Appendix H. Leatherman's Run Stream Assessment Annual Report, 2008

Leatherman's Run Stream Assessment

Year Six - 2008

Newark
New Castle County, DE

KCI Job Order No. 0203019

Prepared for:

STATE OF DELAWARE
Department of Transportation
Carolann Wicks, Secretary

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KCI Technologies, Inc.
February 2009

KCI TECHNOLOGIES

Leatherman's Run
Stream Assessment

Year Six - 2008

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Executive Summary

Analysis of the Leatherman's Run watershed began with a stream assessment in December of 2003. The stream continues to be monitored twice a year, once in the spring and once in the fall. The sixth year of monitoring was conducted in May and November 2008. A summary of the methodologies and results of data collected in 2008 at the monitoring stations is presented here.

Leatherman's Run is a 1,717.3-acre watershed located in New Castle County, Delaware. The watershed is situated to the southeast of Newark, Delaware. The watershed is generally bounded by Route 4 (Chestnut Hill Road) to the northwest and Route 273 (Christiana Road) to the northeast and east. The Leatherman's Run watershed is crossed by Interstate 95 (John Kennedy Memorial Highway) in the central part of the study area and by Road 336 (Old Baltimore Pike) in the most downstream portion of the watershed.

Monitoring included water quality sampling (instream and laboratory-analyzed baseflow grabs), biological assessment (macroinvertebrate and fish collection), physical habitat assessment and geomorphic monitoring. The sixth year of monitoring in the Spring and Fall of 2008 was conducted at the same locations established in previous years. Spring water quality and biological sampling was conducted on May 23, 2008. Fall water quality and biological sampling was conducted on November 18 and 21, 2008 and the geomorphic assessments were conducted on October 30 and 31, 2008.

Of the instream parameters, pH, temperature, dissolved oxygen and turbidity have regulated criteria. All of these parameters except for the turbidity at ST4, in the fall, were within acceptable levels. Based on baseflow grab sampling, there appears to be a higher level of total dissolved solids and chloride for those stations downstream of the I-95 service plaza continuing a trend from Year 4. Fecal coliform levels were elevated at all sites except LR4 and *Enterococcus* levels were also high. Other parameters of significance include phosphorus, zinc and cadmium, which were never detected in previous samples but were detected at all four sampling sites in 2007 and 2008.

Based on the 2008 sampling, there were no major changes evident in the biological community. As in 2006, all sites were classified as Not Supporting an acceptable level of biological health, with ST3 as an exception with Partially Supporting levels. The findings of the 2008 fish sampling are consistent with findings from 2003 – 2007. All three fish samples collected in 2008 decreased in diversity when compared to 2007 samples with one or two species dominating. They also consistently had low numbers of intolerant species and high percentages of tolerant species, indicating a reduction in water quality or habitat that is precluding sensitive species. Little to no change has been seen in the physical habitat and geomorphic assessment results since the baseline conditions were collected. All monitoring sites have the same Rapid Bioassessment Protocol (RBP) habitat rating seen in prior years, except for ST4 which had an RBP of Not Supporting for the first time during this study. Geomorphic assessment results show slight erosion and aggradation of stream channels at the monitoring locations.

1.0 INTRODUCTION

Study of the Leatherman's Run stream system began in Fall 2003 with a stream walk assessment conducted throughout the watershed. The assessment was followed by annual stream monitoring at select locations in the watershed in the Fall from 2003 to 2008, and in the Spring from 2004 to 2008. Monitoring included water quality sampling and biological assessments consisting of macroinvertebrate and fish collection, physical habitat assessment and geomorphic monitoring. Please refer to the *Leatherman's Run Stream Assessment, Baseline Conditions Year One – 2003* for the baseline results and subsequent *Leatherman's Run Stream Assessment* annual reports for the results of yearly monitoring.

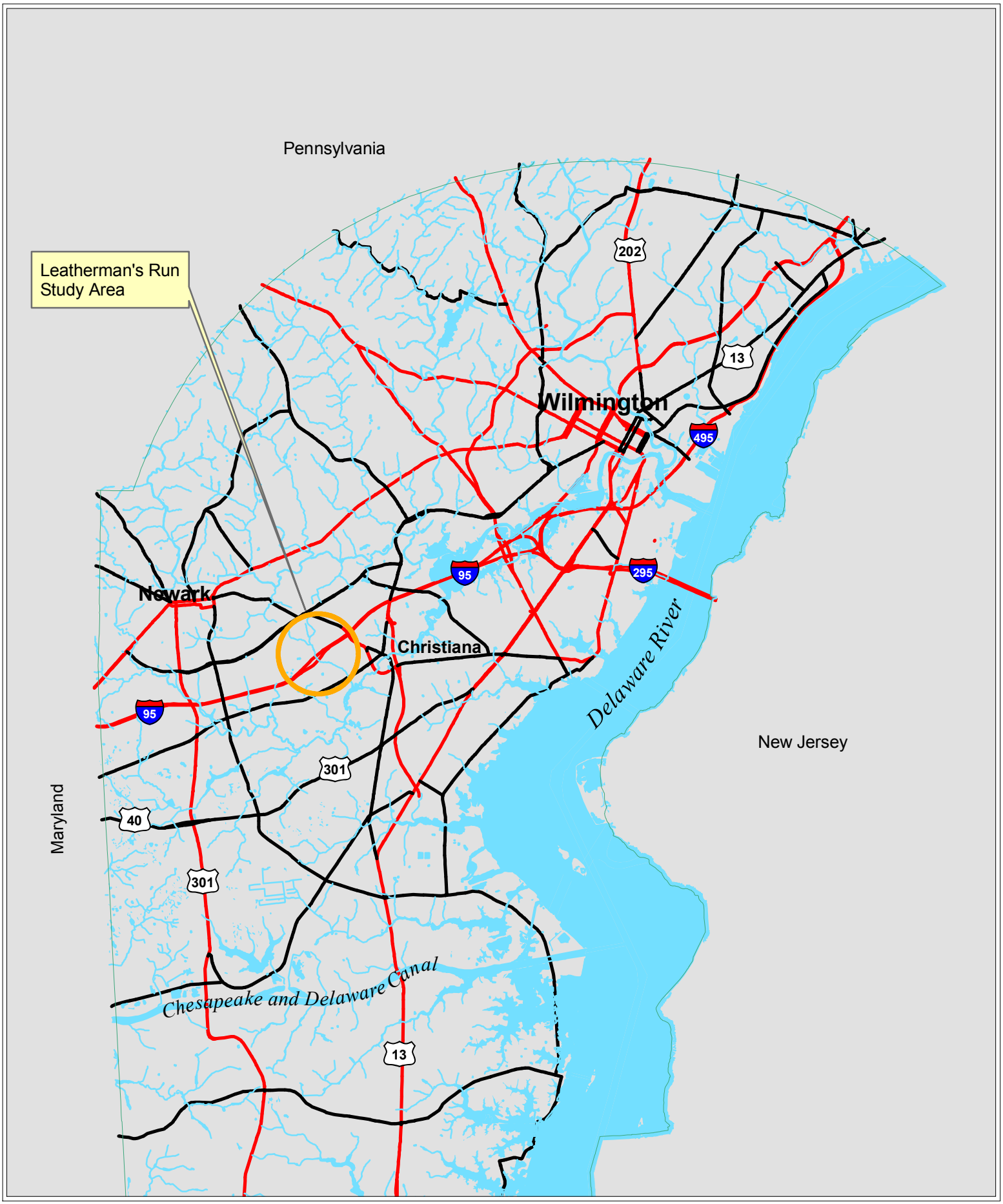
The sixth year of monitoring was conducted in the Spring and Fall of 2008 at the same locations established in previous yearly monitoring. Spring water quality and biological sampling was conducted on May 23, 2008. Fall water quality and biological sampling was conducted on November 18, 2008 and the geomorphic assessments were conducted on October 30 and 31, 2008. A summary of the methodologies and results of data collected at the monitoring stations is presented here.

Study Area Description

Leatherman's Run is a 1717.3-acre watershed located in New Castle County, Delaware. The watershed is situated to the southeast of Newark, Delaware. See **Figure 1** on the following page for details. The watershed is generally bounded by Route 4 (Chestnut Hill Road) to the northwest and Route 273 (Christiana Road) to the northeast and east. The Leatherman's Run watershed is crossed by Interstate 95 (John Kennedy Memorial Highway) in the central part of the study area and by Road 336 (Old Baltimore Pike) in the most downstream portion of the watershed. For the purposes of the stream monitoring, the watershed was subdivided into four catchments, LR1, LR2, LR3 and LR4. Refer to **Figure 2** for the location of the catchments. **Table 1** presents the size of each catchment and the corresponding percent of the total watershed area.

Table 1: Catchment and Watershed Area

Catchment	Area (acres)	Percent of Watershed
LR1	557.4	32.5
LR2	342.1	19.9
LR3	431.8	25.1
LR4	385.9	22.5
TOTAL	1717.3	100.0



Leatherman's Run Stream Assessment

1 inch equals 3 miles

Figure 1 - Vicinity Map

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Physiography

There are five major drainage basins in Delaware, including the Piedmont, Chesapeake Bay, Delaware Bay, Delaware Estuary, and the Inland Bays/Atlantic Ocean basins (DNREC, 2000). Leatherman's Run is in the Piedmont. Other watersheds in the Piedmont include Naamans Creek, Shellpot Creek, Red Clay Creek, White Clay Creek, and Christina River watersheds (DNREC, 2004B). The Leatherman's Run watershed flows generally in a southeasterly direction to Smalleys Pond, which is an in-line pond in the Christina River. The Christina River flows northeast through Newport and discharges to the Delaware River in Wilmington. Leatherman's Run is in the Christina River Sub-Basin. This sub-basin is predominantly in New Castle County, DE, however small portions are located in Maryland and Pennsylvania. The Christina Sub-Basin along with the White Clay Creek, Red Clay Creek and Brandywine Creek sub-basins make up the Christina Basin, which drains much of Chester County, PA and New Castle County, DE. The Leatherman's Run watershed lies near the transition, or the fall line, between the Piedmont geologic province and the Coastal Plain geologic province.

2.0 STREAM MONITORING METHODOLOGIES

Monitoring Station Description

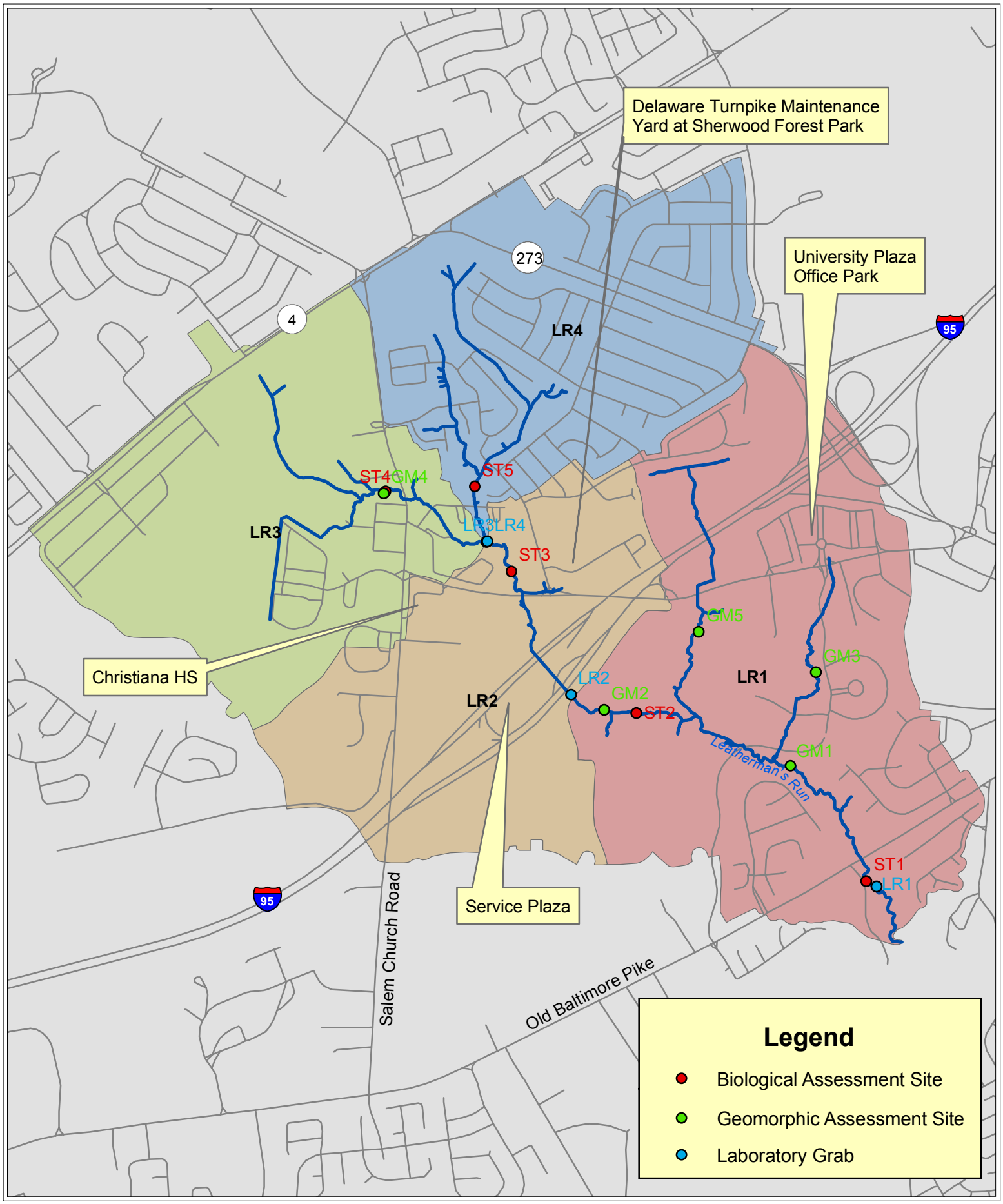
Monitoring sessions involved the collection of water quality data, sampling and analysis of the benthic macroinvertebrate and fish communities, assessment of physical habitat features, collection of geomorphic data, and photo-documentation of site conditions at each monitoring station along the stream. Monitoring stations were selected to provide data throughout the Leatherman's Run watershed on the mainstem and various tributaries.

The laboratory-tested grab samples were collected at four points in the watershed at the downstream end of each of the four delineated catchments. The sampling sites (LR1, LR2, LR3 and LR4) are shown on **Figure 2.** The biological monitoring stations (ST1, ST2, ST3, ST4 and ST5) are also shown. These stations were 100 meters in length and were sampled for instream water quality, physical habitat, and macroinvertebrates. Fish were sampled at ST1, ST2 and ST3. Geomorphic assessments were conducted at four locations (GM1, GM2, GM4, and GM5) and are also depicted on **Figure 2**. Site GM3 was surveyed from 2003 through 2005 however it was discontinued due to stream restoration activities at the site.

Water Quality

Regulations

The Delaware Department of Natural Resources and Environmental Control (DNREC) has set statewide water quality standards and use classifications in the State of Delaware Surface Water Quality Standards (DNREC, 2004A). Leatherman's Run, which drains to Smalley's Pond and the Christina River, is in the Christina River Basin and the Christina River Sub-Basin. Designated uses are applied at the basin level. Designated uses for the Christina Basin, in the vicinity of Leatherman's Run, include public water supply source, industrial water supply, primary and secondary contact recreation, fish, aquatic life and wildlife, and agricultural water supply. Water quality results from Leatherman's Run were compared to the criteria set forth for the designated use.



1 inch equals 1 miles

Leatherman's Run Stream Assessment

Figure 2 - Stream Monitoring - Station Location Map

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Water Quality Criteria and Total Maximum Daily Load (TMDL) endpoints have been established for some parameters for the Christina River Basin by the Environmental Protection Agency (EPA) Region 3 (EPA, 2006A and EPA, 2006B).

- Dissolved Oxygen: average daily minimum of 5.5 mg/l, instantaneous minimum of 4.0 mg/l (both same as DNREC standards)
- Nitrate-Nitrogen: 10 mg/l
- Total Nitrogen: 3.0 mg/l
- Total Phosphorus: 0.2 mg/l (this represents an increase of 0.1 mg/l from previous reports)
- *Enterococcus* Bacteria for primary contact fresh waters: single sample value of 185 colonies per 100 ml or 100 colonies per 100ml as a geometric mean

General summarized DNREC water quality standards (DNREC, 2004A) that apply to Leatherman's Run with its use classification are as follows.

- Temperature: maximum true daily mean 82°F (28°C), daily maximum 86°F (30°C)
- Dissolved Oxygen: average daily minimum of 5.5 mg/l, instantaneous minimum of 4.0 mg/l
- pH: range from 6.5 to 8.5 unless natural conditions permit
- Turbidity: not to exceed natural conditions by more than 10 NTUs
- Bacteria (*Enterococcus*): single sample value of 185 colonies per 100 ml or 100 colonies per 100 ml as a geometric mean
- Nutrients: applied on a site specific basis, for lakes and ponds reduction of nutrient enrichment is the goal
- Metals for protection of human health (fish and water ingestion):
    - Cadmium – 0.005 mg/l
    - Chromium – 0.1 mg/l
    - Copper – 1.3 mg/l
    - Lead – 0.015 mg/l
    - Nickel – 0.1 mg/l
    - Zinc – 7.4 mg/l

Instream

Instream water quality measurements were collected at upstream, midstream and downstream locations at three monitoring stations (ST1-ST3) on May 23, 2008 and November 18, 2008. All parameters were measured with an YSI® 6290 multi-probe and YSI® 650 MDS data logger with the exception of turbidity, which was measured with the Hach 2100 Turbidimeter. The stream was sampled for pH, temperature, dissolved oxygen, turbidity, conductivity and total dissolved solids. The complete list of field-tested parameters and results is located in **Table 8** and in **Appendix A**.

Laboratory-Tested Water Quality Grab Samples

Dry weather grab samples were collected on November 18, 2008 at four locations (LR1-LR4) in order to identify any substances or pollutants that are out of the ordinary. Samples were collected and sent for laboratory analysis of sediment, nutrients, pathogens, metals, organic chemicals, and oxygen demand. The complete list of parameters can be found in **Table 9** and in **Appendix A**.

Macroinvertebrate Sampling

Macroinvertebrate sampling was conducted at each station (ST1, ST2, ST3, ST4, and ST5) following the procedures described in EPA's Revisions to the Rapid Bioassessment Protocol (RBP) (Barbour et al., 1999) and modified by DNREC for the piedmont region of Delaware. The

modified RBP methodologies utilize systematic field collections of benthic macroinvertebrates, laboratory identification to the genus or lowest possible taxonomic level, and data analysis using metrics designed for Delaware piedmont streams.

Macroinvertebrate sampling was conducted using the composite sampling procedure, which consists of sampling a range of habitat types within the stream system. Potential habitats include submerged vegetation, overhanging bank vegetation, leaf packs, mats of organic matter, stream bed substrate, submerged materials (i.e., logs, stumps, snags, dead branches, and other debris), and rocks.

For the composite sampling procedure, Sampling Area Selection Forms were completed at each station to determine the percent coverage for each habitat type. Percentages were based upon visual observation and only represented a rough estimate of available habitat at the time of the sampling. These percentages were, in turn, multiplied by 0.2 to determine how many samples out of 20 would be taken for each habitat type. One sample consists of jabbing a 600 μm D-frame net along potential habitat so that one linear foot of surface is sampled. The bottom portion of the D-frame net is 12 inches in width, so one jab of 12 inches in length will sample one square foot. Twenty jabs of the net will succeed in sampling 20 square feet of stream area.

All samples collected at each station were combined in a sieve bucket (#30 mesh). Large woody debris, rocks and leaves were rinsed to reduce the sample size and the remaining sample was transferred to a sample container and preserved with 95 percent ethanol before transporting to the lab.

Each sample was subsampled to 120 organisms to ensure at least 100 identifiable individuals in each sample. Unidentifiable organisms include early instars or specimen with necessary body parts missing. Subsampling was conducted by first rinsing the sample to remove the ethanol. Large debris remaining from the field were rinsed and removed from the sample. The sample was spread onto a gridded tray and a random number generator was used to select grids for picking. The grids were six centimeters by six centimeters and each was picked completely clean until 120 organisms were picked. Because each grid must be picked clean it is possible for a subsample to have more than 120 organisms. A tally was kept of how many grids were picked for each sample.

Macroinvertebrates were then quantified and identified to the genus or lowest possible level. The organisms were then classified according to Functional Feeding Groups and tolerance to pollutants. Functional Feeding Group classifications and tolerance values were based upon available information from Merritt and Cummins (1996), The EPA's RBP (Barbour et al, 1999), Hilsenhoff (1988) and the Maryland Department of Natural Resources (MD-DNR, 2005). When no information could be found for a particular taxon, the next taxonomic classification (generally family or tribe) up or best professional judgment was used.

Macroinvertebrate Data Analysis

After the organisms from the field samples were identified and quantified, the results were transformed into the series of core metrics. Metrics are numerical values used to measure various components of benthic community structure, including pollution sensitivity. Four core metrics, which reveal the most significant information about stream quality in Delaware piedmont streams, were selected. Each metric was calculated from raw data, which can be compared to values calculated for other sampling points (e.g., reference streams or upstream locations). Metrics included Taxonomic Richness (TOTTAX), which equals the total number of genera or higher taxa present in the sample; Hilsenhoff Biotic Index (HBI), which equals the sum of the total number of individuals in each genus multiplied by their tolerance values, divided by the total number of

organisms in the sample; EPT Richness (EPTTAX), which equals the total number of genera or higher taxa in the sample within the orders Ephemeroptera (E), Plecoptera (P), and Trichoptera (T); and EPT Abundance (EPTABUN), which equals the percentage of EPT individuals in the sample.

A bioassessment score was then completed by comparing the total score for each station to the best possible score of 24. Each station was then given a classification of "fully supporting", "partially supporting", or "not supporting". These classifications were developed based on sampling results from previous studies in Delaware conducted by DNREC. The classifications provide a relative indication of the overall biological quality of a stream sampling station, as compared to the state's reference streams and other sampling stations. The Biological Condition Scoring Criteria and Bioassessment ranges are listed in **Tables 2** and **3**, respectively.

Table 2: Modified RBP Biological Condition Scoring Criteria

Metric	6	3	0
TOTTAX (Taxa Richness)	> 18	9 – 18	< 9
HBI (Hilsenhoff Biotic Index)	< 4.0	4.0 – 5.0	> 5.0
EPTTAX (EPT Richness)	> 9	5 – 9	< 5
EPTABUN (EPT Abundance)	> 51	26 – 51	< 26

Table 3: Modified RBP Bioassessment

Percent comparison	Classification
67 – 100	Fully supporting
34 – 66	Partially Supporting
0 – 33	Not Supporting

Fish Assemblage

The fish community was sampled at three of the monitoring locations, ST1, ST2 and ST3, all of which are on the mainstem of Leatherman's Run. All stations were sampled on November 21, 2008. DNREC currently does not have a full-scale fish monitoring program or a standardized procedure specifically for Delaware streams. Therefore, the EPA's RBP for fish sampling (Barbour et al, 1999) was used. In general the approach uses electro-fishing of the entire 100-meter study reach. All collected fish are enumerated, length and weight are recorded, and all fish are checked for abnormalities. Data analysis was conducted using the methods developed for Maryland's eastern piedmont streams by the MD-DNR for their Maryland Biological Stream Survey (MD-DNR, 2000). The method uses a multimetric approach to calculate measures of diversity, tolerance and biomass. The nine metrics are calculated and a score of one, three or five was assigned. The metrics and their scoring criteria are listed in **Table 4**. The scores are then tabulated and an overall Fish Index of Biotic Integrity (FIBI) score is calculated. The FIBI range of scores and classifications are presented in **Table 5**.

Table 4: Fish Metrics and Scoring Criteria

Metric	5	3	1
Number of native species*	≥ 1.02	0.56 ≤ x < 1.02	< 0.56
Number of benthic species*	≥ 0.99	0.50 ≤ x < 0.99	< 0.50
Number of intolerant species*	≥ 0.59	0.18 ≤ x < 0.59	< 0.18
Percent tolerant species	≤ 41	41 < x ≤ 65	> 65
Percent abundance of dominant species	≤ 30	30 < x ≤ 52	> 52
Percent generalists, omnivores and interivores	≤ 86	86 < x ≤ 99.7	> 99.7
Number of individuals per square meter	≥ 0.81	0.35 ≤ x < 0.81	< 0.35
Biomass per square meter	≥ 8.0	3.7 ≤ x < 8.0	< 3.7
Percent lithophilic spawners	≥ 62	22 ≤ x < 62	< 22

*metric score calculated is corrected for drainage area influence

Table 5: Fish Index of Biotic Integrity

FIBI	Classification
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

Physical Habitat Assessment

Each monitoring station was characterized based on physical characteristics and various habitat parameters following a modified RBP Habitat Assessment for Piedmont Streams. Habitat availability and the quality of that habitat have an effect on the quantity and types of aquatic organisms that can live within a stream system. Habitat impairment has a direct impact on the overall health of a stream. The habitat assessment consisted of a review of 11 biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. The individual parameters are:

- Channel Modification
- Riffle Quality
- Velocity/Depth Diversity
- Shading
- Bottom Substrate Cover
- Frequency of Riffles
- Bank Stability
- Riparian Zone Width
- Embededdness
- Sediment Deposition
- Bank Vegetation

In order to assess a stream's ability to support an acceptable level of biological health, all parameters are totaled and compared to the mean of the reference sites from previous studies conducted in Delaware's piedmont region by DNREC. The percent of comparability is then calculated and the study reach is placed in a classification category. The ranges and classifications are listed in **Table 6**.

In addition to the 11 parameters, the physical characterization included an assessment of water color, water odor, presence or absence of rock staining, water surface substances and stream bed coatings. The assessment also included an evaluation of the recent weather conditions and predominant land use within one-quarter mile of each monitoring station.

Table 6 : Habitat Classification

Percent comparison	Classification
90 – 100	Fully supporting
60 – 89	Partially Supporting
0 – 59	Not Supporting

Geomorphic Assessment

Geomorphic assessments were conducted at five monitoring stations on October 30 and 31, 2008, and included surveyed profiles, cross-sections, pebble counts and measures of sinuosity. See **Figure 2** for the locations of the assessment stations. The focus of the evaluation was on channel width, bankfull depth, width/depth ratios, and bank stability. In the baseline assessment, permanent repeatable surveyed cross-sections were established with profiles and pebble counts at each station. A Rosgen channel type classification was assigned to each reach following the baseline assessment. The general descriptions of each class are provided in **Table 7**. Yearly monitoring data has been compared to baseline data to detect changes over time.

The longitudinal profile was established along the thalweg thread. Major break points in the channel were surveyed. Channel features were identified including the start and end of riffles, runs, pools and glides. Water surface, bankfull elevations, terrace features and the top of bank were also surveyed. Longitudinal profile surveys were completed to determine riffle/pool-sequencing patterns and to determine changes in channel slope.

One cross-section was field surveyed at each station to generate mean depth, cross-sectional area, bankfull depth, bankfull width, width/depth ratio and flood prone width. Cross-sections were located on representative cross-over reaches and were surveyed every two feet out of bank and every one foot within stream banks and at break points. The cross-sections are resurveyed each year and compared over time for changes. Pebble counts were conducted at each station. A representative count was conducted at ten transects across the entire reach in riffles, pools, runs, and glides in the same proportion that these features occur in the reach. An additional count was performed at the cross-section location.

Valley slope and length were also measured for each station. As the stream profile was completed an additional measurement of a straight line distance between the top and bottom of the reach was collected. This provides a measure of sinuosity.

Photographic Documentation

Site photographs were taken during all site visits to document stream and watershed conditions and any changes that are occurring over time. Typical photographic documentation includes photos taken oriented upstream and downstream from the midpoint of the sampling station. Problem areas such as bank failures and sedimentation were also photographed.

Table 7: Level I Channel Type Description

Channel Type	General Description (from Rosgen 1996)
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

3.0 RESULTS AND DISCUSSION

3.1 Stream Monitoring

Water Quality

Tables 8 and **9** list the results of the instream and laboratory grab water quality sampling. Instream results are also presented on **Figure 3** and in **Appendix A**. A description of each instream parameter can be found in the *Leatherman's Run Stream Assessment Baseline Conditions Report - 2003*. Of the instream parameters, pH, temperature, dissolved oxygen and turbidity have regulated criteria. Most of the parameters were within acceptable levels. The turbidity at ST4 (14.6) taken during the Fall 2008 sampling fell above the regulated criteria of 10NTU. The instream water quality samples generally did not detect any parameters that were far out of the ordinary for freshwater streams draining urban land uses. The *Enterococcus* levels for all sites except LR1 exceeded DNREC toxicity standards for human health.

Based on baseflow grab sampling, there appears to be a higher level of total dissolved solids and chloride for those stations downstream of the I-95 service plaza. The Year Five report indicated an increase in total dissolved solids (TDS) and conductivity based on instream readings; however, this trend does not continue in Year Six. While levels are high, they have decreased from levels seen in Year Five monitoring. Similar to Year Five, the highest levels are at ST2, which is located just downstream of the service plaza. Conductivity levels for all stations, including those downstream of the I-95 service plaza, have decreased from Year Five. While the highest conductivity reading during Year Five monitoring was measured at 735.7 µS/cm at ST2, the highest conductivity reading for Year Six was measured at 434.0 µS/cm also at ST2.

Laboratory-analyzed grab samples did not detect any of the petroleum derivatives (benzene, toluene, ethylbenzene and xylene or BTEX) or the polycyclic aromatic hydrocarbons (PAH)

parameters (**Table 9**). As in previous years, the level of total dissolved solids is higher at the two sites downstream of the service plaza, but within a normal range. Total suspended solids were also higher at LR3 than in previous years. The measures of oxygen demand are also in the normal range. Oil and grease were not detected in any of the 2007 samples, however they were detected at LR4 in 2008. Fecal coliform levels were elevated at all sites except LR4. *Enterococcus* levels were also high at LR2 and LR3, with LR3 levels at 1120 mpn/100 ml, significantly higher than the DNREC single sample maximum of 185 colonies per 100 ml. There was no lead or copper detected in any of the 2007 or 2008 samples; however nickel was detected in 2008. Zinc was detected at all four sampling sites at levels similar to previous years, with the exception of LR2 (2008 value was 0.36 mg/L). The 2008 phosphorus level (0.10 mg/L) was similar to that at LR1 in 2007 (0.13 mg/L). Both are higher than any other levels during this study. Cadmium which had never been detected in previous samples until 2007 was again detected at two of the sampling sites in 2008.

Wet weather water quality sampling was also conducted at the I-95 Service Plaza under a separate task. Baseline monitoring began in April 2003. Eleven wet weather events were sampled at the service plaza between April 2003 and December 2004 to assess the impact of the service plaza on Leatherman's Run. Generally the results indicated higher levels of pollutants at the downstream sampling site compared to the upstream sampling site. Values for total suspended solids, total dissolved solids, oxygen demand, chloride, bacteria, and nitrogen were higher at the downstream site, especially in the first flush results. Refer to the *I-95 Service Plaza Baseline Storm Monitoring: Event 11- Final Report* for the complete results of baseline wet weather monitoring data. DelDOT installed five retrofit Best Management Practices (BMPs) at the I-95 Service Plaza between July 2003 and July 2005. Monitoring resumed at the baseline sites and at each BMP in April 2005 to evaluate the effectiveness of installed BMPs in reducing runoff pollution from the service plaza. Between November 2007 and December 2008 one wet weather event was sampled. A summary of the effectiveness of these new BMPs can be found in the *Best Management Practices Wet Weather Monitoring Summary Report – 2008.*

Please refer to **Section 3.2** for a discussion on water quality trends over the course of six years of monitoring.

Table 8: Instream Water Quality Results

Station	Date	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Total Dissolved Solids (mg/L)
ST1	12/23/03	6.9	4.10	10.96	12.0	464.8	297.4
	05/11/04	7.0	18.36	6.68	9.7	414.0	264.9
	12/14/04	9.3	4.59	0.48*	4.1	314.3	201.1
	05/18/05	6.5	13.09	n/a	3.9	591.1	378.3
	01/06/06	3.2	5.42	10.66	8.1	495.4	317.0
	05/11/06	7.8	14.69	8.27	9.3	514.3	334.0
	12/18/06	7.9	6.29	7.99	5.4	393.0	254.0
	05/15/07	8.4	14.13	7.89	5.2	635.0	412.7
	12/19/07	6.3	2.52	13.83	4.3	619.0	n/a
	05/23/08	6.9	12.8	9.91	4.9	394.7	256.3
	11/18/08	7.7	5.26	9.98	5.41	291.3	189.3
ST2	12/23/03	7.2	5.94	10.82	14.3	461.6	306.8
	05/11/04	7.4	18.63	7.19	11.4	441.1	282.4
	12/14/04	8.5	4.78	8.09*	5.0	307.8	196.7
	05/18/05	7.2	13.34	n/a	4.5	718.9	460.4
	01/06/06	4.1	5.87	11.72	4.7	523.2	334.5
	05/11/06	7.8	14.86	8.01	5.8	735.7	478.7
	12/18/06	7.9	6.47	7.99	5.4	423.3	275.0
	05/15/07	8.0	14.35	9.31	4.6	667.3	433.7
	12/19/07	6.5	3.74	13.72	5.2	679.7	441.7
	05/23/08	6.9	13.3	10.35	4.2	434.0	281.7
	11/18/08	7.0	5.43	11.62	4.55	419.0	272.3
ST3	12/23/03	7.1	6.96	10.70	10.3	310.1	198.4
	05/11/04	7.6	20.32	7.35	9.7	272.5	174.5
	12/14/04	8.0	5.34	7.31*	4.3	210.0	134.4
	05/18/05	7.5	13.74	n/a	3.8	278.9	178.5
	01/06/06	5.8	6.01	11.48	4.1	304.5	194.8
	05/11/06	7.8	15.21	8.12	3.3	264.0	172.0
	12/18/06	8.1	9.32	8.15	6.8	223.3	145.3
	05/15/07	8.0	14.65	8.93	4.8	286.3	186.0
	12/19/07	6.7	4.40	14.32	5.3	364.0	236.3
	05/23/08	n/a*	14.10	10.24	4.1	273.0	177.0
	11/18/08	7.6	5.54	13.47	3.9	211.7	125.3

Station	Date	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Total Dissolved Solids (mg/L)
ST4	12/31/03	6.9	3.14	10.56	10.8	224.3	143.8
	05/11/04	7.6	21.78	6.19	9.8	194.4	124.4
	12/14/04	7.8	4.41	0.57*	4.8	181.9	116.4
	05/18/05	7.1	13.95	n/a	7.3	243.8	155.8
	01/06/06	n/a	n/a	n/a	n/a	n/a	n/a
	05/11/06	7.4	15.53	7.81	3.7	254.0	165.0
	12/18/06	8.0	11.37	8.31	5.9	200.0	130.0
	05/15/07	7.9	15.25	9.88	6.0	243.0	157.7
	12/19/07	6.8	6.01	n/a	3.8	294.7	191.7
	05/23/08	6.9	15.50	9.12	4.5	186.7	121.3
	11/18/08	7.5	6.73	15.4	14.6	192.7	125.3
ST5	12/31/03	6.8	5.69	10.85	5.1	456.4	292.1
	05/11/04	7.7	21.09	6.43	8.8	454.8	291.7
	12/14/04	7.7	4.31	0.52*	3.5	259.1	165.0
	05/18/05	7.4	15.07	n/a	3.1	315.9	202.2
	01/06/06	n/a	n/a	n/a	n/a	n/a	n/a
	05/11/06	7.3	15.83	7.77	4.6	242.3	158.0
	12/18/06	7.6	11.25	8.76	3.2	203.7	134.0
	05/15/07	7.7	16.45	8.53	6.2	306.7	199.7
	12/19/07	6.8	4.59	n/a	2.9	401.0	260.7
	05/23/08	6.8	14.5	9.54	4.9	425.0	276.3
	11/18/08	7.7	5.20	18.08	3.7	212.0	138.0

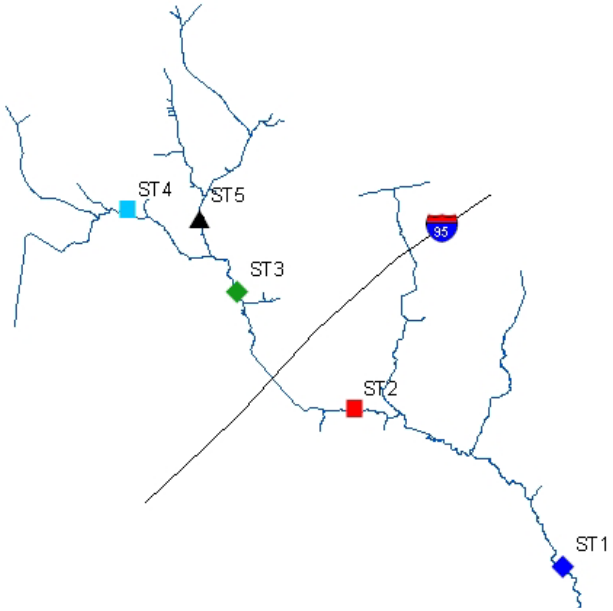
* Sample not collected due to equipment failure.

Table 9: Laboratory Grab Sample Water Quality Results, 2008

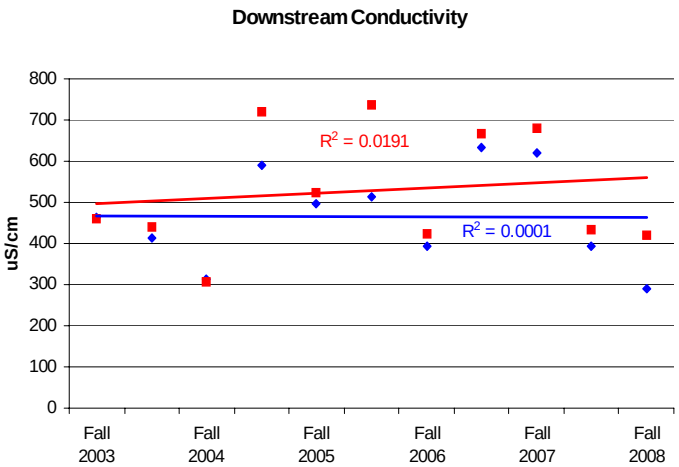
Year	2008			
Parameter	**LR1**	**LR2**	**LR3**	**LR4**
Total Suspended Solids (TSS) mg/L	ND	5	12	ND
Total Dissolved Solids (TDS) mg/L	211	271	143	153
Chemical Oxygen Demand (COD) mg/L	18	30	54	17
Biochemical Oxygen Demand (BOD) mg/L	ND	3	19	ND
Chloride mg/L	66.2	95.7	24.2	27.6
Oil and Grease mg/L	ND	ND	ND	5.4
Fecal Coliform mpn/100 ml	130	1600	1600	50
Enterococcus mpn/100 ml	74.9	345	1120	101
pH	7.46	7.57	7.29	7.72
Total Kjeldahl Nitrogen (TKN) mg/L	0.68	0.61	0.62	0.60
Nitrate-Nitrite mg/L	0.15	ND	ND	ND
Total Ammonia mg/L	ND	ND	ND	ND
Total Phosphorus mg/L	ND	ND	0.1	ND
Orthophosphate mg/L	ND	ND	ND	ND
Total Cadmium mg/L	ND	0.002	0.002	ND
Total Chromium mg/L	ND	ND	ND	ND
Total Copper mg/L	ND	ND	ND	ND
Total Lead mg/L	ND	ND	ND	ND
Total Nickel mg/L	0.007	0.008	0.008	0.007
Total Zinc mg/L	0.032	0.36	0.033	0.017
Total Petroleum Hydrocarbons (TPH) mg/L	ND	ND	ND	ND
Gasoline Range Organics (GRO) µg/L	ND	ND	ND	ND
Benzene µg/L	ND	ND	ND	ND
Toluene µg/L	ND	ND	ND	ND
Ethylbenzene µg/L	ND	ND	ND	ND
Total Xylenes µg/L	ND	ND	ND	ND
Napthalene µg/L	ND	ND	ND	ND
Acenaphthylene µg/L	ND	ND	ND	ND
Fluorine µg/L	ND	ND	ND	ND
Phenanthrene µg/L	ND	ND	ND	ND
Anthracene µg/L	ND	ND	ND	ND
Fluoranthene µg/L	ND	ND	ND	ND
Pyrene µg/L	ND	ND	ND	ND
Chyrsene µg/L	ND	ND	ND	ND
Benzo (a) anthracene µg/L	ND	ND	ND	ND
Benzo (b) fluoranthene µg/L	ND	ND	ND	ND
Benzo (k) fluoranthene µg/L	NT	NT	NT	NT
Benzo (a) pyrene µg/L	ND	ND	ND	ND
Dibenzo (a,h) anthracene µg/L	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene µg/L	ND	ND	ND	ND
Benzo (g,h,i) perylene µg/L	ND	ND	ND	ND
Total Phenols mg/L	ND	ND	ND	ND

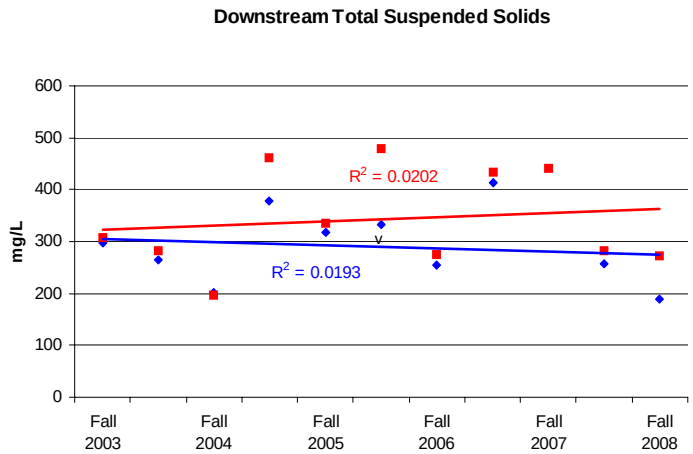
ND = Not Detected
NT = Not Tested

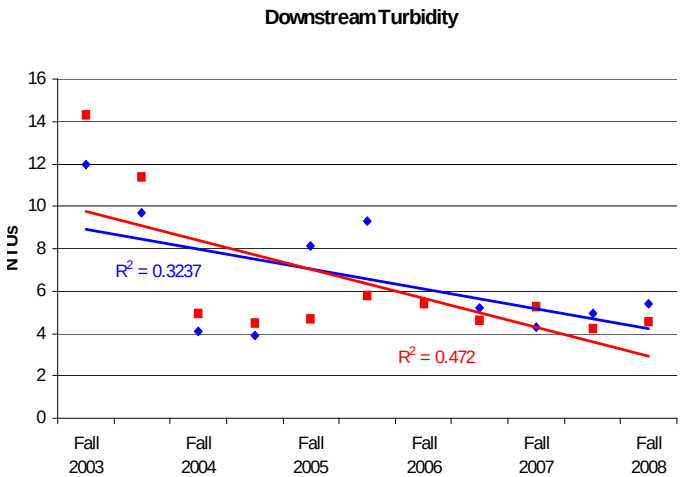
Figure 3
Leatherman's Run
Water Quality Sampling – Results
Fall 2003 – Fall 2008

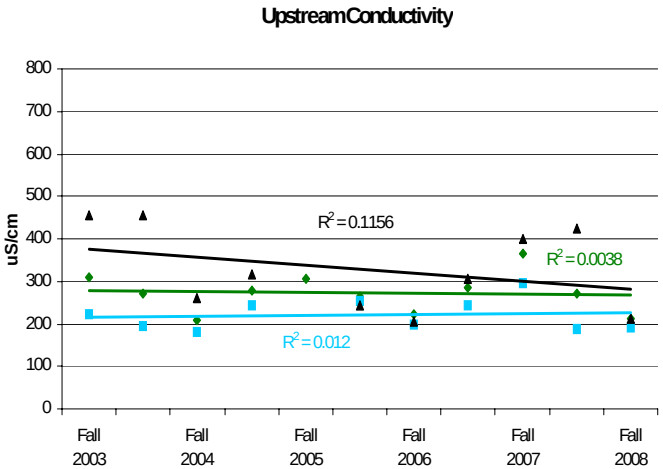


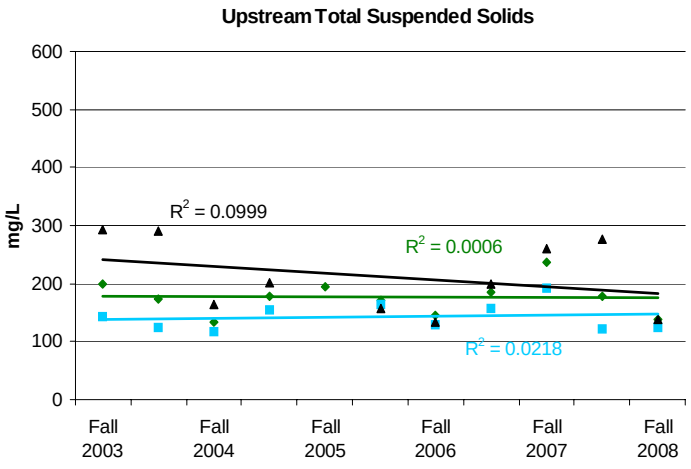
- **ST1, Downstream**
- **ST2, Downstream**
- **ST3, Upstream**
- **ST4, Upstream**
- **ST5, Upstream**

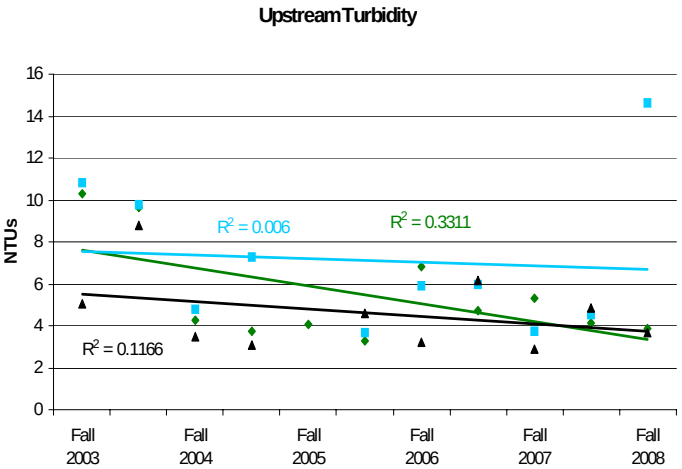












Macroinvertebrate Sampling

Qualitative and quantitative data sheets for benthic macroinvertebrates and results for each of the monitoring stations are located in **Appendix B** and on **Figure 4**. The following provides a description of the results for each station. Summarized RBP scores for stations ST1-ST5 are presented in **Table 10**.

The number of taxa present in the ST1 sample was 17 and 21 for the Spring and Fall 2008 samples, respectively, with the spring sample receiving a score of 3 and the fall sample a score of 6. The remaining three scored metrics indicating EPT richness, EPT abundance and the Hilsenhoff Biotic Index (HBI) all received scores of zero at ST1 for both the spring and fall samples. There were no EPT taxa in the spring sample and 1 in the fall (a caddisfly of the Hydropsychidae family). The spring sample was dominated by chironomids (midges) representing 69 percent of the sample while 13 percent of the sample was oligochaetes (worms) and 3 percent of the sample was amphipods. Thirty-three percent of the fall sample was made up of midges while another 20 percent of the sample was amphipods. Both ST1 samples consisted of pollution-tolerant groups. Few taxa with tolerances of 4 or less were found. No taxa were found in the spring sample with a tolerance value of 4 or less; however, 1 individual of genus *Procladius*, with a tolerance of 1.2, and 1 individual of the genus *Bezzia*, with a tolerance of 3.3, were present in the fall sample. ST1 was rated as 'Not Supporting' for both the Spring and Fall 2008 samples with scores of 13 percent and 25 percent, respectively. This rating has not changed since the Spring 2004 sample.

There were 20 taxa in the Spring 2008 ST2 sample, 3 of which were EPT taxa, leading to a score of 6 for the Total Taxa metric and zeros for both the EPT Taxa and EPT Abundance metrics. There were 19 taxa collected in the fall sample, leading to a score of 6 for the Total Taxa metric. There were no EPT taxa in the fall sample. There was 1 genus with a tolerance of four or less in the spring sample (from the Polycentropodidae family, with a tolerance value of 0.2) and only 1 in the fall sample (2 *Procladius*, with a tolerance value of 1.2). Pollution-tolerant worms (59 percent) and chironomids (28 percent) dominated the Spring 2008 sample, with worms of the Tubificidae family the most dominant taxon. Similarly, the Fall 2008 sample was made up of 58 percent worms and 24 percent chironomids, with the worms of the Tubificidae family and of the Naididae family the most dominant taxa. As with all previous monitoring events, the 2008 ST2 samples were rated as 'Not Supporting'.

There were 23 and 19 taxa in the ST3 Spring and Fall 2008 samples, respectively. Both sites received scores of 6 for the Total Taxa metric indicating good taxa richness. The Spring 2008 sample for ST3 was dominated by oligochaetes (worms) and chironominds (midges), which made up 36 percent and 35 percent of the total sample, respectively. Trichoptera (caddisflies) dominated the Fall 2008 sample, making up 26 percent of the sample and leading to a score of 3 for the EPT Abundance metric. There were 2 pollution-intolerant taxa found in the spring sample (1 *Procladius*, with a tolerance value of 1.2 and 1 taxon from the Heptageniidae family, with a tolerance value of 2.6). There was one pollution-intolerant taxon found in the fall sample (1 *Procladius*, with a tolerance value of 1.2). RBP scoring for all other metrics not mentioned above were zero for both the spring and fall samples, leading to an overall rating of 'Not Supporting' for spring and a rating of 'Partially Supporting' for the fall sample.

The Spring and Fall 2008 samples at ST4 received scores of 6 for the Total Taxa metric, with 26 and 25 taxa in the sample, respectively. There were two EPT taxa identified in the Spring 2008 sample (1 Ephemeroptera and 1 *Hydropsyche*) and 1 in the fall sample, Hydropsychidae, leading to the lowest possible score for the EPT Taxa metric for both samples. There were 2 pollution-intolerant taxa found in the spring sample (1 *Procladius*, with a tolerance value of 1.2 and 1

Ephemeroptera, with a tolerance value of 2.9), but this sample still received the lowest possible score for the HBI metric. There were two pollution intolerant taxa found in the fall sample (1 *Procladius*, with a tolerance of 1.2 and 1 *Bezzia*, with a tolerance of 3.3). Overall, both sites scored in the 'Not Supporting' category.

Table 10: Modified RBP Bioassessment

Station	Date	RBP Score	Classification
ST1	12/23/03	38	Partially Supporting
	05/11/04	25	Not Supporting
	12/14/04	25	Not Supporting
	05/18/05	25	Not Supporting
	12/20/05	25	Not Supporting
	05/11/06	25	Not Supporting
	12/18/06	25	Not Supporting
	05/15/07	25	Not Supporting
	12/19/07	25	Not Supporting
	05/23/08	13	Not Supporting
	11/18/08	25	Not Supporting
ST2	12/23/03	25	Not Supporting
	05/11/04	25	Not Supporting
	12/14/04	25	Not Supporting
	05/18/05	25	Not Supporting
	12/20/05	25	Not Supporting
	05/11/06	13	Not Supporting
	12/18/06	25	Not Supporting
	05/15/07	13	Not Supporting
	12/19/07	25	Not Supporting
	05/23/08	25	Not Supporting
	11/18/08	25	Not Supporting
ST3	12/23/03	38	Partially Supporting
	05/11/04	25	Not Supporting
	12/14/04	38	Partially Supporting
	05/18/05	25	Not Supporting
	12/20/05	38	Partially Supporting
	05/11/06	13	Not Supporting
	12/18/06	13	Not Supporting
	05/15/07	13	Not Supporting
	12/19/07	25	Not Supporting
	05/23/08	25	Not Supporting
	11/18/08	38	Partially Supporting
ST4	12/31/03	25	Not Supporting
	05/11/04	13	Not Supporting
	12/16/04	25	Not Supporting
	05/18/05	38	Partially Supporting
	12/20/05	25	Not Supporting
	05/11/06	13	Not Supporting
	12/18/06	25	Not Supporting
	05/15/07	13	Not Supporting

	12/19/07	25	Not Supporting
	05/23/08	25	Not Supporting
	11/18/08	25	Not Supporting
ST5	12/31/03	25	Not Supporting
	05/11/04	13	Not Supporting
	12/16/04	13	Not Supporting
	05/18/05	13	Not Supporting
	12/20/05	25	Not Supporting
	05/11/06	13	Not Supporting
	12/18/06	13	Not Supporting
	05/15/07	13	Not Supporting
	12/19/07	13	Not Supporting
	05/23/08	13	Not Supporting
	11/18/08	13	Not Supporting

ST5 Spring 2008 sample had the lowest number of taxa of all the Spring and Fall 2008 samples. Of the 12 taxa represented in the spring sample, no pollution-intolerant taxa were present; however, taxa richness did increase to 15 in the Fall 2008 sample. There were no EPT taxa collected in either of the spring or fall samples. The spring sample was dominated by pollution-tolerant oligochaetes (worms), which made up 58 percent of the sample and gastropods (snails), which made up 26 percent. Fifty percent of the fall sample was oligochaetes and only 5 percent of the sample was midges. As with all previous sites and all previous sampling events, ST5 was classified as 'Not Supporting' for both spring and fall samples.

The Whole Basin Management Program reported that 74 percent of the non-tidal streams in the Piedmont region of Delaware have degraded biological condition (DNREC, 2000). The macroinvertebrate populations at these sites were dominated by tolerant species such as fly larvae and worm taxa. Ninety percent of the streams showed signs of some habitat degradation. Five years of Leatherman's Run monitoring support these findings, with worm and midge taxa dominating many of the macroinvertebrate samples collected over the course of sampling.

Please refer to **Section 3.2** for a discussion on macroinvertebrate trends over the course of six years of monitoring.

Fish Assemblage

The summarized results of the fish community assessment are presented in **Table 11**, and on **Figure 5**. Full results are located in **Appendix B**. The emerald shiner and pumpkinseed, both native species, dominated the fish community at ST1 in 2008. There were 12 species of fish identified at ST1 in 2008, one species less than the previous year. Eight of these species are native. Taxa abundance was also high, with 198 individuals collected, more than in any previous year. The high levels in taxa richness and abundance contributed to an overall classification of 'Fair' for this site, the same classification as the 2007 sample.

As with all previous samples, the 2008 ST2 sample was dominated by creek chub and tessellated darter. The total number of individuals in the sample was also higher than in previous years. Of the 266 individuals, 77 percent were creek chub and 17 percent were tessellated darter. The high abundance led to the highest number of individuals per square meter for all ST2 samples. The percentage of lithophilic spawners also increased in score from 2007. However, the number of species and the number of intolerant species both decreased when compared to the 2007 sample.

Because of the lack of intolerant species and high percentage of both dominant species and generalists, omnivores, and invertivores, the mean FIBI was 'Poor' in 2008, the same classification as the 2007 sample.

For the 2008 sample at ST3, abundance and species diversity decreased from 235 individuals with 6 species represented in 2007 to 95 individuals with 3 species represented in 2008. Two of the nine metrics at ST3 decreased in score from 2007 and the remaining seven metrics received the same score as the 2007 sample. The number of native species decreased, as did the number of individuals and biomass per square meter. These combined factors contributed to a decrease in the overall FIBI score from 2.6 in 2007 to 2.1 in 2008.

Table 11: Fish IBI

Station	Date	FIBI	Classification
ST1	12/23/03	1.9	Very Poor
	12/14/04	1.7	Very Poor
	1/6/06	2.3	Poor
	12/20/06	2.3*	Poor
	12/19/07	3.0	Fair
	11/21/08	3.0	Fair
	Mean	**2.4**	**Poor**
ST2	12/23/03	1.9	Very Poor
	12/14/04	1.9	Very Poor
	1/6/06	1.9*	Very Poor*
	12/20/06	1.9	Very Poor
	12/19/07	2.8*	Poor*
	11/21/08	2.3	Poor
	Mean	**2.1***	**Poor**
ST3	12/23/03	1.4	Very Poor
	12/14/04	1.4	Very Poor
	1/6/06	1.7	Very Poor
	12/20/06	1.9	Very Poor
	12/19/07	2.6*	Poor
	11/21/08	2.1	Poor
	Mean	**1.9**	**Very Poor**

*Values were incorrectly reported in previous reports.

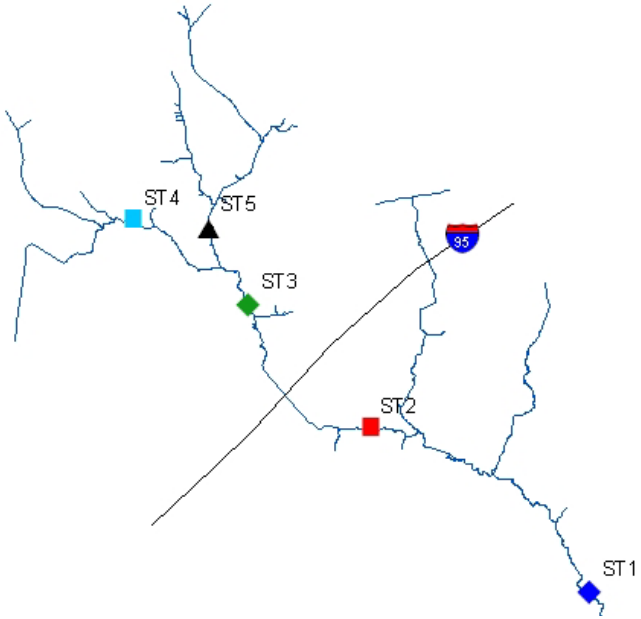
The findings of the 2008 fish sampling are consistent with findings from 2003 – 2007. When compared to 2007, both fish samples from ST2 and ST3 collected in 2008 decreased in some metrics but received the same overall classification as the samples in 2007. For ST1, all metrics received the same score as the 2007 sample. The number of individuals per square meter metric and percentage of lithophilic spawners also scored high at all sites. Overall, the samples were still dominated by one or two species with a high percentage of tolerant individuals, indicating a reduction in water quality or habitat that is precluding sensitive species.

It should be noted that an error was discovered and corrected regarding the calculation of two FIBI metrics, Number of Individuals per Square Meter and Biomass per Square Meter, in previous reports. The error was a result of applying the EPA RBP fish sampling protocol (i.e., 100 meter sampling reach) with the metric calculation approach used by MBSS, which utilizes a 75-meter sampling reach. As a result, prior sampling area calculations were based on a 75-meter sampling reach, even though a 100-meter reach was sampled. Once the sampling area was corrected, values for both metrics were reduced across the entire study, as shown in bold in **Appendix B**. However, of the four instances where the reduced metric values resulted in lower metric scores, only two affected the overall site classifications. Both changes occurred at ST2, with the fish condition being reclassified from 'Poor' to 'Very Poor' in 2005 and 'Fair' to 'Poor' in 2007.

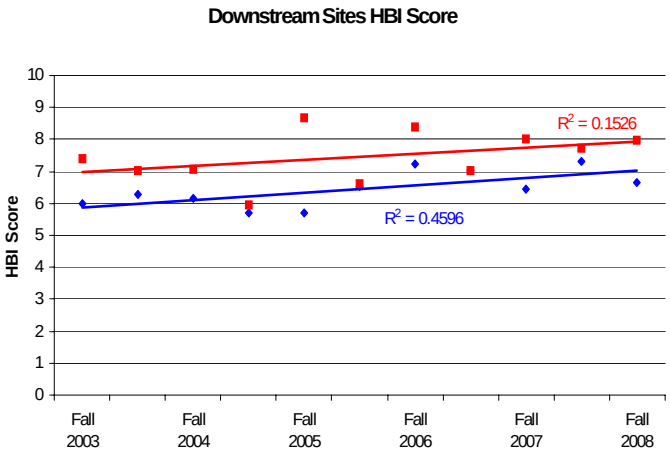
The Delaware fish consumption advisories were reissued in 2008 and include all finfish for the non-tidal Christina River from Smalley's Pond dam to the DE/MD line (not Leatherman's Run). The advisory was based on Polychlorinated Biphenyls (PCBs), Dieldrin and Chlordane and the recommendation is not to consume more than six 8-ounce meals per year. An advisory of no fish consumption is advised for the tidal Christina River due to PCBs and Dieldrin (DNREC, 2008).

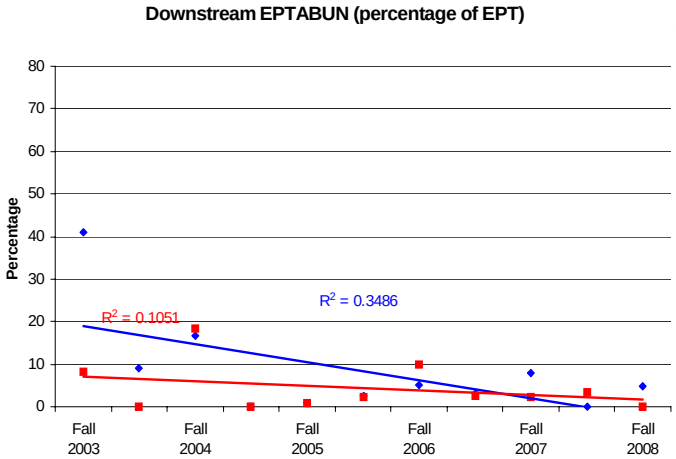
Please refer to **Section 3.2** for a discussion on fish assemblage trends over the course of six years of monitoring.

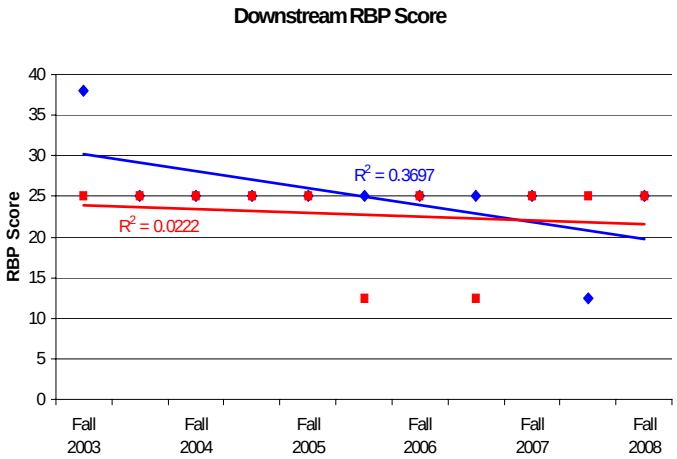
Figure 4
Leatherman's Run
Macroinvertebrate
Assessment – Results
Fall 2003 – Fall 2008

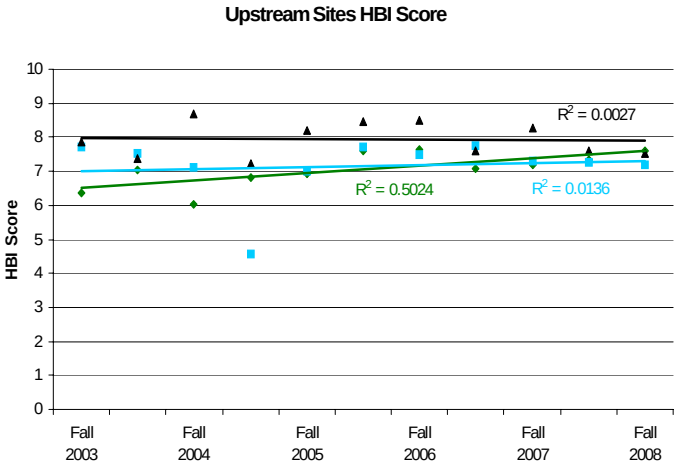


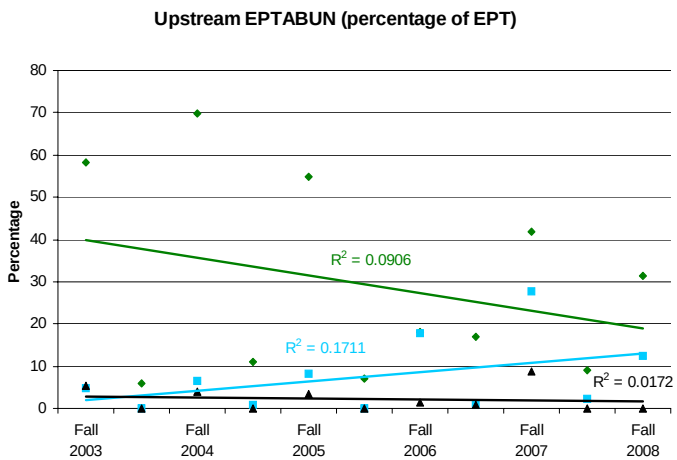
ST1, Downstream
ST2, Downstream
ST3, Upstream
ST4, Upstream
ST5, Upstream











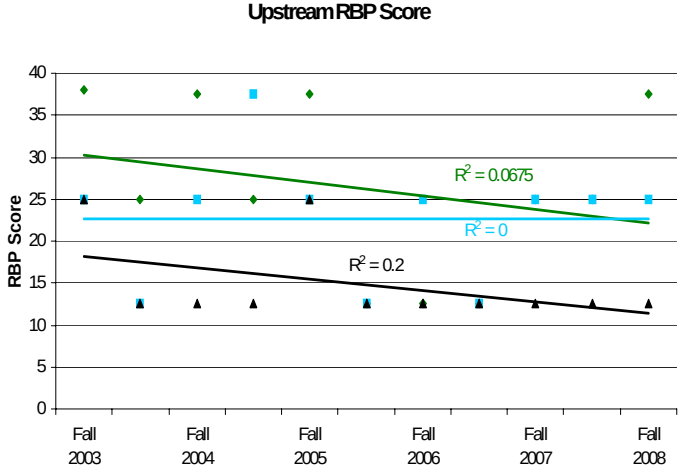
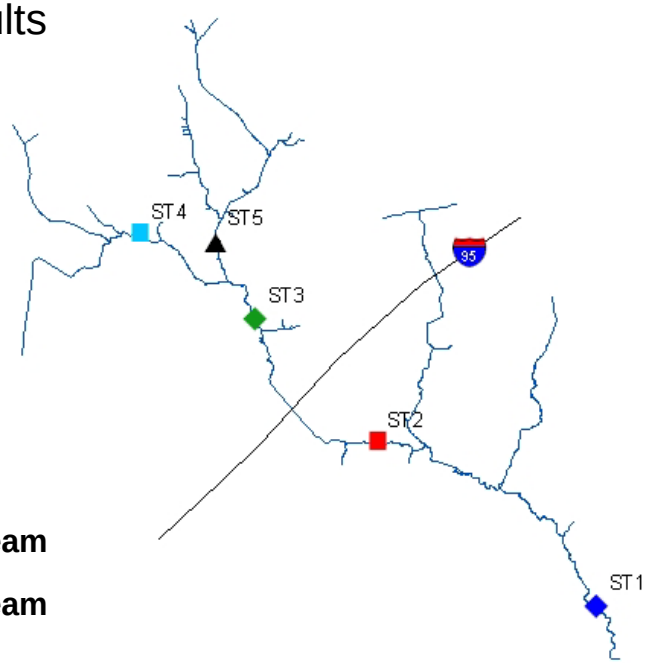


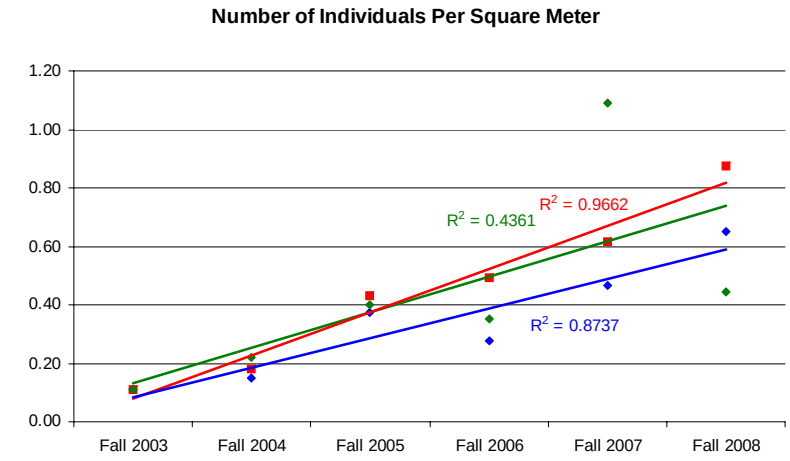
Figure 5
Leatherman's Run
Fish Sampling – Results
Fall 2003 – Fall 2008

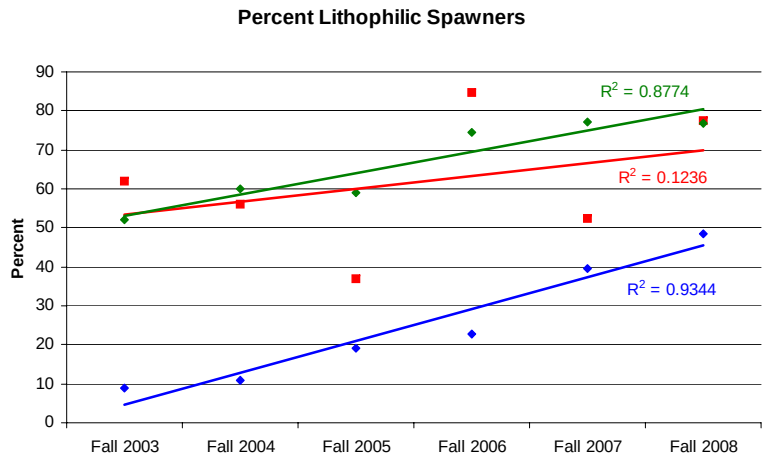


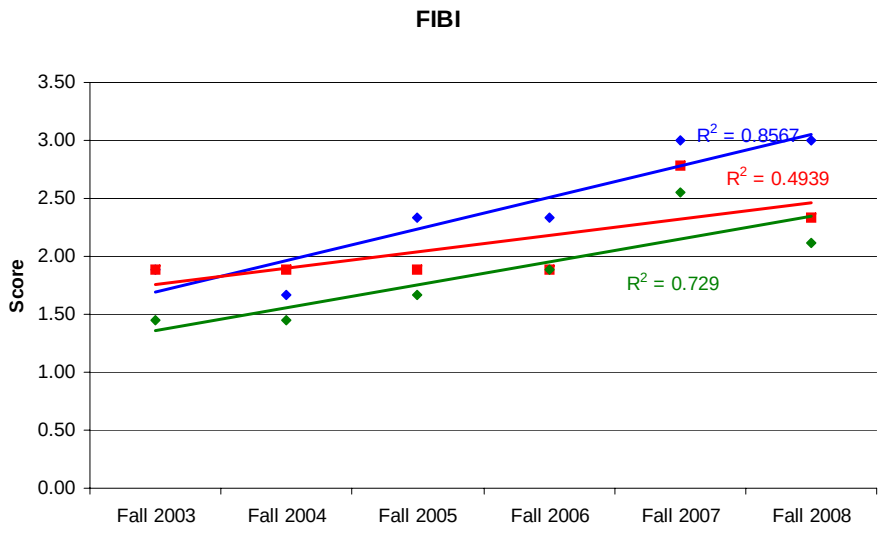
ST1, Downstream

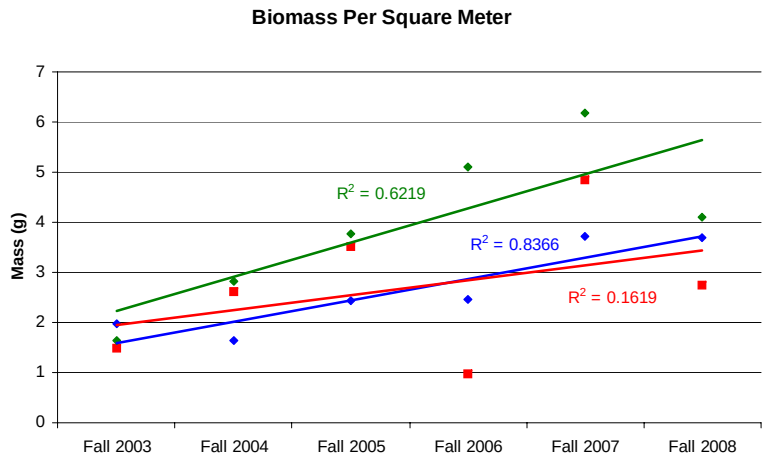
ST2, Downstream

ST3, Upstream









Physical Habitat Assessment

The summarized results of the modified RBP habitat assessment are presented in **Table 12** and on **Figures 6a – 6b**. Habitat data rating specific parameters, summary information for each station and photographs are included in **Appendix C**. Modified RBP habitat assessment results from 2003-2007 are also included in **Appendix C**. The following provides a summary of the overall results for each station.

ST1 is located on the mainstem downstream of Old Baltimore Pike on a sinuous and moderately entrenched reach. The riparian buffer is intact along the sampling reach. The outer meander banks are continuing to erode with deposition on the existing sand and gravel bars. There is a moderate amount of undercut bank habitat and woody debris habitat associated with the debris blockages, throughout the reach, available for macroinvertebrate colonization. The substrate is dominated by sand and hardpan clay, which does not provide quality habitat for macroinvertebrates or fish. Riffles are present but are shallow and infrequent. Field crews noted a mild odor of PCBs as well as an oily sheen on the water surface when sampling. Habitat scores at ST1 between 2003 and 2008 have a mean of 78 with an overall rating of 'Partially Supporting'. The overall rating has remained consistent over the five-year course of monitoring.

ST2 is on the mainstem of Leatherman's Run downstream of I-95. This sampling reach is similar to ST1 with a complete riparian buffer, but is more entrenched than ST1. The riparian buffer is intact along the sampling reach. The riffles along the ST2 sampling reach are shallow and infrequent. Active erosion continues to occur, especially along meander bends, creating unstable undercut banks. This undercutting has caused many areas of bank failure with trees falling across and into the channel. Field crews noted a strong odor of PCBs and an oily sheen on the water surface for most of the reach at ST2 when sampling. Habitat scores at ST2 between 2003 and 2008 have a mean of 75 with an overall rating of 'Partially Supporting'. As with ST1, there has been no change in the overall rating over the course of monitoring.

ST3 is located upstream of I-95 and has a greater frequency of riffles, larger gravel and cobble substrate and is not as embedded as ST1 and ST2. The riparian buffer remains intact along the left bank (facing downstream). The right bank, however, has an interrupted riparian zone of only 5-10 feet, due to an apartment complex with mowed lawns, with very little understory vegetation. Habitat scores for spring and fall sampling in 2008 were in the Partially Supporting category. Despite this lower rating, the mean habitat score at ST3 between 2003 and 2008 is 90 with an overall rating of Fully Supporting, the only station with a mean rating above 'Partially Supporting'.

ST4 is located on the most western headwater tributary upstream of Salem Church Road. ST4 is characterized by a sandy bottom with moderately good bank stability and bank vegetation. The riparian zone is reduced due to housing on either side of the channel. Field crews noted an oily sheen on the water surface when sampling. Habitat scores at ST4 between 2003 and 2008 have a mean of 75 and an overall rating of 'Partially Supporting'.

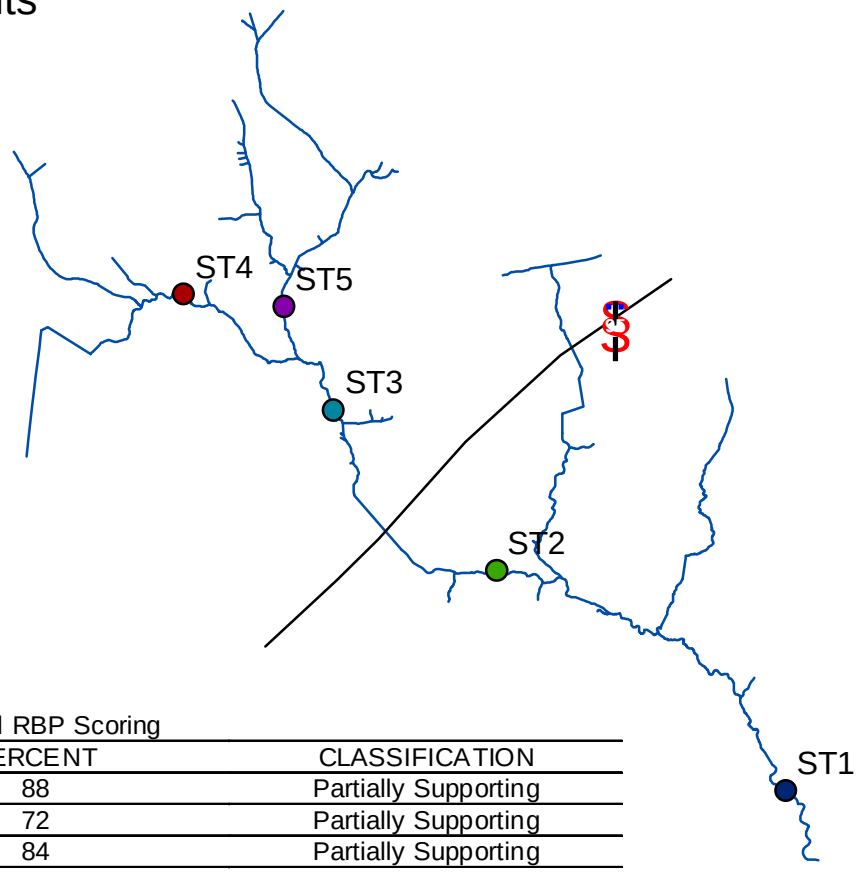
ST5, which is downstream of Regal Boulevard, has a reduced riparian zone on both banks. Riffles are infrequent. The channel bottom is dominated by sand and gravel. The reach is straight with little depth diversity. Instream habitat remains less than desirable with only one riffle and little woody debris. Habitat scores at ST5 between 2003 and 2008 have a mean of 64, significantly lower than any other sampling site. The overall habitat rating is at the low end of the 'Partially Supporting' category.

Table 12: Habitat Assessment

Station	Date	Total	Percent of Reference	Classification
ST1	12/23/03	124	71	Partially Supporting
	5/11/04	143	82	Partially Supporting
	12/14/04	140	80	Partially Supporting
	5/18/05	123	70	Partially Supporting
	12/20/05	142	81	Partially Supporting
	5/11/06	135	77	Partially Supporting
	12/18/06	150	86	Partially Supporting
	5/15/07	149	85	Partially Supporting
	12/19/07	136	78	Partially Supporting
	5/23/08	154	88	Partially Supporting
	11/18/08	114	65	Partially Supporting
	Mean	**137**	**78**	**Partially Supporting**
ST2	12/23/03	123	70	Partially Supporting
	5/11/04	146	83	Partially Supporting
	12/14/04	143	82	Partially Supporting
	5/18/05	127	73	Partially Supporting
	12/20/05	134	77	Partially Supporting
	5/11/06	122	70	Partially Supporting
	12/18/06	153	87	Partially Supporting
	5/15/07	149	85	Partially Supporting
	12/19/07	111	63	Partially Supporting
	5/23/08	126	72	Partially Supporting
	11/18/08	113	65	Partially Supporting
	Mean	**132**	**75**	**Partially Supporting**
ST3	12/23/03	152	87	Partially Supporting
	5/11/04	171	98	Fully Supporting
	12/14/04	170	97	Fully Supporting
	5/18/05	160	91	Fully Supporting
	12/20/05	171	98	Fully Supporting
	5/11/06	170	97	Fully Supporting
	12/18/06	174	99	Fully Supporting
	5/15/07	151	86	Partially Supporting
	12/19/07	140	80	Partially Supporting
	5/23/08	147	84	Partially Supporting
	11/18/08	135	77	Partially Supporting
	Mean	**158**	**90**	**Fully Supporting**
ST4	12/31/03	133	76	Partially Supporting
	5/11/04	128	73	Partially Supporting
	12/16/04	131	75	Partially Supporting
	5/18/05	127	73	Partially Supporting
	12/20/05	124	71	Partially Supporting
	5/11/06	147	84	Partially Supporting
	12/18/06	159	89	Partially Supporting
	5/15/07	155	89	Partially Supporting

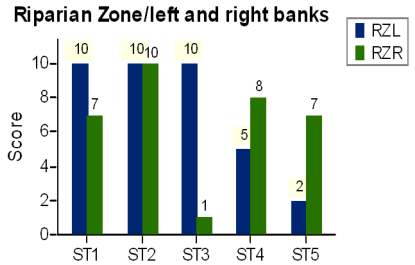
Station	Date	Total	Percent of Reference	Classification
	12/19/07	115	71	Partially Supporting
	5/23/08	145	83	Partially Supporting
	11/18/08	92	53	Not Supporting
	Mean	**132**	**75**	**Partially Supporting**
ST5	12/31/03	103	59	Not Supporting
	5/11/04	120	69	Partially Supporting
	12/16/04	98	56	Not Supporting
	5/18/05	107	61	Partially Supporting
	12/20/05	97	55	Not Supporting
	5/11/06	128	73	Partially Supporting
	12/18/06	141	81	Partially Supporting
	5/15/07	130	74	Partially Supporting
	12/19/07	104	55	Not Supporting
	5/23/08	116	66	Partially Supporting
	11/18/08	92	53	Not Supporting
	Mean	**112**	**64**	**Partially Supporting**

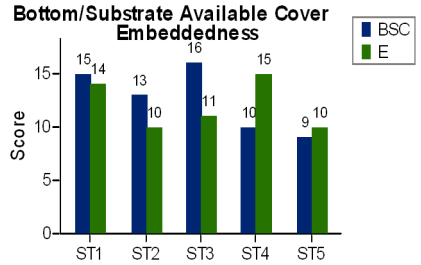
Figure 6a
Leatherman's Run
Habitat Assessment - Results
Spring 2008

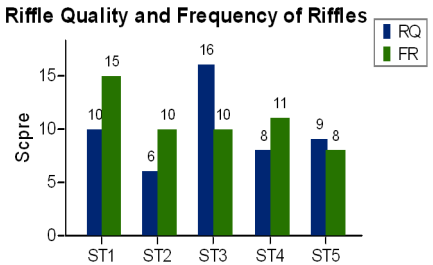


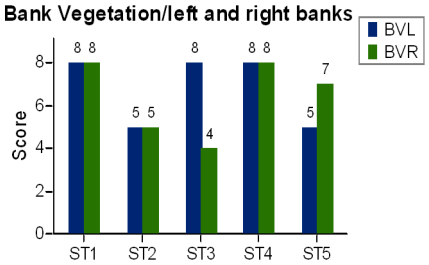
Modified RBP Scoring

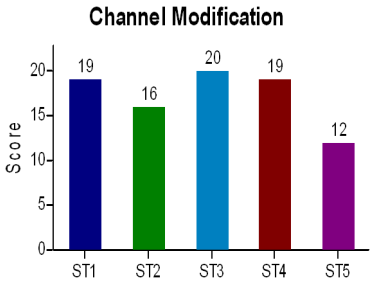
STATION ID	PERCENT	CLASSIFICATION
ST1	88	Partially Supporting
ST2	72	Partially Supporting
ST3	84	Partially Supporting
ST4	83	Partially Supporting
ST5	66	Partially Supporting

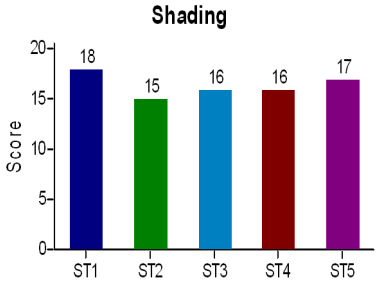


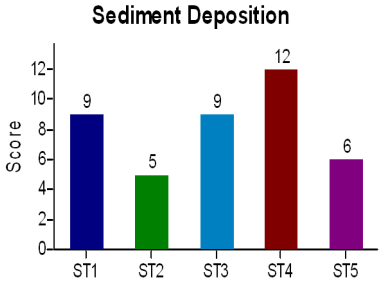


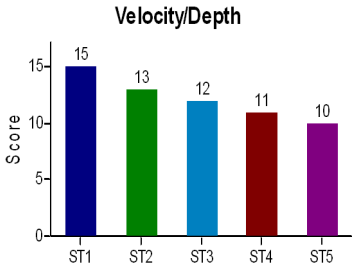












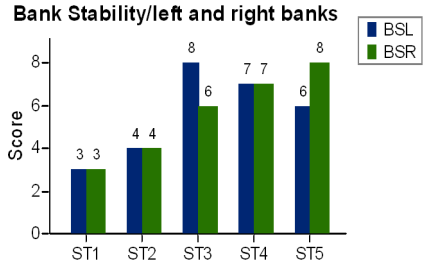
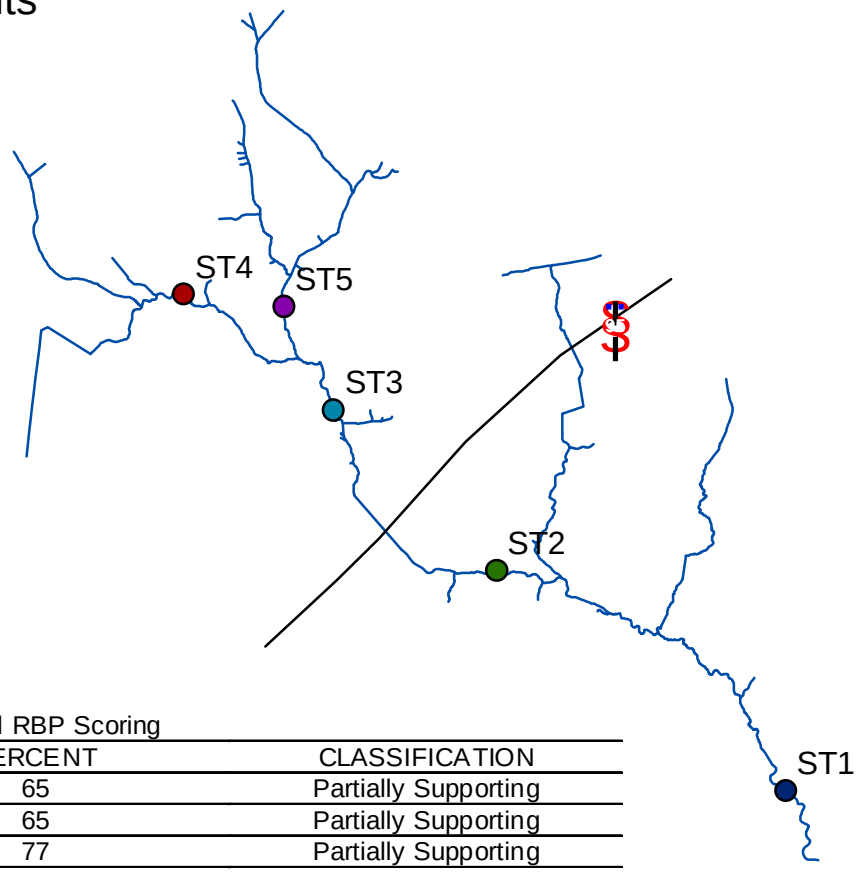
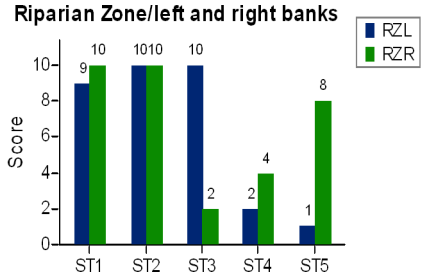


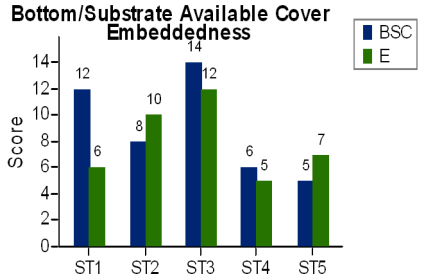
Figure 6b
Leatherman's Run
Habitat Assessment - Results
Fall 2008

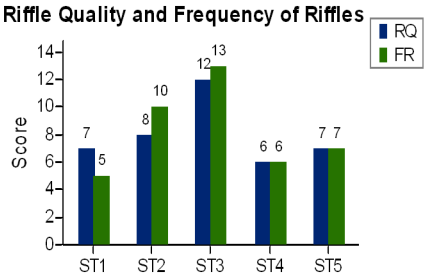


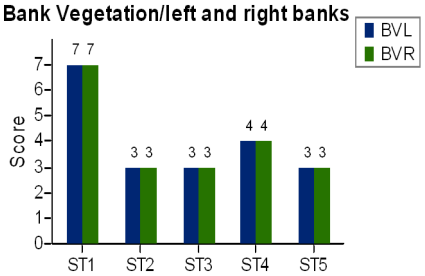
Modified RBP Scoring

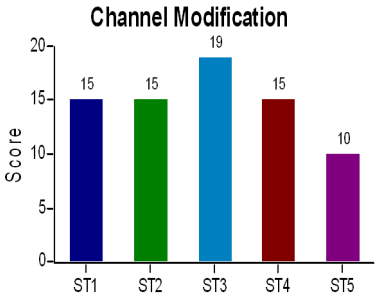
STATION ID	PERCENT	CLASSIFICATION
ST1	65	Partially Supporting
ST2	65	Partially Supporting
ST3	77	Partially Supporting
ST4	53	Not Supporting
ST5	53	Not Supporting

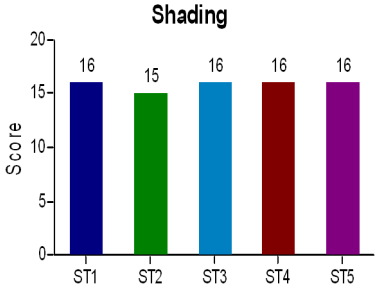


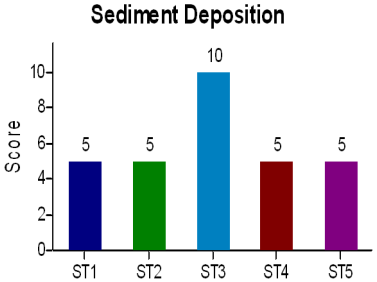


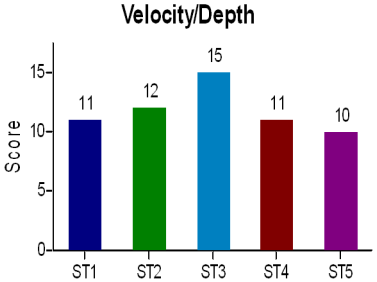


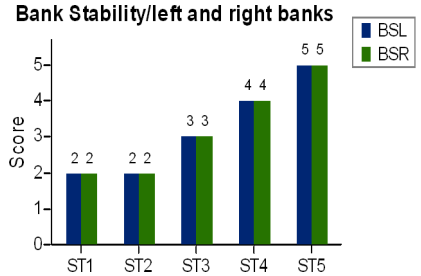












Geomorphic Assessment

Graphical results of the geomorphic assessments, including plotted cross-sections, longitudinal profiles and grain size frequencies and distributions are presented in **Appendix D**. Additional cross-sections with results from all three surveys are included. The following section describes the channel typing and the results of the field data collection with a summary of the data in **Table 13**.

GM1 is located on a very sinuous portion of the mainstem of Leatherman's Run near the intersection of Woodshade Drive and Leaf Lane. The assessment reach is dominated by a gravel and sand substrate. The vertical unvegetated banks along the reach continue to show signs of erosion. The majority of the channel near GM1 appears entrenched. However, the presence of sandy deposition in the floodplain indicates that flow is getting into the floodplain, probably at specific low bank points upstream of the assessment reach. Monitoring data from 2008 shows a decrease in width/depth ratio and an increase in entrenchment ratio. The changes are minor and ratios are similar to those seen in baseline and 2004 monitoring. These differences are most likely due to estimates of bankfull levels rather than any significant change in channel dimensions from 2007. A comparison of cross-sectional surveys collected each year (found in **Appendix D**) shows the amount of erosion that has occurred over the course of six years of monitoring. The channel invert at the cross-section, which is located on a cross-over reach, has dropped by approximately 0.7 foot between 2003 and 2008, further evidence that the channel continues to downcut at the cross-section. Erosion along the left (outer meander) bank appears to have ceased since 2007, showing signs of deposition. The longitudinal slope, which has shown a consistent decrease from 2003 to 2007, is now increasing, providing evidence that the reach overall is receiving sediment from upstream, despite the evidence of erosion and incision at the cross-section. The decrease in slope reflects the downcutting at the upstream end of the reach and the aggradation and sediment deposition occurring at the downsream end.

GM2 is located downstream of the I-95 crossing. As with GM1, the channel at GM2 appears to be entrenched. There are no obvious signs of floodplain connectivity, however, bankfull indicators point to the potential for the stream to get out of banks during high flows. GM2 continues to be dominated by an unconsolidated gravel (54%) substrate. The dominance of gravel in the riffles has been generally increasing from 2003 to 2007, but decreased slightly in 2008. The channel at GM2 appears to be actively eroding as evidenced by the presence of vertical raw and undercut banks. There are large gravel and sand bars within the monitoring reach. GM2 continues to have the highest cross-sectional area, which is increased by stormflow below I-95 resulting in an overwidened channel. The channel bed has remained fairly stable over the six year course of monitoring with areas of both erosion and deposition. The banks of the channel, however, have experienced consistent erosion. The 2008 survey, however, shows that the left bank appears to be receiving deposition. During the 2007 and 2008 monitoring additional measurements were taken to show the extent of undercutting along the right bank at the location of the cross-section. The channel slope has remained consistent with the 2007.

GM3 is located on a tributary to the Leatherman's Run mainstem off of Wakefield Drive North. After the spring sampling in 2006 a large portion of this stream, including the assessment reach, was reconstructed as part of a bank stabilization and stream restoration effort. Therefore, no data collection has been conducted at this site since the Fall of 2005.

GM4 is located on the most western headwater tributary upstream of Salem Church Road. The substrate at GM4 is dominated by sand and gravel and has changed little since baseline monitoring in 2003. The banks are relatively stable and show some floodplain connectivity. However, the general increase in width/depth ratio and bank erosion shown in the cross-sectional comparison all indicate this channel may be actively widening

GM5 is located to the west of Alexis Drive on a tributary to the mainstem and is characterized by a coarse gravel substrate. The channel at cross-section at GM5 experienced some considerable bed and right bank erosion since 2003. The channel is actively migrating toward the right bank as a mid channel bar is forming and depositing sediment in the center of the channel. The left side of the channel is getting cut off from baseflows and only appears to be functional during high flows. The longitudinal slope has been steadily increasing since 2003 from 0.97 percent to 1.7 percent in 2007; however in 2008 it decreased to 1.40 percent.

Table 13: Geomorphic Summary

Section	GM1	GM2	GM3	GM4	GM5
Max depth (thalweg to bankfull) (ft)					
2003 (Baseline)	1.3	1.8	2.1	0.9	1.7
2004	2.1	1.6	3.1	1.4	4.3
2005	3.7	2.2	2.3	2.4	2.1
2006	3.3	2.6	NA	2.8	2.5
2007	2.1	2.2	NA	2.6	1.5
2008	2.0	2.0	NA	2.2	1.6
Mean depth (d_{bkf}) (ft)					
2003 (Baseline)	1	1.3	1.8	0.5	1.2
2004	1.5	1.3	2.3	1	2.4
2005	2.6	2.0	1.8	1.8	1.6
2006	2.5	2.3	NA	2.3	1.7
2007	1.5	1.9	NA	2.1	0.8
2008	1.5	1.7	NA	1.8	0.8
Bankfull width (W_{bkf}) (ft)					
2003 (Baseline)	14.9	22.6	10.3	6.4	14
2004	16.2	22.6	11	6.9	30.3
2005	16.7	23.1	10.6	8.4	14.8
2006	17.0	23.6	NA	7.5	16.2
2007	16.3	25.2	NA	8.9	13.8
2008	16.1	25.0	NA	8.1	14.5
Bankfull cross-sectional area (A_{bkf}) (ft^2)					
2003 (Baseline)	15	29.7	18.3	3.4	16.2
2004	24.6	29.7	24.7	6.6	24.3
2005	42.6	45.2	18.7	15.2	23.2
2006	42.6	54.8	NA	17.2	27.6
2007	23.7	47.4	NA	18.6	11.1
2008	23.5	43.4	NA	14.7	12.2
Width/Depth ratio (W_{bkf} / d_{bkf})					
2003 (Baseline)	14.7	17.3	5.8	12	12
2004	10.7	17.2	4.9	7.3	12.4
2005	6.6	11.8	6	4.6	9.5
2006	6.7	10.2	NA	3.3	9.5
2007	11.2	13.4	NA	4.3	17.3
2008	11.0	14.3	NA	4.4	17.2
Width of flood-prone area (W_{fpa}) (ft)					
2003 (Baseline)	17	23.8	13	7	35
2004	18.8	23.9	15.7	8.6	35

Section	GM1	GM2	GM3	GM4	GM5
2005	125	175	13.6	52	39
2006	125	175	NA	52	48
2007	19	175	NA	75	20
2008	20	175	NA	80	16
Entrenchment Ratio (W_{fpa} / W_{bkf})					
2003 (Baseline)	1.1	1.1	1.3	1.1	2.5
2004	1.2	1.1	1.4	1.2	1.2
2005	7.5	7.6	1.3	6.2	2.6
2006	7.4	7.4	NA	6.9	3.0
2007	1.2	6.9	NA	8.4	1.5
2008	1.2	7.0		9.9	1.1
Slope (water surface, percent)					
2003 (Baseline)	0.33	0.23	1.03	0.31	0.97
2004	0.24	0.23	1.03	0.31	1.1
2005	0.24	0.23	1.00	0.31	1.3
2006	0.20	0.15	NA	0.4	1.4
2007	0.15	0.16	NA	0.4	1.7
2008	0.23	0.16	NA	0.32	1.4
Sinuosity (stream length/valley length)					
2003 (Baseline)	1.4	1.1	1.2	1.17	1.29
2004	1.4	1.1	1.2	1.17	1.29
2005	1.4	1.1	1.2	1.17	1.29
2006	1.4	1.1	NA	1.17	1.29
2007	1.4	1.1	NA	1.17	1.29
2008	1.4	1.1	NA	1.17	1.29
Median particle size, riffle (D50) (mm)					
2003 (Baseline)	24	18	31	4.2	21
2004	21	15	18	2.9	23
2005	17	17	0.95	0.062	23
2006	21	6	NA	5.5	18
2007	15	21	NA	11	39
2008	23	8.4	NA	5.2	20
Median particle size, reach (D50) (mm)					
2003 (Baseline)	2	13	0.68	3.4	19
2004	0.57	16	1	0.93	7.3
2005	0.67	10	0.46	0.57	2.8
2006	1	10	NA	0.37	25
2007	0.41	8.8	NA	0.47	33
2008	0.46	6.9	NA	0.21	23
Dominant particle size class riffle, percent					
2003 (Baseline)	Gravel, 93	Gravel, 74	Gravel, 55	Gravel, 62	Gravel, 86
2004	Gravel, 88	Gravel, 78	Gravel, 49	Gravel, 57	Gravel, 79
2005	Gravel, 63	Gravel, 65	Sand, 49	Sand, 45	Gravel, 76
2006	Gravel, 70	Gravel, 52	NA	Gravel, 69	Gravel, 93
2007	Gravel, 69	Gravel, 88	NA	Gravel, 53	Gravel, 75
2008	Gravel, 76	Gravel, 54	NA	Gravel, 49	Gravel, 77
Dominant particle size class, reach, percent					
2003 (Baseline)	Gravel, 50	Gravel, 71	Sand, 47	Gravel, 49	Gravel, 81

Section	GM1	GM2	GM3	GM4	GM5
2004	Sand, 49	Gravel, 67	Sand, 38	Gravel, 43	Gravel, 53
2005	Sand, 45	Gravel, 51	Sand, 53	Sand, 48	Gravel, 46
2006	Sand, 38	Gravel, 63	NA	Sand, 55	Gravel, 61
2007	Sand, 39	Gravel, 49	NA	Gravel, 43	Gravel, 62
2008	Sand, 61	Gravel, 51	NA	Sand, 54	Gravel, 42
Channel Type					
2003 (Baseline)	F4/5	F4	G4/5c	F4/5	B4c
2004	F4/5	F4	G4/5c	F4/5	B4c
2005	F4/5	F4	G4/5c	F4/5	B4c
2006	F4/5	F4	NA	F4/5	B4c
2007	F4/5	F4	NA	F4/5	B4c
2008	F4/5	F4	NA	F4/5	B4c

3.2 Summary

The following provides a summary of the conditions in each catchment.

LR1

Instream water quality samples were all within acceptable limits. Base flow grab sampling at LR1 indicates levels within normal ranges for all parameters except *Zinc* which, at 0.032 mg/L is over the water quality standard of 0.003 mg/L. Cadmium was detected in 2007 for the first time since the study began in 2003, but was not detected in 2008 samples. Total suspended solids and total phosphorus were not detected in 2008. *Enterococcus* levels have decreased when compared to prior sampling and to upstream sites. Macroinvertebrate samples for both sampling sites in LR1 were again rated as 'Not Supporting'. Only the ST1 Fall 2003 sample scored at a level above the 'Not Supporting' category for the six years of monitoring completed. Results of fish sampling showed an increase in the number of individuals per square meter in 2008, but a decrease in the number of native species and intolerant species. FIBI scores for 2008 generally remained the same with ST1 receiving the same score as in 2007 (3.0 with a rating of 'Fair') and ST2 receiving the same rating of 'Poor'. Habitat conditions in LR1 were again rated 'Partially Supporting' at both bioassessment sites, although field crews noted a PCB odor and an oily sheen on the water surface when conducting the fall sampling. No significant changes in channel morphology, other than additional erosion and/or aggradation were identified. Trash was again identified as an issue in LR1.

LR2

With the exception of *Enterococcus*, the instream and laboratory grab sample water quality results for the LR2 catchment do not indicate levels that are out of the ordinary. The LR2 level of *Enterococcus* was 345 mpn/100mL, higher than the DNREC water quality standard. Physical habitat scores for 2008 remained consistent with those in 2007, receiving a 'Partially Supporting' score for the second time since the baseline assessment. However, ST3 has still maintained an average of 'Fully Supporting'. The macroinvertebrate sampling in LR2 (at site ST3) supports this decrease in physical habitat as it indicates generally decreasing quality. Scores for the bioassessment remain in the 'Not Supporting' range for both Spring 2008 samples, but increased to 'Partially Supporting' for Fall 2008 samples. Fish sampling resulted in a decrease in biomass with three less native species collected in 2008 when compare to the 2007 sample. The sample was dominated by a single species with no intolerant species present.

LR3

Total suspended solids, *Enterococcus*, and total phosphorus were detected above regulated limits. The laboratory analyzed grab samples showed levels of *Enterococcus* at 1120 mpn/100 mL, above the DNREC water quality standard of 185 colonies/100mL. Instream and riparian physical habitat remained relatively unchanged in Spring 2008, but dropped to 'Not Supporting' in Fall 2008 for the first time since sampling began. Geomorphic conditions did not change significantly from 2007. Macroinvertebrate sampling again indicates high taxa richness but a lack of sensitive species and ratings of 'Not Supporting' for both the Fall and Spring 2008 samples.

LR4

Instream samples in LR4 did not detect parameters outside the allowable limits. For the first time since the study began in 2003, oil and grease were detected in this catchment. Instream habitat conditions at the assessment site in LR4 were again rated low compared to the other sites. Biological samples have been rated as 'Not Supporting' for every sample from 2003 to 2008. The 2008 samples were dominated by midges and worms. Overall, stream conditions including habitat and channel morphology in this catchment have changed little over six years of monitoring.

Trend Analysis

A trend analysis was performed for water quality, marcoinvertebrate, and fish assemblage data collected over six years of monitoring; **Figures 3**, **4**, and **5** show the results. Selected metrics were analyzed comparing sites upstream of the I-95 service station (ST3, ST4, and ST5) with those sites located downstream of the station (ST1 and ST2). A time-series linear regression was performed to fit a trend-line to the data and to determine the strength of the straight line relationship between the various parameters and time. R-squared values shown on the figures represent how closely the trendline represents the actual data points with a R-squared value near 1 indicating a very close fit between the trendline and data and a stronger relationship of change over time.

For instream water quality data collected from 2003-2008, turbidity had a slight decreasing trend for both downstream and upstream sites with a marked drop between the Spring 2004 and Fall 2004 sampling (ST1 and ST2 exhibiting values of R^2=0.32 and R^2=0.47, respectively, and R^2=0.33 for ST3). On average, stations downstream of I-95 recorded higher values for conductivity (ranging from 291.3-735.7µS/cm, average: 497.2µS/cm) and total suspended solids (ranging from 189.3-478.7NTUs, average: 317.6NTUs) than stations upstream of I-95 (conductivity ranging from 181.9-456.4µS/cm, average: 273.9µS/cm; total suspended solids ranging from 166.4-292.1NTUs, average: 176.9NTUs). Other water quality parameters did not show any defined patterns trending upwards or downwards over time with R-squared values equating to 0.12 or less.

For macroinvertebrate data collected over six years of monitoring, only a few metrics showed slight trends. Both ST1 (downstream) and ST3 (upstream) had a slight increasing trend for HBI score; R^2=0.46 and R^2=0.50, respectively. ST1 also showed slight decreasing trends for EPT abundance and RBP score (R^2=0.35 and R^2=0.37, respectively). Other metrics did not show trends upward or downward over time with R-squared values equating to 0.2 or less. Fish assemblage data showed relatively strong trends, R-squared values of 0.40 or more, for the majority of metrics analyzed. All stations showed increasing trends for number of individuals per square meter, percent lithophilic spawners, biomass per square meter and FIBI scores from 2003-2008.

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