# THE EFFECTS OF POLLUTION REDUCTION ON A WILD TROUT STREAM

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## ABSTRACT

Spring Run, a spring fed stream located in Grant County, West Virginia, is recognized as one of the best "wild" rainbow trout fisheries in the state. In recent years, fishermen have reported a decline in the fishery and aquatic insects, and an increase in algae in the stream. They are concerned about possible impacts from a WV Division of Natural Resources trout rearing facility, located upstream of the managed fishing section. The facility was cited in 2004 for discharging excess biochemical oxygen demand and total suspended solids into Spring Run in violation of their NPDES permit. In response, the WVDNR installed an effluent treatment process at the facility which became operational in June 2007. This study is investigating the response of Spring Run's biological communities to pollutant reductions following installation of the treatment system. Two years of baseline data were collected in Spring Run and a nearby control stream prior to installation of the effluent treatment system. The first year of post treatment data were collected this year. Data include water quality, stream flow, benthic macroinvertebrates, fish surveys by WVDNR, and fisherman catch records. This paper summarizes the baseline data and preliminary results from the first year of post-treatment data collections.

## INTRODUCTION

Spring Run, a spring fed stream located in Grant County, West Virginia, is recognized as one of the best "wild" rainbow trout fisheries in the state. Since the early 1960’s, landowners and other interested parties have installed and maintained various structures to form hiding and feeding habitat for trout along a one mile long section of the stream, and managed it for catch-and-release only fly fishing. In recent years, fishermen have noted a decline in the fishery, a decline in aquatic insects, and an increase in algae. They suspect pollution from the Spring Run Trout Hatchery (SRH - a WV Division of Natural Resources trout rearing facility), located upstream of the managed fly fishing section, could be the reason for the apparent decline.. SRH was cited in 2004 for discharging excess biochemical oxygen demand and total suspended solids into Spring Run in violation of their NPDES permit. In response, SRH installed an effluent treatment process at the facility that became operational in June 2007.

Concerns over the impacts of fish hatchery effluent on aquatic communities are not new. A study of five Virginia trout farms found that downstream waters had increased ammonia-nitrogen and nitrate nitrogen, decreased dissolved oxygen at post feeding and predawn hours, and found no effect on pH, nitrate nitrogen, and total phosphorus (Selong and Helfrich, 1998). The same report noted reductions in richness and abundance of sensitive macroinvertebrate taxa and increases in pollutant tolerant taxa (isopods and gastropods) below the outfall.

A Total Maximum Daily Load report for six Virginia streams impaired by trout farm effluent noted difficulties in assessing fish farm impacts: the effluent from trout farms is variable and episodic; the natural benthic community composition in limestone spring fed streams is uncertain, poor understanding of natural and other stressors and pollutant thresholds, and the challenge of finding suitable reference streams (VWRC, 2002).

The impending installation of an effluent treatment system at SRH provided an opportunity to assess the chemical and biological effects of the upgrade. A partnership between public and private entities was formed to develop and carry out this study. Two years of baseline data were collected in Spring Run and a nearby control stream prior to installation of the effluent treatment system. This paper summarizes the baseline data and provides partial results from the first year (2007) of post-treatment data collections.

## 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 are spring fed, with 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 component includes three sites in Spring Run: the first site is near the spring upstream of the hatchery; the second site is below the hatchery 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 both within stream and between stream comparisons. The samples collected near the two springs provides information on each stream's primary source water.. Under most conditions of flow the springs constitute the main source of water in both streams. Both streams also have periodic surface flow entering the main channel upstream of the springs.

Water samples were collected monthly from April through September, typically on Wednesday. Collections were avoided on hatchery cleanout days because the biosolids from aquaculture effluent are notoriously patchy and difficult to characterize (Joe Hankins, Freshwater Institute, personal communication). We chose to focus on the residual chronic impacts rather than the “cleanout plume." However, due to scheduling requirements, samples in September 2006 were collected on a Monday during the cleanout.

Water quality parameters included nitrogen in the forms of ammonia-nitrogen, nitrate/nitrite, total Kjeldahl nitrogen, total nitrogen (as the sum of nitrate/nitrite and TKN), soluble reactive phosphorus, total phosphorus, total suspended solids (TSS), biochemical oxygen demand ($BOD_{5}$), pH, temperature, conductivity, and dissolved oxygen. All tests were performed by a certified laboratory using standard methods. Flows were measured on the same day as water samples were collected in each stream.

Benthic invertebrate and periphyton samples were collected twice each year at all sites, in the spring and the autumn, according to standard WV Department of Environmental Protection protocols. WVDNR conducted electro shocking fishery assessments. The fly fishermen of Spring Run recorded information on the size and location of trout caught and released.

## RESULTS

**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. These flow patterns should be taken into account when reviewing the water quality data.

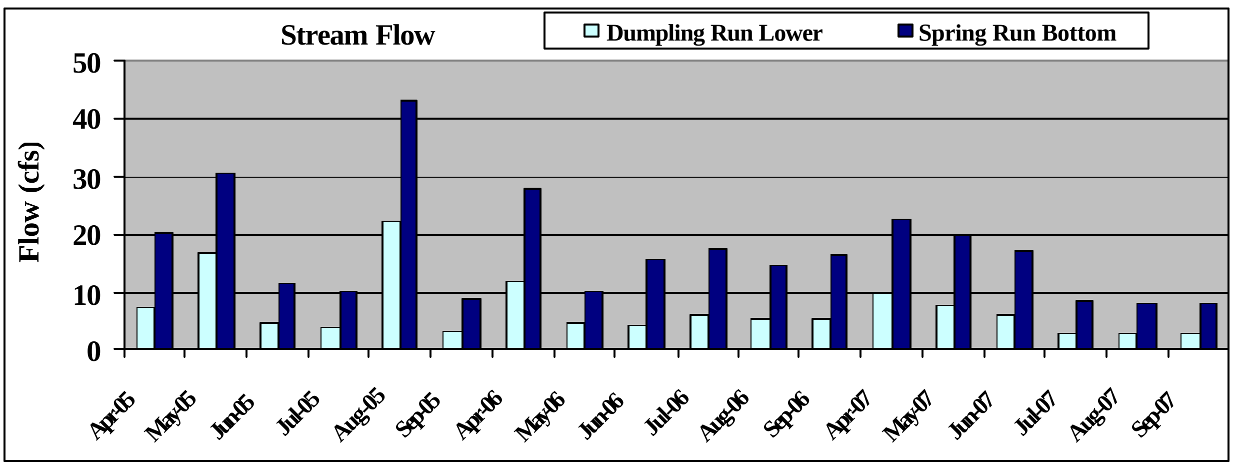


**Figure 1. Stream flow measurements at sites in Spring Run and Dumpling Run.**

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.

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. TP varied widely over time at all sites and, based on correlation analysis, did not vary with flow levels. However, the highest TP concentrations at all sites (except one) were recorded during an active runoff event in April 2006. Elevated TP from the hatchery effluent was evident at all flows at Spring Run Middle and Bottom.

**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 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. 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 '05 during a high water event. TN was always higher in all Spring Run sites than Dumpling Run.

**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 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. 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 noteably low during the one active runoff event in April 2006, and noteably high at all sites except DR Spring during a high water event in August 2005.

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 somewhat in a downstream direction in both streams. Correlation analysis indicated that TSS roughly tracked with flows at all sites. The highest levels for all sites were observed in August '05 during a high water event, but were not noteably high during an active runoff event captured in April 2006.

**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 |

**Benthics**. Certain benthic macroinvertebrate data for 2005 and 2006 is reviewed below in Tables 4 and 5; the data for 2007 is not yet available. All sampling sites were dominated by one of two macroinvertebrate families: Gammaridae and Chironomidae. Gammaridae were the dominant organism at four of the five sites, accounting for 41% to 88% of all the organisms collected. Chironomidae were noteably abundant in both of the Spring Run sampling sites located below the hatchery, and dominant in the site closest to the hatchery. The latter site was notable for the large amount of organic matter and matted algae entrained in the stream sediments. Chironomidae were present in relatively low numbers at the non point source impacted sites (Dumpling Run and Spring Run above the hatchery).

**Table 4. Benthic macroinvertebrate metrics (%EPT and % Dominant) for samples collected in 2005 and 2006.**

| Site | % EPT | | | | % Dominant | | | |
|---|---|---|---|---|---|---|---|---|
| | Spring 2005 | Fall 2005 | Spring 2006 | Fall 2006 | Spring 2005 | Fall 2005 | Spring 2006 | Fall 2006 |
| Dumpling Run @Spring | 14.7 | 7.1 | 10.4 | 10.7 | 80.4 | 87.9 | 82.0 | 83.0 |
| Dumpling Run Bottom | 31 | 25.3 | 1.0 | 10.2 | 43.8 | 68.8 | 88.0 | 84.0 |
| Spring Run @Spring | 40.4 | 6.4 | 32.1 | 5.8 | 41.3 | 87.2 | 55.0 | 90.0 |
| Spring Run Middle | 38.5 | 4.6 | 27.9 | 13.5 | 42.3 | 76.9 | 63.0 | 80.0 |
| Spring Run Bottom | 8.9 | 1.6 | 14.6 | 13.0 | 65.5 | 77.6 | 53.0 | 70.0 |

Percent EPT (Ephemeroptera, Plecoptera, Trichoptera) is a standard benthic invertebrate index where higher values are considered indicative of good water quality. The %EPT metric was never particularly high. It was always low at DR Spring, and SR Bottom. It was quite variable at DR Lower, SR Spring and SR Lower. It tended to be lower in the fall at the latter two sites.

**Table 5. Relative Density of Benthic Macroinvertebrates.**

| Site | 2005 | | 2006 | |
|---|---|---|---|---|
| | Spring | Fall | Spring | Fall |
| Dumpling Run @Spring | 5600 | 5975 | 4600 | 2929 |
| Dumpling Run Bottom | 3500 | 2975 | 2986 | 7533 |
| Spring Run @Spring | 3833 | 3800 | 4180 | 5625 |
| Spring Run Middle | 3042 | 19500 | 523 | 3071 |
| Spring Run Bottom | 7800 | 4800 | 3767 | 2300 |

Abundance, or density, of benthic macroinvertebrates is not a reliable parameter because of the difficulty in collecting truly quantitative samples on hard bottomed streams. However, as the collection method and number of replicates for each site is the same, extrapolating from the numbers collected in the sorted subsample to the entire sample allows a rough estimate of relative density. Table 5 provides these estimates. With the understanding that such data are not terribly reliable, it is notable that relative density varied by a factor of three at the non point source impacted sites and SR Bottom. Relative density was much more variable at SR Middle, ranging from a low of 523 in Spring 2006 and 19,500 in the Fall 2005. This great variability, along with abundant Chironomids and a very heavy mass of entrained algae and organic matter at this site, were probably causally related.

Benthic macroinvertebrate results from this study are skewed by a combination of the extreme dominance by Gammaridae at most sites, and due to the standard 200 organism subsample procedure in use by WVDEP. Organisms that were readily observed during sample collection in many cases did not show up in the final counts due to the two factors noted above. For example, Glossosomatid caddisflies were found in abundance on nearly every rock in Dumpling Run, but rarely showed up on the species list for this reason.

**Fisheries**. The West Virginia Division of Natural Resources, in cooperation with the West Virginia Conservation Agency, conducted two fishery surveys in Spring Run in 2005. Those results are available in the baseline report posted on Cacapon Institute's website.

Anglers with permits to fly fish, catch-and-release were invited 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 into 10 sections of unequal length, marked at streamside: numbered 0 thru 9, beginning with 0 at the downstream boundary and increasing upstream. 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. 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.

From April through December 2005, 65 anglers reported 230 fishing sessions resulting in 16.1 rainbow trout/angler session. From January through December 2006, 76 anglers reported 232 fishing sessions resulting in 9.8 rainbow trout/angler session. During both baseline years, the smaller trout (0 – 10”) were most abundant in the middle sections, while the larger trout (11” to

>2-“) were most abundant in the further upstream. Fishermen indicate that this pattern represents a shift from past years, but there is no specific data on distribution.

**Table 6**. Spring Run Angler Catch Reports, Rainbow Trout: 2005 - 2006

| ***Length*** | ***Stream Section*** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **Total** |
| 0-7 | 95 | 154 | 119 | 219 | 354 | 488 | 313 | 188 | 88 | 80 | **2098** |
| 8--10 | 40 | 49 | 46 | 121 | 249 | 330 | 312 | 351 | 267 | 228 | **1993** |
| 11--13 | 11 | 15 | 35 | 45 | 73 | 121 | 152 | 193 | 279 | 311 | **1235** |
| 14--16 | 0 | 5 | 4 | 24 | 34 | 41 | 64 | 69 | 72 | 178 | **491** |
| 17--19 | 0 | 1 | 1 | 2 | 8 | 6 | 11 | 16 | 14 | 43 | **102** |
| 20--up | 0 | 0 | 1 | 1 | 4 | 5 | 7 | 11 | 7 | 21 | **57** |
| **Total** | **146** | **224** | **206** | **412** | **722** | **991** | **859** | **828** | **727** | **861** | **5976** |
| % | 2.4% | 3.7% | 3.4% | 6.9% | 12.1% | 16.6% | 14.4% | 13.9% | 12.2% | 14.4% | |

## 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. 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.

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 the 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.

Preliminary review of post-treatment water quality data indicates that the plant upgrade did not change the water quality characteristics of the water downstream of the plant on non-cleanout days. Phosphorus remains elevated, and TSS and BOD5 remain lower in SR than DR. However, it is also clear that we are not capturing the reductions in the pollutant plume as a result of the new effluent treatment system. The cleaning process, which went on line June 4, 2007, involves placing blocking weirs in front of the quiescent zones, after which the quiescent zone is brushed cleaned and the wastewater from the quiescent zones is piped into the clarifier. The clarifier is filled to its holding capacity but is not allowed to overflow. Wastewater in the clarifier settles for 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. 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. WVDNR data also indicates that the hatchery's effluent stream, prior to initiating the cleaning process, contains very low levels of phosphorus that are not at all consistent with the concentrations we typically observe further downstream As of this writing, we are working to resolve that anomaly, and plan to include the results of that investigation in our presentation. We also hope to have preliminary results of biological monitoring in 2007.

## ACKNOWLEDGEMENTS

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## LITERATURE

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