Review of Warriors Mark Run and Lower Spruce Creek Data
Submitted by Professor David Lehmann (Juniata College)

Review Conducted by
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9/30/05

Background

Warriors Mark Run is a tributary to Spruce Creek located in Centre and Huntingdon Counties. The entire Spruce Creek watershed has been assessed using the DEP's Unassessed Waters Screening Protocol. Portions of the upper mainstem Spruce Creek and a headwater tributary (Halfmoon Creek) are listed as not attaining aquatic life use due to degraded habitat conditions (Figure 1). The entire Right Branch of Warrior Mark Run watershed and a 1.00 mile-long segment of the mainstem Warrior Mark Run (WMR), immediately downstream of the confluence of the Right and Left Branches, are listed as not attaining aquatic life use due to degraded habitat and biological conditions. Aquatic life use is being attained throughout the remainder of the mainstem WMR downstream to its confluence with Spruce Creek.

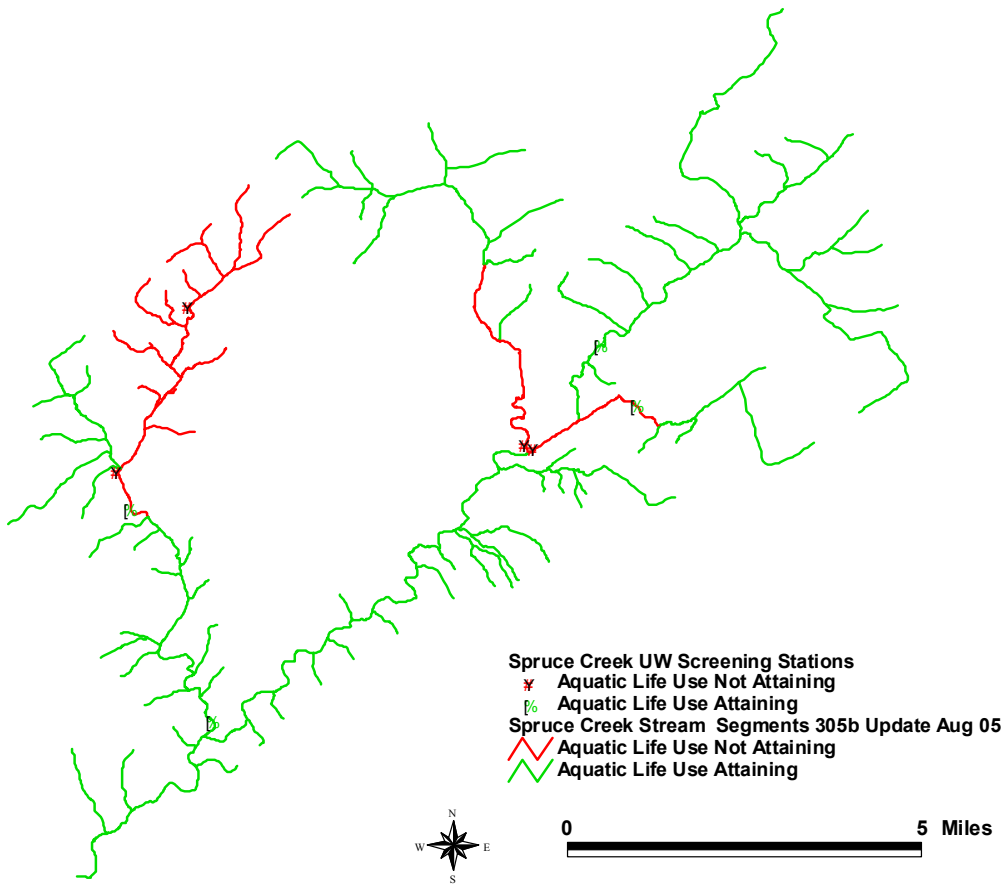

Figure 1. DEP Unassessed Waters Aquatic Life Use Attainment Screening Stations and Aquatic Life Use Attainment Status of Stream Segments in the Spring Creek Watershed, Centre and Huntingdon Counties, Pa.

Over the past several years, students from Juniata College have been collecting chemical water quality data at 17 sample sites in the Spring Creek watershed. In addition to chemical water quality data, stream discharge and benthic macroinvertebrate data have been collected at selected sites. Raw chemical water quality and stream discharge data and a narrative report summarizing the benthic macroinvertebrate data (Wilson and Diesel, 2005), was submitted to the DEP in late August, 2005, by Professor David Lehmann. Raw benthic macroinvertebrate data was submitted to the Department in mid-September, 2005 at the request of Department staff.

All data was submitted electronically along with an e-mail from Professor Lehmann stating that the ultimate goal of the Juniata College monitoring project is to produce a TMDL for Spruce Creek (along with Penn State's Center for Watershed Stewardship). DEP staff reviewed all data submitted to determine if all applicable chemical water quality criteria are being met and to identify inconsistencies between the Juniata College benthic macroinvertebrate data and comments/conclusions expressed in Wilson and Diesel (2005) and the existing aquatic life use attainment status of stream segments in the Spruce Creek watershed.

Comparison of Chemical Water Quality Data to State Criteria

Three parameters with water quality criteria listed in Chapter 93 were included in the data submitted:

Parameter	Criteria	Water Use Protected
pH	6.0 – 9.0	CWF, WWF, TSF, MF
TDS	Max 750 mg/l	
	500 mg/l Monthly Average	PWS
NO2 plus NO3-N	Max 10 mg/l as N	PWS

Minimum and maximum values reported in the data summary table indicate that pH values exceeding the 9.0 maximum criterion were recorded at four sample sites:

Site 1 Little Juniata (upstream of SC)	Max pH = 9.5	Site 13 Neff and 350	Max pH = 9.7
Site 9 McCorkel Tree Farm	Max pH = 9.1	Site 15 Center Line Road	Max pH = 10.0

One of the 211 nitrate-nitrogen values recorded at Site 8 (Warrior's Mark above SC confluence) exceeded the 10 mg/l maximum criterion (maximum NO_3-N = 34.4 mg/l). No exceedances of the TDS maximum criterion of 750 or the monthly average criterion of 500 mg/l were reported in the data submitted.

The water use attainment status of sample sites with monitoring values that exceeded the numeric criterion for a given parameter were determined by comparing the upper 95% confidence limit of the 90th percentile value of the least-squares probability plot (lognormal base$_{10}$) to the appropriate regulatory criterion. For the Juniata College data, this included pH data from Sites 1, 9, & 15 and NO3-N data from Site 8. This analysis was also run on pH data from Site 13 Neff and 350, but no conclusion was drawn re: water use attainment status since the dataset from this site did not meet the minimum requirement of data being collected over a period of at least one year. The results of these analyses indicate that no water uses are impaired based on the data submitted (Table 1). The data also suggest that continued data collection efforts at Site 13 Neff and 350 may result in listing pH as one of the sources of aquatic life use impairment at this site.

Table 1. Summary of Water Use Attainment Status Determination Analysis Results.

Site	1	9	15	8	13*
Parameter	pH	pH	pH	NO_3-N	pH
Maximum value	9.5	9.1	10.0	34.4	9.7
Minimum value	7.2	7.8	7.7	0.2	7.9
Mean	8.1	8.3	8.2	2.9	8.6
Number of Observations	156	173	145	211	25
Number of Exceedances	5	1	1	1	1
Percent Exceedance	3.2	0.6	0.7	0.5	4.0
90th %tile (lognormal base 10 LS, 95% UCL 1-tailed)	8.6	8.6	8.6	6.0	**9.2**
Use Attainment Status	**Attaining**	**Attaining**	**Attaining**	**Attaining**	

* Dataset does not meet the minimum data collection period requirement of one year

Aquatic Life Use Attainment

Juniata College students collected benthic macroinvertebrates using a 500 um D-net to capture organisms dislodged from six different 0.5 m x 0.5 m locations (a total sample area of 1.5 m^2 assuming a 0.5 meter-wide net) within a 10-meter long reach of stream, downstream of riffles. Organisms were then placed in Ziploc bags filled with stream water, transported to the lab, separated by species, and one or more of each of these organisms were placed in a specimen vial with ethanol, and all organisms were then identified to order (Wilson and Diesel, 2005)

The DEP Unassessed Waters macroinvertebrate sampling method used to determine the existing aquatic life use attainment status of stream segments in the Spring Creek watershed involved using a 1.0 m^2 kick-net to collect organisms dislodged from two1.0 m^2 areas of stream substrate in riffle habitat (a total sample area of 2.0 m^2). In the field, all organisms collected in the net were transferred to a pan and identified to family (or genus for some taxa). The relative abundance of each taxon was also documented.

Differences in the macroinvertebrate data collection methods reported by Wilson and Diesel (2005) and those used to make DEP aquatic life use attainment decisions preclude making meaningful, direct comparisons of the raw data generated by these different methods. Thus, only comparisons of the overall conclusions drawn from the two datasets can be meaningfully compared and discussed. The most substantial inconsistencies identified between the conclusions drawn by Wilson and Diesel (2005) and the existing aquatic life use attainment status of stream segments in the Spruce Creek watershed pertain to the Left Branch WMR and the impact of the Left Branch on the mainstem WMR.

Wilson and Diesel (2005) report that based on Family-level taxonomic richness, EPT, and PTI scores, and chemical water quality data (nitrate), water quality in Warriors Mark Run is poorer downstream of the confluence of the Left and Right Branches of WMR, and that generally, the convergence of the Left and Right Branches creates an increase in pollution of the mainstem WMR at sample site WMR 5 (located downstream of the confluence of the Left and Right Branches), compared to other sites located upstream. However, DEP unassessed waters aquatic life use attainment screening data indicate that the mainstem WMR downstream of the confluence of the Left and Right Branches is a transitional area where biological and habitat conditions improve in a downstream direction and the aquatic life use attainment status of WMR changes from impaired to attained. Unassessed waters screening data also suggest this downstream trend of improving biological conditions extends downstream to WMR's confluence with Spruce Creek (Figure 2).

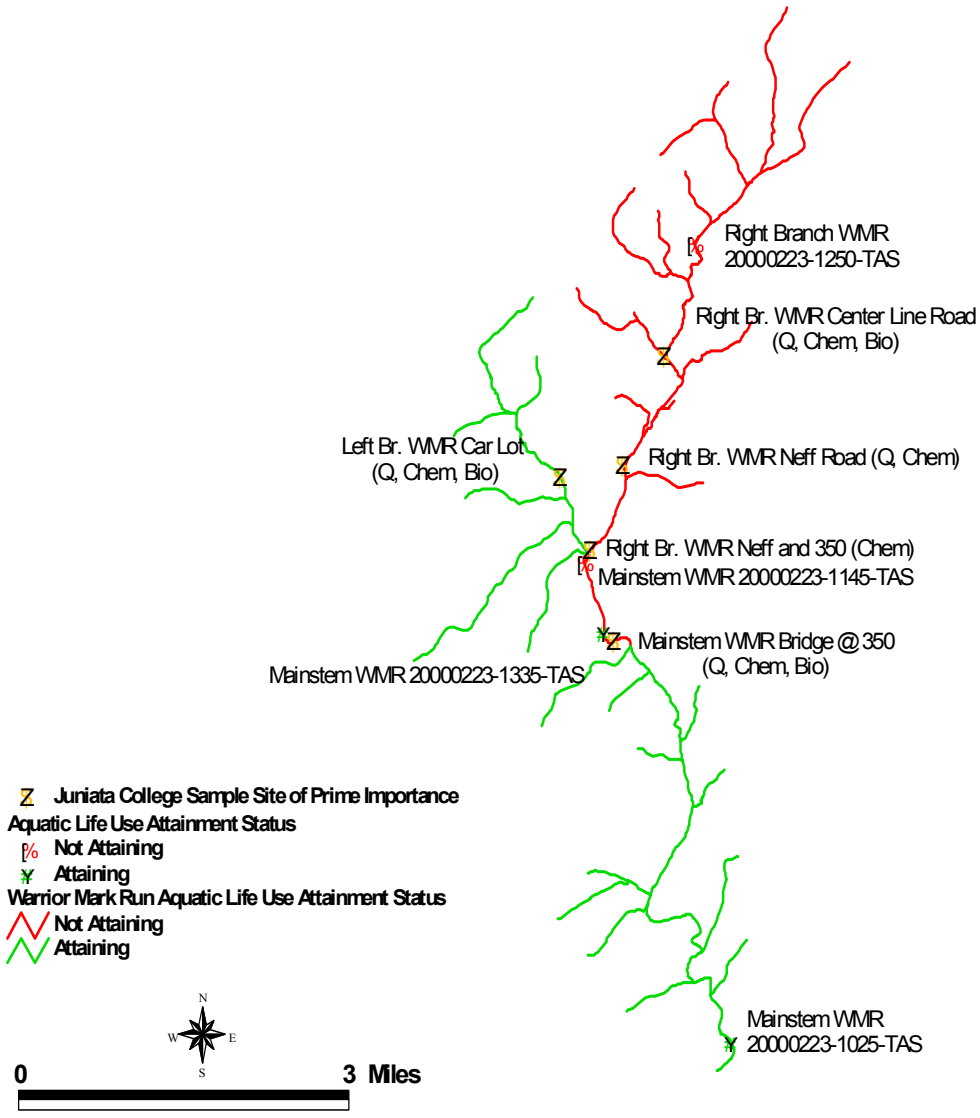

Figure 2. DEP Unassessed Waters Aquatic Life Use Attainment Screening and Juniata College Data Collection Sites in the Warrior Mark Run (WMR) Watershed.

The chemical water quality and stream discharge data collected by Juniata College students provide valuable information about the chemical and stream discharge characteristics of the "transitional area" of WMR downstream of the confluence of the Left and Right Branches. Between 10 June and 2 August 2005, approximately 25 data collection efforts were conducted at sample sites located on the Left Branch (Site 6 Car Lot), the lower Right Branch (Neff & 350), and the mainstem WMR downstream of the confluence of the Left and Right Braches (Site 5 Bridge @ 350). DEP staff used Kruskal-Wallis statistical test results generated from this dataset to determine if there are significant differences ($p<0.05$) in the stream discharge and chemical water quality characteristics of the Left Branch, the Right Branch, and the mainstem WMR below the confluence of the two branches. These analyses yielded the following results:

- There is no significant difference between the TDS values of all three sites (Figure 3)
- Turbidity and pH values of the Right Branch are significantly higher than those of the Left Branch at Site 6 and mainstem WMR downstream of the confluence of the Left and Right Branches (Figs. 4 & 5)
- Temperature values of all three sites are significantly different with those of the Right Branch being the highest, the Left Branch at Site 6 being intermediate, and the mainstem WMR downstream of the confluence of the Left and Right Branches being the lowest (Figure 6)
- Nitrate-N values of the mainstem WMR downstream of the confluence of the Left and Right Branches are significantly higher than those of either the Right Branch or the Left Branch at Site 6, and there is no significant difference in the nitrate-N values of the Right Branch vs. the Left Branch at Site 6 (Figure 7)
- The water yield (cfs/drainage area) of all three sites are significantly different with those of the Right Branch being the lowest, the Left Branch at Site 6 being intermediate, and the mainstem WMR downstream of the confluence of the Left and Right Branches being the highest (Figure 8)
- Stream discharge values measured at the mainstem WMR downstream of the confluence of the Left and Right Branches (WMR Bridge @ 350) are significantly higher than those estimated for this site (Figure 9). Discharge values for the Left and Right Branch watersheds were estimated by multiplying watershed drainage areas by yields calculated from the discharge measurements recorded at Site 6 (Car Lot) on the Left Branch and the Neff Road Site on the Right Branch. Discharge values for the mainstem WMR at the 350 Bridge were estimated based on the sum of the estimated Left and Right Branch discharges plus the product of the yield calculated from the sum of the Left and Right branches and the drainage area of portion of the WMR watershed between the Bridge @ 350 and the confluence of the Left and Right Branches.

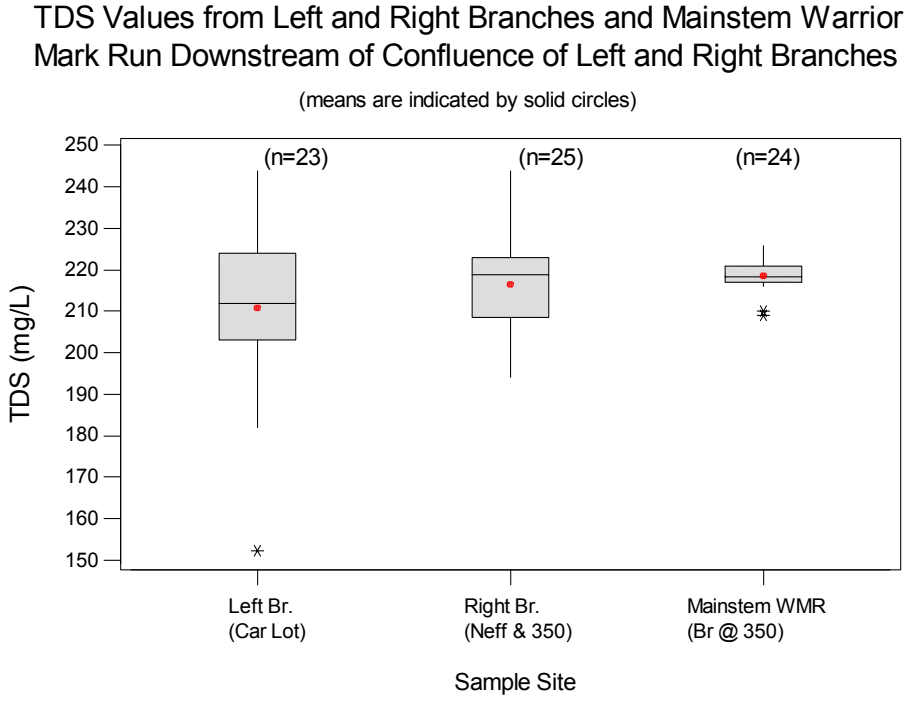

Figure 3. TDS Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

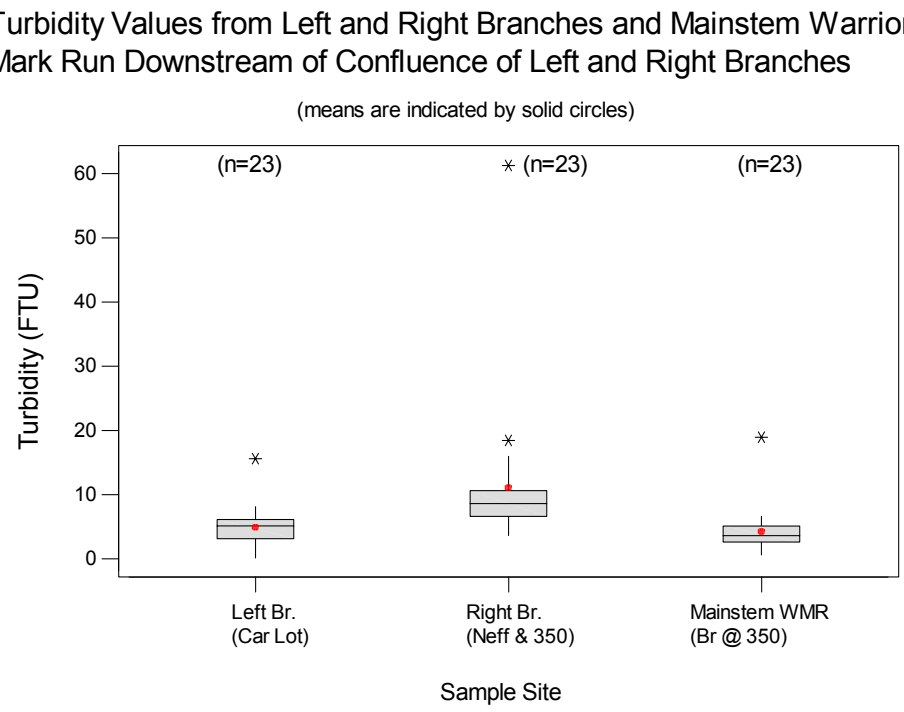

Figure 4. Turbidity Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

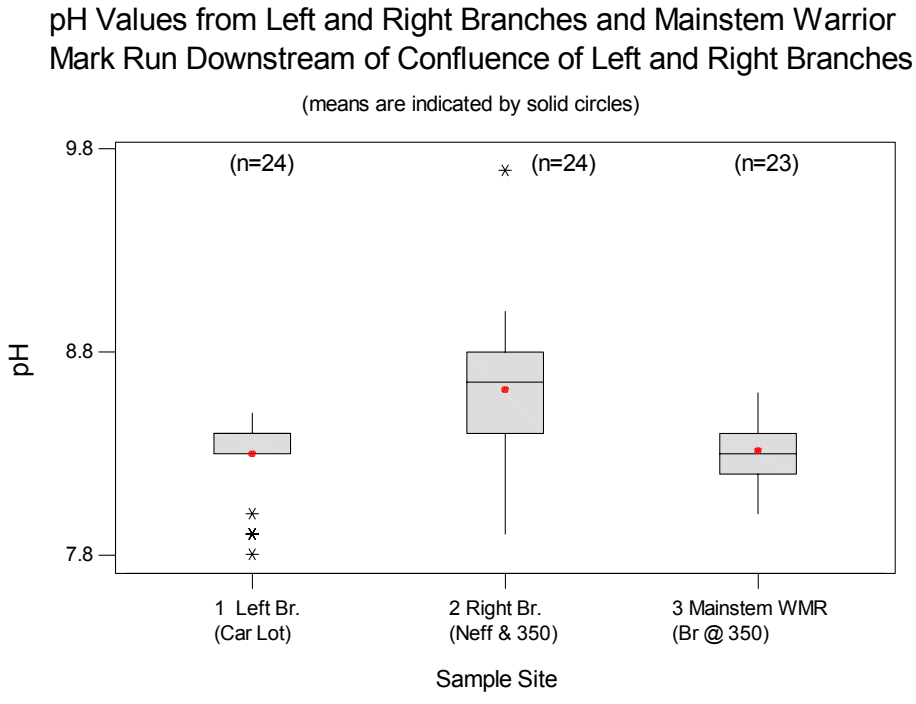

Figure 5. pH Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

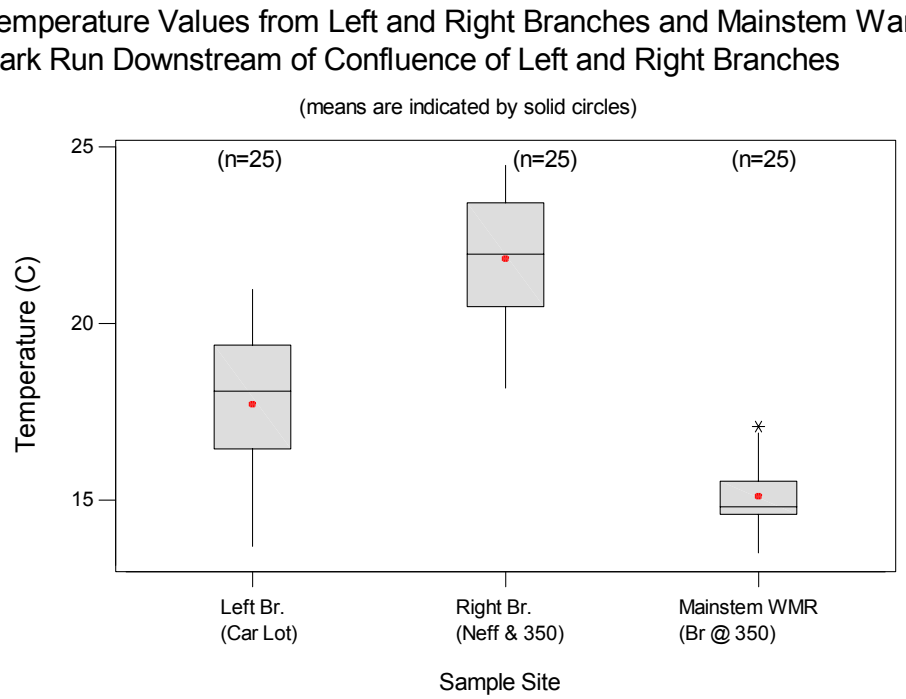

Figure 6. Temperature Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

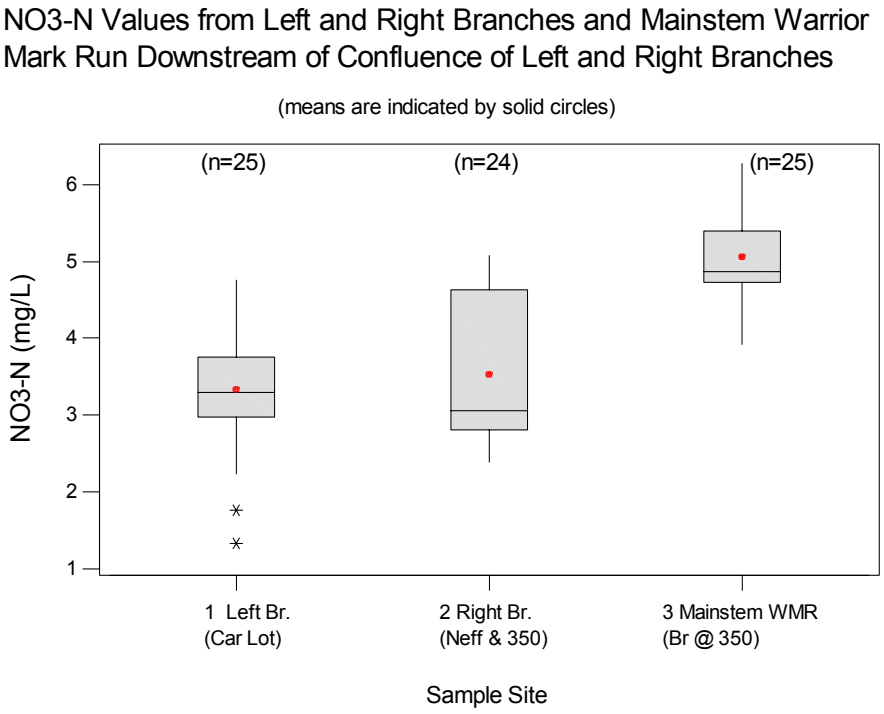

Figure 7. Nitrate-N Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

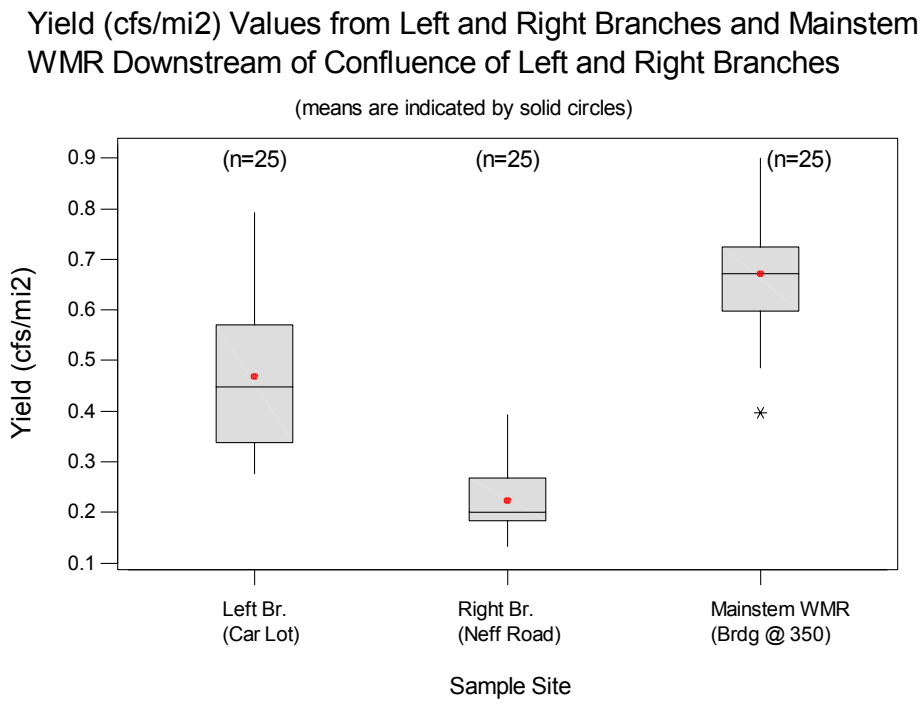

Figure 8. Water Yield Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

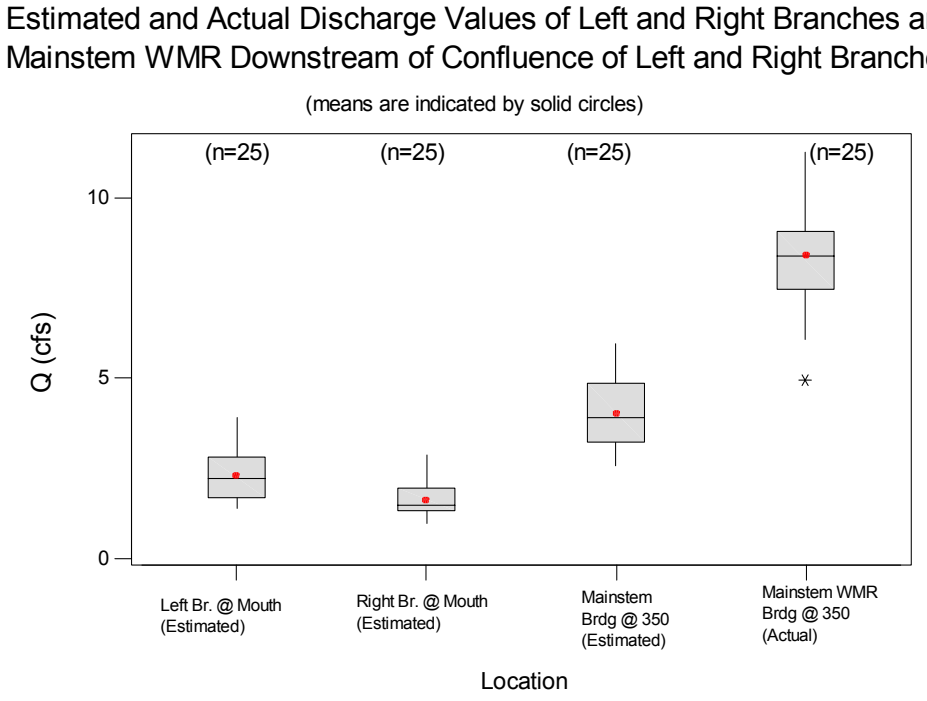

Figure 9. Estimated and Actual Stream Discharge Values from Left and Right Branches and the Mainstem WMR Downstream of the Confluence of the Left and Right Branches.

Summary and Conclusions

The chemical water quality, stream discharge, and biological data collected by Juniata College students and submitted to DEP by Professor David Lehmann contain valuable water resources information from the Spruce Creek Watershed in Centre and Huntingdon Counties. Based on the data submitted, no water uses are impaired due to chemical water quality. However, elevated pH values recorded at Site 13 at the mouth of the Right Branch WMR (Neff and 350) suggest that continued data collection at this aquatic life use-impaired site may result in listing pH as one of the sources of aquatic life use impairment.

The data also provide valuable information about the chemical and stream discharge characteristics of the "transitional area" of WMR downstream of the confluence of the Left and Right Branches. The data suggest that a substantial increase in water yield (discharge/drainage area) occurs somewhere between Site 6 (Car Lot) on the Left Branch and Site 5 on the mainstem Warrior Mark Run (Bridge @ 350). Based on the Juniata College data, the waters responsible for the observed increase in yield at Site 5 on the mainstem WMR between10 June and 2 August 2005 are characterized as follows:

- Temperature: <15 C
- pH: ~8.3
- Nitrate-N: >6.0 mg/l

Based on these estimated chemical and physical characteristics and the presence of carbonate geology throughout the Spruce Creek Watershed, it is reasonable to conclude that the increase in water yield and elevated nitrate concentrations observed at Site 5 on the mainstem WMR downstream of the confluence of the Left and Right Braches is most likely from baseflow (groundwater) sources. Although these waters result in increased nitrate-N to the mainstem WMR, the net effect of this increase in baseflow, relative to the aquatic life use-impaired Right Branch WMR, is a shift to more-favorable temperature, pH, turbidity, water yield, physical habitat and benthic macroinvertebrate community conditions. In spite of the relatively high nitrate-N concentration of these waters, they appear to contribute favorably to the recovery of the aquatic life use attainment status of the mainstem WMR from impaired to attaining.

Based on review of the Juniata College chemical water quality, stream discharge and macroinvertebrate data and the DEP's aquatic life use screening data, the existing aquatic life use attainment status of all stream segments in the Spruce Creek Watershed should remain as shown in Figure 1. It is recommended that future efforts to reduce nitrate-N concentrations of streams in the WMR watershed should include actions geared toward reducing nitrogen loads to groundwater that eventually becomes baseflow for these surface waters.