The Effects of Pollution Reduction on a Wild Trout Stream

Progress Report: 2007

January 2008

TABLE OF CONTENTS

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Introduction

Spring Run is a unique aquatic resource in the Potomac Highlands region of West Virginia. Unlike many small headwater streams that tend to go dry, it is fed by the largest spring in the region, with discharge typically ranging from 3000-3500 gallons per minute. With a temperature of ~53 °F at the spring and a pH of ~8, aquatic conditions are ideal for trout and the aquatic insects they eat. Spring Run flows about two miles from the spring source to its confluence with South Mill Creek, which is about four miles from the South Branch of the Potomac River. Spring Run has no tributaries. Much of the stream is shallow, and does not provide the complex habitat that trout need - but that is not the case in a one mile section in the middle of the Run.

Since the early 1960's, landowner's have issued permits for fly fishing, catch-and-release on about one mile of Spring Run. Landowners and other interested parties have installed and maintained various structures to form pools and overhead cover that provide hiding and feeding habitat for trout. Spring Run is recognized as one of the best "wild" rainbow trout fisheries in West Virginia. Friends of Springs Run's Wild Trout, was formed in 1996 to restore structure to Spring Run following flooding in 1996.

In the last few years, however, fishermen have noted a decline in the fishery. Emergence of the mayfly, Ephemerellidae (sulfurs) largely disappeared in the late 1990s. The number of large trout (14" and above) has decreased and trout in the 11-13" range have also declined in abundance. The population of trout is considerably lower in the lower reach of the three-fourths mile section. Algae formation is heavy in the upper reach of the catch-and-release section, much heavier than in the past, and algae reforms soon after washout by high water.

Spring Run is rich in nutrients, delivered largely in effluent from the Spring Run Trout Hatchery (SRH) which is located about one-third mile upstream from the upper end of the fly fishing section and about one-forth mile below the spring. (SRH is a rearing facility; trout are not spawned there). In recent years, however, SRH has been producing more rainbow and "golden trout" for stocking West Virginia streams, and it seems that the effluent stream now may be a problem for the health of Spring Run. WVDEP issued a citation for violation of the Spring Run Trout Hatchery NPDES permit in January 2004, specifically for discharging excess biochemical oxygen demand (BOD) and total suspended solids (TSS). WVDNR, which operates SRH, installed an effluent treatment system at the facility to meet their permit requirements. It became operational in June 2007.

The prospective installation of effluent treatment at SRH provided a unique opportunity to address a number of issues of both regional and national significance:

1. Will the hatchery effluent treatment process significantly reduce nutrient discharge? Fish hatcheries throughout the country produce nutrient-rich effluents of concern to receiving waters. This study will evaluate the downstream result of effluent reduction of BOD and TSS, as well as nutrients, from a small but high throughput point source. The results of renovation at SRH and this study will provide important information to the WV Potomac Tributary Strategy point source innovation process.
2. What are the biological impacts of Spring Run's high nutrient levels, and how is the biota affected by reductions in nutrients, TSS and BOD following hatchery upgrades? This issue is of importance to the nutrient criteria development process that WV and the other 49 states are currently struggling through, as one of the key questions is: "what does nutrient impairment look like?"

3. Is the wild trout population in Spring Run being harmed by hatchery effluent, and does improvement in that effluent improve the trout fishery?
4. Is the benthic invertebrate population in Spring Run being harmed by hatchery effluent, and does improvement in that effluent improve diversity? Spring Run fishermen have noted the loss in recent years of a certain family of mayflies, the Ephemerellidae (Spiny crawler mayfly) that used to emerge regularly in the springtime. Also, WV DEP's Tim Craddock completed a benthic assessment of Spring Run in 2002, and found the lower part of the fly fishing section to be dominated by Chironomidae (midge) larvae, a group often indicative of pollution by organic waste.
5. Why do trout, especially larger fish, favor the upper part of the fly-fishing section? Why has the density-center of the trout population moved upstream in recent years? Is there a relationship between distribution of benthic invertebrates in the stream and trout distribution? If the Ephemerellidae mayflies and other pollution sensitive macroinvertebrates rebound after the hatchery effluent is treated, will the trout population improve also? In particular, are trout avoiding areas they used to frequent that are now dominated by midge larvae? If upgrades to the hatchery reduce organics in the stream and also the midge populations, will trout return to those areas? If that turns out to be true, and we could demonstrate that it is true, that would buttress public acceptance of benthic invertebrate stream assessments.

Overall, this project has the potential to address many questions beyond the five questions identified above.

This progress report will provide an overview of two years of baseline data and the first partial year of post-treatment data. A second season of post treatment data is planned for 2008.

Partners

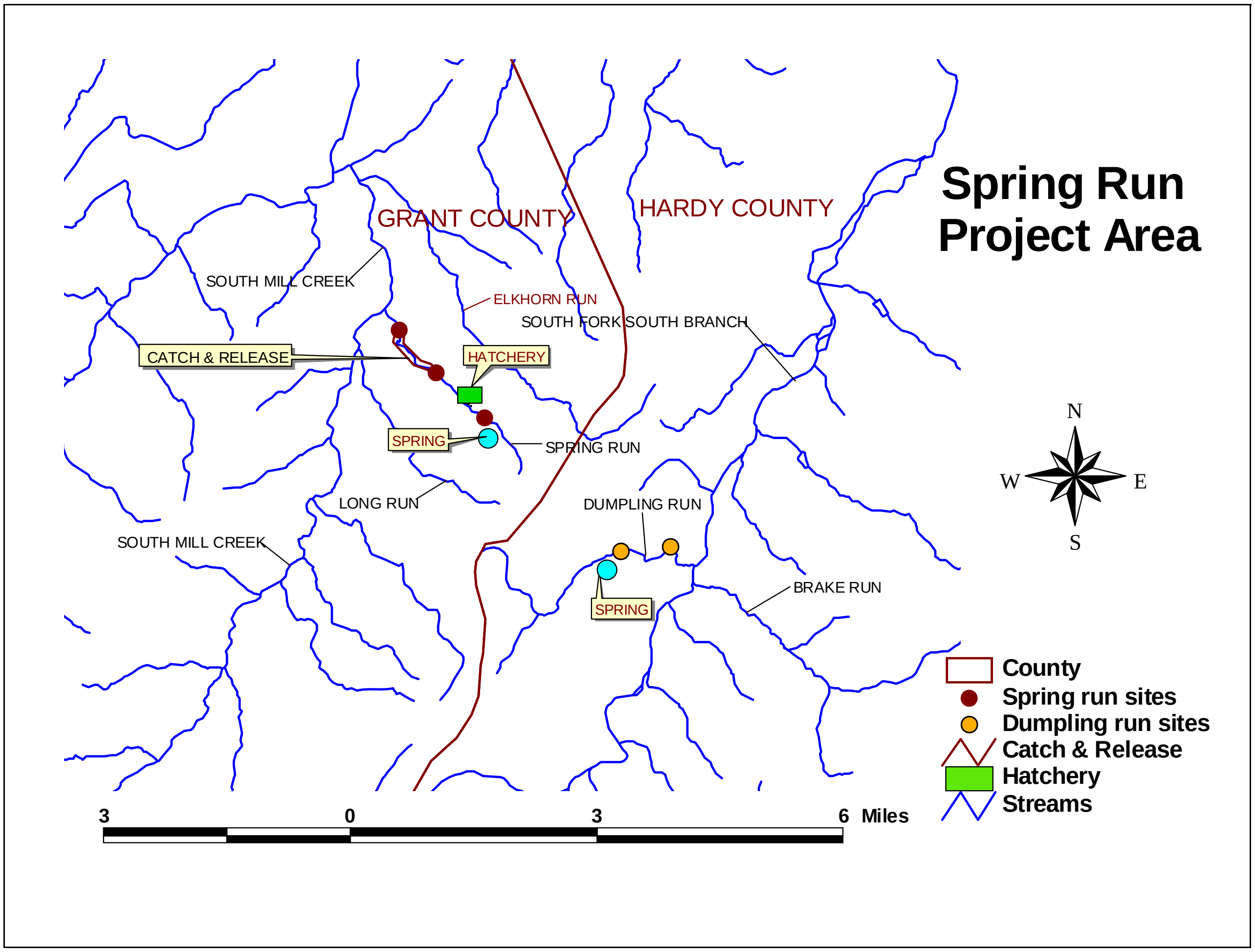
Friends of Spring Run's Wild Trout, Cacapon Institute (CI), the WV Conservation Agency (WVCA), WV Department of Agriculture (WVDA), WV Division of Natural Resources (WVDNR), WV Department of Environmental Protection (WVDEP), and the Freshwater Institute are partnering in this study. This project is funded primarily by West Virginia Conservation Agency's participation through the Chesapeake Bay Program. An associated erosion reduction project is funded through a Friends of Spring Run's Wild Trout 2005 Stream Partners Grant. Additionally, a home school group is monitoring the lower portion of Spring Run on a regular basis.

WVDA, WVDEP and WVDNR are all contributing in-kind services to the project. WVDA is collecting water samples, taking flow measurements, and performing field and laboratory water quality analyses. WVDEP is participating in collections of benthic invertebrate and periphyton and helping to cover the costs of analysis. WVDNR is performing fish surveys and Friends of Spring Run's Wild Trout is providing information on size and location of trout caught and released by permitted fly fisherman, and supplied equipment and labor for erosion-sediment control work..

The Freshwater Institute provided guidance to WVDNR on treatment methods for their effluent and is providing technical guidance for the project. WVCA is acting as project coordinator. Cacapon Institute has overall technical oversight for the project, will participate in field work, and will, in cooperation with partnering organizations, be responsible for data analysis and production of annual reports.

Methods

The project has two experimental components, an upstream/downstream design in Spring Run, and a control/experimental design that includes Dumpling Run, another spring fed stream nearby. Both streams have their origins in the same geology: limestone (Helderberg and Tonoloway/Wills Creek) and sandstone (Oriskany, McKenzie) formations. Spring Run flows off the ridge to the northwest into South Mill Creek, a tributary of the South Branch of the Potomac River. Dumpling Run flows east into the South Fork of the South Branch of the Potomac River.



The upstream/downstream part includes three sites in Spring Run: the first site is near the spring upstream of the hatchery; the second site is near the upper end of the fly fishing stream section; and the third is near the lower end of the fly fishing section. There are two sites on Dumpling Run, one just below the spring, the other some distance downstream. Overall, this design allows within stream and between stream comparisons. Under most conditions of flow the springs constitute the main source of water in both streams, but both streams also have periodic surface flow entering the main channel upstream of the spring. Due to unanticipated delays in construction of the effluent treatment system, the baseline period of data collection lasted for two years (April 2005-May, 2007).

Water chemistries are collected monthly from April through September, typically on Wednesday. We chose to avoid collections on Mondays at the time of the pre-treatment hatchery cleanout because the "biosolids from the aquaculture effluent are notoriously patchy and difficult to characterize in sampling. . . . my thoughts on the nutrients is to focus on the residual chronic impacts, not the pulse of the cleaning plume"

(Joe Hankins, Freshwater Institute, personal communication). However, due to scheduling requirements, samples in September 2006 were collected on a Monday during the cleanout.

Water quality parameters include nitrogen in the forms of ammonia-nitrogen, nitrate/nitrite, total Kjeldahl nitrogen, total nitrogen (the sum of nitrate/nitrite and TKN), soluble reactive phosphorus, total phosphorus, total suspended solids (TSS), biochemical oxygen demand (BOD_5), and basic field parameters (pH, temperature, conductivity) (see Appendix 2 for laboratory methods). Flow measurements are collected at the same time as water samples at one site in each stream. This work is done primarily by the WVDA.

Benthic invertebrate and periphyton samples are collected twice each year at all sites, in spring and autumn, according to the standard protocols in use by the WVDEP. WVDEP format Rapid Bioassessment Protocol habitat analyses is conducted once each year. WVDEP and Cacapon Institute are primarily responsible for this fieldwork.

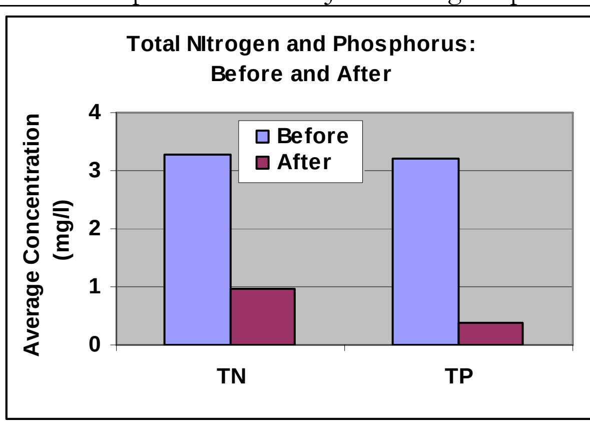
WVDNR will conduct electro shocking fishery assessments, and the permitted fly fishermen of Spring Run are recording information on size and location of trout caught and released.

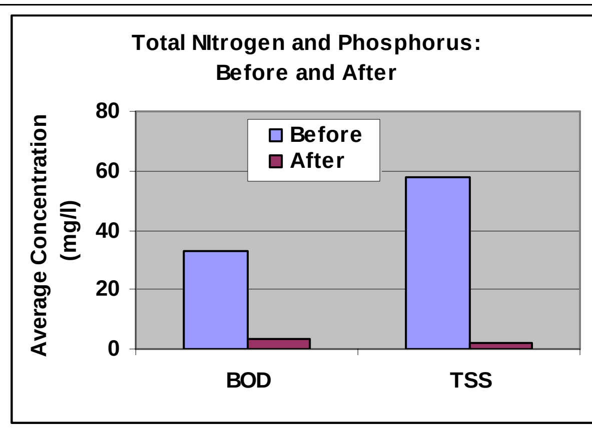
Hatchery Upgrade (per Mike Shingleton, WVDNR)

The Spring Run Trout Hatchery effluent treatment system became fully operational on June 4, 2007. An automated composite sampler was installed as part of the hatchery renovation and was first used in April.

Cleaning process: Blocking weirs are placed in front of the quiescent zone of each raceway prior to cleaning; a standpipe is removed and the quiescent zone is brushed cleaned; 3-4 raceways are cleaned at a time; the wastewater from the quiescent zones is piped into the clarifier while water from raceways not being cleaned is discharged to Spring Run. The clarifier is filled to its holding capacity but is not allowed to overflow. Wastewater in the clarifier is allowed to settle 24-48 hours and the clarified water is then decanted and mixed with hatchery water back into Spring Run. The sludge remaining in the clarifier is pumped to the sludge holding tank for later disposal by land application. The decanting process of discharging water from the clarifier occurs 2-3 times per week and lasts from 1 1/2 to 2 hours each time. The following figures show reductions in total nitrogen, total phosphorus, BOD and TSS due to the treatment process. These results are based on composited samples collected during the cleanout process. Prior to the upgrade, these samples were collected during the actual cleanout. After the treatment system became operational, samples were collected during decanting.

Results of composite sample analysis of Spring Run Hatchery effluent during cleanout before and after treatment system became operational. The "before" period was from September 2006 through May 2007. The "after" period was from June through September 2007.

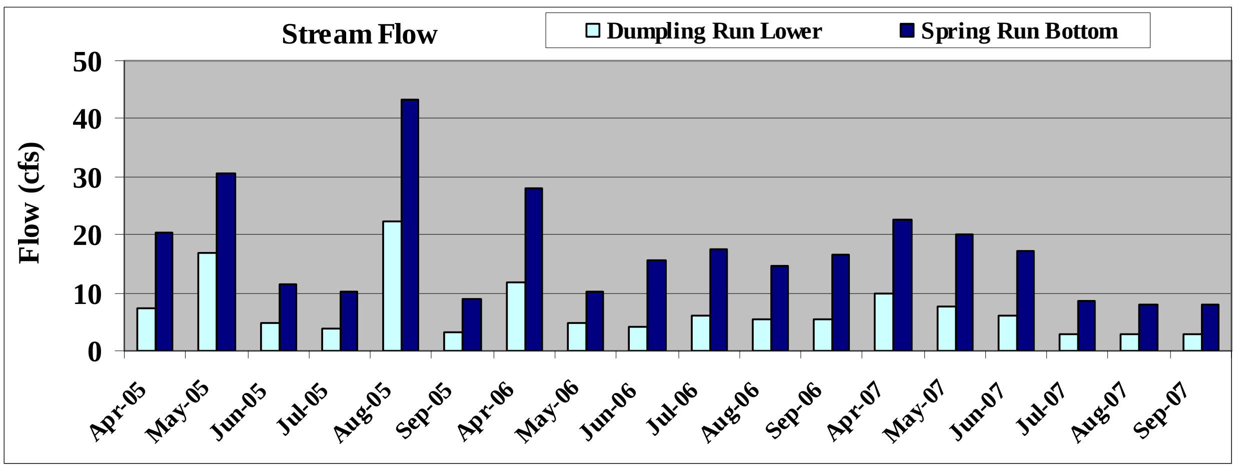




Results

The effluent treatment system at the hatchery became operational in June 2007, leaving only four months (June, July, August, September) of post-operational data in 2007. Because this data set is so limited, this report will simply present the data for each year and in time series graphs for major parameters. No attempt to draw statistical conclusions as to effect of the treatment system will be made until the second year of post-treatment data is collected in 2008. Appendix 1 provides water quality statistics by year. Appendix 4 will provide detailed benthic invertebrate statistics once data are available.

Flow. Stream flows on sampling days for the most downstream sites in Spring Run and Dumpling Run are given in Figure 1. Flow in Spring Run was always at least twice as high as in Dumpling Run. Sampling day flows in 2005 were much more variable than in following years, and the streams were notably low between July and September in 2007 – three of the four months of post-treatment data. These unusual flow conditions reinforced the decision to wait until after the second year of post-treatment data is collected in 2008 to draw statistical conclusions as to effects of the treatment system.



Water Quality. Median values for pH, conductivity and dissolved oxygen by site and by year are provided in Table 1. These data indicate the source water in each stream was very similar, and these median values varied narrowly across all sites and all years. Both streams are alkaline, with moderately high conductivity, and high dissolved oxygen levels. No difference between pre-treatment (2005 and 2006) and post-treatment (2007) periods was evident.

Table 1. Median pH, conductivity, and dissolved oxygen by site and year.

Site	Median pH			Median Conductivity			Median Dissolved Oxygen (mg/L)		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Dumpling Run @Spring	7.8	7.6	7.5	286.9	254.2	257.0	10.3	10.6	10.5
Dumpling Run Bottom	8.1	7.8	7.6	283.5	263.9	271.5	10.4	10.6	10.3
Spring Run @Spring	7.9	7.7	7.7	296.1	330.3	358.0	10.3	10.5	10.1
Spring Run Middle	7.8	7.7	7.5	255.0	255.2	253.5	10.3	10.4	10.3
Spring Run Bottom	7.5	7.6	7.5	247.5	253.2	255.0	10.6	10.7	10.4

Median values for total phosphorus (TP) and total nitrogen (TN) by site and year are provided in Table 2. Source water TP was similar in each stream, and did not increase in the downstream site in the control stream

(Dumpling Run). Both sites below the hatchery in Spring Run (Spring Run Middle and Spring Run Bottom) had significantly higher median TP than all other locations. No difference in TP between pre-treatment (2005 and 2006) and post-treatment (2007) periods was evident.

Table 2. Median total phosphorus (TP) and total nitrogen (TN) by site and year.

Site	TP (mg/L) Median			TN (mg/L) Median		
	2005	2006	2007	2005	2006	2007
Dumpling Run @Spring	0.028	0.054	0.041	0.341	0.364	0.312
Dumpling Run Bottom	0.026	0.044	0.038	0.364	0.356	0.336
Spring Run @Spring	0.025	0.049	0.036	0.641	0.570	0.517
Spring Run Middle	0.075	0.103	0.106	0.887	0.634	0.775
Spring Run Bottom	0.087	0.103	0.085	0.877	0.734	0.747

Median total nitrogen was significantly higher in the Spring Run source water than in Dumpling Run. Median TN did not increase in the downstream site in the control stream (Dumpling Run). Both sites below the hatchery in Spring Run (Spring Run Middle and Spring Run Bottom) had significantly higher TN than control sites in Dumpling Run, and higher (but not significantly) TN than the source water in the Spring Run spring. No difference in TN between pre-treatment (2005 and 2006) and post-treatment (2007) periods was evident.

Median values for BOD5 and TSS by site and year are provided in Table 3. Source water BOD5 was distinctly (but not significantly) higher in Dumpling Run than Spring Run. There was no marked change in BOD5 in the downstream direction in either stream. However, median BOD5 decreased in each sampling year at all sites.

Table 3. Median BOD5 and TSS by site and year.

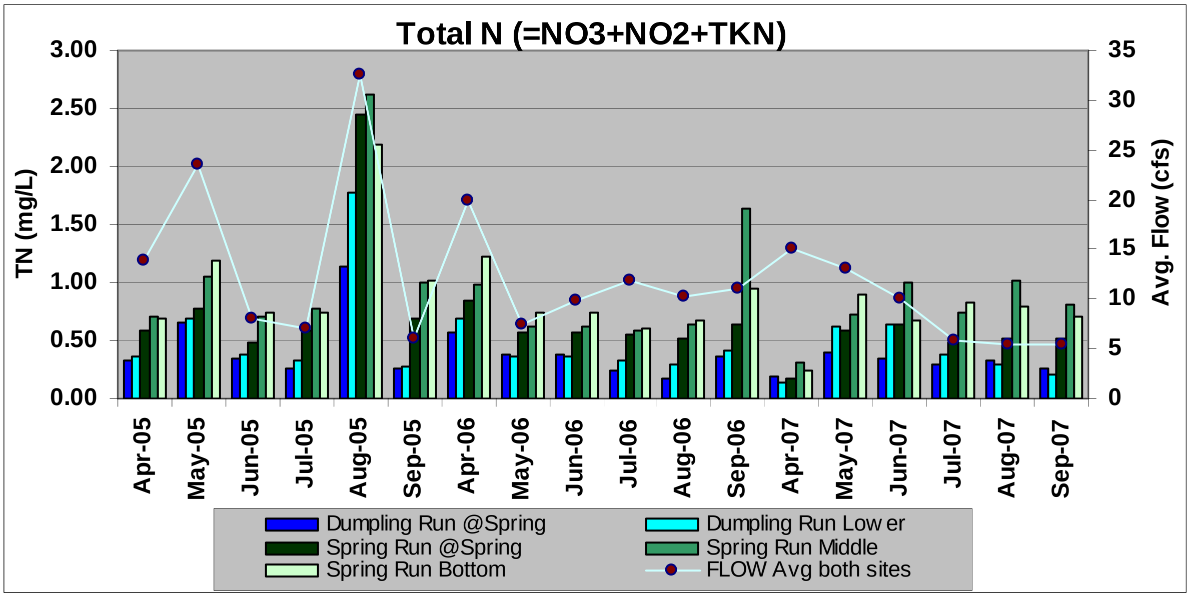
Site	Median BOD5 (mg/L)			Median TSS (mg/L)		
	2005	2006	2007	2005	2006	2007
Dumpling Run @Spring	1.54	1.400	0.68	4.50	1.15	2.50
Dumpling Run Bottom	1.515	1.100	0.605	2.08	5.50	4.50
Spring Run @Spring	0.985	0.645	0.415	1.58	2.58	3.50
Spring Run Middle	0.91	0.760	0.53	5.50	5.00	3.00
Spring Run Bottom	1.01	0.425	0.415	6.50	7.00	6.00

TSS was similar in the source water for the two streams, with data ranging broadly from 1.15 to 45 and 1.0 to 78.0 (mg/l) in Dumpling Run and Spring Run, respectively. Median TSS tended to increase in a downstream direction in both streams.

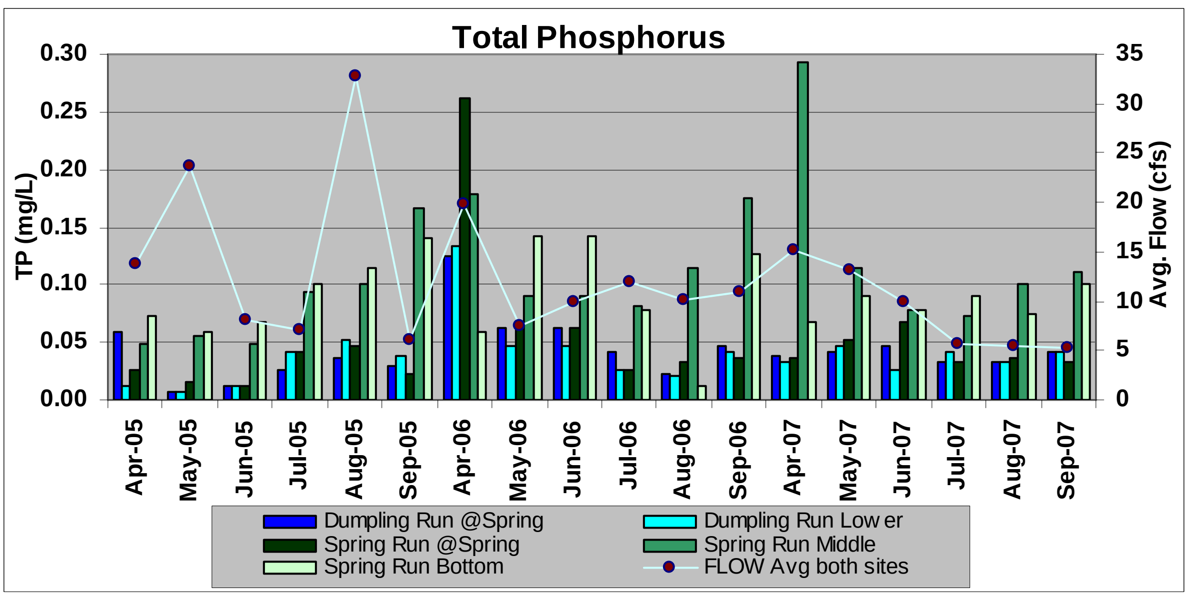
How did water quality vary over time?

The following four time-series bar graphs and associated text show how total N, total P, TSS and BOD5 concentrations varied during the study period to date. Also shown on each graph is the average of the flows at the two flow stations for each sampling period; this was done for the sake of graphic simplification, justified because these values were very strongly correlated ($r^2 = 0.94$).

Time series bar graphs of total nitrogen, total phosphorus concentrations at all permanent study sites.

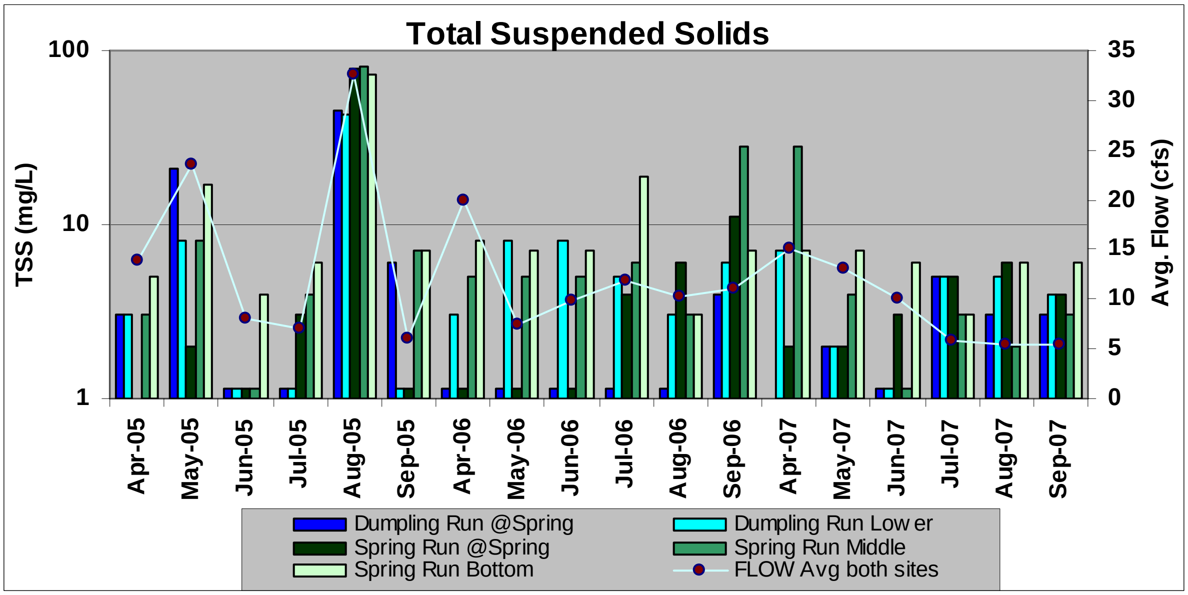


Total nitrogen (TN) varied widely and, based on correlation analysis, generally tracked with flows at all sites. The highest levels at all sites were observed in August 2005 during a high water event. TN was usually higher in all Spring Run sites than Dumpling Run. Elevated TN at SR Middle and SR Bottom in September 2006 was probably due to sampling that occurred on hatchery cleanout day. However, sampling in April 2007 also occurred on a cleanout day, and a similar increase in TN at SR Middle and SR Bottom was not observed. TN remained elevated, relatve to other sites, in the two point source impacted Spring Run sites after the treatment system became operational in June 2007.

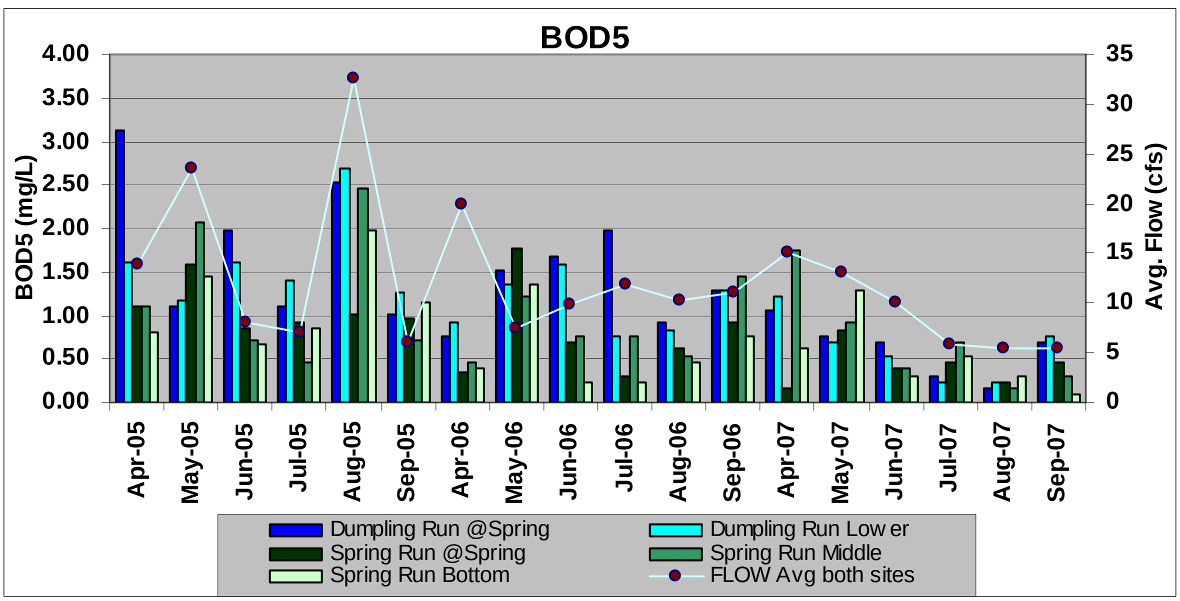


Total phosphorus (TP) varied widely over time at all sites and did not apparently vary with flow levels (see correlation tables below). However, the highest TP concentrations at all sites except SR MIddle and Bottom were recorded during an active runoff event in April 2006. The highest TP concentration at SR MIddle occurred when sampling occurred on a hatchery cleanout day in April 2007. The highest TP concentrations at SR Bottom occurred on September 2005, May and June 2006, for no apparent reason. Elevated TP downstream of the hatchery was evident at all flows at SR Middle and Bottom (with a noteable exception in August 2006 at SR Bottom). TP concentrations at the two point source sites were often distinctly different in 2006; this was not the case in 2005 and 2007. Elevated TP at SR Middle and SR Bottom in September 2006 may have been due to sampling that occurred on hatchery cleanout day; however, TP was similarly high at these two sites in September 2005 when cleanout was not occurring. TP remained elevated, relatve to other sites, in the two point source impacted Spring Run sites after the treatment system became operational in June 2007.

Time series bar graphs of total suspended solids, and biochemical oxygen demand concentrations at all permanent study sites.



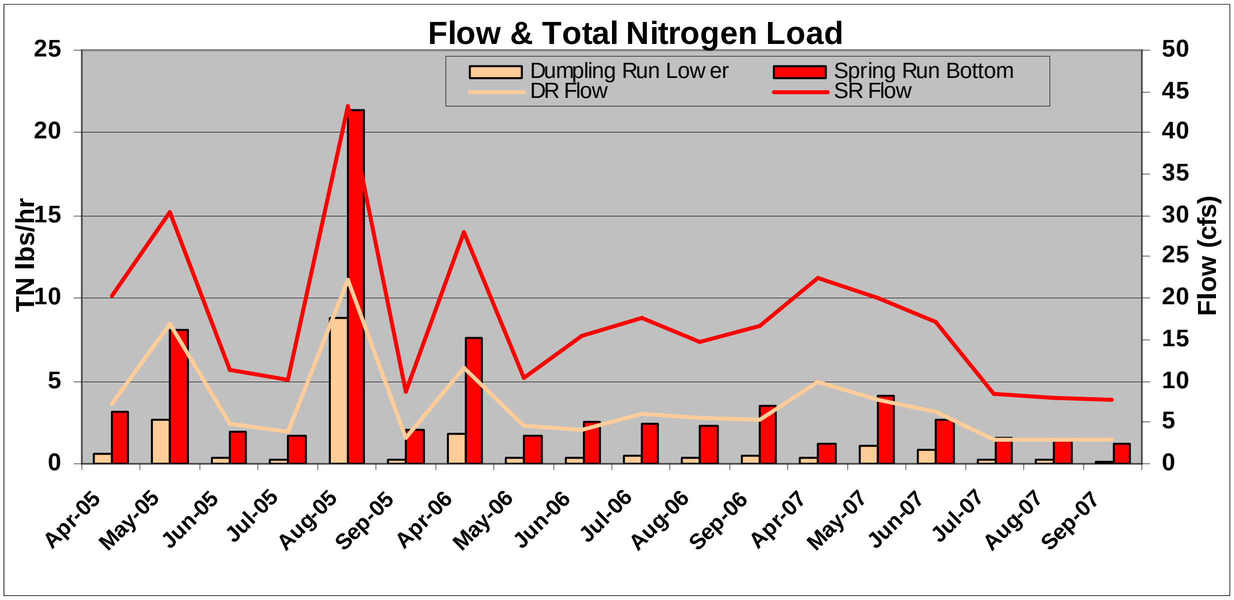
TSS varied widely and very roughly tracked with flows at all sites. The highest TSS levels for all sites were observed in August '05 during a high water event, but were not notably high during an active runoff event in April 2006. TSS concentrations were more consistently elevated at DR Lower, SR Middle and SR Bottom in 2006 than 2005. Elevated TSS at SR Middle and SR Bottom in September 2006 and April 2007 may have been due to sampling on hatchery cleanout day; however, TSS was also high at both spring sampling sites in September 2006. TSS was similarly elevated at all sites during the low water period from July through September 2007.



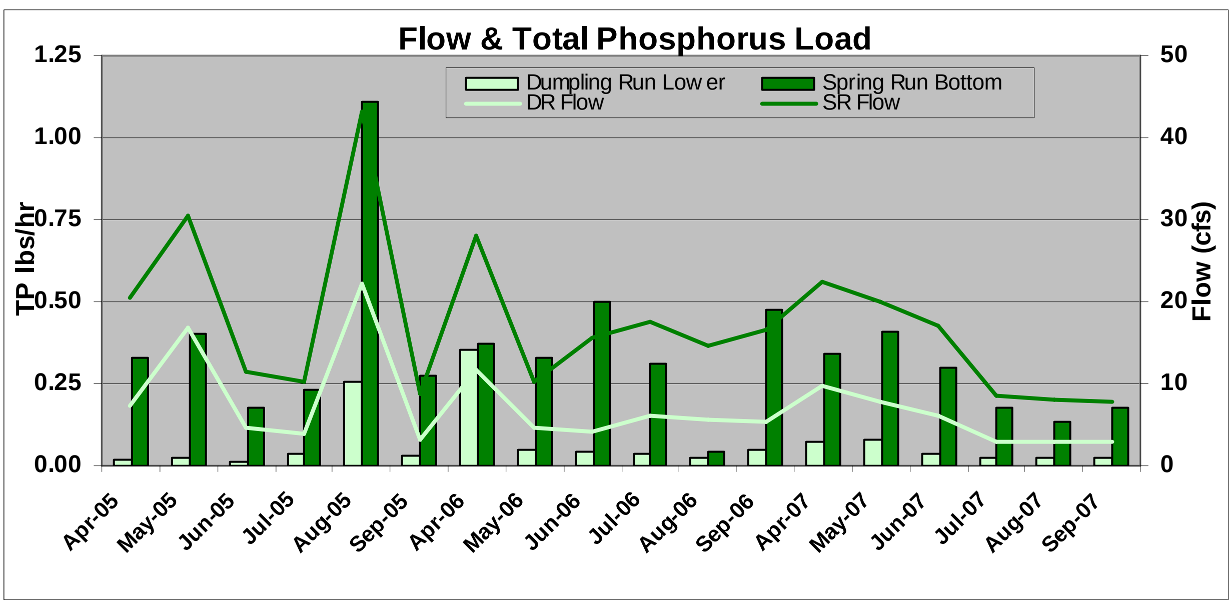
BOD5 varied substantially between sites. Correlation analysis indicated that BOD5 at Spring Run point source impacted sites tended to vary with flow, while patterns of BOD5 concentrations in non point sites had no apparent relationship to flow. BOD5 concentrations were notably low during the one active runoff event in April 2006, and notably high at all sites except SR Spring during a high water event in August 2005.

How did loads of key parameters vary over time? The following four time-series bar graphs and associated text show how total N, total P, TSS and BOD5 loads (in pounds per hour) varied at the two flow station sites during the baseline and the June-Sept 2007 post treatment sampling period.

Time series bar graphs of total nitrogen and total phosphorus loads (in pounds per hour) at the two flow sites.

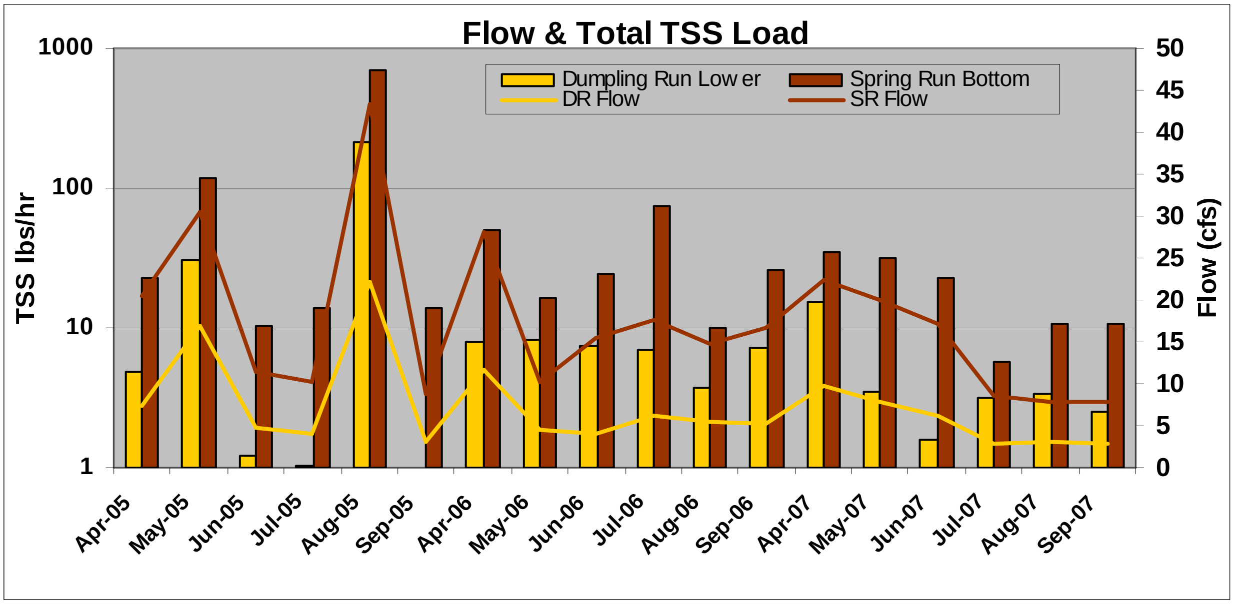


Total nitrogen loads varied widely and generally tracked with flows at all sites. As with TN concentrations, SR consistently had the higher TN loads. The highest loads at both sites were delivered during the three highest water events.

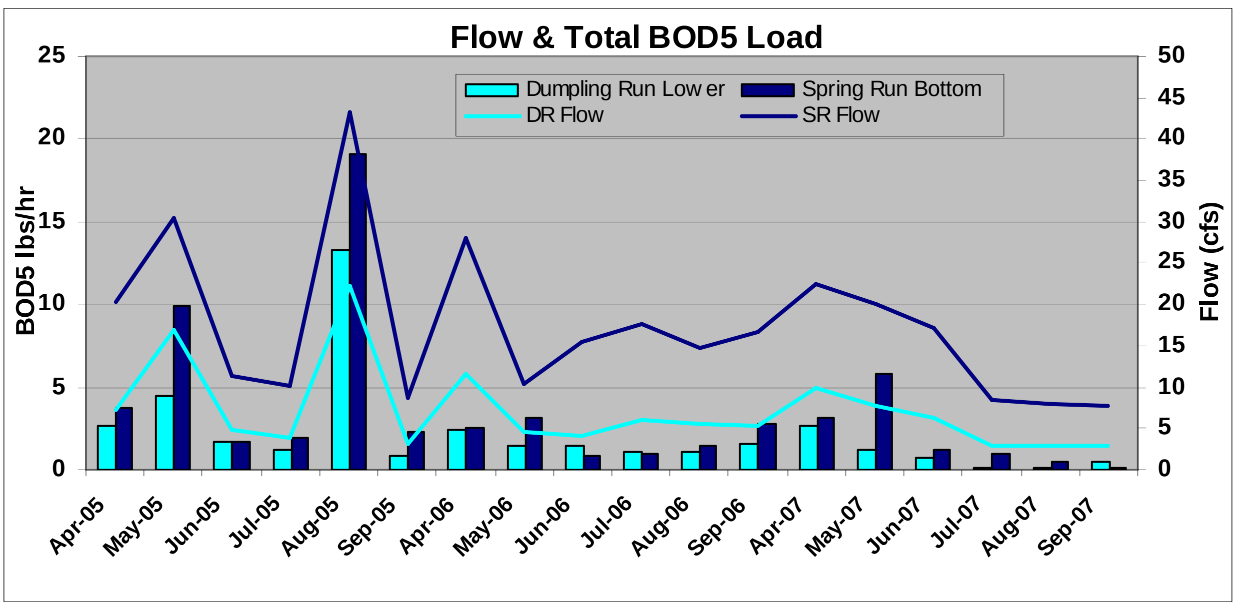


Total phosphorus loads varied much more widely over time in DR than SR. As with TP concentrations, SR consistently had the higher TP loads.

Time series bar graphs of total suspended solids and biochemical oxygen demand loads (in pounds per hour) at the two flow sites.



TSS loads varied widely and roughly tracked with flows at both sites. The highest loads were observed in August 2005 during a high water event. SR consistently had the higher TSS loads.



BOD5 loads varied substantially between the two sites and roughly varied with flows. The highest loads at both sites were observed in August 2005 during a high water event.

Benthic Macroinvertebrate & Periphyton Analysis

To be included when 2007 data is available.

Fisherman Survey

Table 6. Spring Run angler catch reports.

Spring Run Angler Catch Reports, Rainbow Trout: April thru Dec 2005												
65 Anglers Reporting 230 Fishing Sessions												
	Stream Section											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	%
0-7	70	108	77	130	220	335	201	142	58	47	**1388**	37.5
8--10	22	35	26	72	146	221	191	217	203	162	**1295**	35
11--13	7	5	17	27	39	75	75	89	170	175	**679**	18.3
14--16		1		16	25	23	33	27	29	86	**240**	6.5
17--19				1	5	4	9	7	10	24	**60**	1.6
20--up			1		1	4	7	10	6	13	**42**	1.1
Total	**99**	**149**	**121**	**246**	**436**	**662**	**516**	**492**	**476**	**507**	**3704**	
%	2.7	4	3.3	6.6	11.8	17.9	13.9	13.3	12.9	13.7		
16.1 rainbow trout/angler session												

Spring Run Angler Catch Reports, Rainbow Trout: Jan thru Dec 2006												
76 Anglers Reporting 232 Fishing Sessions												
	Stream Section											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**%**
0-7	25	46	42	89	134	153	112	46	30	33	718	31.6
8--10	18	14	20	49	103	109	121	134	64	66	698	30.7
11--13	4	10	18	18	34	46	77	104	109	136	536	23.6
14--16		4	4	8	9	18	31	42	43	92	251	11
17--19		1	1	1	3	2	2	9	4	19	42	1.8
20--up				1	3	1		1	1	8	15	O.7
Total	**47**	**75**	**85**	**160**	**286**	**329**	**343**	**336**	**251**	**354**	**2272**	
%	2.1	3.3	3.7	7	12.6	14.5	15.1	14.8	11	15.6		
9.8 rainbow trout/angler session												

Spring Run Angler Catch Reports, Rainbow Trout: Jan thru Dec 2007												
59 Anglers Reporting 211 Fishing Sessions												
	Stream Section											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**SUMS**	**%**
0-7	20	54	30	51	61	89	51	37	27	22	**442**	**29.3%**
8-10	8	19	18	35	65	88	38	36	29	48	**384**	**25.4%**
11-13	3	9	8	15	65	62	63	53	36	76	**390**	**25.8%**
14-16			5	8	30	27	36	54	29	55	**244**	**16.2%**
17-19		1		2	7	3	2	4	2	14	**35**	**2.3%**
20-up						2	2	2	1	7	**14**	**0.9%**
SUMS	**31**	**83**	**61**	**111**	**228**	**271**	**192**	**186**	**124**	**222**	**1509**	
% by Section	**2.1%**	**5.5%**	**4.0%**	**7.4%**	**15.1%**	**18.0%**	**12.7%**	**12.3%**	**8.2%**	**14.7%**		
7.2 rainbow trout/angler session												

Anglers with permits to fly fish, catch-and-release were invited, by a notice posted at the Spring Run parking area, to report the date fished, species, length, and stream location of their catch. The fly-fishing, catch-and-release section of Spring Run extends for about ¾ mile. This section was arbitrarily divided into10 sections, marked at streamside; Numbered 0 thru 9, beginning with 0 at the downstream boundary and increasing upstream. Sections were not of equal length. Anglers fished wherever they chose. Fishing sessions ranged from less than an hour to several hours. Anglers reported on a card designed with stream sections vs. 6 length categories, in inches; 0-7, 8-10, 11-13, 14-16, 17-19, 20-up. This card was available from a box located convenient to the parking area and next to a locked box for depositing completed reports. The parking area was adjacent to stream section Number 4. A member of the monitoring team collected reports frequently and summarized data monthly. The purpose of the study was to acquire data on number, size, and location of Spring Run trout, not to evaluate angler success.

Anglers cooperated in collecting data with a participation rate estimated above 80% for sessions fished.

Summary data presented above are for April through December in 2005, January through December in 2006, and January through December in 2007. The most heavily fished period is April through September. In 2005, 65 anglers reported 230 fishing sessions in 2005, 76 anglers reported 232 fishing sessions in 2006, and 59 anglers reported 210 fishing sessions in 2007. The number of trout caught per session declined each year, from 16.1 to 9.8 to 7.2 (in 2005, 2006, and 2007, respectively).

Data presented are for rainbow trout. A small number of brown, brook and golden trout were reported. A more detailed presentation of data will be done after another year or more of data collection.

DISCUSSION

The two study streams are impacted by a variety of potential sources of pollution, some readily apparent and some not. The Spring Run watershed contains the trout rearing facility, which is a known source of BOD, TSS and nutrients, as well as a number of non point sources including poultry houses, residences, roads, and occasional cattle. The Dumpling Run watershed has no point sources, and apparently no poultry houses, but includes residences and small farms with livestock, as well as a dirt and gravel road. In addition, the source springs in both watersheds both originate in limestone and sandstone strata and show rapid changes (turbidity, increase in flow) following heavy precipitation; this is indicative of solution channel connections through limestone at the surface of the ground.

Despite the wealth of confounding variables, some patterns are reasonably clear from the baseline data. The spring source water for the two streams has similar pH, conductivity, dissolved oxygen, TSS, and phosphorus, and supports similar communities of benthic macroinvertebrates. Source water in Dumpling Run tends to have less nitrate, and total N than Spring Run, and higher BOD5. Conductivity and pH tend to increase or not change in a downstream direction in Dumpling Run, and tend to decrease in a downstream direction in Spring Run. Nutrients and TSS are generally similar in the two Dumpling Run sites, and tend to increase in a downstream direction in Spring Run, often dramatically. Benthic macroinvertebrate diversity is higher in the lower Dumpling run site than in the two point source impacted sites in Spring Run

The decision to collect water samples two days after the scheduled cleanouts at the hatchery probably contributed to the apparently anomalous result of Dumpling Run, the control stream, having somewhat more BOD5 and TSS than Spring Run, the stream with hatchery effluent containing excess BOD and TSS. It is quite clear that we do not observe a significant residual impact in the water column from those cleanouts two days after the fact, as suspended material is readily observable in Spring Run on cleanout days. It seems likely that the deposition of effluent solids in the Spring Run streambed impacts the benthic macroinvertebrate community.

Preliminary review of post-treatment water quality data indicates that the plant upgrade did not change the water quality characteristics of Spring Run's water downstream of the plant on non-cleanout days. Phosphorus in particular remains elevated. TSS and BOD5 in Spring Run remain lower, on non cleanout days, than Dumpling Run. However, it is also clear that our sampling protocol is not capturing reductions in the pollutant plume that may have occurred during cleanout as a result of the new effluent treatment system (see Hatchery Upgrade section above). Data provided by WVDNR indicates that this process reduces pollutant loads related to cleanout by roughly 90%. For example, TP concentrations in the effluent stream during cleanout fell from an average of 4.5 mg/L to 0.54 mg/L.

Erosion Control Projects

Friends of Spring Runs Wild Trout, supported by a WV Stream Partners grant, partnered with the WVCA to reduce channel erosion and the resulting sedimentation problem in Spring Run. In 2006 WVCA supplied the design and heavy equipment to reshape and seed 210 feet of severely eroding roadside channel immediately above the spring source of Spring Run. In 2007 Friends of Spring Runs Wild Trout, with volunteered design, labor and equipment, installed three sediment basins and numerous sediment check dams and sections of rip-rap in three storm water runoff ditches, totaling about 600 feet, from developed areas. Sediment check dams of wood construction were placed in four woodland hollows which funnel run-off into Spring Run. Tree seedlings will be planted in work areas in early 2008.

Landowners remain concerned about sediment entering Spring Run from public roadway ditches. It is the hope of the working group and Friends of Spring Run's Wild Trout that this will become more of a priority for WV Division of Highways in the coming months. Cattle have been observed within the stream and along the unstable banks of the Spring Run above the fly fishing section.

Outreach

A paper on the Spring Run project was presented at the 2007 Virginia/West Virginia Water Research Symposium in November 2007 by Cacapon Institute. This paper was coauthored by Neil Gillies (CI), Carla Hardy (WVCA), and Tim Craddock (WVDEP).

Priority Watershed Planning

The Mill Creek Watershed, of which Spring Run is a part, was listed by the WVDEP as impaired for excess fecal coliform bacteria in 1996. Following a Total Maximum Daily Load (TMDL) study, EPA called for a 37% reduction in fecal coliform loadings. A watershed based plan to implement the TMDL is in development and will be submitted to EPA during the winter of 2008. Mill Creek is also a priority watershed for West Virginia's Potomac Tributary Strategy's Implementation Program, a Chesapeake Bay Program initiative.

A working group comprised of representatives from West Virginia Conservation Agency, West Virginia Department of Agriculture, Cacapon Institute, USDA Natural Resources Conservation Service and WVU Extension Service has worked to identify areas within the watershed that would benefit from BMP installation. A voluntary survey was mailed to all landowners within the entire watershed during the spring of 2007 requesting that they rank their environmental concerns. This information has been tallied and the working group has plans to bring educational programs that address these concerns to the local community as the project progresses.

The above steps all contribute to a process that will bring funds to the watershed for the purpose of improving water quality in the Mill Creek watershed. The funds will be used for projects such as feedlot relocations, installation of streambank fencing, alternative livestock water development, riparian buffers, failing septic upgrades, and wetland restoration. Funding for this project is anticipated in the summer of 2009.

Year Four expectations

Sampling will begin in April 2008, and continue through the September of 2008. This will be followed by compilation of a final report.

Appendix 1. Water Quality Statistics by Year.

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Ammonia-N (mg/L)						
Dumpling Run @Spring	2005	0.003	0.007	0.082	0.025	0.033
Dumpling Run Bottom		0.003	0.007	0.079	0.028	0.037
Spring Run @Spring		0.003	0.012	0.915	0.167	0.367
Spring Run Middle		0.051	0.093	0.214	0.107	0.063
Spring Run Bottom		0.017	0.043	0.161	0.070	0.059
Dumpling Run @Spring	2006	0.008	0.008	0.008	0.008	0.000
Dumpling Run Bottom		0.008	0.008	0.008	0.008	0.000
Spring Run @Spring		0.008	0.008	0.008	0.008	0.000
Spring Run Middle		0.008	0.046	0.102	0.048	0.034
Spring Run Bottom		0.008	0.008	0.041	0.019	0.017
Dumpling Run @Spring	2007	0.003	0.003	0.003	0.003	0.000
Dumpling Run Bottom		0.003	0.003	0.003	0.003	0.000
Spring Run @Spring		0.003	0.003	0.026	0.007	0.009
Spring Run Middle		0.029	0.048	0.283	0.090	0.099
Spring Run Bottom		0.003	0.003	0.153	0.028	0.061
Nitrate-N (mg/L)						
Dumpling Run @Spring	2005	0.170	0.225	0.380	0.260	0.079
Dumpling Run Bottom		0.190	0.255	0.500	0.310	0.117
Spring Run @Spring		0.370	0.475	0.590	0.480	0.083
Spring Run Middle		0.430	0.490	1.140	0.630	0.273
Spring Run Bottom		0.500	0.605	1.230	0.700	0.275
Dumpling Run @Spring	2006	0.120	0.160	0.360	0.185	0.088
Dumpling Run Bottom		0.130	0.180	0.400	0.207	0.097
Spring Run @Spring		0.340	0.405	0.550	0.413	0.079
Spring Run Middle		0.390	0.410	0.570	0.448	0.074
Spring Run Bottom		0.420	0.480	0.620	0.503	0.078
Dumpling Run @Spring	2007	0.004	0.155	0.220	0.144	0.077
Dumpling Run Bottom		0.015	0.175	0.250	0.163	0.082
Spring Run @Spring		0.017	0.390	0.410	0.330	0.154
Spring Run Middle		0.004	0.505	0.690	0.454	0.234
Spring Run Bottom		0.021	0.590	0.630	0.494	0.233
Nitrite-N (mg/L)						
Dumpling Run @Spring	2005	0.001	0.001	0.005	0.001	0.002
Dumpling Run Bottom		0.001	0.001	0.014	0.003	0.006
Spring Run @Spring		0.001	0.001	0.003	0.001	0.001
Spring Run Middle		0.001	0.007	0.023	0.009	0.009
Spring Run Bottom		0.001	0.006	0.029	0.010	0.011
Dumpling Run @Spring	2006	0.001	0.001	0.001	0.001	0.000
Dumpling Run Bottom		0.001	0.001	0.001	0.001	0.000
Spring Run @Spring		0.001	0.001	0.001	0.001	0.000
Spring Run Middle		0.004	0.009	0.031	0.014	0.010
Spring Run Bottom		0.004	0.007	0.016	0.008	0.004
Dumpling Run @Spring	2007	0.001	0.001	0.001	0.001	0.000
Dumpling Run Bottom		0.001	0.001	0.001	0.001	0.000

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Spring Run @Spring		0.001	0.001	0.001	0.001	0.000
Spring Run Middle		0.001	0.010	0.018	0.010	0.006
Spring Run Bottom		0.001	0.003	0.006	0.003	0.003
TKN (mg/L)						
Dumpling Run @Spring	2005	0.041	0.115	0.758	0.240	0.273
Dumpling Run Bottom		0.081	0.108	1.270	0.330	0.471
Spring Run @Spring		0.099	0.150	1.890	0.440	0.711
Spring Run Middle		0.214	0.305	1.460	0.510	0.475
Spring Run Bottom		0.167	0.291	0.938	0.380	0.291
Dumpling Run @Spring	2006	0.035	0.203	0.233	0.163	0.079
Dumpling Run Bottom		0.135	0.175	0.294	0.200	0.068
Spring Run @Spring		0.091	0.214	0.287	0.201	0.066
Spring Run Middle		0.181	0.214	1.090	0.387	0.355
Spring Run Bottom		0.156	0.277	0.642	0.307	0.176
Dumpling Run @Spring	2007	0.117	0.167	0.196	0.161	0.035
Dumpling Run Bottom		0.041	0.170	0.419	0.217	0.148
Spring Run @Spring		0.089	0.149	0.243	0.155	0.051
Spring Run Middle		0.167	0.288	0.527	0.302	0.122
Spring Run Bottom		0.069	0.216	0.304	0.196	0.083
Total N (mg/L)						
Dumpling Run @Spring	2005	0.252	0.341	1.143	0.500	0.348
Dumpling Run Bottom		0.274	0.364	1.784	0.630	0.583
Spring Run @Spring		0.476	0.641	2.453	0.930	0.755
Spring Run Middle		0.710	0.887	2.616	1.140	0.736
Spring Run Bottom		0.688	0.877	2.197	1.090	0.574
Dumpling Run @Spring	2006	0.176	0.364	0.569	0.348	0.134
Dumpling Run Bottom		0.296	0.356	0.695	0.407	0.146
Spring Run @Spring		0.522	0.570	0.838	0.615	0.116
Spring Run Middle		0.580	0.634	1.631	0.849	0.412
Spring Run Bottom		0.601	0.734	1.216	0.818	0.227
Dumpling Run @Spring	2007	0.197	0.312	0.405	0.305	0.073
Dumpling Run Bottom		0.146	0.336	0.640	0.380	0.211
Spring Run @Spring		0.165	0.517	0.644	0.485	0.167
Spring Run Middle		0.306	0.775	1.010	0.766	0.258
Spring Run Bottom		0.250	0.747	0.899	0.692	0.232
TP (mg/L)						
Dumpling Run @Spring	2005	0.007	0.028	0.059	0.028	0.019
Dumpling Run Bottom		0.007	0.026	0.052	0.028	0.019
Spring Run @Spring		0.013	0.025	0.046	0.028	0.014
Spring Run Middle		0.049	0.075	0.166	0.086	0.046
Spring Run Bottom		0.059	0.087	0.140	0.092	0.031
Dumpling Run @Spring	2006	0.022	0.054	0.124	0.060	0.035
Dumpling Run Bottom		0.020	0.044	0.134	0.052	0.041
Spring Run @Spring		0.026	0.049	0.261	0.080	0.090
Spring Run Middle		0.081	0.103	0.179	0.122	0.044
Spring Run Bottom		0.012	0.103	0.143	0.094	0.053

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Dumpling Run @Spring	2007	0.033	0.041	0.046	0.039	0.005
Dumpling Run Bottom		0.026	0.038	0.047	0.037	0.008
Spring Run @Spring		0.033	0.036	0.068	0.043	0.014
Spring Run Middle		0.072	0.106	0.293	0.128	0.083
Spring Run Bottom		0.068	0.085	0.101	0.084	0.012
TSS (mg/L)						
Dumpling Run @Spring	2005	1.150	4.500	45.000	12.880	17.423
Dumpling Run Bottom		1.150	2.075	43.000	9.580	16.588
Spring Run @Spring		1.000	1.575	78.000	14.380	31.175
Spring Run Middle		1.150	5.500	81.000	17.360	31.281
Spring Run Bottom		4.000	6.500	72.000	18.500	26.629
Dumpling Run @Spring	2006	1.150	1.150	4.000	1.625	1.164
Dumpling Run Bottom		3.000	5.500	8.000	5.500	2.258
Spring Run @Spring		1.150	2.575	11.000	4.075	3.933
Spring Run Middle		3.000	5.000	28.000	8.667	9.522
Spring Run Bottom		3.000	7.000	19.000	8.500	5.431
Dumpling Run @Spring	2007	0.800	2.500	5.000	2.433	1.597
Dumpling Run Bottom		0.800	4.500	7.000	3.967	2.246
Spring Run @Spring		2.000	3.500	6.000	3.667	1.633
Spring Run Middle		0.800	3.000	28.000	6.800	10.442
Spring Run Bottom		3.000	6.000	7.000	5.833	1.472
Turbidity (NTU)						
Dumpling Run @Spring	2005	0.45	0.90	22.95	7.52	10.60
Dumpling Run Bottom		1.24	2.12	43.80	10.29	16.83
Spring Run @Spring		1.03	1.95	18.42	5.22	6.84
Spring Run Middle		1.31	3.40	36.00	9.58	13.52
Spring Run Bottom		1.96	3.15	51.30	13.40	19.66
Dumpling Run @Spring	2006	0.67	0.97	2.15	1.14	0.59
Dumpling Run Bottom		2.71	3.54	4.31	3.61	0.58
Spring Run @Spring		3.14	4.78	7.47	4.86	1.66
Spring Run Middle		2.43	3.65	12.80	5.27	4.00
Spring Run Bottom		4.82	5.82	7.88	6.02	1.27
Dumpling Run @Spring	2007	1.20	1.58	6.82	2.49	2.18
Dumpling Run Bottom		3.32	3.82	6.89	4.45	1.33
Spring Run @Spring		2.27	4.98	7.27	4.88	1.72
Spring Run Middle		1.95	3.11	25.10	7.43	9.04
Spring Run Bottom		3.30	4.86	9.82	5.40	2.43
BOD5 (mg/L)						
Dumpling Run @Spring	2005	1.01	1.54	3.13	1.81	0.88
Dumpling Run Bottom		1.18	1.52	2.68	1.63	0.55
Spring Run @Spring		0.86	0.99	1.58	1.07	0.26
Spring Run Middle		0.45	0.91	2.47	1.26	0.83
Spring Run Bottom		0.66	1.01	1.97	1.15	0.49
Dumpling Run @Spring	2006	0.76	1.40	1.97	1.35	0.46
Dumpling Run Bottom		0.76	1.10	1.59	1.12	0.34
Spring Run @Spring		0.30	0.65	1.76	0.77	0.53

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Spring Run Middle		0.45	0.76	1.44	0.86	0.39
Spring Run Bottom		0.23	0.43	1.36	0.57	0.43
Dumpling Run @Spring	2007	0.15	0.68	1.06	0.61	0.33
Dumpling Run Bottom		0.23	0.61	1.21	0.61	0.37
Spring Run @Spring		0.15	0.42	0.83	0.42	0.24
Spring Run Middle		0.15	0.53	1.74	0.69	0.58
Spring Run Bottom		0.15	0.42	1.29	0.53	0.41
DO (mg/L)						
Dumpling Run @Spring	2005	9.2	10.3	11.1	10.2	0.62
Dumpling Run Bottom		9.4	10.4	11.5	10.5	0.69
Spring Run @Spring		10.0	10.3	11.5	10.6	0.63
Spring Run Middle		10.2	10.3	11.4	10.6	0.53
Spring Run Bottom		10.0	10.6	11.2	10.6	0.48
Dumpling Run @Spring	2006	9.7	10.6	12.2	10.7	0.98
Dumpling Run Bottom		9.8	10.6	12.2	10.7	0.86
Spring Run @Spring		9.8	10.5	12.8	10.8	1.17
Spring Run Middle		9.8	10.4	12.6	10.7	1.09
Spring Run Bottom		9.9	10.7	12.6	10.9	1.00
Dumpling Run @Spring	2007	10.2	10.5	11.2	10.6	0.35
Dumpling Run Bottom		9.7	10.3	10.9	10.3	0.39
Spring Run @Spring		8.9	10.1	11.2	10.2	0.82
Spring Run Middle		9.6	10.3	10.9	10.3	0.49
Spring Run Bottom		9.9	10.4	11.1	10.5	0.45
pH						
Dumpling Run @Spring	2005	7.4	7.8	8.0	7.7	0.24
Dumpling Run Bottom		7.5	8.1	8.5	8.0	0.36
Spring Run @Spring		7.4	7.9	8.2	7.8	0.31
Spring Run Middle		7.3	7.8	8.0	7.8	0.25
Spring Run Bottom		7.2	7.5	7.7	7.5	0.23
Dumpling Run @Spring	2006	7.3	7.6	7.8	7.6	0.17
Dumpling Run Bottom		7.4	7.8	8.4	7.8	0.38
Spring Run @Spring		7.3	7.7	8.2	7.7	0.31
Spring Run Middle		7.3	7.7	8.4	7.7	0.42
Spring Run Bottom		7.3	7.6	8.1	7.6	0.31
Dumpling Run @Spring	2007	7.1	7.5	7.9	7.5	0.34
Dumpling Run Bottom		7.3	7.6	8.2	7.7	0.38
Spring Run @Spring		7.2	7.7	8.2	7.7	0.33
Spring Run Middle		6.9	7.5	8.1	7.5	0.44
Spring Run Bottom		6.9	7.5	8.2	7.5	0.44
Conductivity (us/cm)						
Dumpling Run @Spring	2005	45.8	286.9	372.0	260.0	112.41
Dumpling Run Bottom		48.1	283.5	352.0	257.0	106.74
Spring Run @Spring		64.6	296.1	390.0	269.0	109.38
Spring Run Middle		44.9	255.0	284.0	223.0	88.65
Spring Run Bottom		45.1	247.5	276.0	213.0	85.87
Dumpling Run @Spring	2006	39.0	254.2	372.0	239.6	108.86

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Dumpling Run Bottom		44.9	263.9	352.0	241.3	103.48
Spring Run @Spring		49.0	330.3	391.1	263.0	153.97
Spring Run Middle		37.7	255.2	284.0	211.2	93.67
Spring Run Bottom		36.3	253.2	276.0	213.0	90.60
Dumpling Run @Spring	2007	234.0	257.0	345.0	271.7	39.83
Dumpling Run Bottom		253.0	271.5	340.0	283.2	31.72
Spring Run @Spring		271.0	358.0	375.0	347.5	38.30
Spring Run Middle		241.0	253.5	277.0	257.2	14.26
Spring Run Bottom		240.0	255.0	265.0	253.3	9.33

Appendix 2. Laboratory Methods for Water Quality Parameters.

Parameter	Method
Ammonia Nitrogen	EPA 350.2
Nitrate	EPA 353.2
Nitrite	EPA 353.2
* Ortho Phosphate	HACH 8048
Total Phosphate	EPA 365.2
Total Kjeldahl Nitrogen	EPA 351.2
Total Suspended Solids	SM 2540D
* Turbidity	HACH 2100N
Biochemical Oxygen Demand 5	SM5210B

Appendix 3. WV Save Our Streams Macroinvertebrate Assessment July 2003

Station 1 (catch-and-release)

Ephemeroptera (mayflies)	
Baetidae	73
Heptageniidae	2
Trichoptera (caddisflies)	
Rhyacophilidae	2
Hydropsychidae	13
Diptera (true flies)	
Simuliidae	8
Chironomidae	67
Amphipoda (scuds)	
Gammaridae	31
Total	196

Station 2 (catch-and-release)

Ephemeroptera (mayflies)	
Ephemerellidae	1
Heptageniidae	4
Baetidae	45
Plecoptera (stoneflies)	
Capniidae	1
Chloroperlidae	1
Perlodidae	4
Trichoptera (caddisflies)	
Glossosomatidae	2
Rhyacophilidae	1
Hydropsychidae	18
Coleoptera (beetles)	
Elmidae	4
Diptera (true flies)	
Simuliidae	16
Chironomidae	37
Amphipoda (scuds)	
Gammaridae	125
Total	259

Station 3 (above hatchery)

Ephemeroptera (mayflies)	
Isonychiidae	2
Ephemerellidae	3
Baetidae	30
Plecoptera (stoneflies)	
Capniidae	17
Perlodidae	6
Trichoptera (caddisflies)	
Rhyacophilidae	3
Hydropsychidae	17
Coleoptera (beetles)	
Elmidae	12
Psephenidae	1
Diptera (true flies)	
Dixidae	1
Simuliidae	12
Chironomidae	6
Amphipoda (scuds)	
Gammaridae	60
Total	170

Appendix 4. Assessing the Condition of the Macroinvertebrate Communities of Spring Run (Tim Craddock, Citizen's Monitoring Coordinator).

Pending availability of 2007 data.