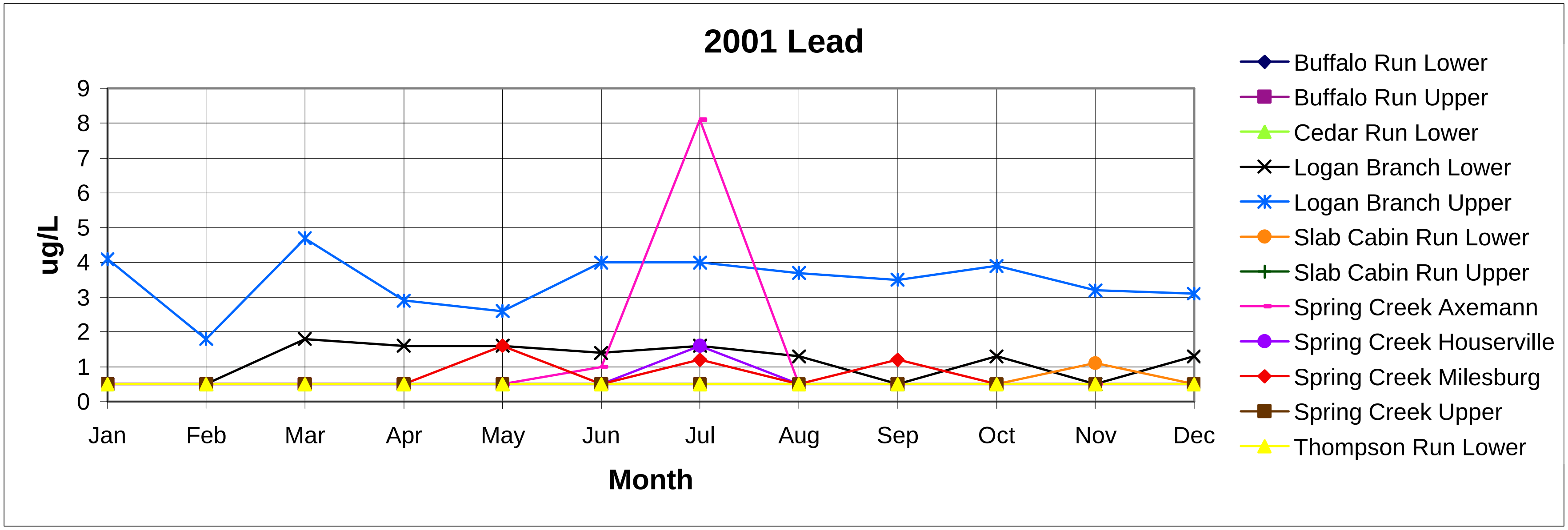

Figure A.8. 2001 WRMP Lead Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 1.0 ug/L.

Table A.9. 2001 WRMP Copper Concentrations* (ug/L).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Buffalo Run Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	Dry	Dry	Dry	Dry	Dry	2.0	2.0
Cedar Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Logan Branch Lower	4.6	6.3	4.9	2.0	2.0	2.0	2.0	6.2	2.0	6.6	4.1	2.0	3.7	3.1
Logan Branch Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Slab Cabin Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Slab Cabin Run Upper	Dry	2.0	2.0	2.0	2.0	2.0	2.0	Dry	Dry	Dry	Dry	Dry	2.0	2.0
Spring Creek Axemann	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Houserville	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Milesburg	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Thompson Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

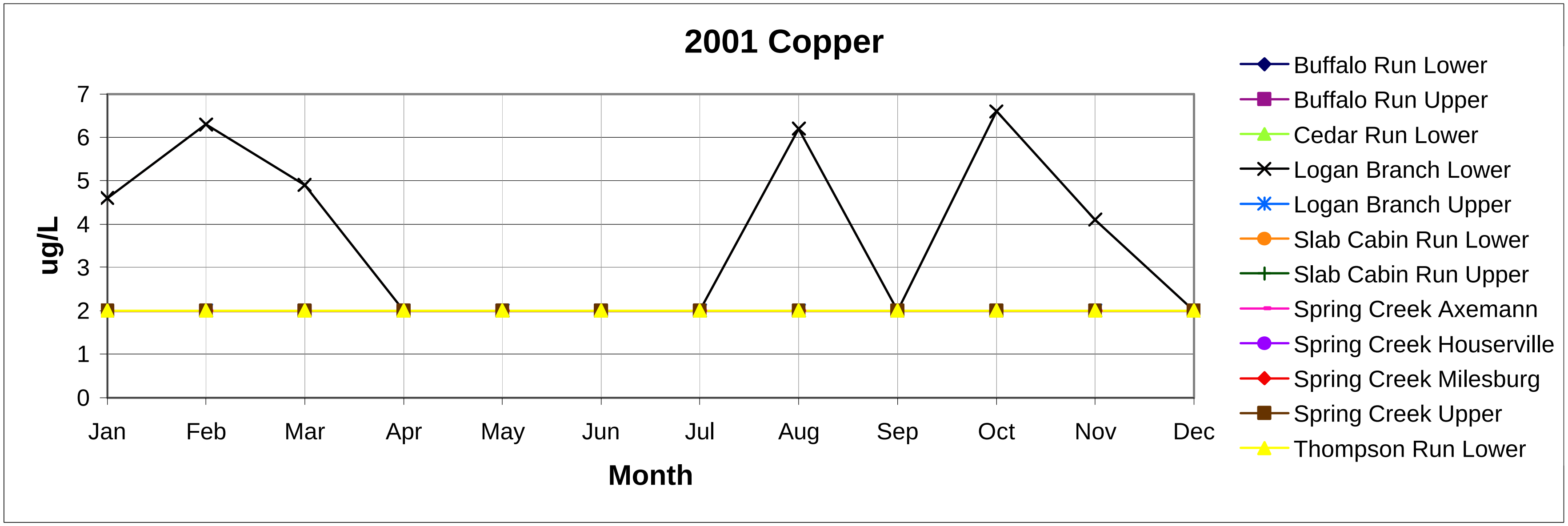

Figure A.9. 2001 WRMP Copper Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 4.0 ug/L.

Table A.10. 2001 WRMP Zinc Concentrations* (ug/L).														
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**	**MEDIAN**
Buffalo Run Lower	5	5	5	5	5	5	5	5	5	5	5	20	6	5
Buffalo Run Upper	5	5	5	5	5	5	5	Dry	Dry	Dry	Dry	Dry	5	5
Cedar Run Lower	5	5	5	5	11	5	5	5	5	5	5	5	6	5
Logan Branch Lower	49	41	34	39	20	18	14	14	22	19	15	20	25	20
Logan Branch Upper	5	5	5	5	5	5	11	5	5	5	5	5	6	5
Slab Cabin Run Lower	5	5	5	5	12	5	5	5	5	5	5	5	6	5
Slab Cabin Run Upper	Dry	5	5	5	10	5	5	Dry	Dry	Dry	Dry	Dry	6	5
Spring Creek Axemann	5	10	5	5	46	5	12	5	5	5	12	5	10	5
Spring Creek Houserville	5	5	5	5	11	5	5	5	5	5	5	5	6	5
Spring Creek Milesburg	18	15	11	10	11	5	5	5	5	5	11	10	9	10
Spring Creek Upper	5	5	5	5	12	5	5	5	5	5	5	5	6	5
Thompson Run Lower	5	5	5	5	14	5	11	5	5	5	5	10	7	5

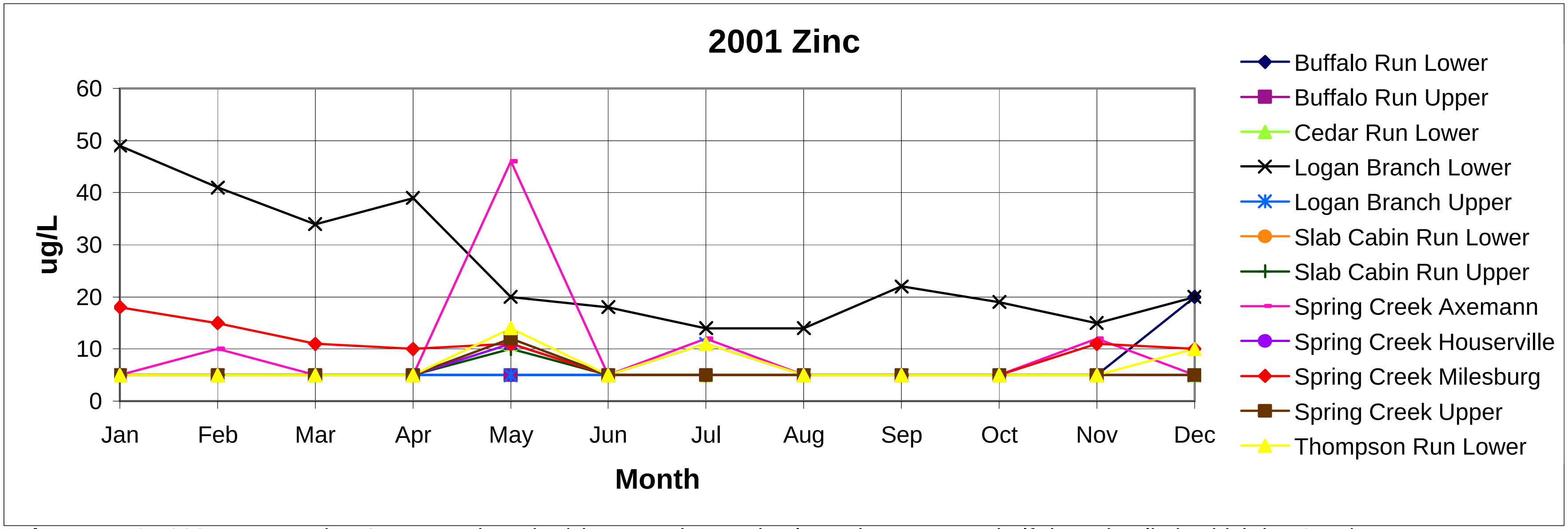

Figure A.10. 2001 WRMP Zinc Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 10 ug/L.

Table A.11. 2001 WRMP Nitrate Concentrations* (mg/L).	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.01	2.17	1.46	1.54	1.68	1.82	1.84	1.79	1.44	1.50	1.56	1.76	1.71	1.72
Buffalo Run Upper	1.39	1.58	1.04	1.11	1.26	1.48	1.69	Dry	Dry	Dry	Dry	Dry	1.36	1.39
Cedar Run Lower	4.55	4.43	4.60	4.82	4.08	3.63	4.40	4.10	4.04	5.08	4.94	3.81	4.37	4.42
Logan Branch Lower	2.55	2.98	2.63	2.81	3.13	3.36	3.08	2.78	3.19	2.81	3.58	2.58	2.96	2.90
Logan Branch Upper	2.53	3.06	2.11	2.57	2.35	2.37	3.45	2.60	3.06	2.61	2.90	2.84	2.70	2.61
Slab Cabin Run Lower	2.14	2.22	1.70	2.01	2.37	1.90	1.69	0.39	1.32	1.73	0.89	1.76	1.68	1.75
Slab Cabin Run Upper	Dry	2.99	1.53	2.01	2.83	2.62	2.37	Dry	Dry	Dry	Dry	Dry	2.39	2.50
Spring Creek Axemann	4.16	5.10	3.65	3.72	4.66	4.68	4.68	4.48	5.98	5.58	7.35	4.65	4.89	4.67
Spring Creek Houserville	3.19	3.32	2.52	2.49	2.60	2.46	2.95	3.43	3.66	3.74	3.61	2.63	3.05	3.07
Spring Creek Milesburg	3.25	3.65	2.74	2.85	2.72	6.80	3.15	3.25	3.29	3.72	3.82	3.45	3.56	3.27
Spring Creek Upper	2.29	2.55	1.38	1.43	1.89	2.43	2.55	2.81	3.03	3.61	3.14	1.86	2.41	2.49
Thompson Run Lower	4.17	4.49	4.30	3.99	3.61	3.97	4.02	4.28	3.89	4.40	4.06	3.37	4.05	4.04

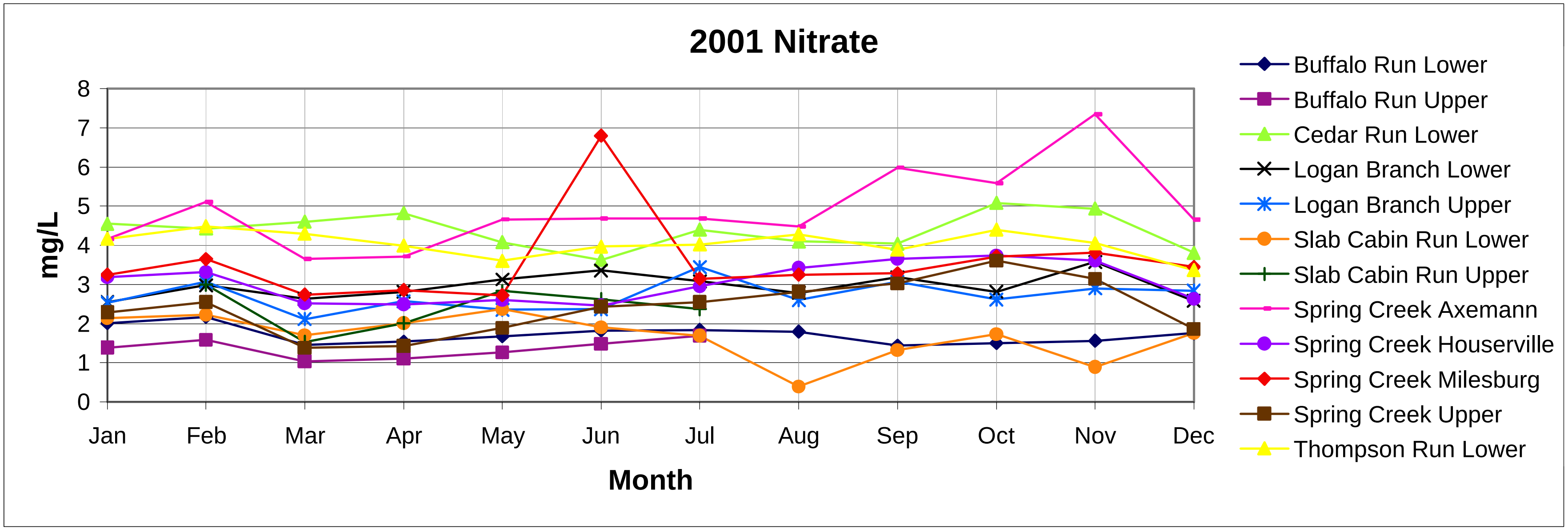

Figure A.11. 2001 WRMP Nitrate Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 0.04 mg/L.

Table A.12. 2001 WRMP Orthophosphate Concentrations* (mg/L).														
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**	**MEDIAN**
Buffalo Run Lower	0.005	0.005	0.021	0.014	0.012	0.017	0.028	0.019	0.024	0.011	0.005	0.005	0.014	0.013
Buffalo Run Upper	0.012	0.020	0.022	0.012	0.005	0.020	0.029	Dry	Dry	Dry	Dry	Dry	0.017	0.020
Cedar Run Lower	0.005	0.015	0.019	0.005	0.013	0.022	0.022	0.018	0.020	0.014	0.014	0.018	0.015	0.017
Logan Branch Lower	0.011	0.014	0.015	0.014	0.010	0.013	0.018	0.013	0.018	0.012	0.012	0.015	0.014	0.014
Logan Branch Upper	0.060	0.048	0.026	0.028	0.016	0.038	0.034	0.057	0.056	0.054	0.051	0.085	0.046	0.050
Slab Cabin Run Lower	0.005	0.005	0.012	0.005	0.005	0.028	0.030	0.061	0.016	0.005	0.011	0.012	0.016	0.012
Slab Cabin Run Upper	Dry	0.120	0.108	0.019	0.047	0.067	0.088	Dry	Dry	Dry	Dry	Dry	0.075	0.078
Spring Creek Axemann	0.017	0.028	0.032	0.025	0.022	0.034	0.057	0.028	0.027	0.022	0.031	0.050	0.031	0.028
Spring Creek Houserville	0.005	0.010	0.012	0.005	0.005	0.015	0.022	0.019	0.019	0.012	0.010	0.022	0.013	0.012
Spring Creek Milesburg	0.023	0.034	0.021	0.020	0.021	0.030	0.038	0.030	0.037	0.023	0.032	0.043	0.029	0.030
Spring Creek Upper	0.005	0.012	0.013	0.005	0.005	0.010	0.017	0.005	0.012	0.005	0.005	0.013	0.009	0.008
Thompson Run Lower	0.020	0.022	0.018	0.005	0.010	0.023	0.023	0.024	0.031	0.017	0.014	0.036	0.020	0.021

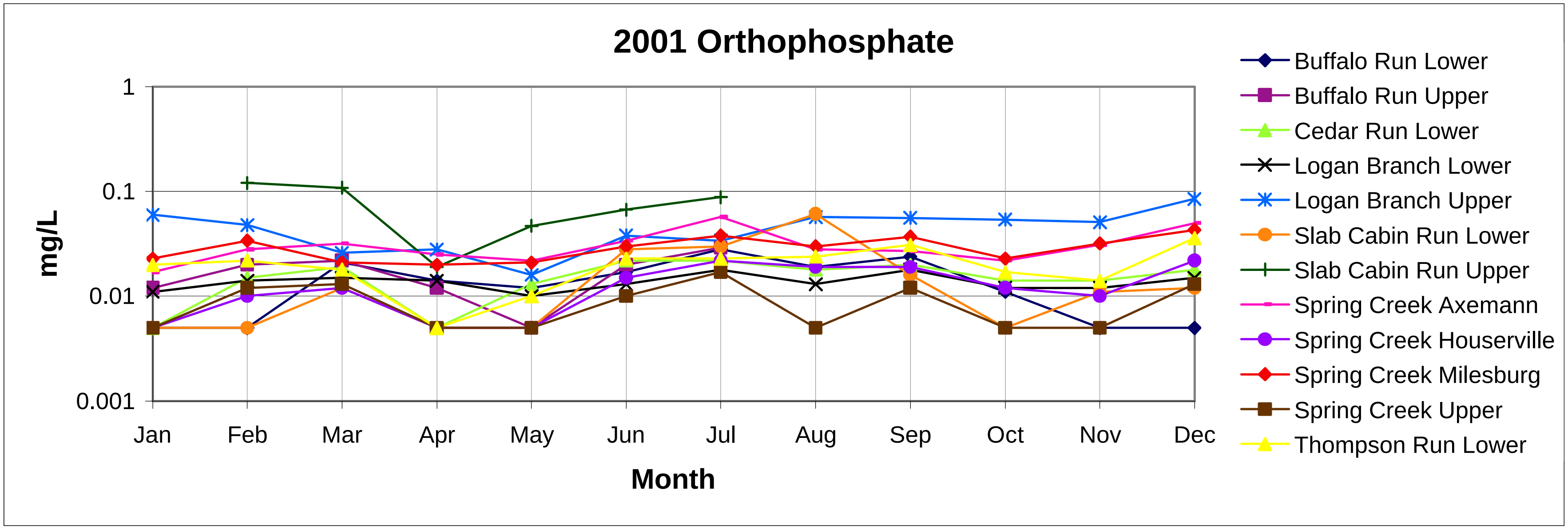

Figure A.12. 2001 WRMP Orthophosphate Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 0.010 mg/L.

Table A.13. 2001 WRMP Total Organic Carbon Concentrations* (mg/L).	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	1.0	1.4	1.3	1.2	1.6	1.4	1.6	1.4	1.4	1.9	1.3	1.2	1.4	1.4
Buffalo Run Upper	1.2	1.6	1.6	1.2	1.4	1.7	1.7	Dry	Dry	Dry	Dry	Dry	1.5	1.6
Cedar Run Lower	0.5	1.1	1.0	1.1	1.2	1.1	1.0	1.3	1.4	1.2	1.0	1.1	1.1	1.1
Logan Branch Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Logan Branch Upper	2.3	2.2	1.6	1.4	1.5	1.6	2.1	2.4	2.3	2.1	2.4	2.5	2.0	2.2
Slab Cabin Run Lower	1.5	1.7	1.6	1.4	1.8	2.0	2.2	2.4	2.0	1.7	1.7	1.7	1.8	1.7
Slab Cabin Run Upper	Dry	3.6	2.4	1.6	2.1	2.1	2.5	Dry	Dry	Dry	Dry	Dry	2.4	2.3
Spring Creek Axemann	1.7	2.0	1.9	1.6	1.7	2.0	2.5	2.4	2.0	1.8	2.1	1.8	2.0	2.0
Spring Creek Houserville	0.5	1.2	1.1	1.3	1.3	1.4	1.4	1.1	1.3	0.5	0.5	1.1	1.1	1.2
Spring Creek Milesburg	1.3	1.4	1.5	1.3	1.6	1.4	1.6	1.4	1.3	1.2	1.1	1.2	1.4	1.4
Spring Creek Upper	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.6	0.5
Thompson Run Lower	0.5	0.5	0.5	1.3	1.3	1.0	1.1	0.5	1.0	0.5	0.5	1.0	0.8	0.8

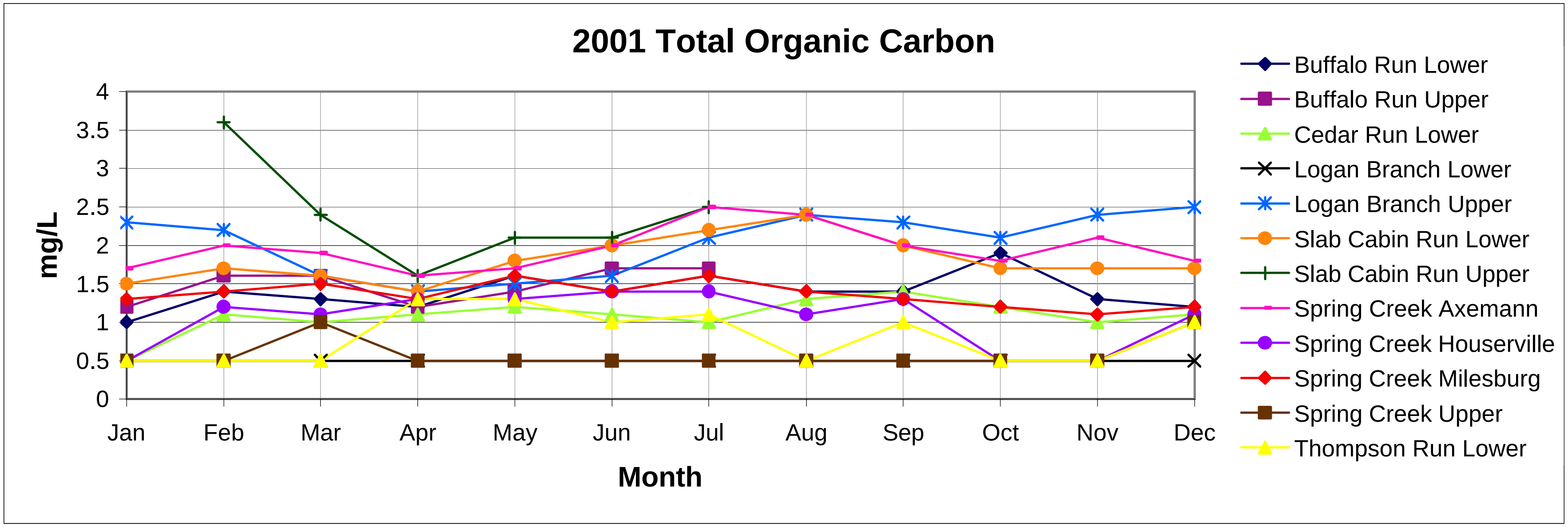

Figure A.13. 2001 WRMP Total Organic Carbon Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 1.0 mg/L.

Table A.14. 2001 WRMP Petroleum Hydrocarbon Concentrations* (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Buffalo Run Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Dry	Dry	Dry	Dry	Dry	2.5	2.5
Cedar Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	No data	2.5	2.5	2.5	2.5	2.5
Logan Branch Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Logan Branch Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.5	2.5	2.5	2.8	2.5
Slab Cabin Run Lower	2.5	2.5	2.5	5.0	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.7	2.5
Slab Cabin Run Upper	Dry	2.5	2.5	2.5	2.5	2.5	2.5	Dry	Dry	Dry	Dry	Dry	2.5	2.5
Spring Creek Axemann	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Spring Creek Houserville	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Spring Creek Milesburg	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.2	2.7	2.5
Spring Creek Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Thompson Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5

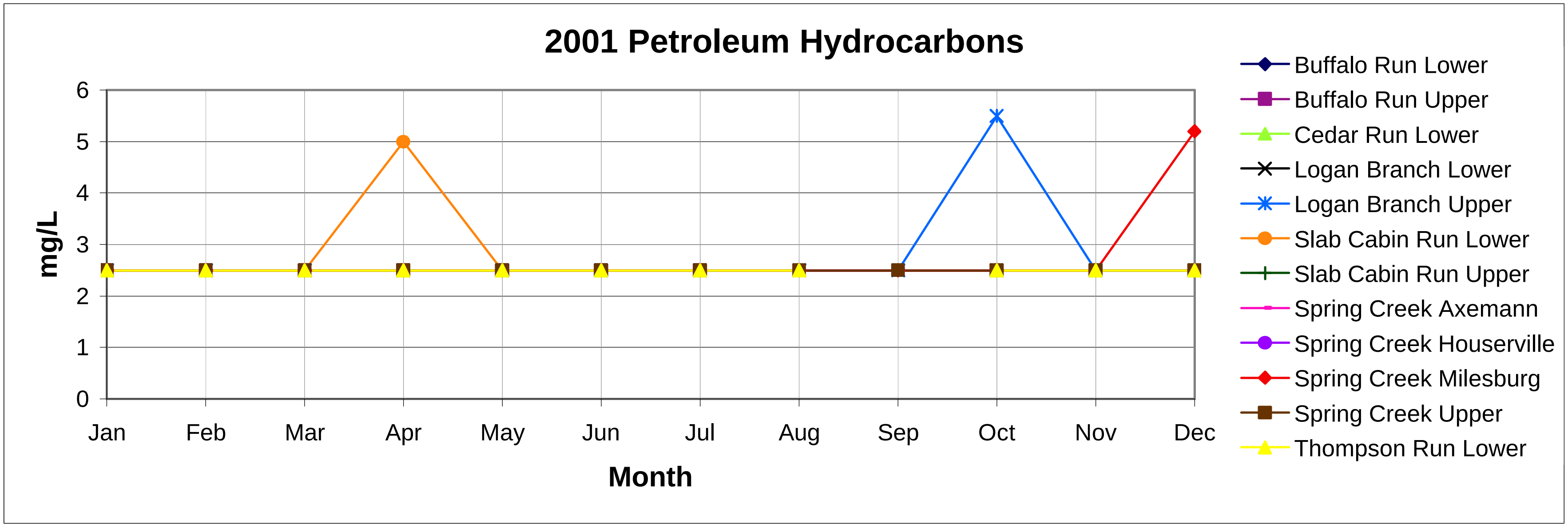

Figure A.14. 2001 WRMP Petroleum Hydrocarbon Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 5.0

APPENDIX A: 2001 MONTHLY DATA

Table A.1. 2001 WRMP Mean monthly stream flow in cubic feet per second (cfs).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.28	7.12	16.93	20.60	7.71	4.63	2.21	1.62	1.85	2.50	1.31	1.51	5.86	2.50
Buffalo Run Upper	6.13	5.29	9.86	10.99	2.68	1.31	0.20	0.10	0.08	Dry	Dry	0.03	3.06	1.31
Cedar Run Lower	6.03	8.35	14.47	22.03	12.94	8.69	6.72	5.21	5.07	4.84	4.01	5.62	8.67	6.72
Logan Branch Lower	53.44	49.05	64.54	91.95	72.61	57.77	56.45	56.77	46.73	44.92	43.03	41.96	56.60	56.45
Logan Branch Upper	30.29	35.80	43.32	52.30	14.43	8.67	11.85	24.12	8.27	10.02	7.38	10.23	21.39	14.43
Slab Cabin Run Lower	0.34	2.09	10.05	23.68	7.86	3.65	1.11	1.68	1.01	0.78	0.47	0.88	4.46	1.68
Slab Cabin Run Upper	0.50	1.23	6.77	14.63	4.82	2.07	0.39	0.02	NO data	Dry	0.04	Dry	2.77	0.86
Spring Creek Axemann	48.94	57.39	95.58	132.77	69.00	58.67	53.39	52.52	46.90	38.90	38.53	46.03	61.55	53.39
Spring Creek Houserville	23.71	38.18	69.84	99.33	46.23	37.20	26.97	26.94	23.43	20.81	18.60	24.45	37.97	26.97
Spring Creek Milesburg	124.26	155.46	229.71	298.60	179.32	150.07	133.06	136.58	128.37	114.61	108.77	122.29	156.76	136.58
Spring Creek Upper	8.30	10.45	19.38	28.13	12.99	12.36	13.16	14.60	9.89	7.05	6.83	7.40	12.54	12.36
Thompson Run Lower	5.73	5.85	8.18	11.24	7.85	9.49	11.52	11.17	8.16	6.57	6.64	6.47	8.24	8.16

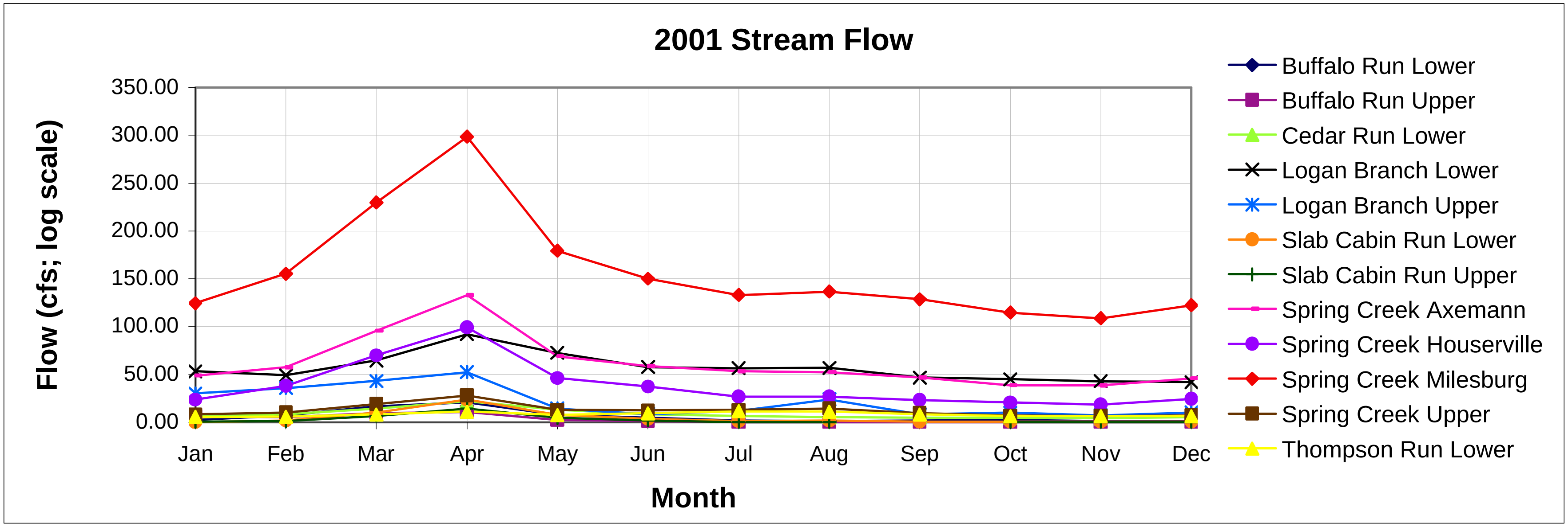

Figure A.1. 2001 WRMP mean monthly stream flow (cfs).

Table A.2. 2001 WRMP Mean monthly stream temperature (ºF).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	35.0	39.5	41.6	50.7	58.1	63.9	65.6	68.6	60.2	51.2	43.6	39.4	51.5	51.0
Buffalo Run Upper	32.1	36.4	39.0	49.9	56.7	63.1	63.5	69.2	60.4	Dry	Dry	36.6	50.4	49.9
Cedar Run Lower	38.8	42.6	44.1	51.4	56.0	60.4	61.9	64.8	59.4	52.4	46.9	42.5	51.8	51.9
Logan Branch Lower	48.0	48.2	48.2	50.9	54.0	54.8	55.2	55.2	53.4	51.8	50.3	48.9	51.6	51.3
Logan Branch Upper	43.8	45.3	45.5	50.9	57.8	62.6	64.8	65.1	60.3	55.9	51.6	47.5	54.3	53.8
Slab Cabin Run Lower	34.2	37.8	42.2	50.5	58.7	64.8	66.5	69.4	61.7	53.3	48.8	43.0	52.6	51.9
Slab Cabin Run Upper	32.0	36.0	39.8	49.9	57.8	67.5	67.2	71.6	66.5	Dry	No data	Dry	53.9	54.3
Spring Creek Axemann	39.5	42.3	43.8	52.9	60.1	65.5	66.4	67.9	62.2	54.9	49.9	45.2	54.2	53.9
Spring Creek Houserville	39.3	42.1	43.2	50.7	56.5	61.5	62.6	64.4	58.4	52.1	47.6	43.4	51.8	51.4
Spring Creek Milesburg	42.8	44.3	45.0	52.0	57.6	61.4	61.8	62.6	58.3	53.5	50.2	46.9	53.0	52.7
Spring Creek Upper	46.3	45.1	44.8	49.6	53.0	54.6	55.0	54.9	54.0	52.6	51.7	48.8	50.9	52.1
Thompson Run Lower	45.78	47.1	47.5	52.3	55.0	57.6	57.5	58.3	55.7	52.4	50.2	48.0	52.3	52.3

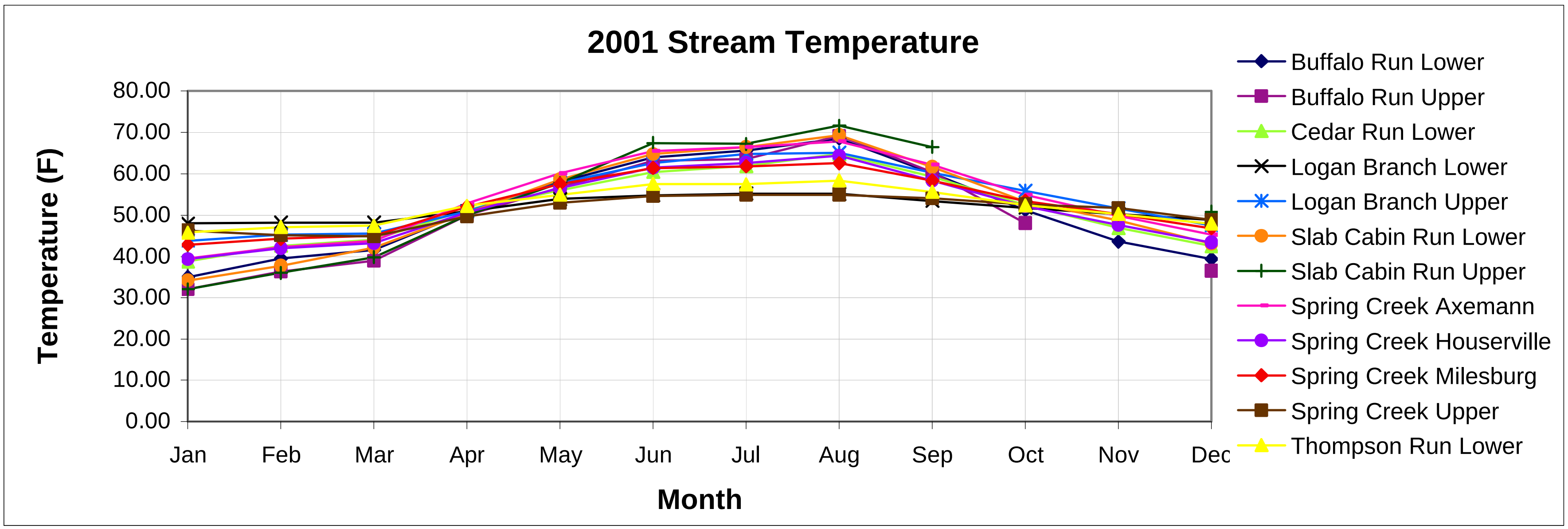

Figure A.2. 2001 WRMP mean monthly stream temperature (ºF).

Table A.3. 2001 WRMP Total Suspended Solids Concentrations* (mg/L).														
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**	**MEDIAN**
Buffalo Run Lower	4	28	20	24	14	18	22	6	1	12	4	1	13	13
Buffalo Run Upper	1	58	6	4	46	8	12	Dry	Dry	Dry	Dry	Dry	19	8
Cedar Run Lower	6	1	30	10	12	66	30	1	28	1	4	10	17	10
Logan Branch Lower	1	48	14	1	12	4	1	22	1	6	1	2	9	3
Logan Branch Upper	1	40	2	18	1	1	18	8	1	6	4	1	8	3
Slab Cabin Run Lower	1	1	1	6	1	8	1	1	18	1	20	16	6	1
Slab Cabin Run Upper	Dry	4	16	4	8	38	22	Dry	Dry	Dry	Dry	Dry	15	12
Spring Creek Axemann	1	62	36	1	36	18	18	20	1	14	20	8	20	18
Spring Creek Houserville	1	1	20	16	1	16	1	1	14	1	14	10	8	6
Spring Creek Milesburg	1	38	1	14	8	1	6	10	1	1	1	4	7	3
Spring Creek Upper	1	1	8	10	6	32	10	1	14	1	1	12	8	7
Thompson Run Lower	8	8	8	6	16	14	6	1	8	1	6	8	8	8

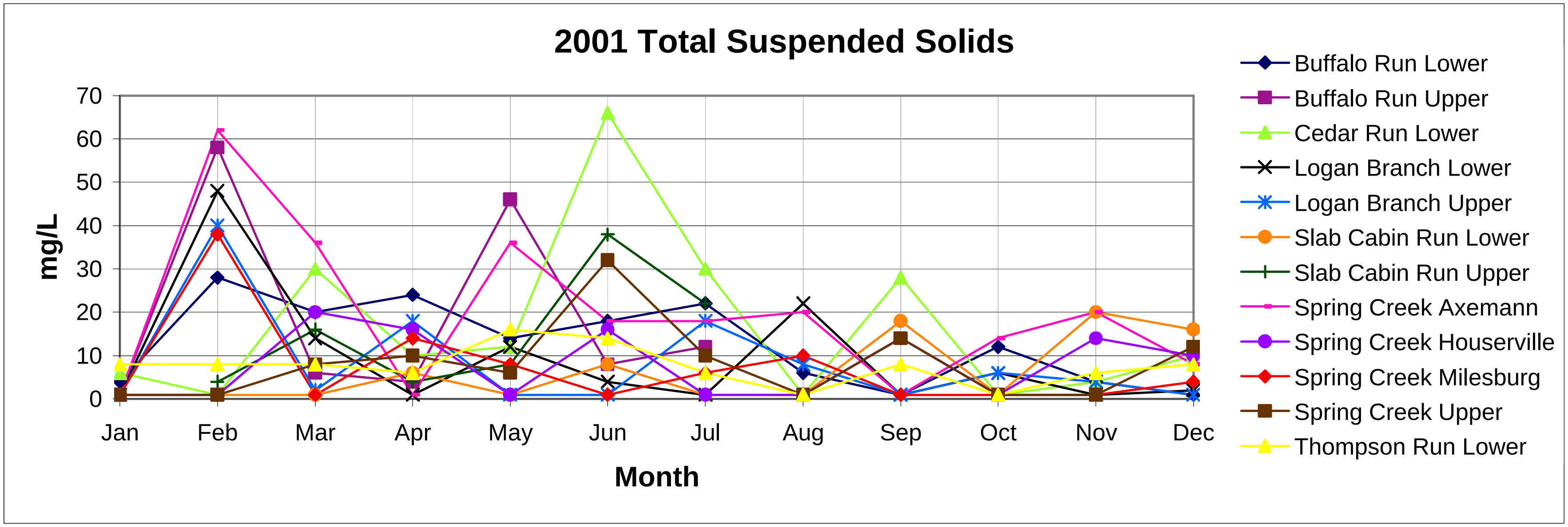

Figure A.3. 2001 WRMP Total Suspended Solids Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 2 mg/L.

Table A.4. 2001 WRMP Turbidity Levels* (NTU).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	1.76	1.78	10.90	8.29	3.92	3.45	8.94	7.24	4.60	3.86	0.50	2.63	4.82	3.89
Buffalo Run Upper	2.09	2.80	10.70	5.50	2.47	3.39	6.28	Dry	Dry	Dry	Dry	Dry	4.75	3.39
Cedar Run Lower	1.14	1.53	13.80	7.48	2.61	4.59	5.15	4.70	5.02	2.61	3.47	3.60	4.64	4.10
Logan Branch Lower	0.50	0.50	5.23	5.20	1.81	0.50	0.50	1.43	1.82	2.66	0.50	0.50	1.76	0.97
Logan Branch Upper	2.05	1.50	8.60	6.81	2.34	1.80	2.92	3.94	3.90	5.86	4.16	2.43	3.86	3.41
Slab Cabin Run Lower	0.50	0.50	7.25	5.01	2.14	2.28	1.51	4.16	1.86	1.06	2.52	1.41	2.52	2.00
Slab Cabin Run Upper	Dry	3.08	10.90	7.24	2.85	3.06	3.72	Dry	Dry	Dry	Dry	Dry	5.14	3.40
Spring Creek Axemann	0.50	1.90	8.10	9.03	4.23	3.80	8.88	5.69	3.55	3.34	2.50	2.95	4.54	3.68
Spring Creek Houserville	1.10	1.17	8.14	4.98	2.04	3.70	3.00	3.52	3.39	2.09	1.61	2.19	3.08	2.60
Spring Creek Milesburg	1.11	1.26	6.34	6.16	4.62	2.12	5.16	3.23	6.22	2.58	3.26	2.67	3.73	3.25
Spring Creek Upper	1.31	0.50	4.90	2.97	1.63	2.04	2.81	2.31	2.04	0.50	0.50	1.68	1.93	1.86
Thompson Run Lower	2.68	1.36	4.00	4.49	1.52	1.90	1.75	1.79	3.21	1.06	1.81	2.58	2.35	1.86

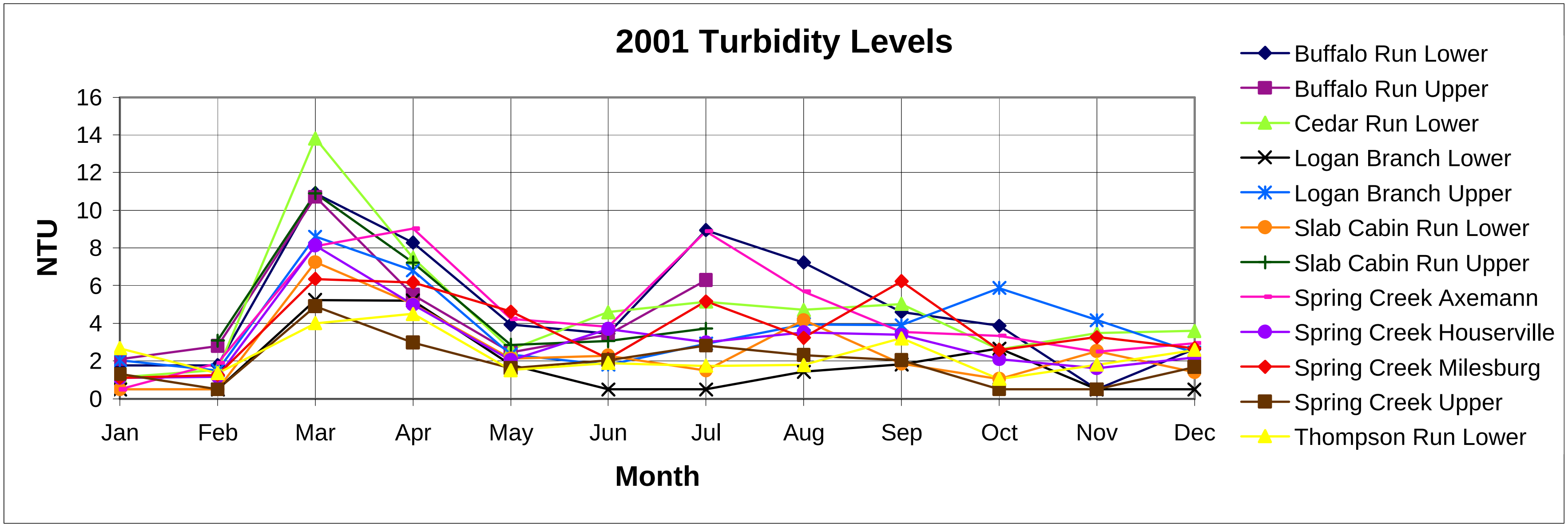

Figure A.4. 2001 WRMP Turbidity Levels (NTU). *Non-detected values shown at one-half detection limit which is 1 NTU.

Table A.5. 2001 WRMP Dissolved Oxygen Concentrations (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	13.7	13.9	13.8	12.7	10.2	10.1	9.3	8.4	10.6	12.3	13.2	12.0	11.7	12.2
Buffalo Run Upper	7.0	12.8	13.9	14.8	11.5	9.9	9.2	Dry	Dry	Dry	Dry	Dry	11.3	11.5
Cedar Run Lower	14.9	13.4	11.8	11.8	11.5	11.9	11.0	11.3	10.8	12.5	12.4	12.5	12.2	11.9
Logan Branch Lower	10.1	11.1	12.5	11.8	10.7	10.7	11.2	10.4	11.8	10.7	11.5	11.1	11.1	11.1
Logan Branch Upper	10.3	10.9	13.6	12.9	12.2	10.2	10.6	9.5	9.6	9.7	8.6	8.8	10.6	10.3
Slab Cabin Run Lower	15.1	16.1	13.3	12.4	13.0	10.7	10.3	9.8	12.0	11.5	11.6	10.8	12.2	11.8
Slab Cabin Run Upper	Dry	11.9	12.8	11.3	12.0	10.2	7.7	Dry	Dry	Dry	Dry	Dry	11.0	11.6
Spring Creek Axemann	12.7	13.4	13.7	13.7	10.7	11.3	11.4	9.4	12.9	11.5	12.1	10.5	11.9	11.8
Spring Creek Houserville	14.6	14.5	13.5	12.6	13.9	13.3	11.3	12.4	12.3	11.0	13.7	12.8	13.0	13.1
Spring Creek Milesburg	11.3	11.6	12.9	12.3	10.1	10.6	10.4	10.2	11.4	11.8	12.1	11.3	11.3	11.4
Spring Creek Upper	10.6	10.7	11.3	11.1	11.2	10.6	9.2	9.9	8.9	9.4	8.5	9.7	10.1	10.3
Thompson Run Lower	13.4	12.2	11.2	11.4	13.4	10.7	10.0	12.6	13.1	13.1	13.2	10.8	12.1	12.4

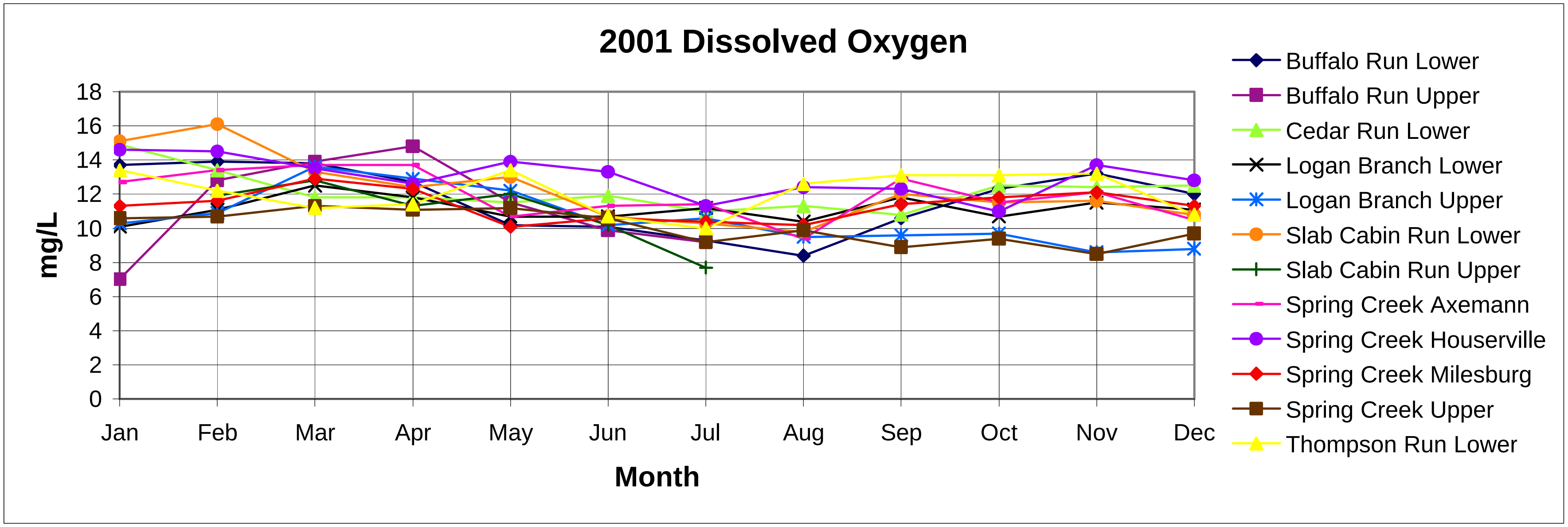

Figure A.5. 2001 WRMP Dissolved Oxygen Concentrations (mg/L).

Table A.6. 2001 WRMP stream pH (Standard Units)														
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP***	**OCT***	**NOV**	**DEC**	**MEAN**	**MEDIAN**
Buffalo Run Lower	8.1	8.0	7.4	7.5	7.7	7.5	8.1	7.9	8.44	8.17	8.2	8.6	8.0	8.1
Buffalo Run Upper	7.5	7.6	7.2	7.7	7.5	7.1	8.3	Dry	Dry	Dry	Dry	Dry	7.6	7.5
Cedar Run Lower	7.8	8.2	7.7	7.1	7.9	7.6	7.6	7.8	8.24	8.17	8.3	8.3	7.9	7.9
Logan Branch Lower	7.7	7.7	7.3	7.3	7.5	7.1	7.7	7.6	8.29	8.00	7.9	8.0	7.7	7.7
Logan Branch Upper	7.3	7.8	7.6	7.3	7.7	7.4	7.8	8.2	8.14	8.04	7.7	8.0	7.7	7.8
Slab Cabin Run Lower	7.8	8.0	7.5	7.2	8.2	7.5	7.4	7.4	8.28	8.22	8.1	8.0	7.8	7.9
Slab Cabin Run Upper	Dry	7.1	7.3	7.1	7.5	7.1	7.1	Dry	Dry	Dry	Dry	Dry	7.2	7.1
Spring Creek Axemann	7.7	8.0	7.4	7.5	7.3	7.5	8.0	7.6	8.38	8.23	8.1	8.0	7.8	7.9
Spring Creek Houserville	8.0	8.2	7.4	7.1	7.9	7.9	7.7	8.0	8.29	8.00	8.4	8.2	7.9	8.0
Spring Creek Milesburg	8.0	8.1	7.8	7.5	7.9	7.6	8.1	8.1	8.54	8.23	8.3	8.6	8.1	8.1
Spring Creek Upper	7.1	7.1	7.2	7.1	7.3	6.9	7.1	7.2	No data	7.68	7.5	7.6	7.3	7.2
Thompson Run Lower	7.8	7.8	7.4	6.9	8.0	7.8	7.3	7.8	8.30	8.24	8.4	8.0	7.8	7.8

*pH measured from water samples collected in field within 36 hours of collection.

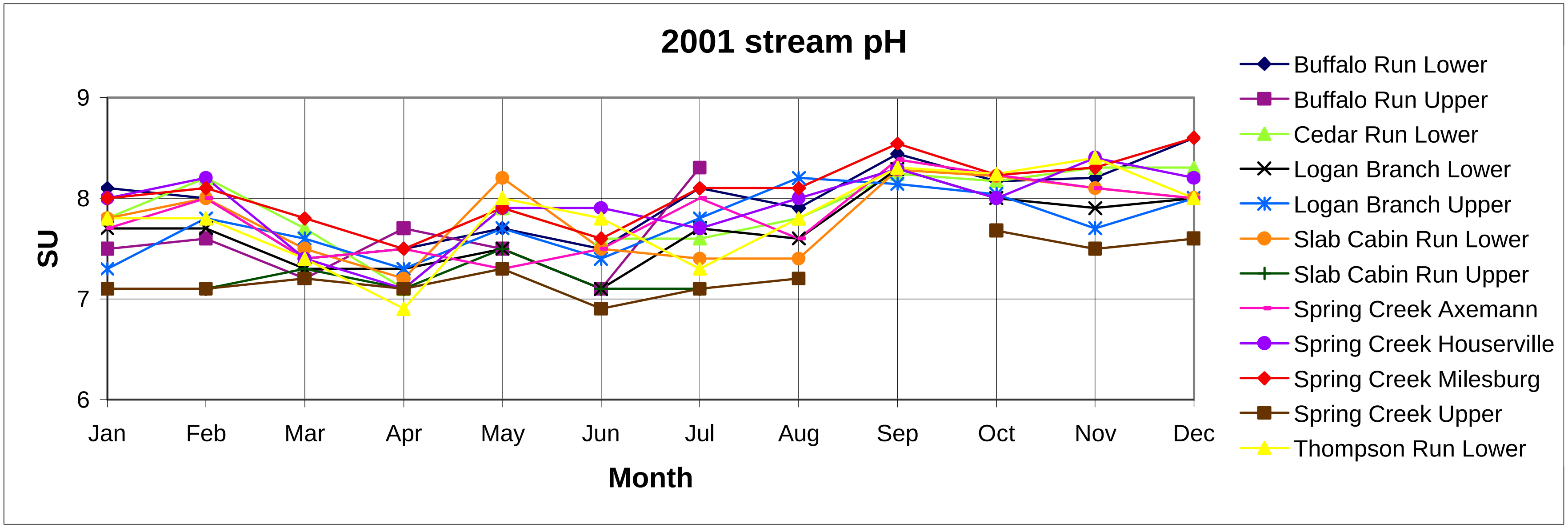

Figure A.6. 2001 WRMP stream pH (Standard Units).

Table A.7. 2001 WRMP Chloride Concentrations* (mg/L).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	14	21	22	19	17	18	16	15	15	14	15	14	17	16
Buffalo Run Upper	21	40	27	23	22	27	28	Dry	Dry	Dry	Dry	Dry	27	27
Cedar Run Lower	13	19	20	18	14	15	16	14	14	14	15	17	16	15
Logan Branch Lower	21	23	26	23	21	22	22	22	21	19	19	21	22	22
Logan Branch Upper	36	39	26	21	31	31	34	37	48	35	34	30	34	34
Slab Cabin Run Lower	100	114	59	41	33	47	60	92	82	71	79	73	71	72
Slab Cabin Run Upper	Dry	49	36	27	25	32	37	Dry	Dry	Dry	Dry	Dry	34	34
Spring Creek Axemann	51	54	48	40	41	50	44	48	56	54	56	48	49	49
Spring Creek Houserville	35	42	37	29	28	33	34	33	36	38	39	34	35	35
Spring Creek Milesburg	36	37	38	33	29	35	33	34	37	33	35	37	35	35
Spring Creek Upper	11	18	14	14	14	18	18	17	17	19	18	14	16	17
Thompson Run Lower	66	59	66	68	58	53	48	49	60	54	54	54	57	56

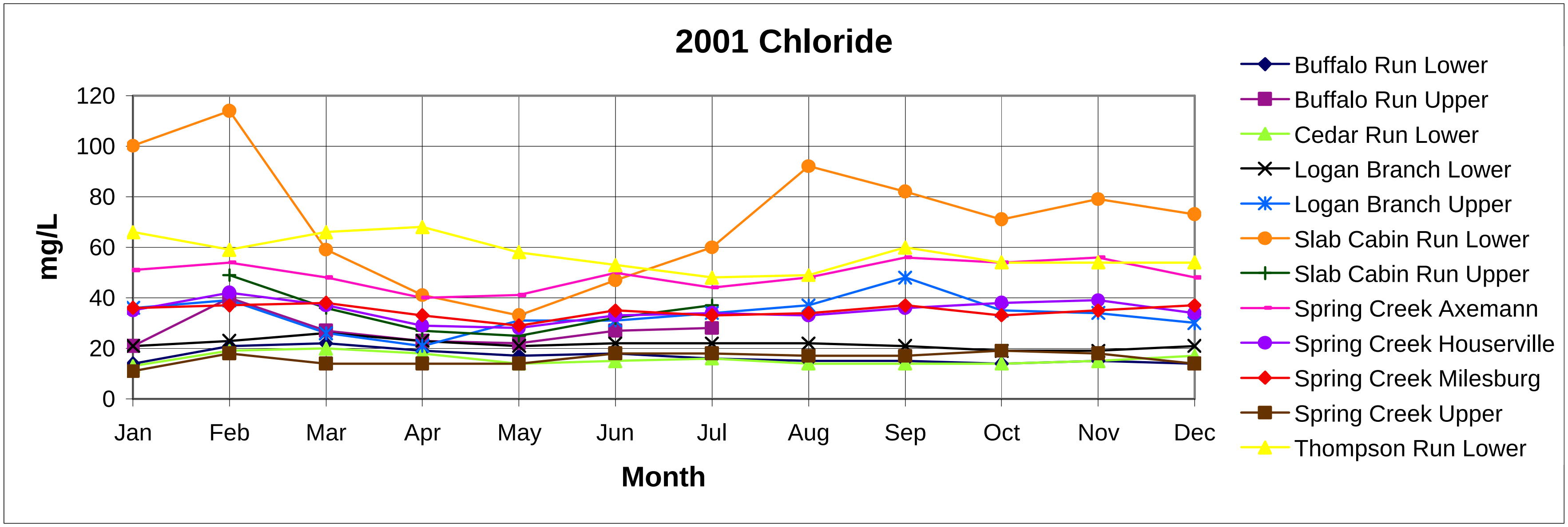

Figure A.7. 2001 WRMP Chloride Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 1 mg/L.

Table A.8. 2001 WRMP Lead Concentrations* (ug/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Buffalo Run Upper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Dry	Dry	Dry	Dry	Dry	0.5	0.5
Cedar Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Logan Branch Lower	0.5	0.5	1.8	1.6	1.6	1.4	1.6	1.3	0.5	1.3	0.5	1.3	1.2	1.3
Logan Branch Upper	4.1	1.8	4.7	2.9	2.6	4.0	4.0	3.7	3.5	3.9	3.2	3.1	3.5	3.6
Slab Cabin Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.1	0.5	0.6	0.5
Slab Cabin Run Upper	Dry	0.5	0.5	0.5	0.5	0.5	0.5	Dry	Dry	Dry	Dry	Dry	0.5	0.5
Spring Creek Axemann	0.5	0.5	0.5	0.5	0.5	1.0	8.1	0.5	0.5	0.5	0.5	0.5	1.2	0.5
Spring Creek Houserville	0.5	0.5	0.5	0.5	0.5	0.5	1.6	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Spring Creek Milesburg	0.5	0.5	0.5	0.5	1.6	0.5	1.2	0.5	1.2	0.5	0.5	0.5	0.7	0.5
Spring Creek Upper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thompson Run Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

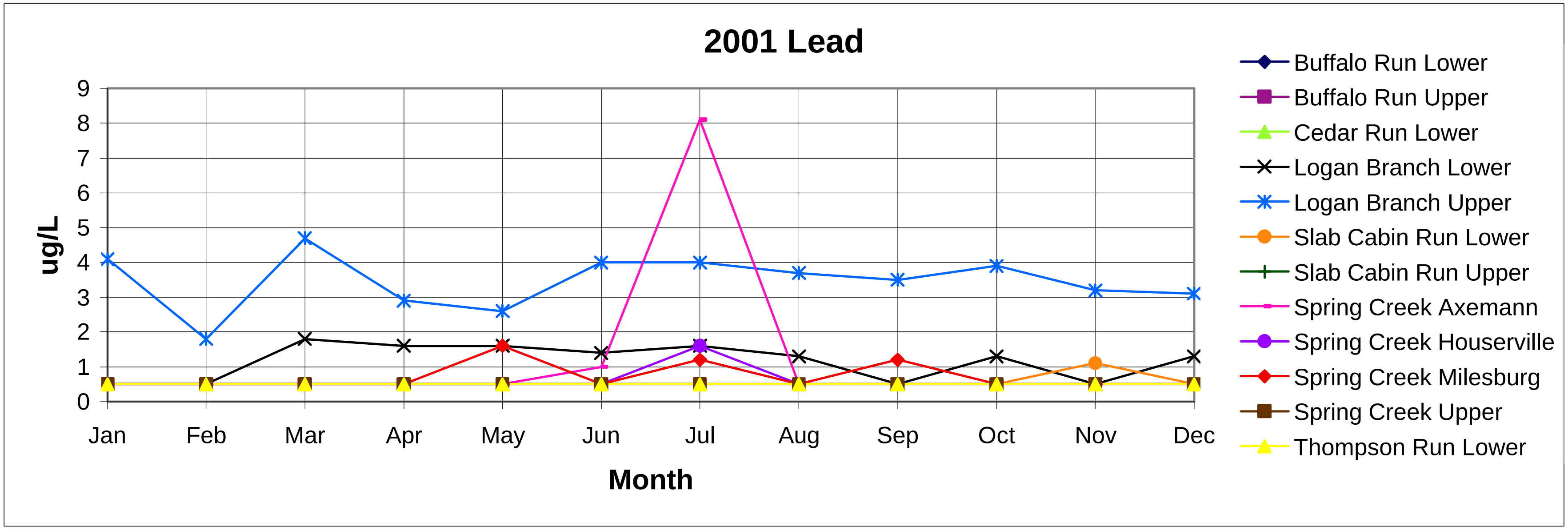

Figure A.8. 2001 WRMP Lead Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 1.0 ug/L.

Table A.9. 2001 WRMP Copper Concentrations* (ug/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Buffalo Run Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	Dry	Dry	Dry	Dry	Dry	2.0	2.0
Cedar Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Logan Branch Lower	4.6	6.3	4.9	2.0	2.0	2.0	2.0	6.2	2.0	6.6	4.1	2.0	3.7	3.1
Logan Branch Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Slab Cabin Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Slab Cabin Run Upper	Dry	2.0	2.0	2.0	2.0	2.0	2.0	Dry	Dry	Dry	Dry	Dry	2.0	2.0
Spring Creek Axemann	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Houserville	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Milesburg	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Spring Creek Upper	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Thompson Run Lower	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

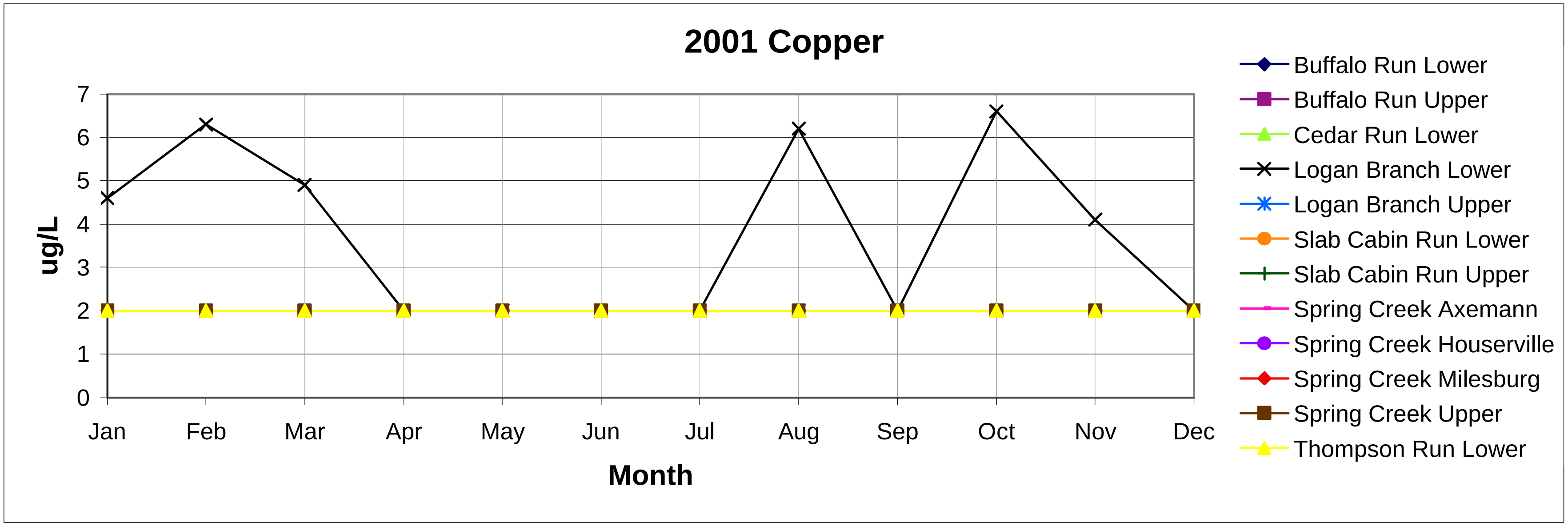

Figure A.9. 2001 WRMP Copper Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 4.0 ug/L.

Table A.10. 2001 WRMP Zinc Concentrations* (ug/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	5	5	5	5	5	5	5	5	5	5	5	20	6	5
Buffalo Run Upper	5	5	5	5	5	5	5	Dry	Dry	Dry	Dry	Dry	5	5
Cedar Run Lower	5	5	5	5	11	5	5	5	5	5	5	5	6	5
Logan Branch Lower	49	41	34	39	20	18	14	14	22	19	15	20	25	20
Logan Branch Upper	5	5	5	5	5	5	11	5	5	5	5	5	6	5
Slab Cabin Run Lower	5	5	5	5	12	5	5	5	5	5	5	5	6	5
Slab Cabin Run Upper	Dry	5	5	5	10	5	5	Dry	Dry	Dry	Dry	Dry	6	5
Spring Creek Axemann	5	10	5	5	46	5	12	5	5	5	12	5	10	5
Spring Creek Houserville	5	5	5	5	11	5	5	5	5	5	5	5	6	5
Spring Creek Milesburg	18	15	11	10	11	5	5	5	5	5	11	10	9	10
Spring Creek Upper	5	5	5	5	12	5	5	5	5	5	5	5	6	5
Thompson Run Lower	5	5	5	5	14	5	11	5	5	5	5	10	7	5

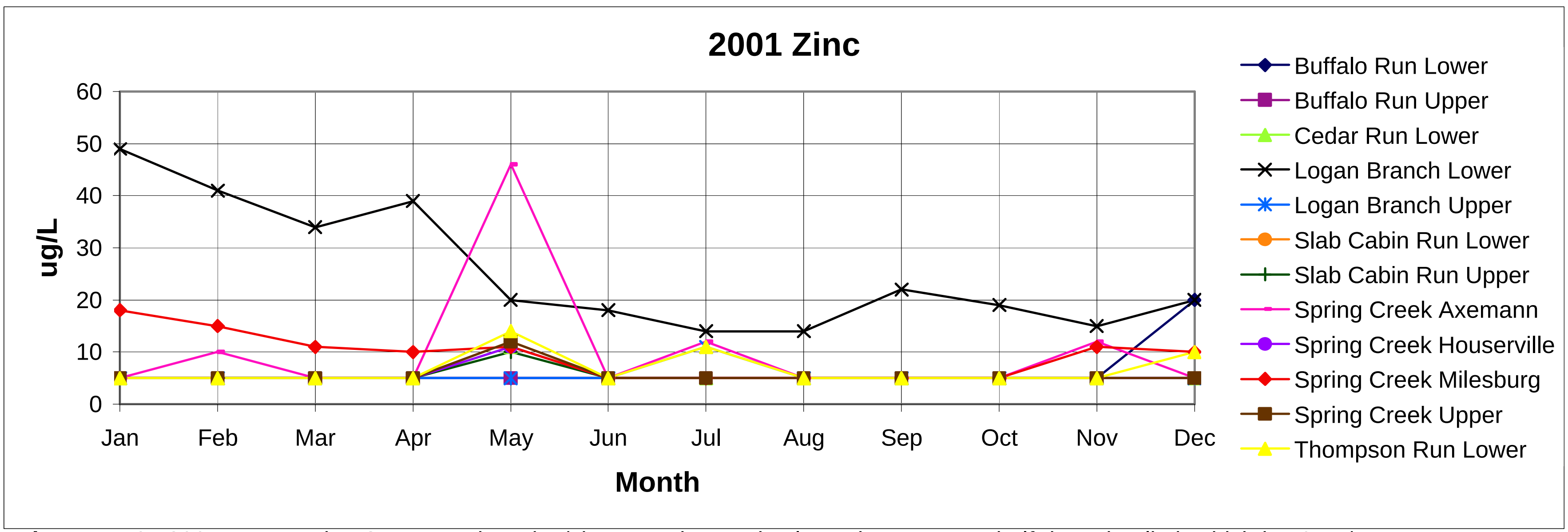

Figure A.10. 2001 WRMP Zinc Concentrations (ug/L). *Non-detected values shown at one-half detection limit which is 10 ug/L.

Table A.11. 2001 WRMP Nitrate Concentrations* (mg/L).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.01	2.17	1.46	1.54	1.68	1.82	1.84	1.79	1.44	1.50	1.56	1.76	1.71	1.72
Buffalo Run Upper	1.39	1.58	1.04	1.11	1.26	1.48	1.69	Dry	Dry	Dry	Dry	Dry	1.36	1.39
Cedar Run Lower	4.55	4.43	4.60	4.82	4.08	3.63	4.40	4.10	4.04	5.08	4.94	3.81	4.37	4.42
Logan Branch Lower	2.55	2.98	2.63	2.81	3.13	3.36	3.08	2.78	3.19	2.81	3.58	2.58	2.96	2.90
Logan Branch Upper	2.53	3.06	2.11	2.57	2.35	2.37	3.45	2.60	3.06	2.61	2.90	2.84	2.70	2.61
Slab Cabin Run Lower	2.14	2.22	1.70	2.01	2.37	1.90	1.69	0.39	1.32	1.73	0.89	1.76	1.68	1.75
Slab Cabin Run Upper	Dry	2.99	1.53	2.01	2.83	2.62	2.37	Dry	Dry	Dry	Dry	Dry	2.39	2.50
Spring Creek Axemann	4.16	5.10	3.65	3.72	4.66	4.68	4.68	4.48	5.98	5.58	7.35	4.65	4.89	4.67
Spring Creek Houserville	3.19	3.32	2.52	2.49	2.60	2.46	2.95	3.43	3.66	3.74	3.61	2.63	3.05	3.07
Spring Creek Milesburg	3.25	3.65	2.74	2.85	2.72	6.80	3.15	3.25	3.29	3.72	3.82	3.45	3.56	3.27
Spring Creek Upper	2.29	2.55	1.38	1.43	1.89	2.43	2.55	2.81	3.03	3.61	3.14	1.86	2.41	2.49
Thompson Run Lower	4.17	4.49	4.30	3.99	3.61	3.97	4.02	4.28	3.89	4.40	4.06	3.37	4.05	4.04

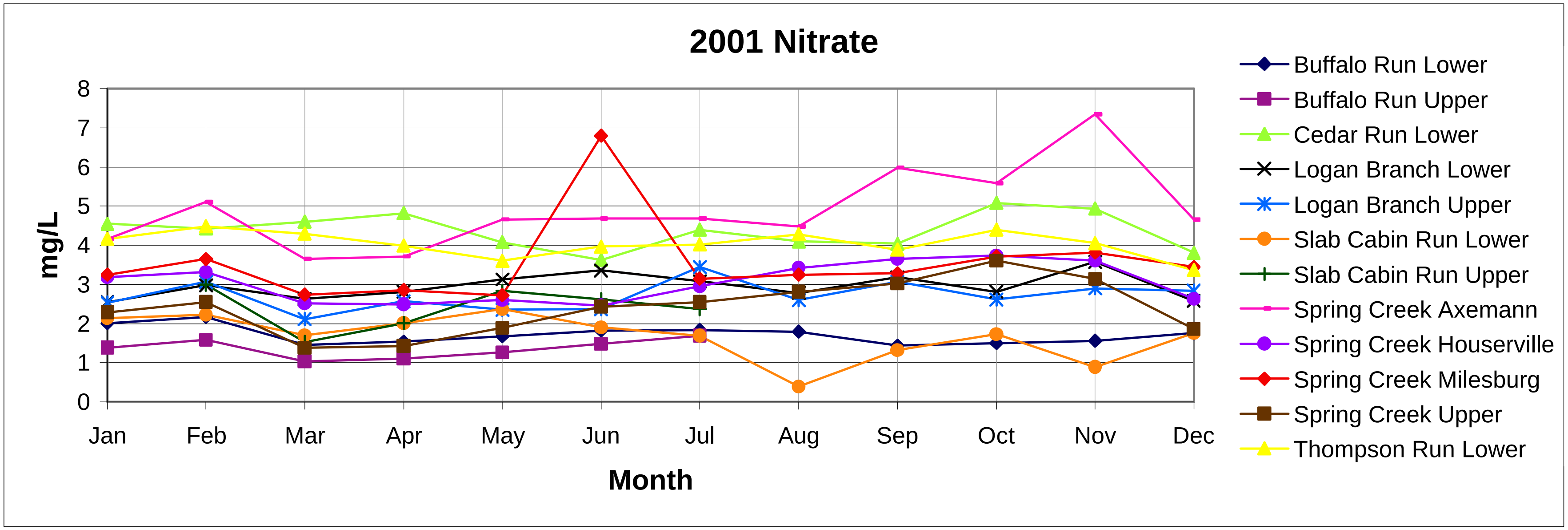

Figure A.11. 2001 WRMP Nitrate Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 0.04 mg/L.

Table A.12. 2001 WRMP Orthophosphate Concentrations* (mg/L).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	0.005	0.005	0.021	0.014	0.012	0.017	0.028	0.019	0.024	0.011	0.005	0.005	0.014	0.013
Buffalo Run Upper	0.012	0.020	0.022	0.012	0.005	0.020	0.029	Dry	Dry	Dry	Dry	Dry	0.017	0.020
Cedar Run Lower	0.005	0.015	0.019	0.005	0.013	0.022	0.022	0.018	0.020	0.014	0.014	0.018	0.015	0.017
Logan Branch Lower	0.011	0.014	0.015	0.014	0.010	0.013	0.018	0.013	0.018	0.012	0.012	0.015	0.014	0.014
Logan Branch Upper	0.060	0.048	0.026	0.028	0.016	0.038	0.034	0.057	0.056	0.054	0.051	0.085	0.046	0.050
Slab Cabin Run Lower	0.005	0.005	0.012	0.005	0.005	0.028	0.030	0.061	0.016	0.005	0.011	0.012	0.016	0.012
Slab Cabin Run Upper	Dry	0.120	0.108	0.019	0.047	0.067	0.088	Dry	Dry	Dry	Dry	Dry	0.075	0.078
Spring Creek Axemann	0.017	0.028	0.032	0.025	0.022	0.034	0.057	0.028	0.027	0.022	0.031	0.050	0.031	0.028
Spring Creek Houserville	0.005	0.010	0.012	0.005	0.005	0.015	0.022	0.019	0.019	0.012	0.010	0.022	0.013	0.012
Spring Creek Milesburg	0.023	0.034	0.021	0.020	0.021	0.030	0.038	0.030	0.037	0.023	0.032	0.043	0.029	0.030
Spring Creek Upper	0.005	0.012	0.013	0.005	0.005	0.010	0.017	0.005	0.012	0.005	0.005	0.013	0.009	0.008
Thompson Run Lower	0.020	0.022	0.018	0.005	0.010	0.023	0.023	0.024	0.031	0.017	0.014	0.036	0.020	0.021

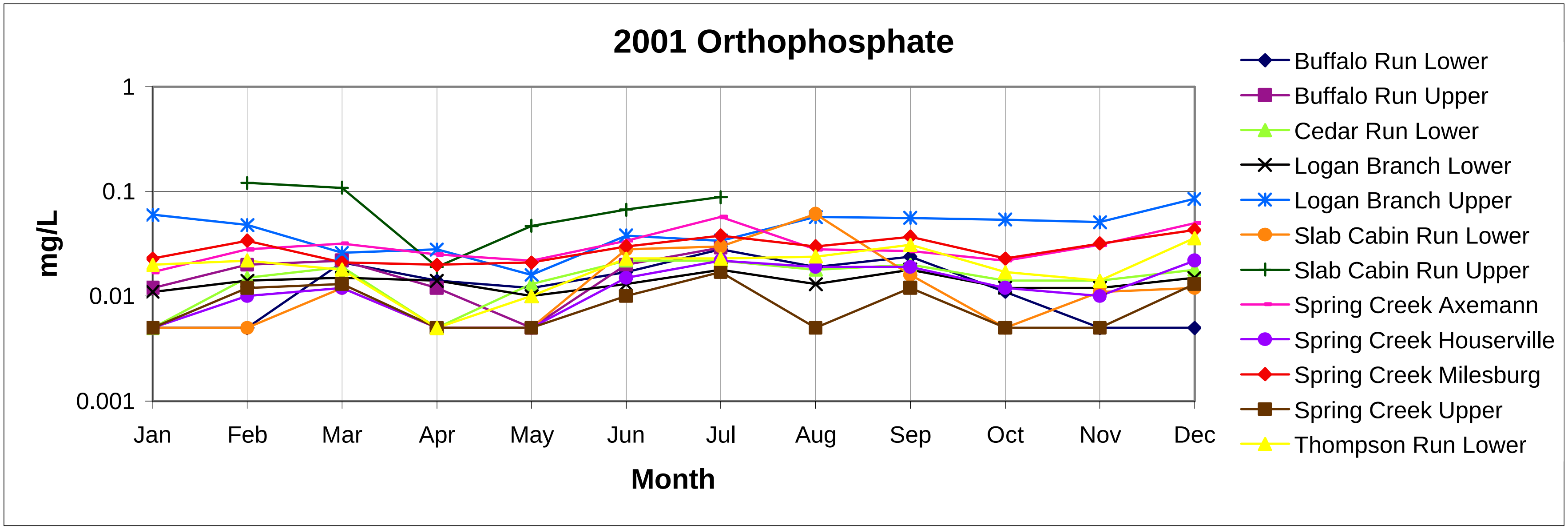

Figure A.12. 2001 WRMP Orthophosphate Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 0.010 mg/L.

Table A.13. 2001 WRMP Total Organic Carbon Concentrations* (mg/L).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	1.0	1.4	1.3	1.2	1.6	1.4	1.6	1.4	1.4	1.9	1.3	1.2	1.4	1.4
Buffalo Run Upper	1.2	1.6	1.6	1.2	1.4	1.7	1.7	Dry	Dry	Dry	Dry	Dry	1.5	1.6
Cedar Run Lower	0.5	1.1	1.0	1.1	1.2	1.1	1.0	1.3	1.4	1.2	1.0	1.1	1.1	1.1
Logan Branch Lower	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Logan Branch Upper	2.3	2.2	1.6	1.4	1.5	1.6	2.1	2.4	2.3	2.1	2.4	2.5	2.0	2.2
Slab Cabin Run Lower	1.5	1.7	1.6	1.4	1.8	2.0	2.2	2.4	2.0	1.7	1.7	1.7	1.8	1.7
Slab Cabin Run Upper	Dry	3.6	2.4	1.6	2.1	2.1	2.5	Dry	Dry	Dry	Dry	Dry	2.4	2.3
Spring Creek Axemann	1.7	2.0	1.9	1.6	1.7	2.0	2.5	2.4	2.0	1.8	2.1	1.8	2.0	2.0
Spring Creek Houserville	0.5	1.2	1.1	1.3	1.3	1.4	1.4	1.1	1.3	0.5	0.5	1.1	1.1	1.2
Spring Creek Milesburg	1.3	1.4	1.5	1.3	1.6	1.4	1.6	1.4	1.3	1.2	1.1	1.2	1.4	1.4
Spring Creek Upper	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.6	0.5
Thompson Run Lower	0.5	0.5	0.5	1.3	1.3	1.0	1.1	0.5	1.0	0.5	0.5	1.0	0.8	0.8

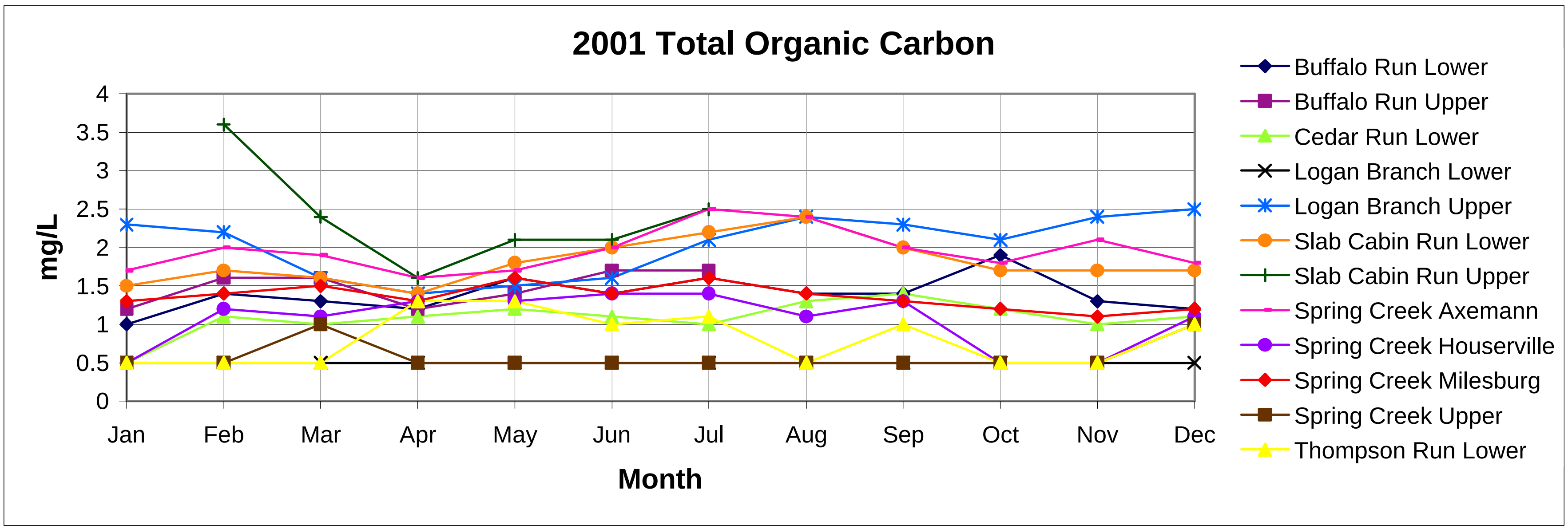

Figure A.13. 2001 WRMP Total Organic Carbon Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 1.0 mg/L.

Table A.14. 2001 WRMP Petroleum Hydrocarbon Concentrations* (mg/L).														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MEDIAN
Buffalo Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Buffalo Run Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Dry	Dry	Dry	Dry	Dry	2.5	2.5
Cedar Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	No data	2.5	2.5	2.5	2.5	2.5
Logan Branch Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Logan Branch Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.5	2.5	2.5	2.8	2.5
Slab Cabin Run Lower	2.5	2.5	2.5	5.0	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.7	2.5
Slab Cabin Run Upper	Dry	2.5	2.5	2.5	2.5	2.5	2.5	Dry	Dry	Dry	Dry	Dry	2.5	2.5
Spring Creek Axemann	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Spring Creek Houserville	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5
Spring Creek Milesburg	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.2	2.7	2.5
Spring Creek Upper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Thompson Run Lower	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	No data	2.5	2.5	2.5	2.5	2.5

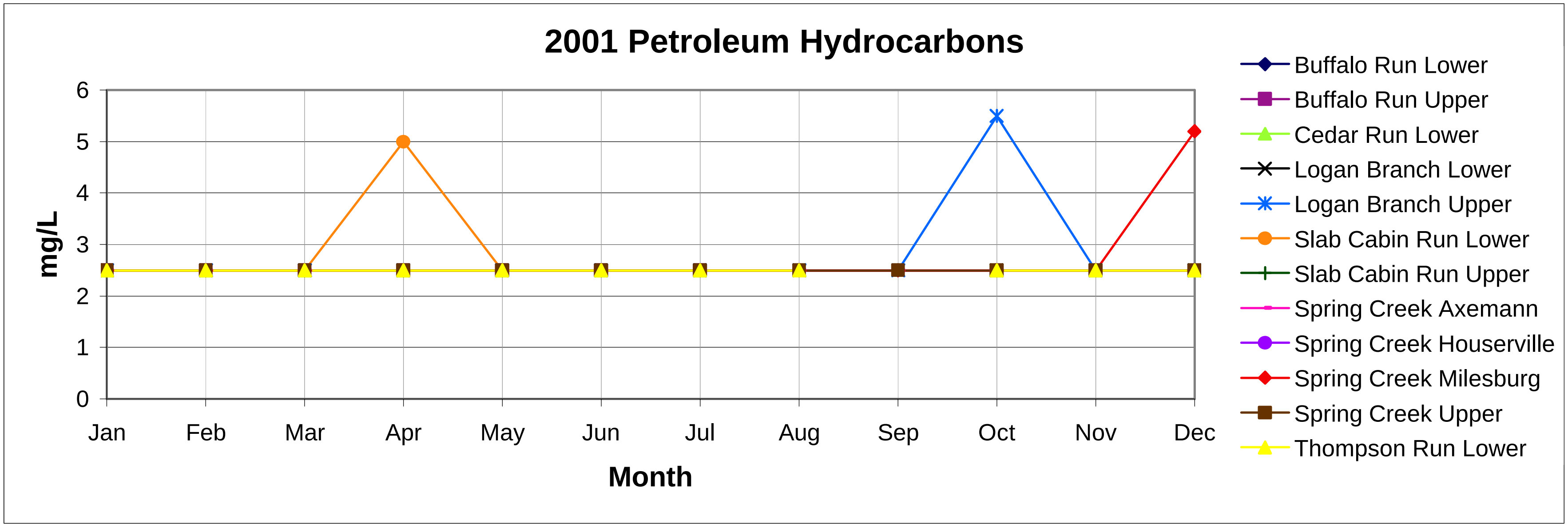

Figure A.14. 2001 WRMP Petroleum Hydrocarbon Concentrations (mg/L). *Non-detected values shown at one-half detection limit which is 5.0