

Water Quality Nutrient Analysis of Spruce Creek, Pennsylvania
Evan Teeters, Juniata College
Dr. Ryan Mathur, Juniata College



Figure 1: Spruce Creek at SC2

Abstract

Spruce Creek flows through seven miles of limestone bedrock in Huntingdon County, Pennsylvania. Being one of the premier trout fisheries in the state, Spruce Creek economically bolsters an otherwise agricultural economy. Several large farms, including the state's largest Concentrated Animal Feeding Operation (CAFO), are found along the banks of the stream and have caused contention between farmers and sportsmen who are concerned about the health of the fishery. In order to monitor the health of the stream, we conducted a baseline study focusing on nitrates and phosphates, total dissolved solids, pH, temperature, and discharge.

Nitrate concentrations on Spruce Creek averaged between 9.0 and 11.0 ppm NO_3 . Phosphate concentrations averaged between 0.0 and 0.06 ppm PO_4 . Phosphate concentrations showed a direct relationship with discharge, while nitrate concentrations were primarily independent of discharge. These findings suggest a different source of the two nutrients entering the stream, which contradicts the initial assumption that agricultural runoff was the primary source for nutrients. Nitrate and phosphate

concentrations were higher directly below farm areas than above, and tended to decrease with increasing distance from farms. Total dissolved solids also followed a similar trend. For comparison purposes, the same baseline was also conducted upstream and downstream of the confluence of Spruce Creek and the Little Juniata River. Total dissolved solids below the confluence were 20.0 to 50.0 ppm higher than above the confluence, and nitrate concentrations were 40 percent higher below the confluence. Phosphate concentrations did not differ considerably.

Introduction

Spruce Creek is one of the many spring-fed, limestone streams flowing through central Pennsylvania. The stream is roughly seven miles long, and is mostly straight with several small meanders dotted along its length. Its cool, clear waters provide excellent habitat to the large rainbow and brown trout for which it is known. Most of the stream banks are posted, and public access is limited to one stretch of

lease land from landowners, and provide fishing opportunities on the stream. Many anglers travel from outside the area to fish the stream and bring money into the economy, not only by paying to fish, but by patronizing local restaurants, lodges, and businesses.

Agriculture is also important along the banks of Spruce Creek. Pennsylvania's largest livestock operation is located along the stream, and is home to over 1,300 head of cattle. Most of the required feed is grown on the large agricultural complex, and animal wastes are stored on the grounds for use as fertilizer. Pennsylvania State University's agricultural complex is also located on Spruce Creek, as are several smaller farms.

Over the years, those who live along its banks and those who frequent its waters have noticed a dramatic decline in the quality of Spruce Creek's fishery. Many people point to the large farms that share the stream bank as the major contributors to the problem, claiming that agricultural inputs have led to higher levels of algae, lower oxygen levels, decreased insect populations, and higher temperatures.

The major problem in either substantiating or dismissing these claims is a glaring lack of information on the water itself. While many studies have been done on Spruce Creek, most of them focus on the stream's biota. When locals notify the Department of Environmental Protection (DEP) concerning possible releases into the stream, the DEP will take water samples to test. However, since there have been no known studies done on the water chemistry itself, there is no background data with which to compare these samples.

Overcoming this lack of background data is the focus of this study. Nutrient concentrations are a good indicator of water quality, and seem particularly pertinent in assessing the agricultural impacts on the stream. The nutrient indicators chosen for study are phosphates and nitrates; total dissolved solids, temperature, turbidity, discharge, and time of day are used for comparison purposes. Samples are taken from six different sites, three on Spruce Creek, one on Warrior's Mark Run (a small tributary of Spruce Creek),

and two on the Little Juniata River. Sampling sites are shown in Figure 2. All data is then compiled into a nutrient baseline for future reference

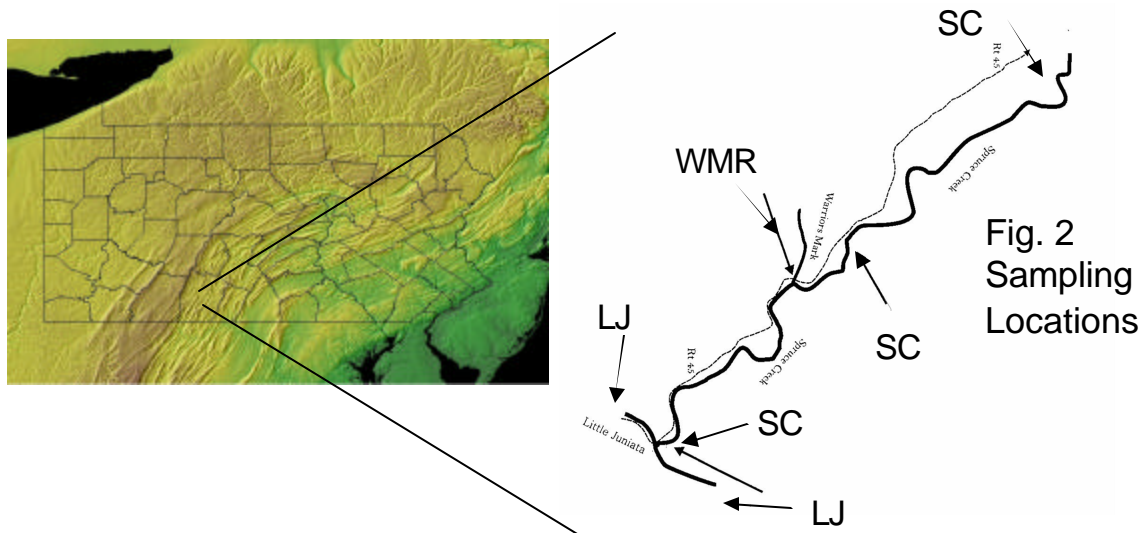


Figure 2: Sampling Locations

Methods

Sampling

Six main locations were used for this study. Site SC1 is the farthest point upstream, located in the small town of Graysville, PA. Although this location is downstream of several small farms and Penn State University's agricultural fields (thus prone to agricultural influence), SC1 was chosen as the pre-agricultural control site because of its location immediately above a large agricultural complex. Site SC2 is located immediately downstream of the agricultural complex, in the town of Franklinville, PA. It was chosen due to its proximity to the farm and accessibility on land open to the public. Site WMR1 is located approximately one-half mile downstream from SC2. WMR1 is on Warrior's Mark Run, a small tributary to Spruce Creek. Warrior's Mark represents a slightly different drainage than Spruce Creek, and was the site of an agricultural spill in the early 1980's that led to a large fish kill on Spruce Creek. Site SC3 is located in the town of Spruce Creek, PA, at the mouth of Spruce Creek. Site LJ1 is located approximately three hundred yards downstream from the confluence of Spruce Creek and the Little Juniata River. LJ1 allows for comparison between Spruce Creek and a river with a much larger drainage, and also enables the monitoring of the stream's downstream effects on the river. LJ2 is located approximately five-hundred yards upstream from the confluence and is used to monitor nutrient levels in the Little Juniata River before it mixes with Spruce Creek.

Several other sampling locations were also briefly used during the summer. The Cottage Pool (CP) on Spruce Creek was used for collection in the beginning of the summer, but was soon discontinued due to frequent unavailability. Two locations on the Little Juniata River were used only once in order to trace a possible source of phosphate contamination.

Samples were taken five days each week between May and August, and have been taken two days each week since then. Additional samples are also collected following rain events. Sampling was done at various times of day to account for temporal variation.

Laboratory Procedure

Nitrates are tested using a cadmium reduction method. Phosphates are tested using potassium persulfate followed by sulfuric acid digestion. Turbidity is measured by simple spectrophotometric analysis. All procedures are outlined in the HACH Water Analysis Handbook, 2nd edition.

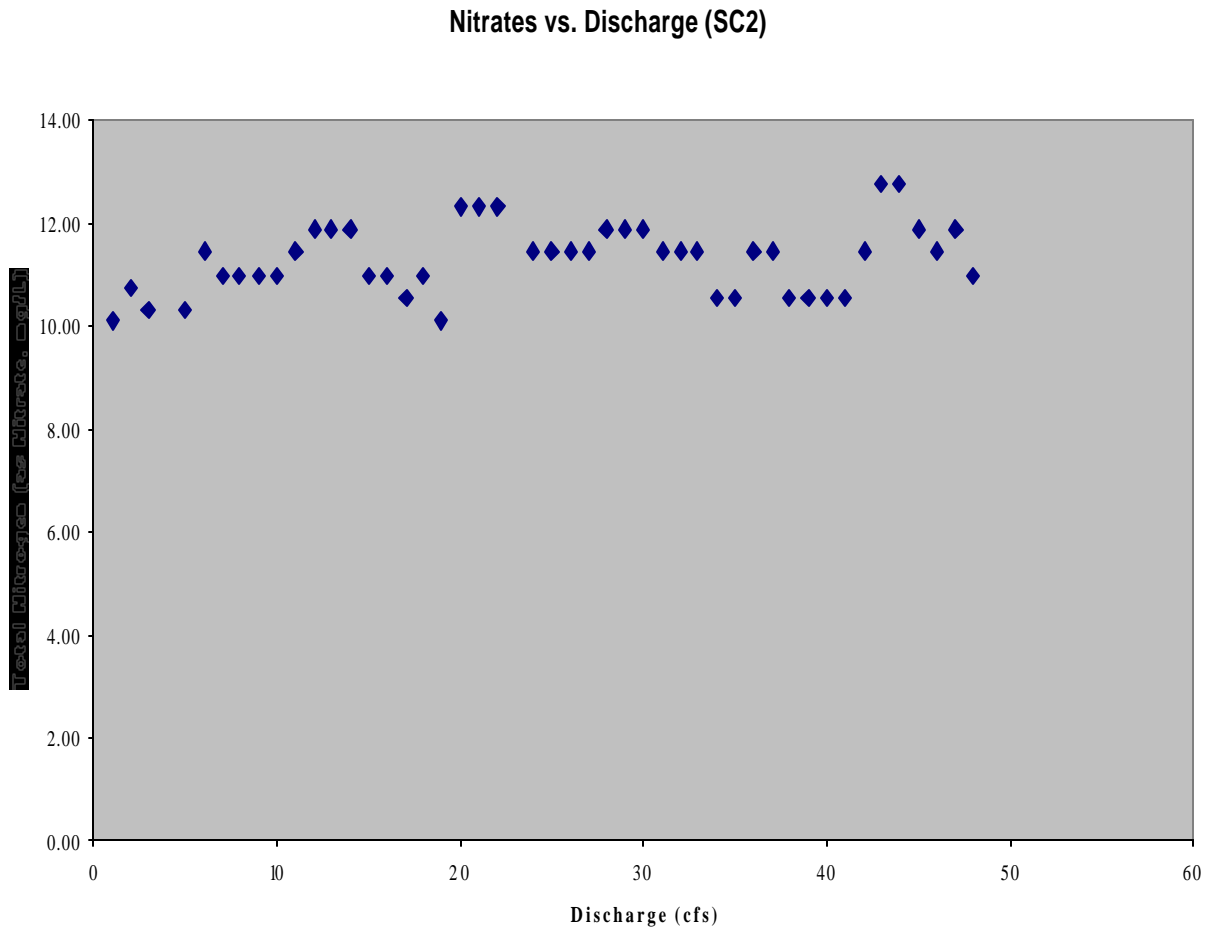


Figure 3

Phosphate vs. Discharge

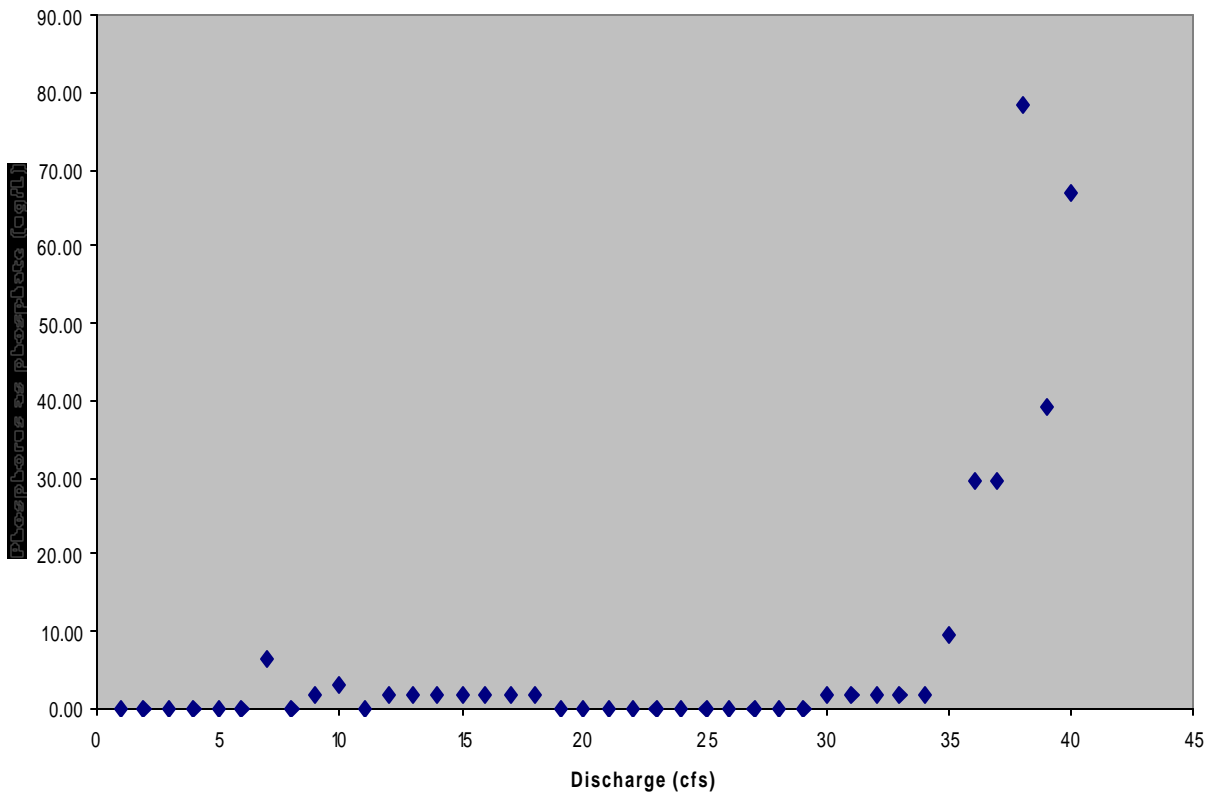


Figure 4

Results

Nutrient Concentrations

Nitrate concentrations on Spruce Creek (reported as total nitrogen) were relatively constant throughout the study period, staying mainly between 10.5-mg/L and 11.5-mg/L. Nitrate concentrations also showed little variation with discharge, as seen in Fig. 3. Nitrate concentrations on Warrior's Mark Run (WMR1) were also relatively stable, remaining between 7.5-mg/L and 8.5-mg/L, but showed variation with discharge. On the Little Juniata River, nitrate concentrations varied widely. For the majority of the summer, concentrations stayed between 7-mg/L to 8.5-mg/L. In September, however, concentrations peaked at 14.6 mg/L.

Phosphate concentrations on Spruce Creek (reported as total phosphorus) were also fairly constant throughout the summer, with levels staying near 2.0-µg/L. In September, however, phosphate levels peaked at 87.0-µg/L, nearly fifty times the summer levels. Phosphate levels on Warrior's Mark Run remained nearly constant at 0.002-mg/L throughout the summer, but peaked at 39.0-µg/L in September. Concentrations on the

Little Juniata River varied greatly, averaging 2.0- $\mu\text{g/L}$ during the summer and peaking at 485.0- $\mu\text{g/L}$ in September. Phosphate levels varied greatly with discharge, as seen in Fig.4.

Lateral Variation

Nutrient concentrations increase from SC1 downstream to SC2. Concentrations are consistently highest immediately downstream from Evergreen Farms, Inc. (SC2) and decrease as one travels to the mouth of Spruce Creek (Figs. 5 and 6). Temperature increases downstream, as one would expect.

For most of the summer, Warrior's Mark Run (WMR 1) showed lower nutrient concentrations and temperature than Spruce Creek (SC 1, 2, and 3). The Little Juniata River downstream from Spruce Creek (LJ1) was very similar to the mouth of Spruce Creek (SC3), while upstream (LJ2) nutrient concentrations tended to be lower throughout the summer. Both LJ1 and LJ2 maintained similar or lower nutrient concentrations compared to Spruce Creek.

The beginning of September brought drastic changes in lateral patterns, especially on the Little Juniata River. Although nutrient concentrations on Spruce Creek rose drastically in the beginning of September, the lateral pattern of nutrient decrease downstream continued. Concentrations on Warrior's Mark Run remained lower than Spruce Creek during this time. The lateral pattern on the Little Juniata River, however, dramatically reversed, with LJ2 showing much higher concentrations than LJ1 (Figs. 5 and 6).

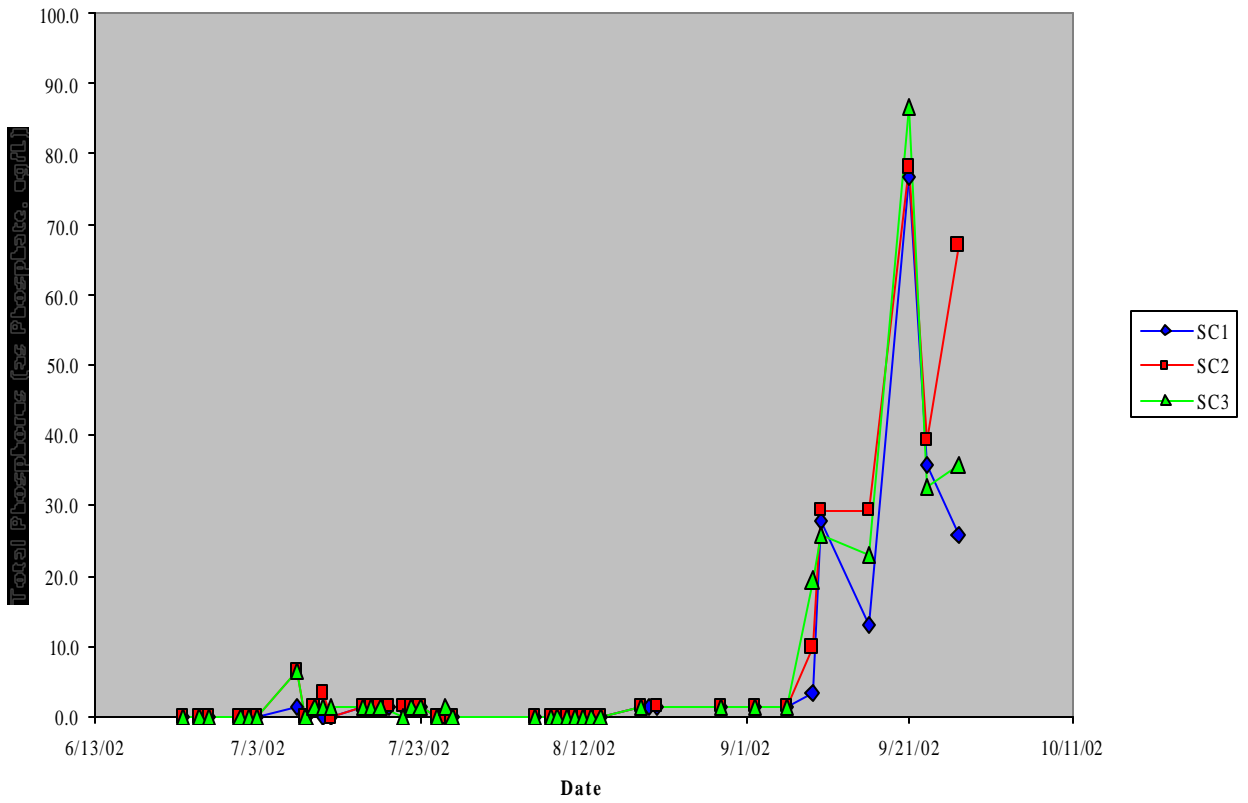
Discussion

Agricultural Impacts

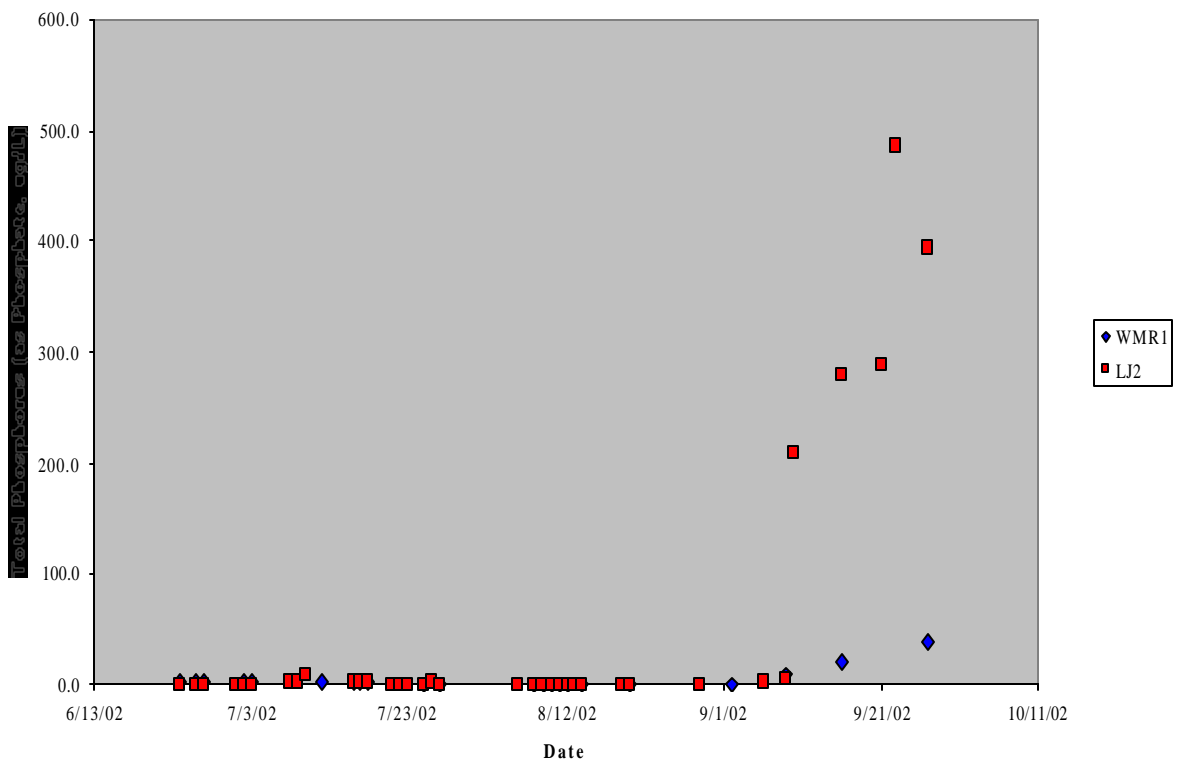
Comparison of nutrient concentrations on Spruce Creek with water quality standards as established by the Environmental Protection Agency (EPA) in the Clean Water Act provides an indication of the stream's relative health. EPA standards for total nitrogen and total phosphorus on moving waters not emptying into standing water are 0.31- mg/L and 10.0- $\mu\text{g/L}$, respectively. Average values of 10.5- mg/L to 11.5- mg/L for total nitrogen are significantly higher than levels recommended by the EPA (Fig. 5). Summer values of 2.0- $\mu\text{g/L}$ total phosphorus are below recommended levels, but raise dramatically above EPA guidelines in early September (Fig 6).

Below: Figures 5a, 5b and 6a, 6b

Phosphate Concentrations for Spruce Creek, PA



Phosphate concentrations for Warrior's Mark Run and the Little Juniata



Undoubtedly, agricultural activities along Spruce Creek are a major factor in the nutrient enrichment of the stream. Highest nutrient levels at SC2, which decrease with distance downstream of the large agricultural complex, illustrate this impact. This nutrient loading leads to several changes not indicated in the data, but observed throughout the summer. At SC1, heavy insect hatches were frequent and numbers of insects on the water were nearly impossible to determine. At SC2, however, these hatches were sparse to nonexistent, and did not return until much further downstream

Stream Comparison

If drainage size were the determining factor in nutrient levels, the Little Juniata River should have had the highest concentrations, followed by Spruce Creek and then Warrior's Mark Run. Throughout the summer, however, Spruce Creek had the highest nutrient levels of the three streams studied. Agricultural influences were obviously high enough to overcome the influence of drainage size (Dingman, 1984).

The negative impacts of Warrior's Mark Run on Spruce Creek were minimal, as concentrations were consistently lower. However, lower concentrations at WMR1 may have been due to lower discharge. If Warrior's Mark had any impact on Spruce Creek, it was to dilute nutrient concentrations, even if minimally.

Spruce Creek had two opposing effects on the Little Juniata River. During the summer, Spruce Creek added nutrient-rich water to the river and increased concentrations downstream. On the other hand, during times of nutrient loading in the river, the added volume of Spruce Creek diluted nutrient concentrations downstream.

Nutrient Variations

The initial assumption upon beginning this study was that nitrates and phosphates in Spruce Creek came from the same source – fertilizers. If this were true, examination of nitrate and phosphate levels versus discharge would reveal similar patterns. However, as Fig. 4 and Fig. 5 show, this is not the case. Since nitrate levels fluctuate relatively little with discharge, there must be a constant supply of nitrates to the stream.

One possible source of nitrates is waste from the livestock that are constantly in contact with the stream and stream banks. Nitrogen fixation by vegetation, both natural and planted, along the stream bank could also account for a constant supply of nitrates (Kehew, 2001). Since phosphate concentration varies significantly with discharge, it is assumed that phosphorus is introduced from outside the stream. The likely source of phosphorus is synthetic fertilizer applied to the field, which is then washed into the stream by runoff. Since very little rain fell in the region during the summer, very few of these fertilizers reached the stream, but instead remained in the vegetation and the soil. This lack of runoff, along with the fact that phosphorus is the limiting nutrient in freshwater and any excess would be quickly used for algae and plant growth, resulted in the low phosphate concentrations during the summer.

Several factors led to the dramatic increase in nutrient concentrations in September. During the first week of the month, farmers harvested crops, reducing vegetative cover and exposing the ground to direct rainfall. At the same time, fertilizers were applied liberally to the now almost bare ground. Beginning the second week of September, heavy rains fell in the region for the first time since late May. Crop cover no longer absorbed the rain, which washed the newly applied fertilizers (along with those remaining in the soil) into the stream. The combination of these factors led to the large peaks seen in Fig. 5 and Fig. 6.

There could be several reasons for the excessive increase in nutrient concentrations seen in the Little Juniata River during September. Although farming is prevalent along its banks, it is unlikely that all of the nutrients came from farm runoff. No septic tank or manure pit leaks were reported, nor were any highway spills. Two railroad bridges cross the river roughly one mile upstream from LJ2, and chemicals or fertilizers carried in railroad cars could have leaked

Summary/Conclusions

Agriculture along the banks of Spruce Creek has impacted the water quality of the stream. Nutrient levels on Spruce Creek are highest immediately below its most heavily farmed stretch, and decrease with increasing distance from agricultural areas. Average nitrate concentrations of 10.5-mg/L to 11.5mg/L total nitrogen are higher than EPA recommendations for rivers and streams in the area. Summer phosphate concentrations of 2- μ g/L total phosphorus are below EPA recommendations, but rise dramatically in the fall to nearly 90- μ g/L total phosphorus, well over EPA standards. Continued testing will enable a more accurate view of seasonal variations in water quality and of the impacts of farming on the stream.

Acknowledgements

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Colerain Fishing Club. (personal communication)

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