9.0 Permit Requirements

F. Watershed Assessment and Planning

Baltimore County shall continue to update and revise watershed assessments that have been developed for its 10 urban watersheds (Baltimore Harbor, Bird River, Back River, Gwynns Falls, Jones Falls, Little Gunpowder, Loch Raven, Lower Gunpowder River, Middle River, and the Patapsco River). The overall goal is to ensure that each County watershed is thoroughly evaluated and has an action plan to maximize water quality improvements. Additionally, the County shall encourage the public to participate in the development and implementation of watershed restoration activities. At a minimum, the County shall:

1. Continue to perform and update detailed assessments in all of its urban watersheds. These watershed assessments shall include:
    a. Determining current water quality conditions;
    b. Identifying and ranking water quality problems;
    c. Identifying all structural and non-structural water quality improvements opportunities;
    d. Reporting the results of a visual watershed inspection;
    e. Specifying how the restoration efforts will be monitored; and
    f. Providing an estimated cost and a detailed implementation schedule for those improvement opportunities identified above.

H. Assessment of Controls

Assessment of controls is critical for determining the effectiveness of the NPDES stormwater management program and progress toward improving water quality. Therefore, Baltimore County shall use chemical, biological, and physical monitoring to document work toward meeting the watershed restoration goals identified above.

9.1 Introduction

In order to meet the permit requirements detailed in section F (1. a-e) and section H, Baltimore County has initiated chemical, biological, and geomorphological monitoring programs in addition to the specific monitoring required by the permit and detailed in Section 8. The chemical monitoring program (9.2) consists of two elements, stream baseflow monitoring and tidal water monitoring. A third element consisting of storm event monitoring at USGS gage sites has been sporadic and will not be included in this report. The stream geomorphological monitoring program (9.3) includes monitoring of stream restoration projects and conducting stream assessments in support of the Small Watershed Action Plan preparation. The biological monitoring program (9.4) has four elements including probabilistic monitoring, CIP monitoring, reference site monitoring, and submerged aquatic vegetation monitoring. Baltimore County recently began monitoring brook trout populations in streams of the Prettyboy Reservoir watershed to support the Prettyboy Reservoir Watershed Restoration Action Strategy (9.5). The

SCA survey (9.6) provides descriptive and positional data for potential environmental problems along a watershed's non-tidal stream network.

9.2 Chemical Monitoring Program

In order to determine the chemical condition of Baltimore County waters two chemical monitoring programs have been implemented. The chemical monitoring program is intended to provide information on ambient chemical conditions and, over time, to assess trends in both chemical concentrations and chemical loads. The information will be used to better target restoration activities, to provide data for the calibration of pollutant load models, and to provide local data to assess the results of the Chesapeake Bay Program modeling efforts and TMDL modeling. The data will be used to assess water quality improvements that are the result of restoration efforts. It will also be used to determine progress in meeting the pollutant load reductions required by the Chesapeake Bay restoration efforts and as determined by the development of Total Maximum Daily Loads (TMDLs). These programs will partially fulfill the restoration effectiveness monitoring required under NPDES Permit section F.1 and H above.

The two current, chemically oriented programs, the Baseflow Monitoring Program and the Tidal Waters Monitoring Program are described in Sections 9.2.1 and 9.2.2, respectively.

9.2.1 Baseflow Monitoring

A baseflow monitoring program was initiated in 1999. The initial effort was targeted at watersheds that were undergoing or about to undergo the preparation of a Water Quality Management plan. The targeted watersheds included the Lower Gunpowder, the Little Gunpowder, the Middle River and the Baltimore Harbor watersheds. The limited data was used in the calibration of the SWMM pollutant load models that were included in the Water Quality Management plans. In the fall of 2000, the baseflow monitoring was shifted to the Back River, Jones Falls and Gwynns Falls watersheds. The shift was intended to address the lack of chemical monitoring information available for these watersheds. These watersheds were monitored until the spring of 2001. The data collected was presented in the NPDES – 2001 Annual Report. Staffing levels curtailed the continuance of the baseflow monitoring program until the spring of 2003.

The baseflow monitoring program, which resumed in 2003 was also redesigned. Baseflows are monitored in the Patapsco/Back River Basin in odd-numbered years, while the Gunpowder Basin/Deer Creek are monitored in the even-numbered years. In 2007, because of staff time constraints, we created Tier 1 and Tier 2 sites. The Tier 1 sites are our regular sampling sites. Tier 2 are sites that were removed from sampling, but will be picked back up if we have a Small Watershed Action Plan (SWAP) or other project in that area. There are 31 Tier 1 and 9 Tier 2 sites in the Patapsco Back River Basin. Four of the Tier 2 sites were sampled because of our SWAP in the Upper Back River and Lower Jones Falls. There are 53 Tier 1 and 22 Tier 2 sites in the Gunpowder Basin/Deer Creek. The points were chosen to maximize the number of subwatersheds monitored. The monitoring points within the Patapsco/Back River Basin are displayed in Figure 9-1, while the Gunpowder Basin/Deer Creek monitoring points are displayed in Figure 9-2. Appendix 9-1, at the end of this section, displays the watersheds and subwatersheds associated with each monitoring point.

The target number of baseflow samples is eight samples per year at each site. The actual number sampled will vary depending on weather conditions, staffing and other duties. The standard set

of monitored pollutants includes (TSS, TS, TKN, Nitrate/Nitrite, Total Phosphorus, Ortho-phosphorus, Cadmium, Copper, Lead, Zinc, BOD, COD, Chlorides, Sodium, Hardness, Magnesium and Calcium) as well as temperature and pH determined in *situ*. Discharge measurements are taken during each sample collection. A minimum of three days of dry weather is required prior to monitoring any baseflow site.

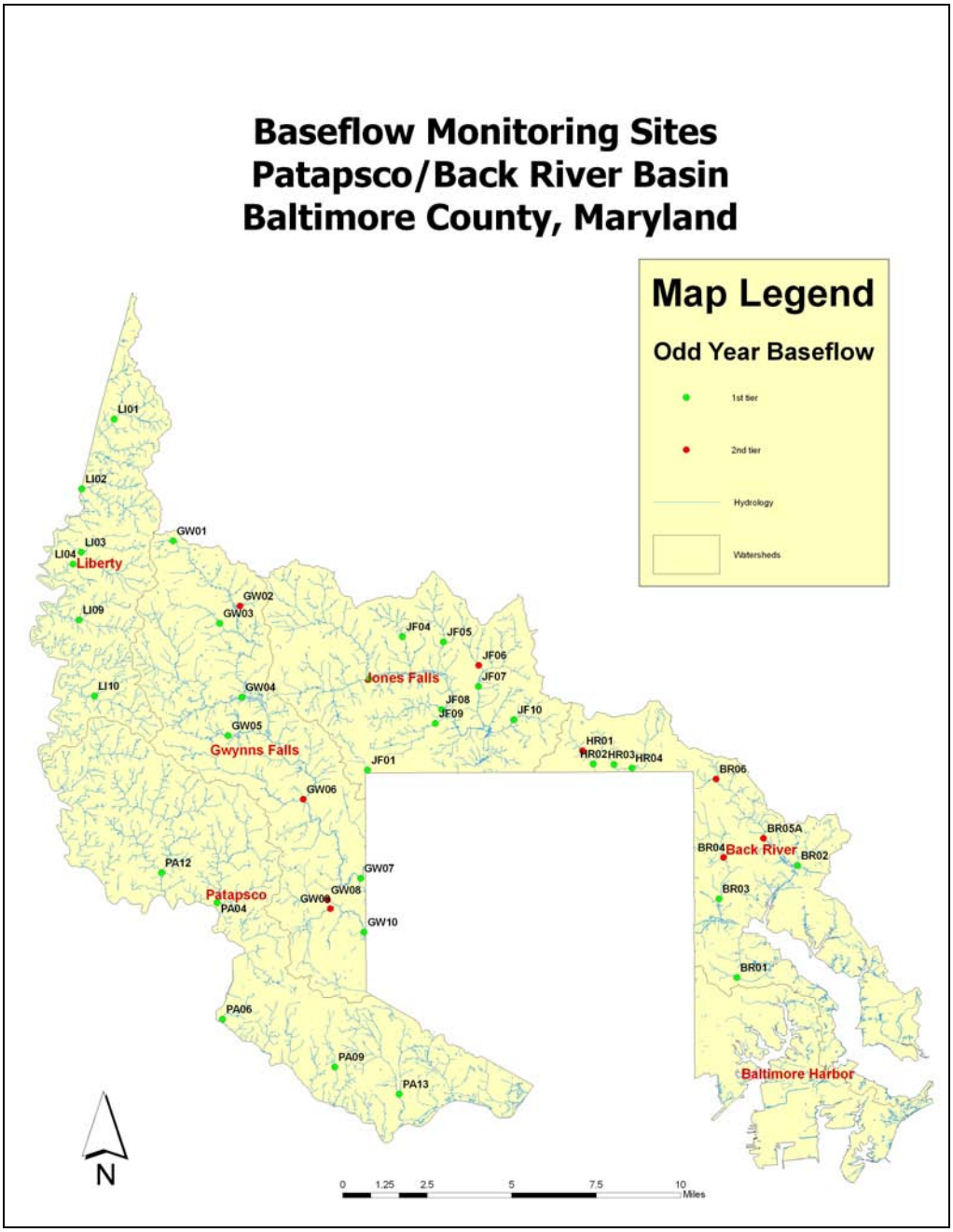


Figure 9-1: Patapsco/Back River Basin – Baseflow Monitoring Sites

The design will allow determination of ambient water quality for major portions of each watershed. The two-year sampling cycle will allow an analysis of baseflow water quality trends for the pollutant parameters analyzed.

Figure 9-2: Gunpowder Basin/Deer Creek – Baseflow Monitoring Sites

A total of 183 baseflow samples were collected in the Gunpowder/Deer Creek Basin in 2008. The number of samples per site varied from two to five, with the majority of being done three times. In addition to the baseflow samples, 35 field blanks and 35 duplicate samples were collected; these are excluded from calculations and are only for quality control purposes. The mean, number of samples and the standard deviation for each site are presented at the end of this section in Appendix 9-2 for each parameter analyzed.

A frequency analysis was conducted on the metals data to determine exceedance of water quality criteria. All statistical analyses were conducted using Statistica (Ver. 6.1). Figure 9-3 displays

the frequency distribution for both total copper and dissolved copper. Maryland Department of the Environment water quality criteria was used. The water quality criteria are based on dissolved metals and the toxicity is influenced by hardness. The total copper samples exceeded the chronic criteria for aquatic life for 24.0% and exceeded the acute criteria for 9.8% of the samples. On June 10, 2008 LR-18, LR-19, LR-20 all had unusually high total copper. While out that day, LR-20 was observed to be cloudy and foul smelling with lots of gnats flying around. When we went back the following day to investigate further, the problem was gone. For dissolved copper, 2.7% of the samples exceeded the chronic standard and 1.1% exceeded the acute criteria. The sample results for total and dissolved zinc and cadmium indicated they did not exceed the water quality standards for chronic or acute conditions. Total lead exceeded the chronic standard (.0025 mg/L) once for total metals at a concentration of .003 mg/L.

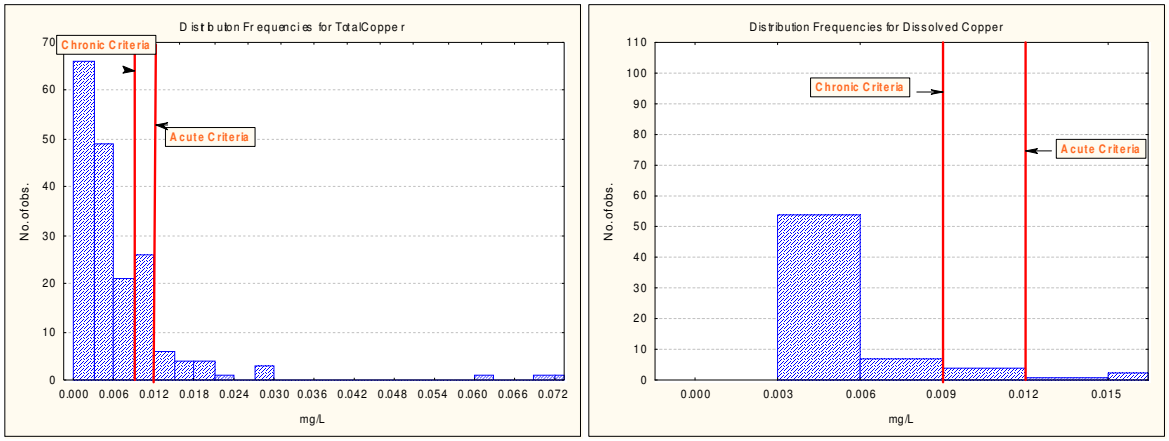


Figure 9-3: Frequency distributions by concentration for Total Copper and Dissolved Copper for the 2008 Gunpowder/Deer Creek samples.

The baseflow data collected in 2008 were analyzed for differences in concentration for each pollutant between the six watersheds sampled. ANOVA and Duncan's Multiple Range tests were used to examine relationships among the watersheds. The results are displayed in Table 9-1. The results of the Duncan's Multiple Range Test are displayed with the watersheds having the highest concentrations to the left and progressing in order to the lowest concentrations on the right. The watersheds joined by the same line are not significantly different. Total and dissolved cadmium had no variance and therefore was not included.

Table 9-1: Baseflow Pollutant ANOVA and Duncan's Multiple Range Test Results

Pollutant Parameter	df Effect	Df Error	F	P
pH	5	177	24.57	<.001
TSS	5	177	0.67	NS
TS	5	177	8.93	<.001
TKN	5	176	3.75	<.05
Nitrate/Nitrite	5	171	10.30	<.001
TP	5	176	1.21	NS
Total Copper	5	177	2.30	<.05
Dissolved Copper	5	177	2.74	<.05
Lead	5	177	1.43	NS
Dissolved Lead	5	177	1.01	NS
Zinc	5	177	2.68	<.05
Dissolved Zinc	5	177	2.85	<.05

BOD	5	177	0.48	NS
COD	5	176	2.68	<.05
Chloride	5	171	11.06	<.001
Hardness	5	177	17.00	<.001
Sodium	5	173	21.73	<.001
TN	5	170	9.15	<.001
Magnesium	5	173	6.79	<.001
Calcium	5	173	18.37	<.001

Duncan's Multiple Range Test

pH	GU LR LG DC BI PR
TS	BI GU LR LG DC PR
Total Kjedahl Nitrogen (TKN)	BI PR LG LR DC GU
Nitrate/Nitrite	DC PR GU LR LG BI
Total Copper	LR DC BI GU LG PR
Dissolved Copper	LR GU LG BI DC PR
Total Zinc	BI LG LR GU DC PR
Dissolved Zinc	BI LR LG GU DC PR
Chemical Oxygen Demand (COD)	BI LR PR LG DC GU
Chloride	BI GU DC LR LG PR
Hardness	GU BI LR DC LG PR
Sodium	BI LR GU DC LG PR
Total Nitrogen (TN)	DC PR GU LR LG BI
Magnesium	BI GU LR DC LG PR
Calcium	GU BI LR LG DC PR

The concentrations of fifteen parameters were found to differ significantly between watersheds. The Bird River watershed had the highest concentrations for eight of the parameters thirteen parameters, including Total Solids, TKN, Total and Dissolved Zinc, COD, Chloride, Sodium and Magnesium. Magnesium and Calcium are now included in our water testing. Sodium can displace the Magnesium and Calcium, binding with the soil, and is used as another indicator of road salt pollution. The Lower Gunpowder Falls was highest for pH, Hardness, and Calcium. The Loch Raven watershed was highest in Total and Dissolved Copper, while Deer Creek was highest in Nitrate/Nitrite and Total Nitrogen. In contrast, the Prettyboy Reservoir exhibited low concentrations for ten of the pollutants: pH, TS, Total and Dissolved Copper, Total and Dissolved Zinc, Chloride, Hardness, Sodium, Magnesium and Calcium. Figure 9-4 displays the results of the Duncan's Multiple Range Test for COD, TN, Dissolved Copper, and Chlorides. Figure 9-5 displays the results for COD, TN, Dissolved Copper, and Chlorides, as these are of major concern.

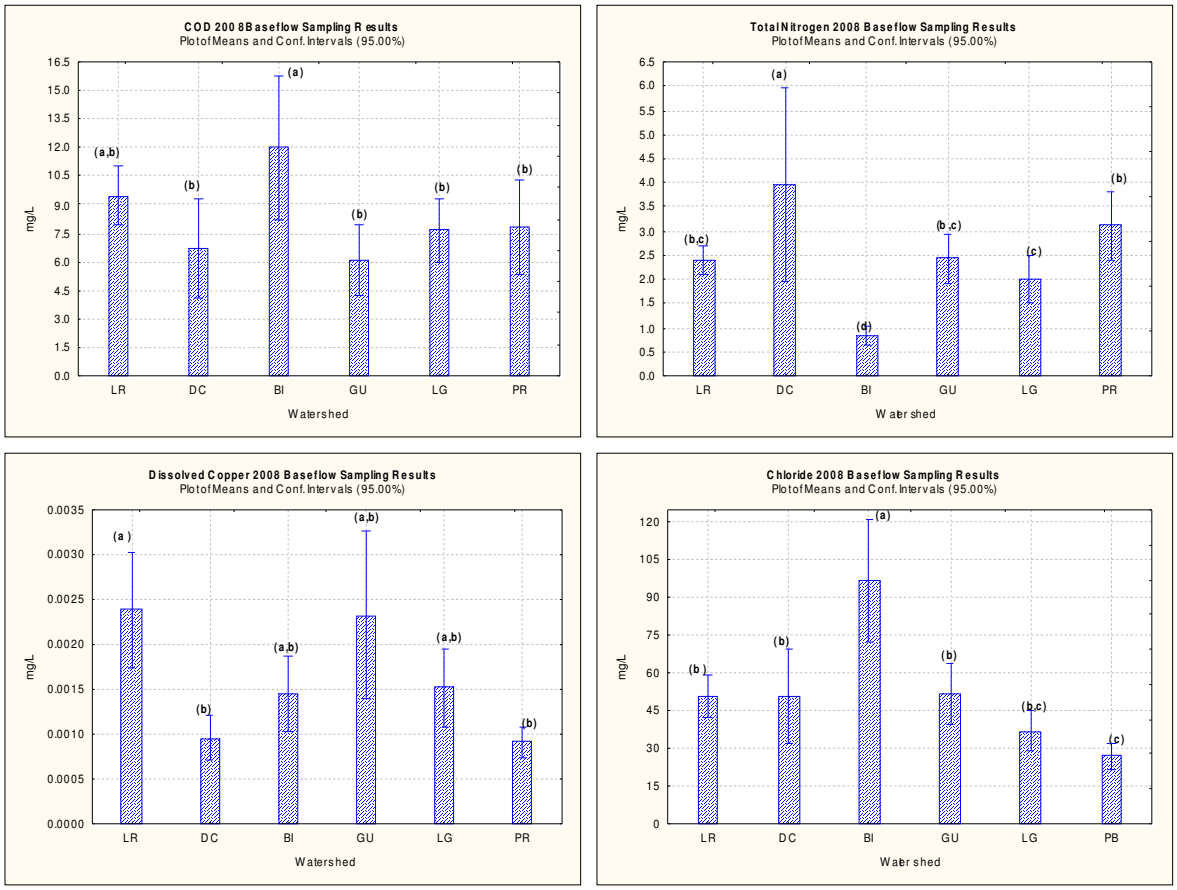


Figure 9-4: Duncan's Multiple Range Test results for COD, TN, Dissolved Copper, and Chlorides.

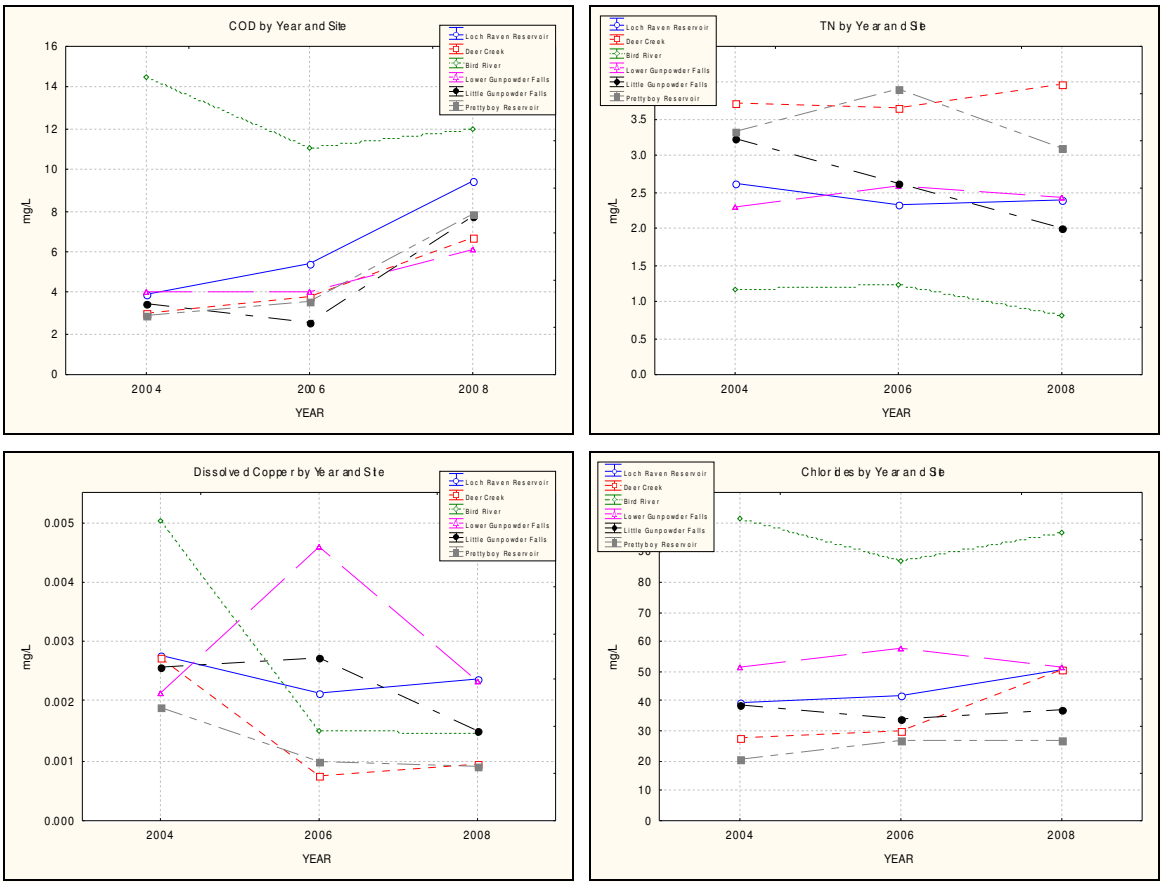


Figure 9-5: Baseflow COD, TN, Dissolved Copper, and Chlorides for sampling years 2004, 2006, and 2008.

Several interesting trends can be seen from the graphs in Figure 9-5.

For COD:

- After only slight changes from 2004 to 2006, Loch Raven, Deer Creek, Lower Gunpowder, Little Gunpowder and Prettyboy increased in 2008.
- Bird River consistently has concentrations higher than the other watersheds.

For TN:

- Prettyboy, Little Gunpowder, Lower Gunpowder and Back River decreased from 2006 to 2008.
- Deer Creek and Loch Raven increased from 2006 to 2008.
- Little Gunpowder is the only watershed that has showed a steady trend, declining since 2004.

For Dissolved Copper:

- Unlike the dramatic increases and decreases from 2004 to 2006, Loch Raven, Bird River, Prettyboy and Deer Creek only had slight changes between 2006 and 2008.
- The Lower Gunpowder had the largest change from 2006 to 2008, falling from 0.0046 mg/L to 0.0023 mg/L.

- The Little Gunpowder had the next largest change from 2006 to 2008 falling from 0.0027 mg/L to 0.0015 mg/L

For Chlorides:

- Bird River, Loch Raven, Deer Creek, and Little Gunpowder all increased from 2006 to 2008.
- Lower Gunpowder and Prettyboy were the only watersheds to show decreases.
- Bird River consistently has higher concentrations than the other watersheds.

Two map displays showing the Total Nitrogen and Total Phosphorus mean concentrations are shown in Figures 9-6 and 9-7 on the following two pages. As can be seen from Figure 9-6, the highest concentrations of Total Nitrogen predominate in the agricultural portions of the County. These increased Total Nitrogen concentrations may be the result of agricultural activities, septic system inputs, or a combination of both. The upper Gwynns Falls, a predominately urban area shows high values of Total Nitrogen, as well as one sub-watershed in the Back River.

The distribution of Total Phosphorus concentrations conversely shows the highest concentrations in the predominately in the urban areas, with several notable exceptions, including upper Lower Gunpowder Falls, and the rural portions of the Liberty Reservoir and Loch Raven watersheds. The majority of Total Phosphorus is delivered during storm events, associated with sediment. Thus the concentrations measured in baseflow sampling are much lower than during storm event sampling. The elevated concentrations in the urban areas are likely the result of increases in orthophosphate, which occurs in a dissolved form. The source is currently not known, but may be associated with sewage and various industrial processes. The elevated and very high concentrations in rural areas may be associated with animal operations where livestock have access to the stream.

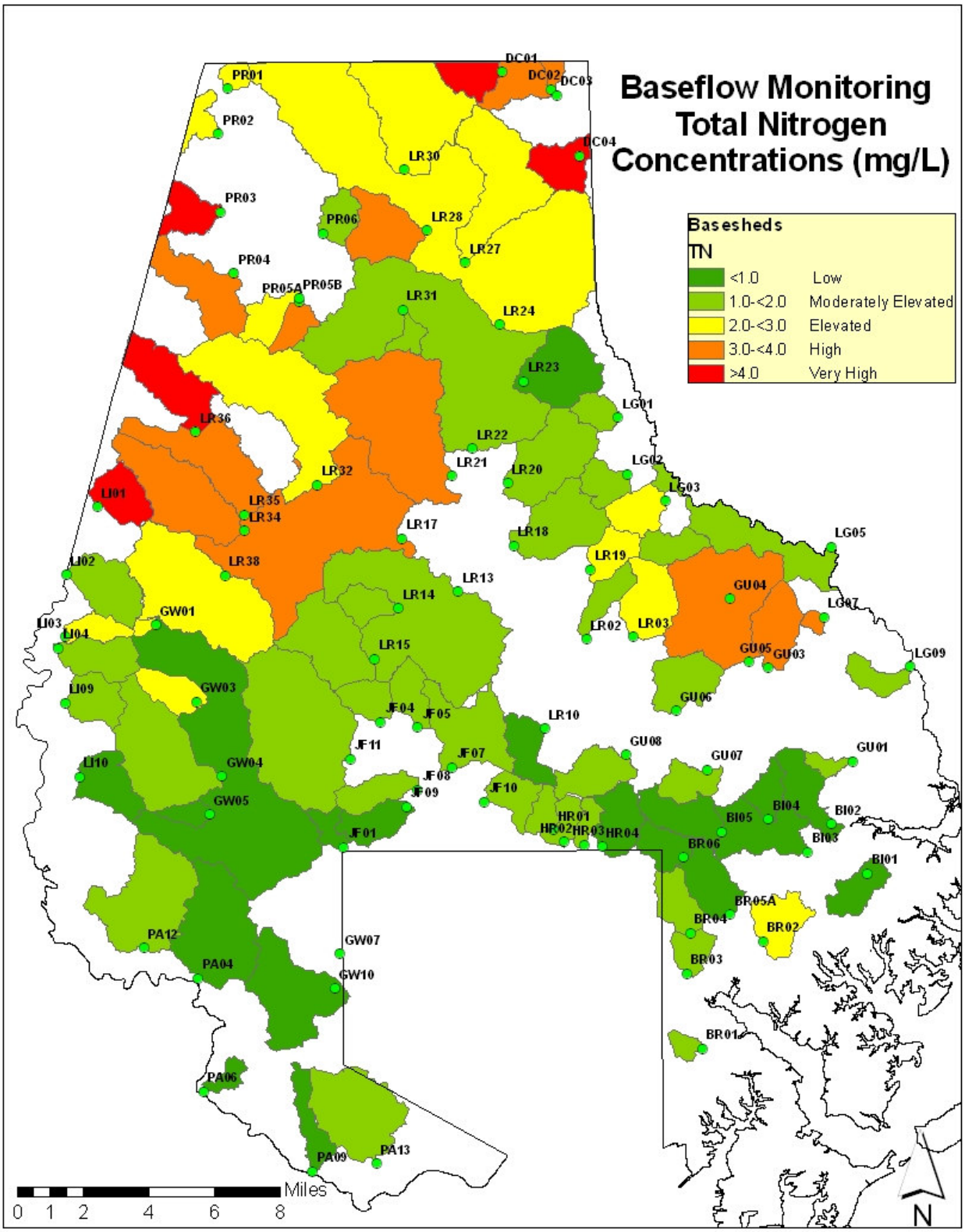


Figure 9-6: Baseflow Total Nitrogen Mean Concentrations for Monitoring Years 2007 (Patapsco/Back River Basin) and 2008 (Gunpowder Basin).

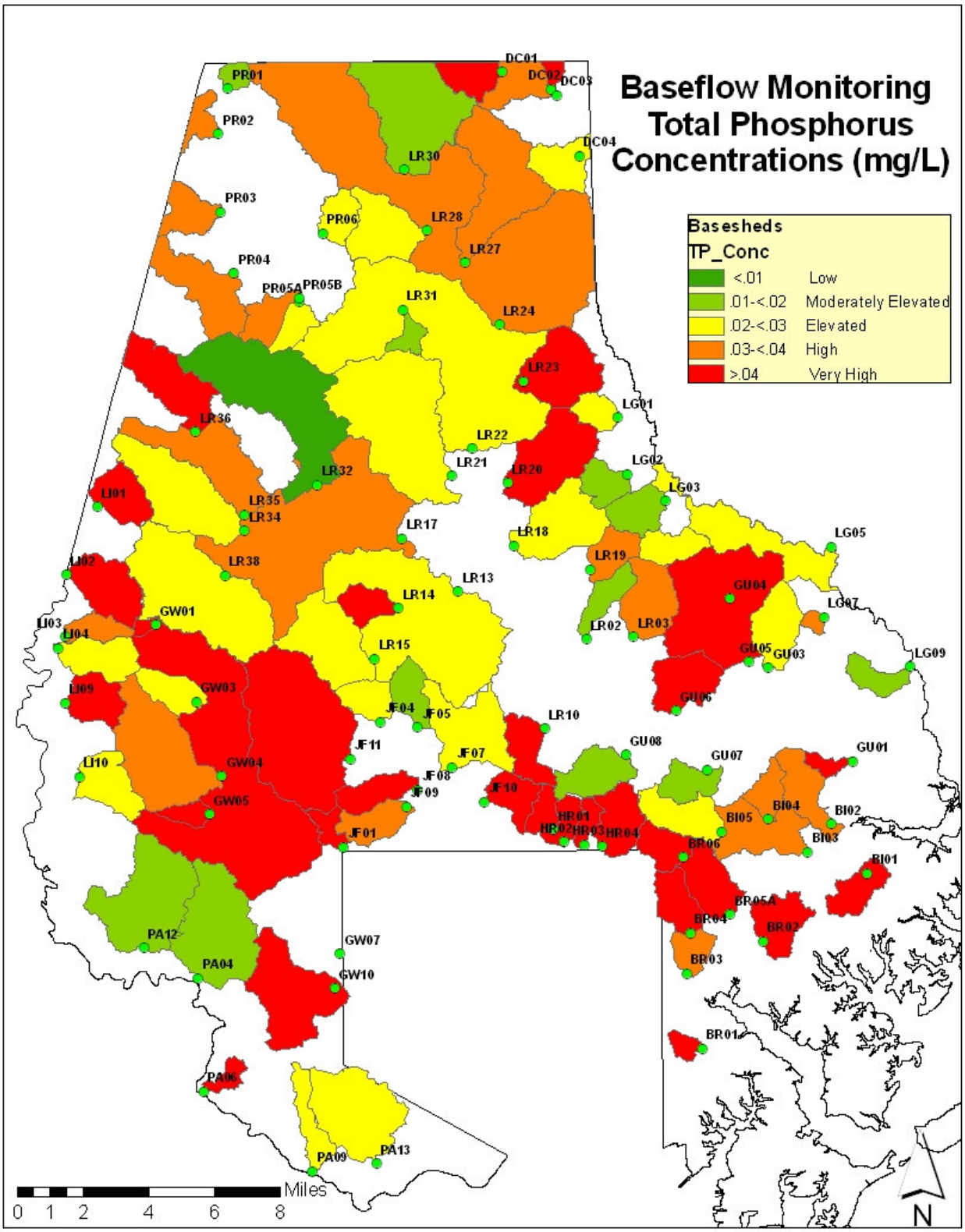


Figure 9-7: Baseflow Total Phosphorus Mean Concentrations for Monitoring Years 2007 (Patapsco/Back River Basin) and 2008 (Gunpowder Basin).

9.2.2 Tidal Waters Monitoring Program

Baltimore County has had a tidal recreational water-monitoring program since 1970. Early bacteriological sampling was conducted on a monthly basis between, Labor Day and Memorial Day, for fecal coliform. Since 2000, and the advent of the US EPA Beach Act, tidal water sampling has been conducted bi-weekly by boat for the indicator organism Enterococci. The sampling season has been extended to cover the period of April through November (weather permitting). Multiple bacteriological samples are taken in 10 zones representing areas of heavy recreational use with 4 single grab samples taken in less utilized areas. In addition, beach sampling also utilizing Enterococci is conducted at 3 permitted beach locations, on a basis alternate to recreational water sampling.

Individual sample results are recorded as well as the Geometric Mean of multiple sample zones. A value of 35 MPN (geomean) Enterococci is required to be utilized as a threshold for public safety and water contact only in association with a known or suspected sewage overflow. 35 MPN is otherwise used for comparison purposes to make general characterizations of open water. The results of the bacteriological sampling can be viewed on the internet at: http://www.baltimorecountymd.gov/Agencies/environment/watersampling/results.html.

Special sampling is also conducted to support environmental/public health evaluations after severe storm events or sanitary sewage overflows.

Starting in 2002, chemical sampling of surface waters was initiated at locations designed to represent major county tidal basins. This sampling takes place during the recreational water-sampling run and has recently been expanded to ten locations. The codes for those locations as noted on the "Beach, Beach Area, And Recreational Water Sampling Locations" map (Figure 9-8) and the tidal water basins they represent are found on Table 9-2.

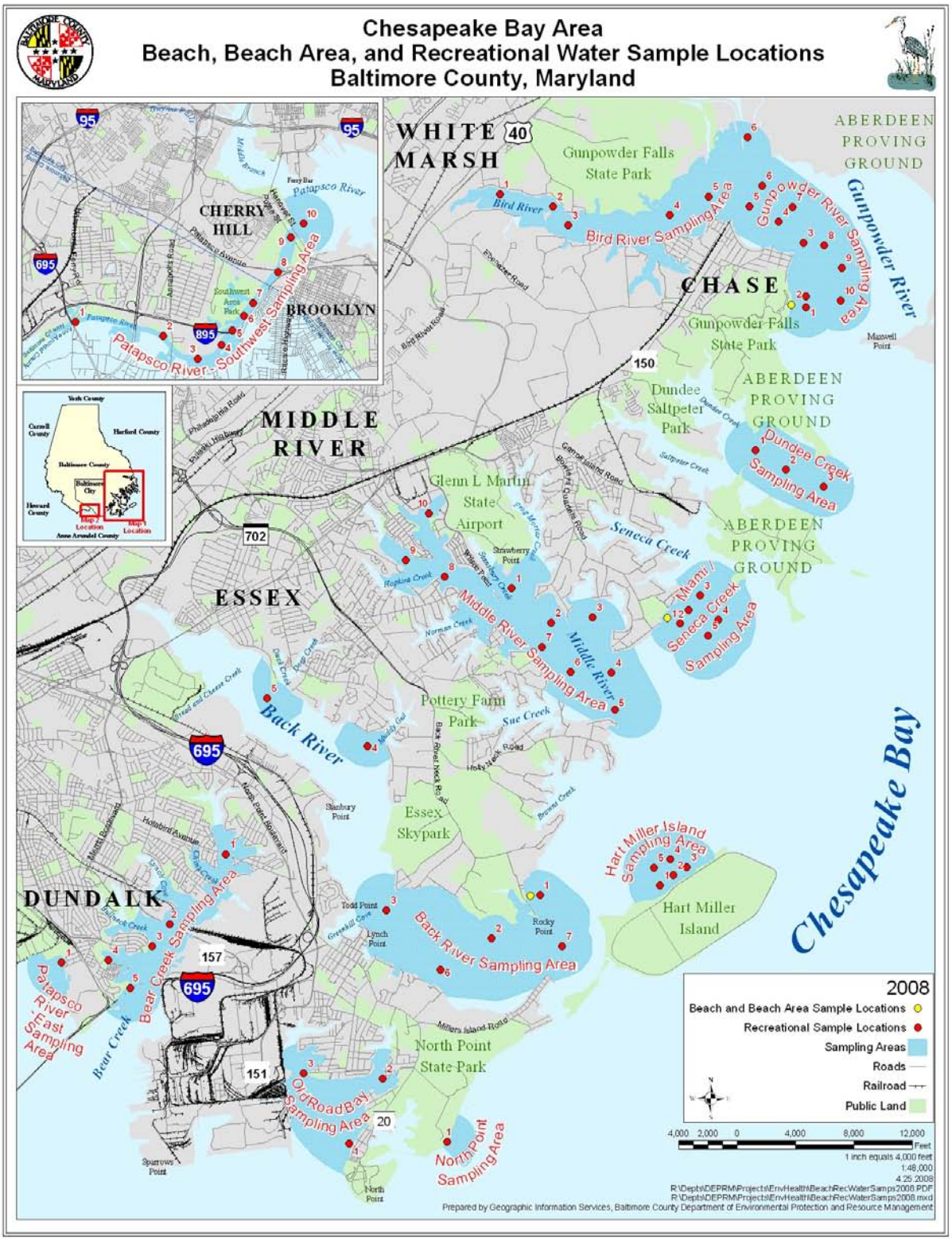


Figure 9-8: Tidal Waters Monitoring Site Locations.

Table 9-2: Site Codes and the Associated Tidal Water body

Code	Water Body
BC	Bear Creek
PR	Patapsco River - Outer
GR	Gunpowder River
MS	Miami Beach/Seneca Creek
MR	Middle River
BR	Back River
HM	Hart Miller Island
BD	Bird River
PS-F	Patapsco River – Fresh Water
PS-E	Patapsco River – Estuarine
DD	Dundee Creek
ORB	Old Road Bay

All twelve stations were monitored between eleven and thirty-one times during the time period of April 2008 through November 2008. The same standard set of pollutant parameters detailed in Section 9.1.1, were monitored in the tidal waters. The data are summarized by site in Appendix 9-3, which presents the means, number of samples and the standard deviation for each pollutant parameter presented.

An analysis of variance (ANOVA) was used for each pollutant to determine if there were significant differences between the twelve sites. The results of the ANOVA are displayed in Table 9-3. If a significant difference was found a post hoc Duncan's Multiple Range Test was used to determine which sites were significantly different. The results of the Duncan's Multiple Range Test are presented at the end of Table 9-3. When interpreting the results of the Duncan's Multiple Range Test, the sites are arranged from highest concentration of the parameter to the lowest concentration. The sites joined by the same line are not significantly different. All statistical analyses were conducted using Statistica (Ver. 6.1).

Table 9-3: ANOVA and Duncan's Multiple Range Test Results

Pollutant Parameter	df Effect	Df Error	F	P
TSS	11	200	2.80	<.01
TS	11	200	14.46	<.001
TKN	11	203	25.51	<.001
Nitrate/Nitrite	11	173	2.95	<.05
TN	11	173	14.69	<.001
TP	11	203	13.66	<.001
Total Copper	11	203	0.94	NS
Dissolved Copper	11	203	0.90	NS
Total Lead	11	203	.33	NS
Dissolved Lead	11	203	0.81	NS
Total Zinc	11	203	0.77	NS
Dissolved Zinc	11	203	0.76	NS
BOD	11	203	27.20	<.001
COD	11	203	5.08	<.001
Chloride	11	176	7.56	<.001
Fluoride	11	179	0.53	NS
Sulfate	11	176	8.90	<.001

Duncan's Multiple Range Test

Total Suspended Solids (TSS)	PR	BC	ORB	MS	PSE	DD	MR	BR	GR	HM	BD	PSF
Total Solids (TS)	PR	BC	ORB	PSE	MS	MR	HM	DD	GR	BR	BD	PSF
Total Kjedahl Nitrogen (TKN)	BR	BC	BD	PR	ORB	PSE	HM	DD	PSF	MR	GR	MS
Nitrate/Nitrite	PSF	BC	BR	ORB	PSE	HM	MR	BD	PR	MS	DD	GR
Total Nitrogen	BR	BC	PSF	BD	ORB	PSE	PR	HM	MR	DD	MS	GR
Total Phosphorus (TP)	BR	BD	BC	GR	PR	PSE	ORB	PSF	MR	DD	MS	HM
Biological Oxygen Demand (BOD)	BC	BR	BD	PR	ORB	PSE	MR	HM	DD	GR	MS	PSF
Chemical Oxygen Demand (COD)	BC	PR	ORB	BR	PSE	MS	HM	MR	BD	DD	GR	PSF
Chloride	PR	BC	ORB	MS	PSE	DD	MR	HM	GR	BR	BD	PSF
Sulfate	PR	BC	ORB	MS	PSE	DD	HM	MR	GR	BR	BD	PSF

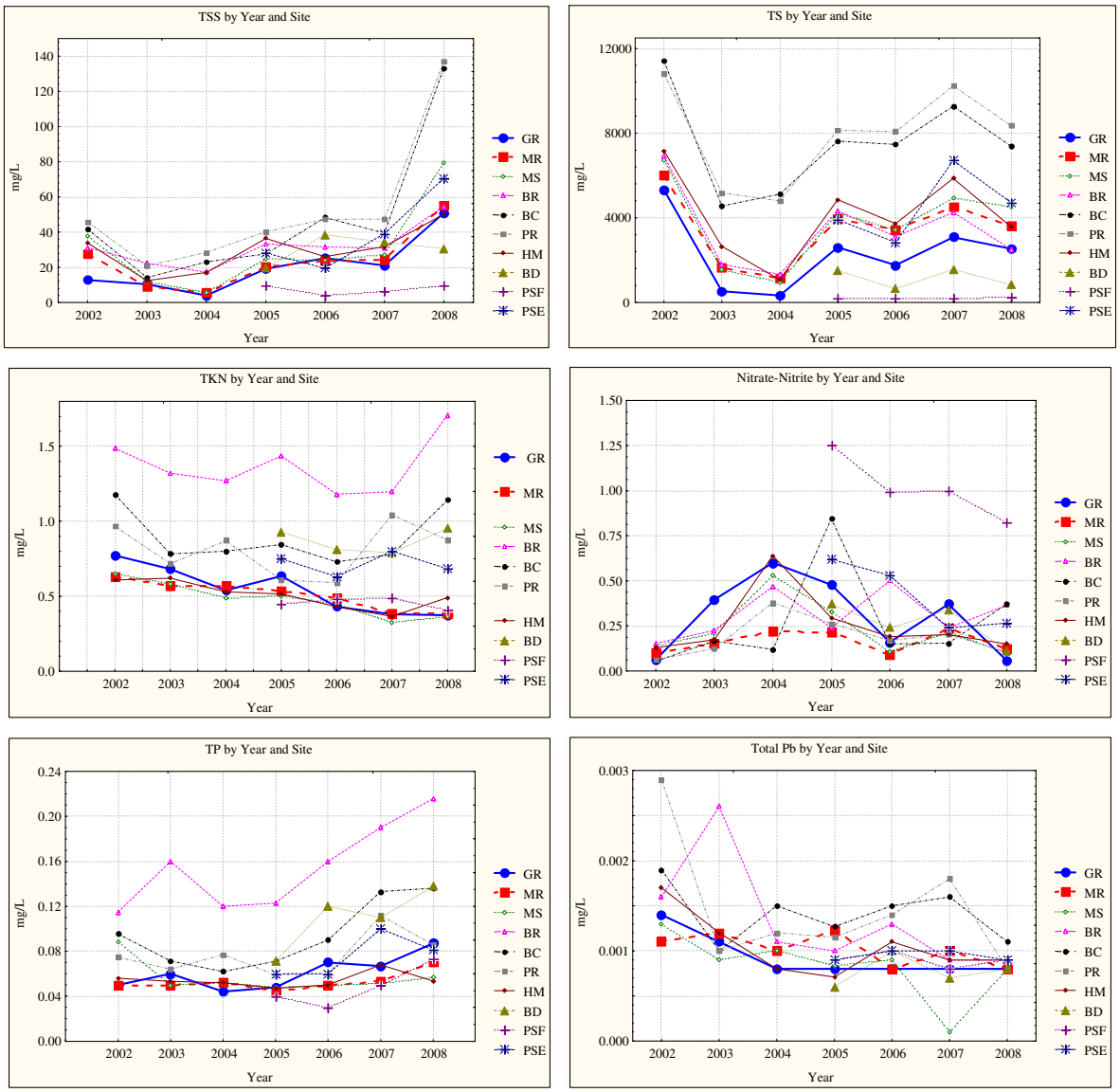
Sampling results for 2008 indicated that ten of the parameters (TSS, TS, TKN, Nitrate/Nitrite, TN, TP, BOD, COD, Chloride, and Sulfate had mean concentrations that differed among sites.

There were few changes in the relative ranking of the sites from highest to lowest between years for the ten parameters that were found to have a significant difference among sites. Both the TS and chloride parameters were highest in concentrations for the Patapsco River (PR), Bear Creek (BC), and Old Road Bay (ORB). This would indicate that these sites had the highest mean salinity. The Back River (BR) had significantly higher TKN concentrations than the other nine sites. This is probably due to the presence of the Waste Water Treatment Plant (WWTP) in this area. BD (Bird River) and BC (Bear Creek) also have relatively high TKN concentrations. This may also be related to the relatively poorer connection with open bay waters and the presence of algal populations, which would increase the organic nitrogen concentration. BR (Back River)

had the highest concentration and HM had the lowest concentration for Total Phosphorus mean concentrations. Last year the lowest concentration for TP was PSF, which this year is in the middle of the rankings. The presence of the Back River WWTP could account for the elevated concentrations of Total Phosphorus.

Bear Creek (BC) had the highest mean concentration for biological oxygen demand and chemical oxygen demand. This could indicate that the BC had a greater algal population than the other sites. A graphical comparison between years for site and select pollutants was conducted. Bird River (BD), PS-F (Patapsco River – Fresh), and PS-E (Patapsco River – Estuarine) have only four years of data. Old Road Bay (ORB) and (DD) are not included because they were added this year. The results are presented in Figure 9-9.

Figure 9-9: Pollutant Between Year Variation by Site



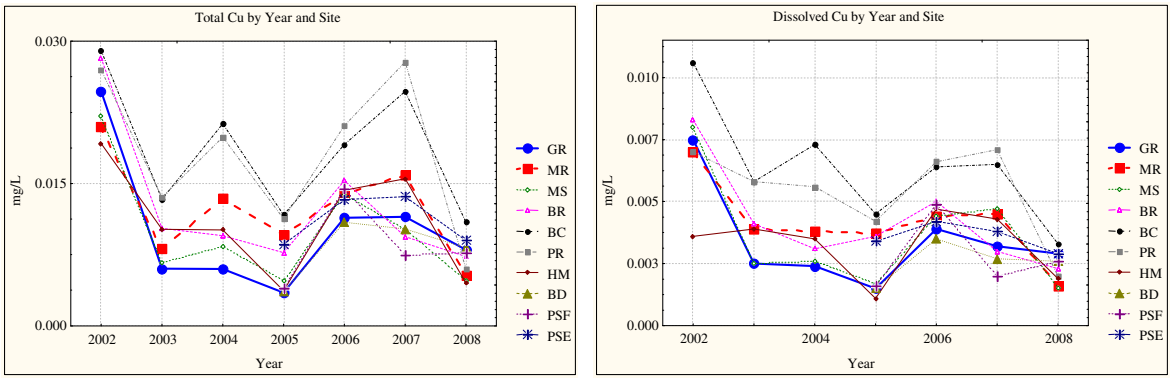


Figure 9-9: Pollutant Between Year Variation by Site (continued).

Several interesting trends can be seen from the graphs in Figure 9-9.

For Total Suspended Solids (TSS):

- All the sites are following the same trend except PSF (Patapsco River- Fresh), which has much lower levels than the other sites.
- A noted decrease in concentrations for all sites can be noted between 2002 and 2003.
- Since 2004, there has generally been an increasing trend, with the highest increases taking place between 2007 and 2008.

For Total Solids (TS) and Total Copper:

- The TS reduction between 2002 and 2003 is undoubtedly related to the reduced salinity that resulted from the increased runoff.
- There was an increase in TS and a decrease in Total Copper for all sites in 2005.
- From 2006 to 2007 there was again a moderate increase for all sites except PSF.
- For 2007, both TS and Total Copper increased, except for Total Copper levels in BR (Back River) and MS (Miami Beach/Seneca Creek).
- In 2008 all sites experienced declines in both TS and Total Copper relative to the 2007 results.

For Dissolved Copper and Total Lead:

- They both continued to decrease in 2004 and 2005 for all sites followed by an increase in 2006.
- For 2007, Dissolved Copper decreased slightly in about half the sites including BD, GR, PSF, and BR while the remaining sites held steady.
- Total Lead held steady in 2006 and 2007.
- PR had the largest decrease for both Dissolved Copper and Total Lead.
- Dissolved copper never exceeded the acute (0.0061 mg/L) Maryland Department of the Environment estuarine water quality standards for 2008.

For Nitrate/Nitrite:

- Concentrations increased in 2004 (with the exception of Bear Creek) relative to the 2003 and 2002 concentrations
- They decreased in 2005 (except for the HM site).
- Concentrations saw a large decrease in 2006, with the exception of Back River (BR), which increased by 48%.
- GR had the greatest decrease from 2007 to 2008, falling from 0.37 mg/L to 0.06 mg/L.
- PSF, a fresh water site, generally has higher concentrations than the other sites.

For Total Kjeldahl Nitrogen (TKN):

- Concentrations continue to decrease or stay about the same, except for PR (Patapsco River) and PSE (Patapsco River – Estuarine), which increased significantly in 2007.
- BR had the highest increase from 2007 to 2008 going from 1.20 mg/L to 1.71 mg/L. BR consistently has higher concentrations than the other stations.

For Total Phosphorus:

- Concentrations varied little among sites until 2006.
- Total Phosphorus in Back River (BR) has consistently risen since 2006. The concentrations are always higher for BR than the other sites, probably due to the presence of the Back River WWTP.

9.3 Stream Geomorphological Monitoring

Baltimore County DEPRM performs post-project monitoring of its completed stream restoration projects in accordance with applicable federal and state waterway construction permit requirements. The field monitoring and reports are either done completely in-house or by consulting firms competent in this work. These monitoring activities also provide compliance with the NPDES permit requirement to monitor effectiveness of restoration projects.

9.3.1 Stream Restoration Project Monitoring

The U.S. Army Corps of Engineers authorization for stream restoration activity is generally required pursuant to Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act of 1899. Additionally, projects are normally eligible for authorization by the Maryland State Programmatic General Permit (MDSPGP) as published in the Special Public Notice 96-19 issued in June, 1996. For these projects, the conditions of the (MDSPGP) authorization normally require the development of a monitoring plan that will be used to identify and evaluate changes in the completed stream restoration project and to take remedial measures as necessary in coordination with the regulatory agencies. For each project, specific elements of the monitoring plan are identified as determined by the regulatory agencies. See Exhibit 5-1 of the 2003 NPDES Report for an example of an authorization document/permit and monitoring criteria. Periodic field monitoring followed by a written report of findings and any proposed remedial measures are submitted to the Army Corps of Engineers, Maryland Section Northern and to the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division as called for in the monitoring plans. Monitoring is also utilized to determine if the capital project implementation meets the goals of the project. Further, the DEPRM believes that

the post construction monitoring program provides valuable feed-back information that enables it to improve the effectiveness of its future project design and construction approaches.

The post construction monitoring plans require periodic collection of field data – usually annually for 2 to 5 years. Additional monitoring may be required after large storms. In most cases, monumented and surveyed channel cross-sections located at strategic points along the project are required. Occasionally, longitudinal profiles are required or elected to be done by DEPRM. Field data are collected using Standard Operating Procedures for pebble counts, cross sectional surveys, and longitudinal surveys. Data from the cross-sections and longitudinal surveys are entered into a computer program and plotted. For multi-year surveys these plots are overlayed (current over prior year(s)) to detect any changes in morphology that may have occurred between these periods. Bed material characterization via the Wolman pebble count procedure, inspection of the condition of any riparian plantings, visual inspection of the degree of channel erosion or deposition etc., and photographing the channel and banks at key locations are other components that may be included in the monitoring plan and report.

Table 9-4 summarizes the streams and stream restoration projects monitored and/or reported to the regulatory agencies in 2008. Copies of the completed reports submitted and listed in Table 9-4 are on file at the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division and at the DEPRM CIP Section where they are available for inspection.

Table 9-4: Summary of Capital Improvements Projects Monitoring Reports Submitted for 2008

Project	Submitted	Responsible Personnel
Hampton Branch Stream Restoration	2008	In-House WMM
Minebank Run II Stream Restoration	2008	GPI/BioHabitats
North Fork Stream Restoration	2008	KCI

9.3.2 Stream Stability Assessments

DEPRM is utilizing consulting assistance through a multi-year on-call contract to perform planning level stream stability assessments on various streams in Baltimore County. These assessments entail field teams who "cruise", by walking, assigned stream reaches collecting morphological, riparian, habitat quality, and other data useful in making evaluative assessments of stream condition and evidence of change. Other information will be collected related to infrastructure conflicts, pollution sources, fish blockages, etc. The stream assessments will be in support of the Small Watershed Action Plan (SWAP) process, TMDL's, and for comparison of baseline conditions and stream management/restoration needs, and for consideration of potential stream restoration projects. Four stream stability assessments have been completed to date: *Hunt Valley Stream Stability Assessment, Prettyboy Reservoir Stream Stability Assessment (Compass Run and Frog Hollow Subwatersheds), Lower Jones Falls Stream Stability Assessment, and Upper Back River Stream Stability Assessment*. An electronic copy of the first two reports was submitted with the NPDES 2006 Annual Report. Electronic copies of the Lower Jones Falls and Upper Back River reports are included with this report. These assessments have identified potential restoration projects by category, including:

- Stream restoration/stabilization,
- Buffer enhancement,
- Bank plantings,
- Utility conflict resolution,
- Habitat enhancement,
- Trash cleanup,

- Yard waste cleanup, and
- Invasive species removal.

9.3.3 Geomorphological Monitoring Summary

In summarizing the results of the in-house monitoring completed through 2008, it can be stated that the stream restoration projects have been successful in achieving the goals of self-maintaining channel stability, reduction of bed and bank erosion, protection of private and public infrastructure, and habitat improvement. Improvements in aesthetics and public safety aspects have been additional benefits. Most of the problems observed have been localized and minor in scale such as shifting of rock elements in grade control structures, bank scouring at the downstream end of bank protection structures, depositional bar build-up in the vicinity of grade control structures, and channel erosion at intra project segments that were not restored or modified during the overall project. The information gained from the monitoring has enabled DEPRM to improve its stream restoration approaches such as increasing the size of the rock elements in grade control structures subject to high tractive forces, and more closely relating the height of bank protection structures to bank full elevation. The challenges of effective stream improvement in an urban setting are formidable. Through the knowledge and experience gained with its design, construction, and monitoring efforts, DEPRM continues to build upon a successful stream restoration program.

9.4 Biological Monitoring

In addition to the biological monitoring required at Scotts Level Branch under Baltimore County's NPDES permit, the County has four additional biological monitoring programs. These programs use the biological community to assess the ecological health of the streams within the County (Probabilistic Monitoring Program, Section 9.4.1), assess the effectiveness of stream restoration projects (CIP Monitoring Program, Section 9.4.2), provide data on the best streams in Baltimore County to serve as bench marks for other stream assessments (Reference Site Monitoring Program, Section 9.4.3), and assess Submerged Aquatic Vegetation (Submerged Aquatic Vegetation (SAV) Monitoring Program, Section 9.4.4). The first three programs use assessments based on the benthic macroinvertebrate community and, in some cases, the fish assemblage. It is widely accepted that the biological community of streams is sensitive to anthropogenic perturbations. By monitoring the biological community, the County can assess the amount of change due to anthropogenic activities and the benefit of stream restoration to stream organisms. The SAV Monitoring Program provides an assessment of the coverage of SAV and progress made in meeting the new water quality standards for water clarity and SAV coverage in Baltimore County tidal waters.

9.4.1 Probabilistic Monitoring

The County adopted Maryland Biological Stream Survey (MBSS) methodologies in 2003, which has allowed for direct comparisons with State generated data. This has expanded upon the available data for assessing County waters. Probabilistic monitoring (randomly selected monitoring sites) has allowed statistically valid statements regarding the state of the waters.

The County has contracted a consultant to perform the probabilistic monitoring. Each year a different basin is sampled, with the Patapsco/Back River Basin (Liberty Reservoir, Patapsco River, Gwynns Falls, Jones Falls, and Back River) monitored in odd years and the Gunpowder River Basin and Deer Creek watersheds (Deer Creek, Prettyboy Reservoir, Loch Raven

Reservoir, Lower Gunpowder, Little Gunpowder, and Bird River) monitored in the even years. Three watersheds are not assessed using the Biological Probabilistic Monitoring Program (Baltimore Harbor, Middle River, and Gunpowder River) due to the limited miles of free flowing streams in the watersheds.

One hundred sites are selected at random for each year's sampling effort. The contractor samples these 100 sites during the spring index period, March 1 to April 30, for macroinvertebrates using the MBSS protocols. These samples are sub-sampled to 100 organisms and identified to Genus or the lowest possible taxonomic level. A Benthic Index of Biotic Integrity (BIBI) is calculated. The BIBI describes the biological condition of the streams in the County. In 2006, a subset of previously sampled random sites was selected to serve as sentinel sites. The sites were located towards the base of major subwatersheds. Eighteen sentinel sites were selected in the Patapsco/Back River basin, and 13 sentinel sites were selected in the Gunpowder/Deer Creek basin. The sentinel sites will be used to monitor biological condition over a range of watershed and stream conditions.

The current BIBI uses six metrics. These six metrics, what they measure and the expected response to stressors are displayed in Table 9-5.

Table 9-5: BIBI Metrics

BIBI Metric	Metric Measure	Expected Response
Number of Taxa	Species Richness	Decrease
Number of EPT	Species Richness	Decrease
Number of Ephemeroptera	Species Richness	Decrease
Percent Intolerant to Urban	Tolerance/Intolerance	Decrease
Percent Chironomidae	Taxonomic Composition	Increase
Percent Clingers	Habit	Decrease

The results for each site from the 2008 probabilistic monitoring are displayed in Appendix 9-4 at the end of this section. The sites are grouped by subwatershed and 12-digit watershed, along with their respective BIBI and condition rating. The sites are assigned condition ratings based on the BIBI scores, with 1.00 – 1.99 being "Very Poor," 2.00 – 2.99 being "Poor," 3.00 – 3.99 being "Fair," and 4.00 – 5.00 being "Good." Figure 9-10 displays the site condition by color code for each of the 192 sites sampled in 2005 and 2006. Figure 9-11 displays the same information for sites sampled in 2007 and 2008.

Table 9-6 shows the results by watershed, as the percentage of sites within each BIBI range, for the entire six-year probabilistic data set. The Patapsco/Back River Basin data show an improvement in biological condition. Sites within the Good and Fair categories increased from 15% in 2003 to 44% in 2007. Liberty Reservoir had all 20 sampled sites in the Fair and Good categories in 2007. As in 2005, Jones Falls had the next highest percentage of sites in the Fair and Good categories (46%).

The 2004 and 2006 sampling results for the Gunpowder Basin/Deer Creek watersheds indicated a decrease in water quality. In 2004, 79% of sites were in the Fair and Good categories, while in 2008 only 62% of sites rated Fair and Good. The biological condition of streams in the Gunpowder River/Deer Creek watersheds continues to be better than in Patapsco/Back River. Gunpowder River/Deer Creek streams had higher percentages of sites rated Fair and Good, and Patapsco/Back River had higher percentages of streams rated Very Poor and Poor. This is likely a reflection of higher population density and greater development pressure in Patapsco/Back River. However, over the entire county for the 6-year sampling period, the percentages of

streams rated Fair and Good (47%) is roughly equal to percentage rated Very Poor and Poor (53%).

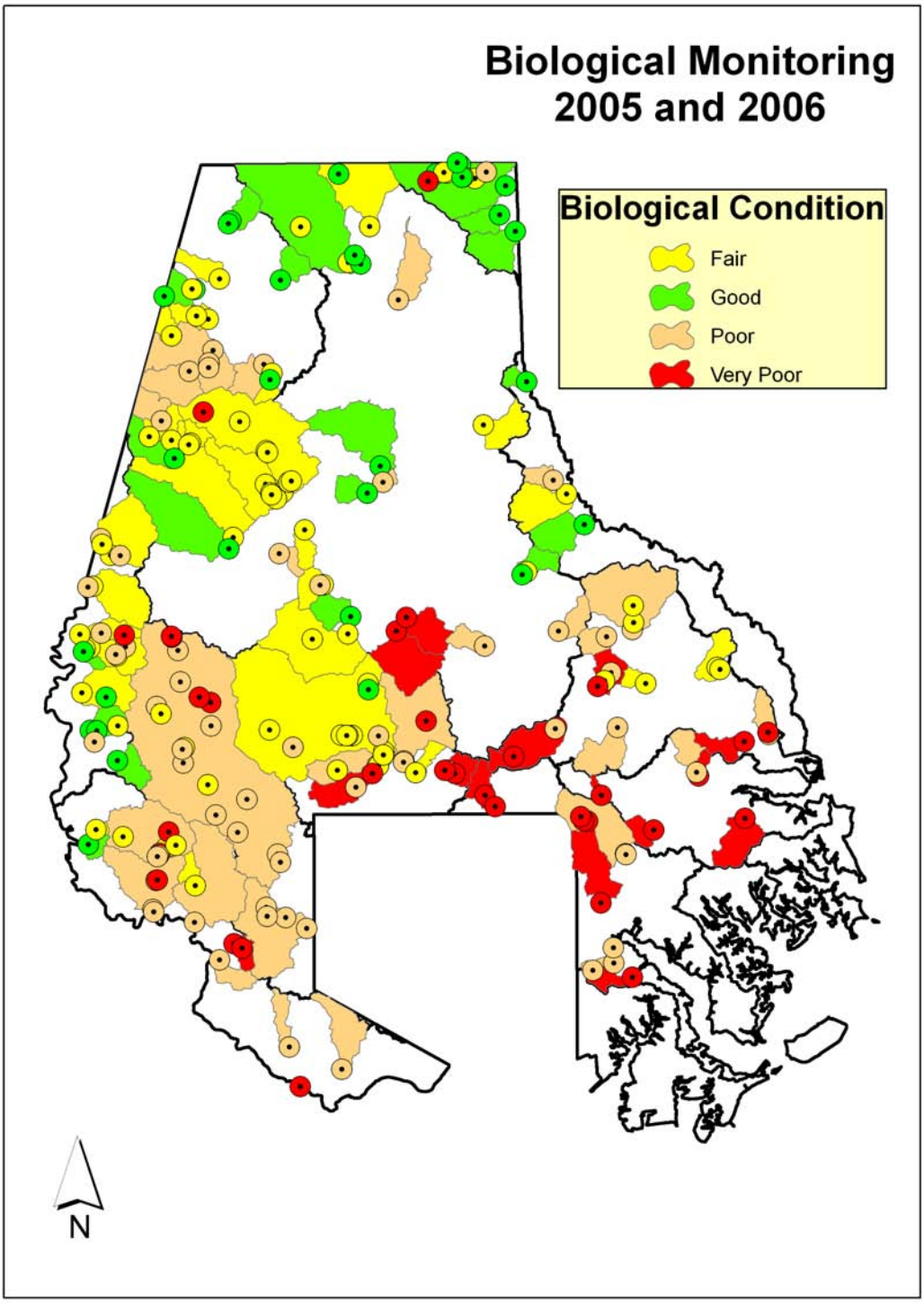


Figure 9-10: Probabilistic Biological Monitoring results for 2005 and 2006.

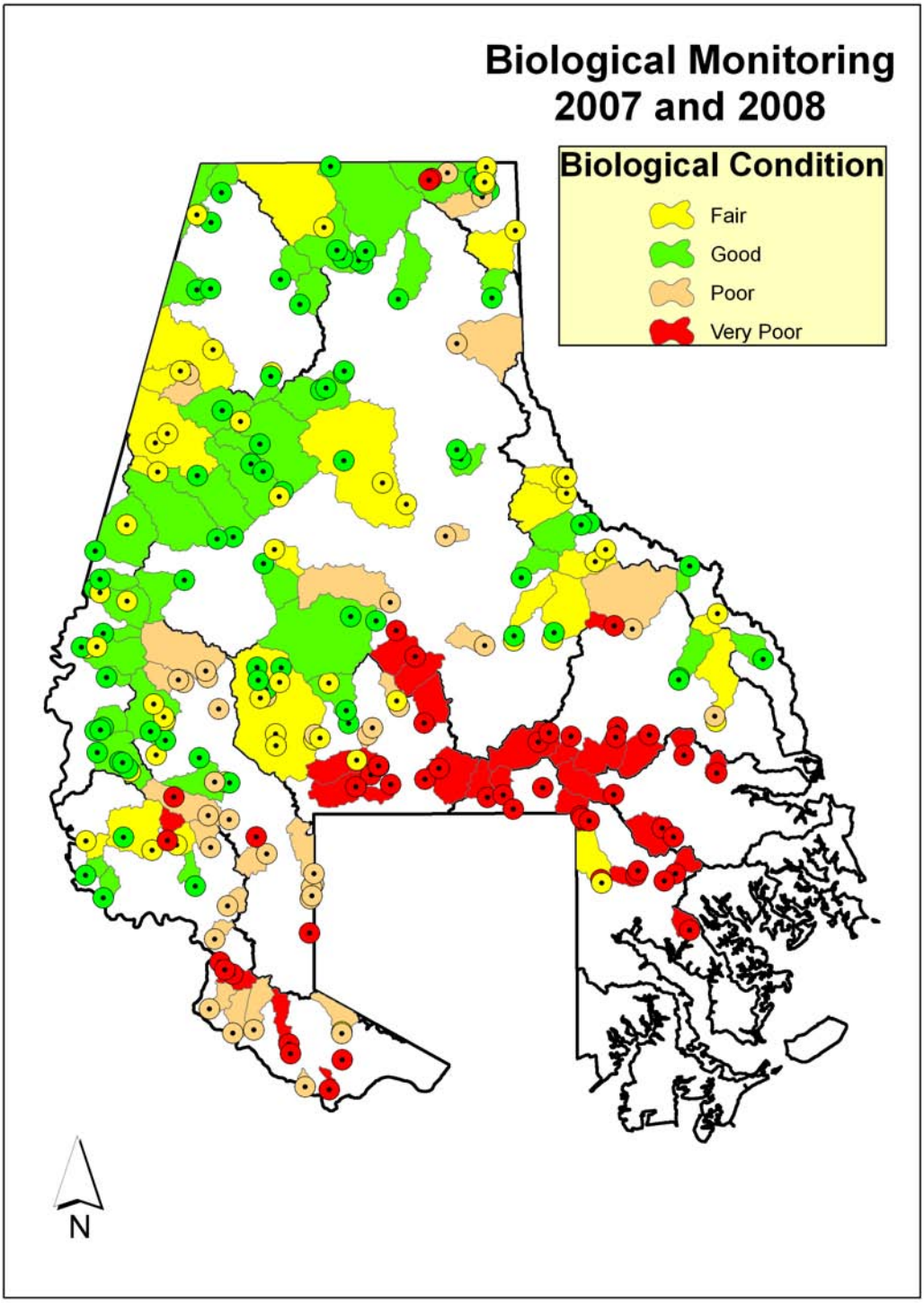


Figure 9-11: Probabilistic Biological Monitoring results for 2007 and 2008.

Table 9-6: BIBI Score Distribution by Watershed (% by Category)

Watershed	N	1.00-1.99 Very Poor	2.00-2.99 Poor	3.00-3.99 Fair	4.00-5.00 Good
Patapsco/Back River Basin – Sampled in 2003					
Liberty Reservoir	10	10	50	30	10
Patapsco River	13	54	46	0	0
Gwynns Falls	30	43	53	3	0
Jones Falls	32	38	31	25	6
Back River	15	87	13	0	0
Total	**100**	**46**	**39**	**12**	**3**
Gunpowder River Basin/Deer Creek – Sampled in 2004					
Deer Creek	3	0	33	67	0
Prettyboy Reservoir	7	0	14	43	43
Loch Raven Res.	67	6	9	43	42
Lower Gunpowder	7	29	43	29	0
Little Gunpowder	6	0	0	50	50
Bird River	2	50	50	0	0
Total	**92**	**8**	**13**	**42**	**37**
Patapsco/Back River Basin – Sampled in 2005					
Liberty Reservoir	22	5	32	41	23
Patapsco River	21	29	43	24	4
Gwynns Falls	22	18	68	14	0
Jones Falls	23	17	30	48	4
Back River	12	58	42	0	0
Total	**100**	**22**	**43**	**28**	**7**
Gunpowder River Basin/Deer Creek – Sampled in 2006					
Deer Creek	13	8	8	31	53
Prettyboy Reservoir	17	0	30	35	35
Loch Raven Res.	44	7	16	57	20
Lower Gunpowder	17	30	35	35	0
Little Gunpowder	4	0	25	25	50
Bird River	5	80	20	0	0
Total	**100**	**13**	**21**	**42**	**24**
Patapsco/Back River Basin – Sampled in 2007					
Liberty Reservoir	20	0	0	30	70
Patapsco River	24	33	33	17	17
Gwynns Falls	26	12	54	19	15
Jones Falls	28	29	25	25	21
Back River	19	84	11	5	0
Total	**117**	**30**	**26**	**20**	**24**
Gunpowder River Basin/Deer Creek – Sampled in 2008					
Deer Creek	12	17	17	33	33
Prettyboy Reservoir	13	0	8	38	54
Loch Raven Res.	47	4	9	23	64
Lower Gunpowder	12	58	17	8	17
Little Gunpowder	11	0	0	64	36
Bird River	5	100	0	0	0
Total	**100**	**30**	**8**	**28**	**34**
County Total	**509**	**24**	**29**	**28**	**19**

Figures 9-12 and 9-13 show the means and one standard deviation of the mean BIBI scores for each watershed between 2003 and 2008. The mean scores for Liberty, Patapsco, and Gwynns increased over the period. Watersheds in the Gunpowder River and Deer Creek basins were stable.

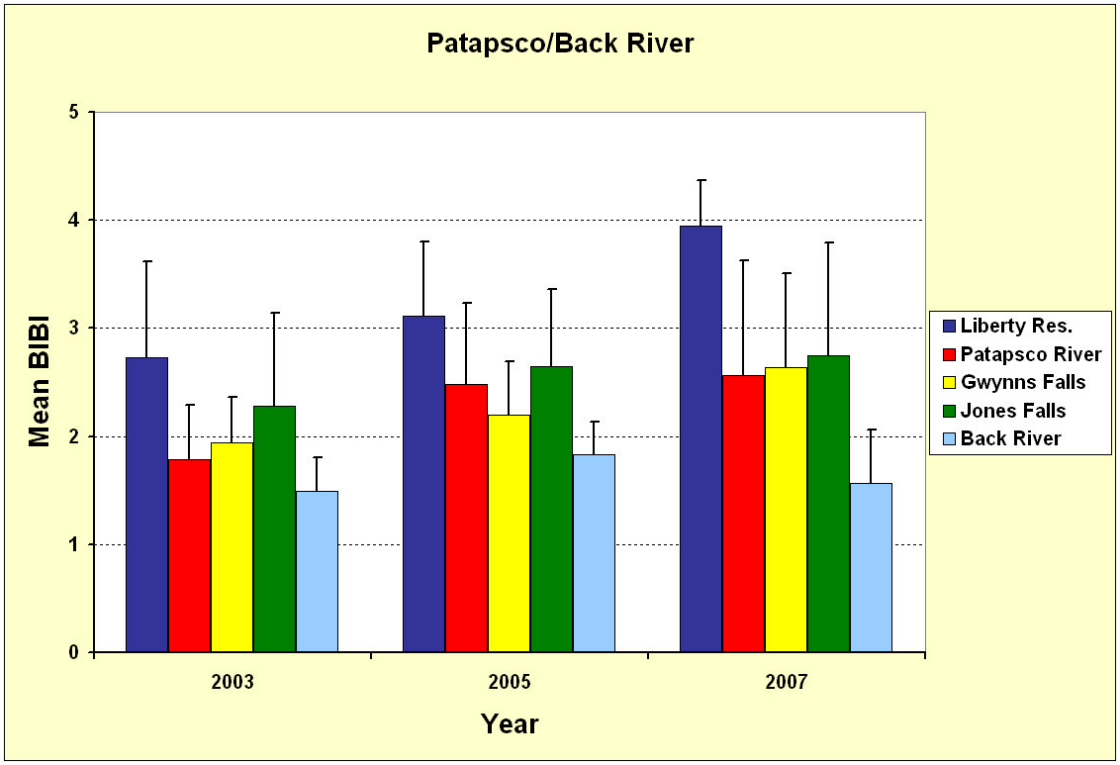


Figure 9-12: Means and one standard deviation of BIBI scores for Patapsco/Back River watersheds between 2003 and 2007.

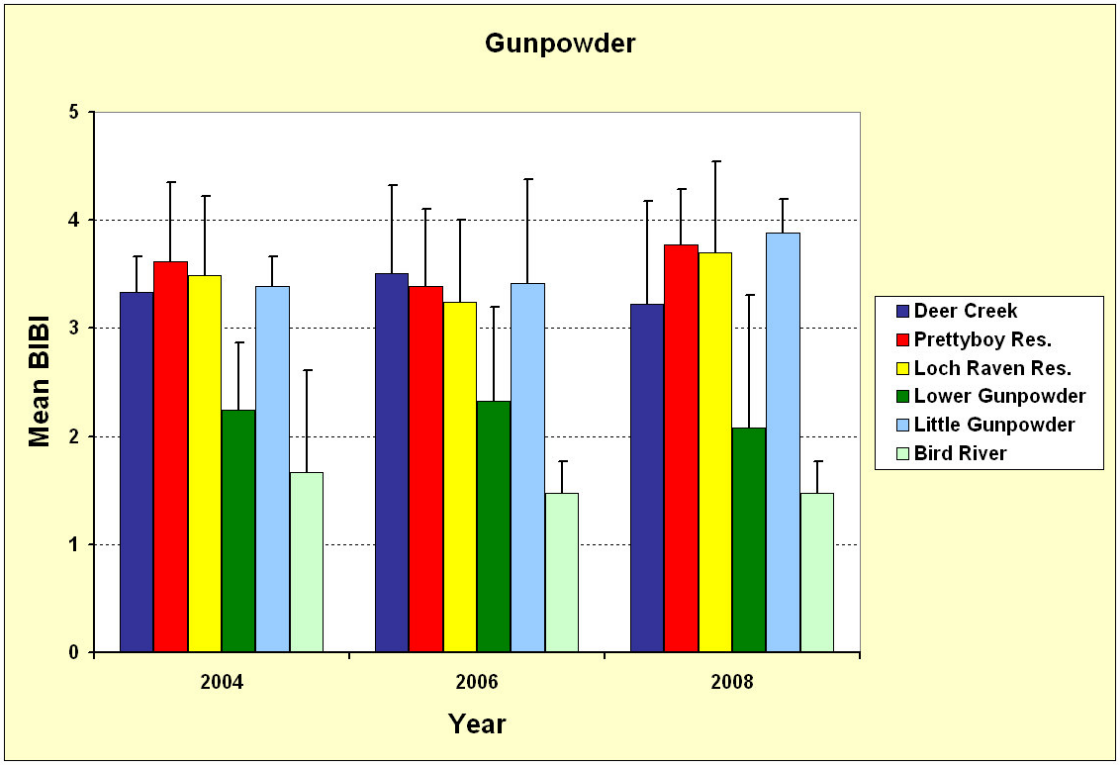


Figure 9-13: Means and one standard deviation of BIBI scores of Gunpowder Falls/Deer Creek watersheds between 2004 and 2008.

The methodology developed by Maryland Department of the Environment and Maryland Department of Natural Resources to determine biological impairment of fresh water streams was used to determine the watershed condition for all five sampling years. The methodology is detailed in Part C.2.1 at the following web site:

http://www.mde.state.md.us/assets/document/2008_IR_Parts_A_thru_E(1).pdf

The method assesses watersheds at the Maryland 8-digit scale, and uses 90% confidence limits around the proportion of degraded stream miles to determine whether the proportion of degraded stream miles is significantly different than reference conditions. Watersheds are listed as "Attaining," "Impaired," or "Inconclusive." The former methodology calculated mean BIBI and 90% confidence intervals in watersheds with a minimum of 10 sampling locations. Less than 10 sampling locations in a watershed were considered to have insufficient data to make a determination. The results of the revised biological listing method are presented in Table 9-7, and the results of the former (average IBI) biological listing method are presented in Table 9-8.

Table 9-7: Watershed Biological Condition Using Percent Stream Mile Method

Watershed	Sites Degraded	N	% Stream Miles With Possible Degradation	CL_{Lower} (%)	CL_{Upper} (%)	Category
2003 Sampling Year						
Liberty	6	10	60	35	81	Impaired
Patapsco River	13	13	100	84	100	Impaired
Gwynns Falls	29	30	97	88	99	Impaired
Jones Falls	22	32	69	56	80	Impaired
Back River	15	15	100	86	100	Impaired
2004 Sampling Year						
Deer Creek	1	3	33	3	80	Inconclusive
Prettyboy	1	7	14	1	45	Attaining
Loch Raven	10	67	15	9	22	Attaining
Lower Gunpowder	5	7	71	40	92	Impaired
Little Gunpowder	0	6	0	0	32	Attaining
Bird River	2	2	100	32	100	Impaired
2005 Sampling Year						
Liberty	8	22	36	22	52	Impaired
Patapsco River	15	21	71	55	84	Impaired
Gwynns Falls	19	22	86	72	95	Impaired
Jones Falls	11	23	48	33	63	Impaired
Back River	12	12	100	83	100	Impaired
2006 Sampling Year						
Deer Creek	2	13	15	4	36	Attaining
Prettyboy	5	17	29	15	48	Impaired
Loch Raven	10	44	23	15	33	Impaired
Lower Gunpowder	11	17	65	46	80	Impaired
Little Gunpowder	1	4	25	3	68	Inconclusive
Bird River	5	5	100	63	100	Impaired
2007 Sampling Year						
Liberty	0	20	0	0	11	Attaining
Patapsco River	16	24	67	52	80	Impaired
Gwynns Falls	17	26	65	51	78	Impaired

Jones Falls	15	28	54	40	67	Impaired
Back River	18	19	95	81	99	Impaired
2008 Sampling Year						
Deer Creek	4	12	33	15	56	Impaired
Prettyboy	1	13	8	1	27	Attaining
Loch Raven	6	47	13	7	21	Attaining
Lower Gunpowder	9	12	75	52	90	Impaired
Little Gunpowder	0	11	0	0	19	Attaining
Bird River	5	5	100	63	100	Impaired

Table 9-8: Watershed Biological Condition Using Average IBI Method

Watershed	BIBI Mean	N	CL_{Lower}	CL_{Upper}	Condition
2003 Sampling Year					
Liberty	2.73	10	2.37	3.09	Inconclusive
Patapsco River	1.79	13	1.61	1.97	Impaired
Gwynns Falls	1.94	30	1.84	2.04	Impaired
Jones Falls	2.28	32	2.09	2.47	Impaired
Back River	1.49	15	1.39	1.59	Impaired
2004 Sampling Year					
Deer Creek	3.33	3	3.09	3.57	Insufficient Data
Prettyboy	3.62	7	3.27	3.97	Insufficient Data
Loch Raven	3.49	67	3.38	3.60	Meets Criteria
Lower Gunpowder	2.24	7	1.94	2.54	Insufficient Data
Little Gunpowder	3.89	6	3.25	3.53	Insufficient Data
Bird River	1.67	2	0.82	2.52	Insufficient Data
2005 Sampling Year					
Liberty	3.11	22	2.92	3.30	Inconclusive
Patapsco River	2.48	21	2.27	2.69	Impaired
Gwynns Falls	2.20	22	2.07	2.33	Impaired
Jones Falls	2.65	23	2.46	2.84	Impaired
Back River	1.83	12	1.72	1.94	Impaired
2006 Sampling Year					
Deer Creek	3.51	13	3.22	3.80	Meets Criteria
Prettyboy	3.39	17	3.17	3.61	Meets Criteria
Loch Raven	3.24	44	3.09	3.39	Meets Criteria
Lower Gunpowder	2.33	17	2.06	2.60	Impaired
Little Gunpowder	3.42	4	2.81	4.03	Insufficient Data
Bird River	1.47	5	1.30	1.64	Insufficient Data
2007 Sampling Year					
Liberty	3.95	20	3.83	4.07	Meets Criteria
Patapsco River	2.56	24	2.28	2.84	Impaired
Gwynns Falls	2.64	26	2.42	2.86	Impaired
Jones Falls	2.75	28	2.50	3.00	Inconclusive
Back River	1.58	19	1.43	1.71	Impaired
2008 Sampling Year					
Deer Creek	3.22	12	2.87	3.57	Inconclusive
Prettyboy	3.77	13	3.59	3.95	Meets Criteria
Loch Raven	3.70	47	3.54	3.86	Meets Criteria
Lower Gunpowder	2.08	12	1.63	2.53	Impaired
Little Gunpowder	3.88	11	3.76	4.00	Meets Criteria
Bird River	1.47	5	1.30	1.64	Insufficient Data

Based on the percent stream mile criteria, Patapsco River, Gwynns Falls, Jones Falls, Back River, Lower Gunpowder, and Bird River are impaired, as they have consistently failed to meet biological criteria. The Liberty Reservoir watershed attained biological water quality standards in 2007, but was considered impaired in 2003 and 2005. The Prettyboy Reservoir, Loch Raven Reservoir, and Little Gunpowder Falls watersheds attained water quality standards in two of the three years in which data are available. The Deer Creek watershed attained water quality standards in only one year (2006).

There are 18 sentinel sites in the Patapsco/Back River drainage and 13 sentinel sites in the Gunpowder River/Deer Creek drainage. Sentinel sites were sampled 2003, 2004, 2006, 2007, and 2008. Figure 9-14 shows the mean BIBI scores for the sentinel sites between 2003 and 2008. As with the probabilistic monitoring, the biological condition of sentinel sites in the

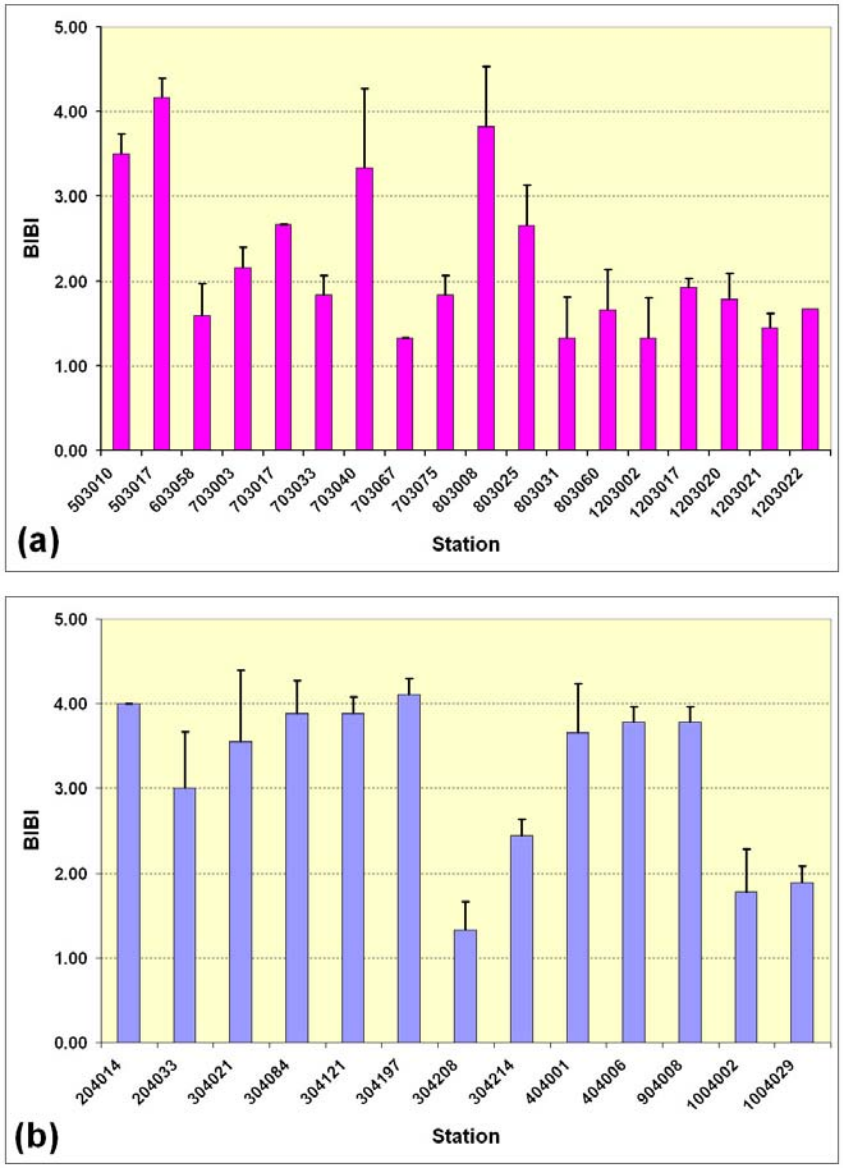


Figure 9-14: Mean BIBI scores for (a) Patapsco/Back River and (b) Gunpowder/Deer Creek Sentinel Sites between 2003 and 2008. Error bars indicate one standard deviation of the mean. N=2 for Patapsco/Back River, N=3 for Gunpowder/Deer Creek.

Gunpowder River/Deer Creek drainage was generally better than the biological condition of sentinel sites in the Patapsco/Back River drainage. As more data is collected from the sentinel sites, a trend analysis will be performed.

9.4.2 Capital Improvement Projects Monitoring

Baltimore County monitors benthic macroinvertebrate and fish assemblages in conjunction with several capital improvement stream restoration projects. Stream segments are monitored pre- and post-construction to document any change in the biological community. As with the Probablistic Monitoring Program, MBSS methods are followed, including stream physical habitat assessments. Habitat assessments are based on visual ratings of instream and riparian zone characteristics that are important to stream biological communities. A physical habitat index (PHI) is calculated based on the visual ratings. The Minebank Run and Woodvalley projects are currently being monitored under the Capital Improvement Projects Monitoring Program. Their ADC map locations are displayed in Table 9-9.

Table 9-9: Stream Restoration Biological Monitoring Site Locations

Station	Stream and Location	ADC Map, Grid
Minebank Run II Stream Restoration		
MNBK-1	Minebank Run upstream of Gunpowder River	28 C2
MNBK-2	Minebank Run upstream of USGS gage	28 B3
MNBK-3	Minebank Run downstream of bridge @ park	28 A4
MNBK-4	Minebank Run upstream of bridge @ park	28 A4
MNBK-5	Minebank Run behind Loch Raven High School	27 K5
MNBK-6	Minebank Run upstream of Cowpens Road	27 J5
MNBK-7	Minebank Run upstream of Glen Eagles Court	27 H6
MNBK-8	Minebank Run upstream of MNBK-7	27 H6
MNBK-9	Minebank Run downstream of Cromwell ES	27 G6
JB-1	Jennifer Branch upstream of Gunpowder River	28 J2
JB-2	Jennifer Branch near archery range	28 J3
Woodvalley Stream Restoration		
WDVL-1	Unnamed Trib to Jones Falls at Michelle Way	25 F7
WDVL-2	Unnamed Trib to Jones Falls at Gardenview Way	25 G6
WDVL-3	Unnamed Trib to Jones Falls at Evan Way	25 F6

The Minebank Run stream restoration project has been monitored annually since April, 2004, at eleven sampling stations (Figure 9-15). The stream restoration was completed in 2002 (Phase I) on the reach where MNBK-6, MNBK-7, MNBK-8, and MNBK-9 are located. The stream restoration was completed in 2005 (Phase II) where MNBK-2, MNBK-3, MNBK-4, and MNBK-5 are located. Stations MNBK-1, JB-1, and JB-2 are controls. As of 2008, DEPRM has collected five years of post-restoration data at the Phase I stations, and two years of pre-restoration and four years of post-restoration data at the Phase II stations. While all eleven stations are sampled for macroinvertebrates, fish are sampled at a sub-set of the stations: MNBK-1, MNBK-2, MNBK-4, MNBK-7, and JB-1.

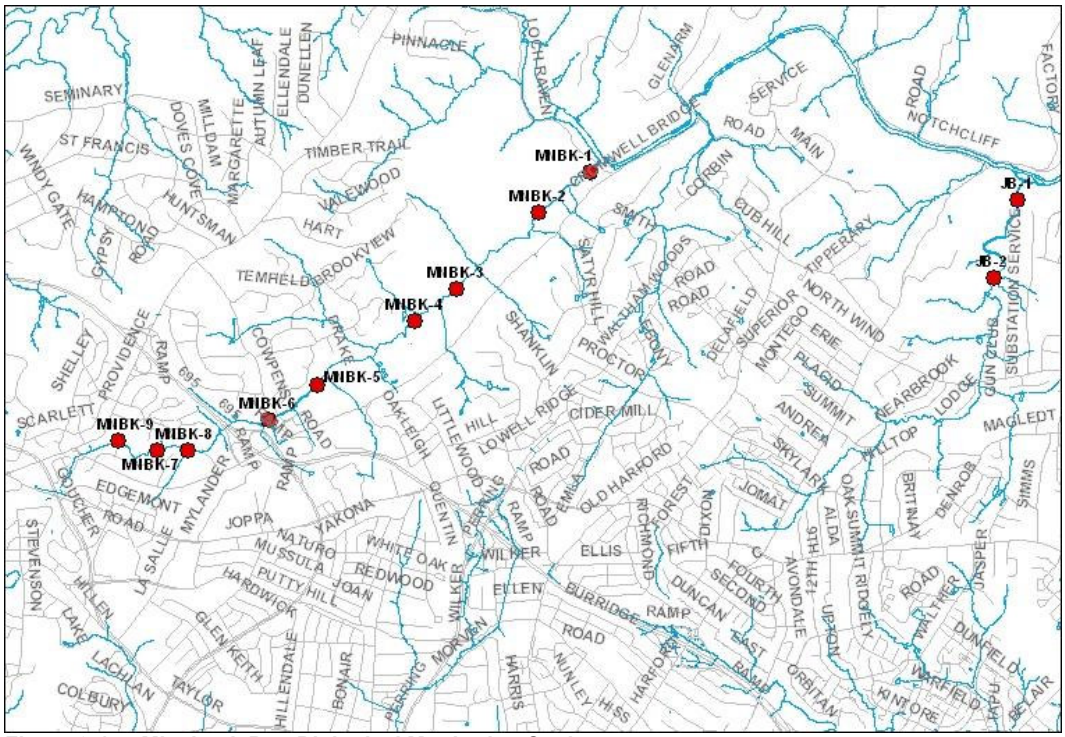


Figure 9-15: Minebank Run Biological Monitoring Stations.

As in 2007, BIBI scores across all treatments were Very Poor at both control and restored stations (all scores 1.00). The FIBI scores were 2.67 (JB-1) and 4.00 (MNBK-1) at the control stations. All other stations had FIBI scores of 2.33 (MNBK-2, MNBK-4, and MNBK-7). To examine the cumulative effect of the restoration on IBI scores, we plotted BIBI and FIBI scores at MNBK-1, the downstream control, over time (Figure 9-16). It is not possible to definitively determine the effect of the Phase I restoration on the downstream control, as pre-restoration data are not available. However, it appears that both benthos and fish were showing signs of improvement until the completion of Phase II. Post-Phase II sampling showed stable fish and initially declining then stabilizing benthic populations. These data suggest inherent differences in the organisms' ability to adapt to changing stream condition. The depressed benthic populations are likely related to the continued flashy hydrology of Minebank Run. Fish are more mobile and thus better able to use flow refugia during high flow events. Benthic macroinvertebrates are dependent on stable, diverse substrate. The benthic community of MNBK-1 is dominated by pollution tolerant, generalist taxa with short life cycles (Table 9-10). Only 12% of the organisms collected were specialized feeders (predators and filterers), and even these were highly tolerant of pollution. Over 99% of the organisms present had moderate to high pollution tolerances (tolerance value > 5). The one relatively intolerant individual (Ephemeroptera: *Ameletus*) employs a generalist feeding strategy (collector). Post-restoration geomorphic monitoring shows that the restoration was successful in stabilizing the stream banks and reducing sediment fluxes within Minebank Run. It is possible that improvements in biological function at the microbiological level have occurred, but that it is too soon after restoration to see conclusive changes in the benthic and fish communities.

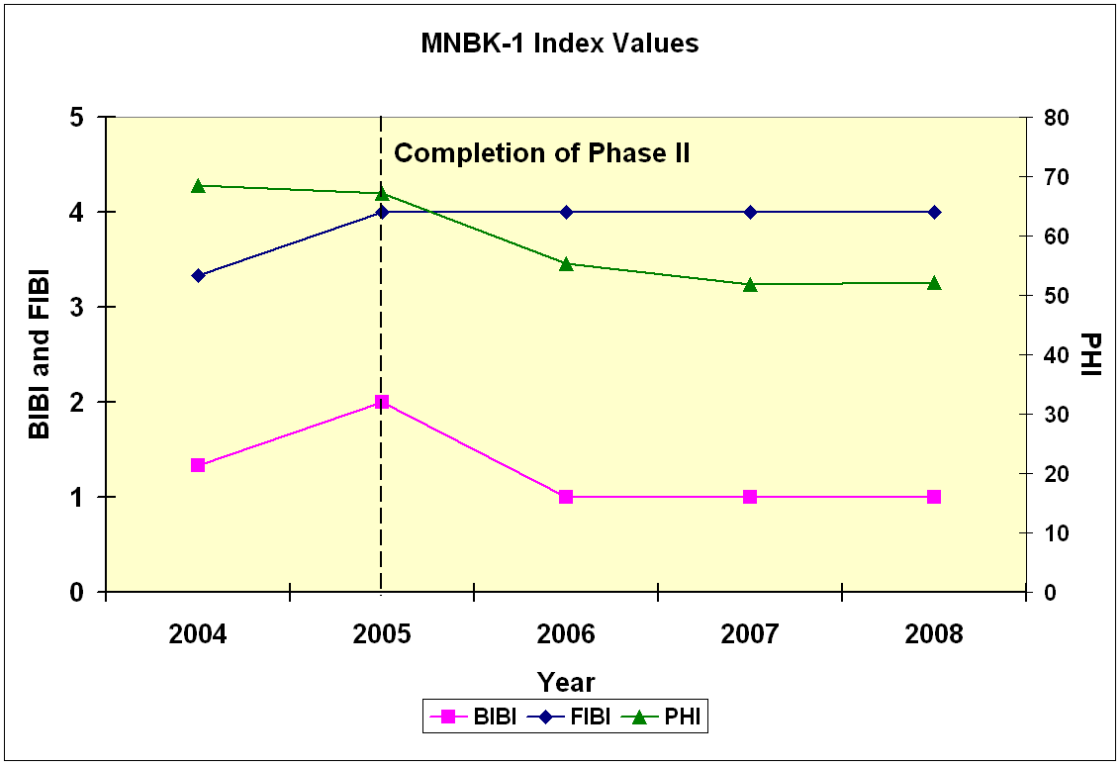


Figure 9-16: Biological index values at MNBK-1 from beginning of monitoring to present.

Table 9-10: Taxonomic composition of MNBK-1, 2008. FFG=Functional Feeding Group

Taxon	No. of organisms	Tolerance Value	FFG
Ameletus	1	3	Collector
Clinocera	11	7	Predator
Diamesa	5	8	Collector
Muscidae	1	7	Predator
Oligochaeta	5	10	Collector
Orthocladiinae	2	8	Collector
Orthocladius	69	9	Collector
Simulium	1	6	Filterer
Sympotthastia	11	8	Collector
Thienemanniella	1	5	Collector

The Woodvalley stream restoration project was completed in 2005. Pre-restoration data were collected in 2004 at two stations: (1) WDVL-1, unnamed tributary to Jones Falls at Michelle Way (within the restored reach), and (2) WDVL-2, unnamed tributary to Jones Falls at Gardenview Way. WDVL-2 served as a control for the restored reach. Post-restoration data were collected beginning in 2005. A third station, WDVL-3, unnamed tributary to Jones Falls at Evan Way and Park Heights Avenue, was added as a control in 2005 because no fish were collected at WDVL-2 in 2004. See Figure 9-17 for station locations. Presently, biological sampling is done at WDVL-1 and WDVL-3. As with the Minebank Run restoration project, all data from 2004-2007 were presented in the 2008 annual report. Therefore, only data from 2008 will be discussed here.

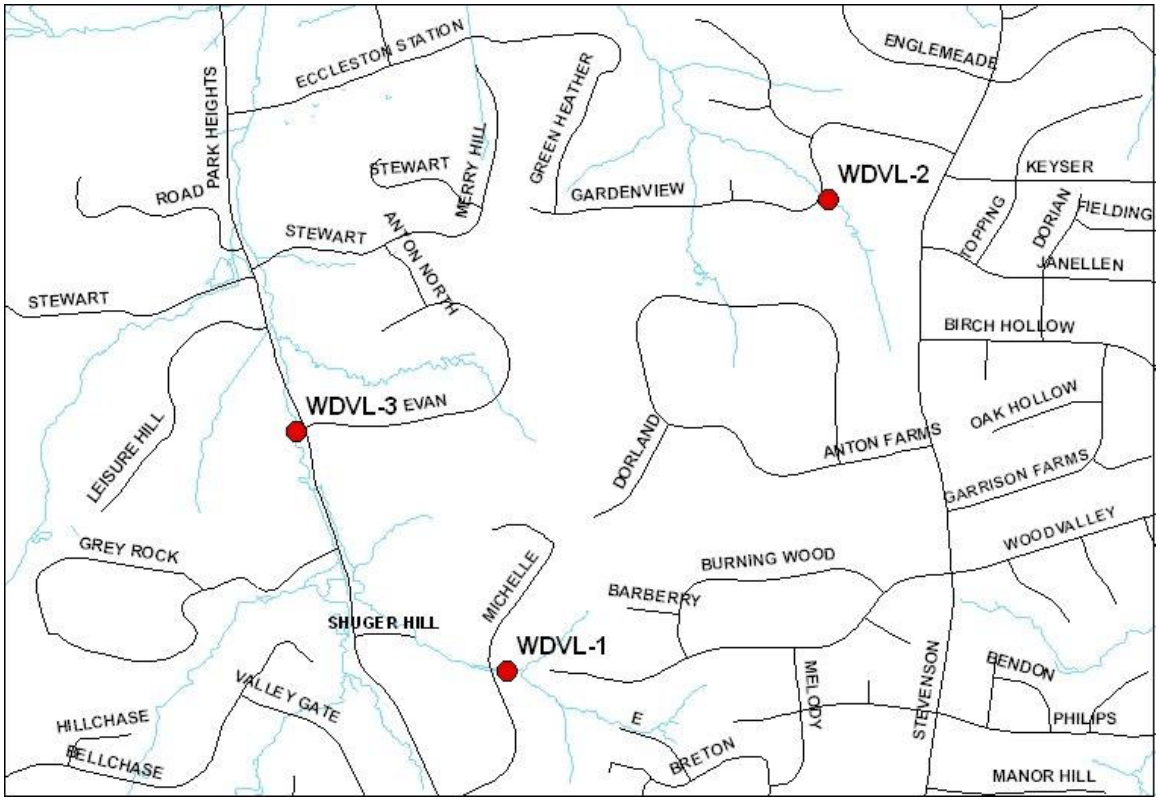
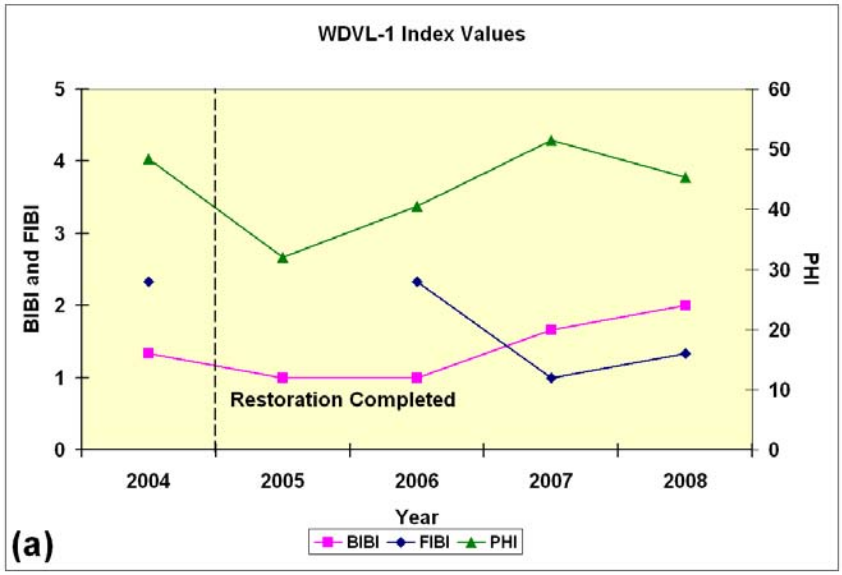


Figure 9-17: Woodvalley Biological Monitoring Station Locations.

The BIBI and FIBI scores at WDVL-1 rated Poor and Very Poor, respectively (Figure 9-18). Both index scores at WDVL-3 were Poor. The PHI at WDVL-1 was Severely Degraded while the PHI at WDVL-3 was Degraded. Both biological indices suggested slight improvement from 2007 at both control and restored sites. Physical habitat has generally shown slight improvement at both control and restored sites since completion of restoration.



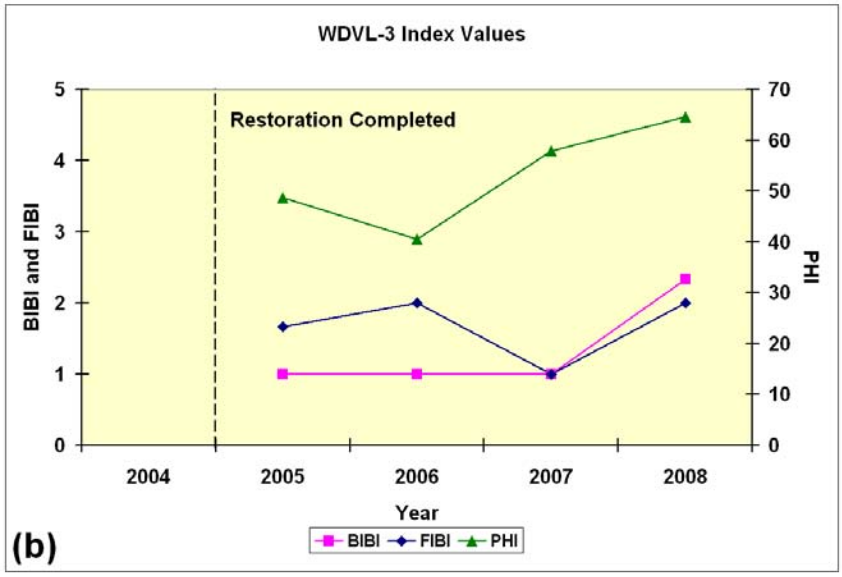


Figure 9-18: Benthic and Fish IBI and Physical Habitat Index Values for (a) WDVL-1 (restored) and (b) WDVL-3 (control).

Based on biological index values, the restored station is performing similarly to the control, although there are differences in the taxonomic composition of benthos and fish. Table 9-11 shows benthic and fish taxa and numbers of individuals collected in 2008. The Percent Similarity Index is 38% for benthos and 80% for fish. Two wild brown trout were collected from within the control reach. The continued presence of brown trout (documented in previous NPDES reports) suggests the potential of the restored reach to provide habitat for wild salmonids.

Table 9-11: Benthic and fish taxa collected at WDVL-1 and WDVL-3, 2008

Benthos				Fish			
WDVL-1		WDVL-3		WDVL-1		WDVL-3	
Taxon	No.	Taxon	No.	Taxon	No.	Taxon	No.
Antocha	2	Antocha	2	Blacknose dace	129	Blacknose dace	106
Cheumatopsyche	8	Baetis	1	Creek chub	22	Brown trout	2
Chironomidae	1	Caecidotea	1			Creek chub	36
Cricotopus	7	Chaetocladius	1			Longnose dace	17
Diamesa	1	Cheumatopsyche	7				
Dicrotendipes	3	Chimarra	1				
Hydropsyche	28	Chironomidae	1				
Microtendipes	2	Corynoneura	5				
Oligochaeta	5	Diplectrona	4				
Orthocladius	28	Glossosoma	1				
Parametriocnemus	1	Glossosomatidae	2				
Physidae	2	Hydropsyche	14				
Sympotthastia	1	Oligochaeta	1				
Tanypodinae	1	Orthocladiinae	1				
Tanytarsini	3	Orthocladius	2				
Tanytarsus	15	Paracricotopus	1				
Thienemannimyia	10	Parametriocnemus	8				

Tipula	2	Physidae	1				
Tvetenia	1	Polypedilum	2				
		Simulium	1				
		Sympotthastia	5				
		Tanytarsus	1				
		Thienemanniella	1				
		Tipula	3				
		Trichoptera	1				
		Tvetenia	8				
Total	121		76		151		161

9.4.3 Reference Site Monitoring

Baltimore County has been monitoring eight (8) reference sites since spring of 2001. GIS was used to identify watersheds within the County that contained greater than 50% forested land use and less than 20% urban land use. An initial suite of twenty-one (21) sites was reduced to eight (8) sites for future monitoring based on land use, chemical, and stream physical habitat benchmarks. The ADC map site locations, along with the stream name are displayed in Table 9-12.

Table 9-12: Reference Site Locations

Station	Stream Name and Location	ADC Map, Grid
REF-001	Baisman Run upstream of Ivy Hill Road	18 C5
REF-004	Poplar Run upstream of Gunpowder Road	1 H11
REF-009B	Springhouse Run downstream of Gunpowder Rd	1 H8
REF-012	Panther Branch upstream of Gunpowder Falls	7 H8
REF-013	Mingo Branch upstream of Gunpowder Falls	7 C7
REF-015	Charles Run upstream of Gerting Road	8 F11
REF-017	Sunnyking Run near Sunnyking Drive	24 A3
REF-019	Fourth Mine Branch upstream of Stablers Church Road	3 H12

The eight sites are sampled annually for benthic macroinvertebrates in the spring index period using MBSS sampling protocols. The samples are sorted and identified in the laboratory to genus or the lowest practical taxonomic level. The metrics in Table 9-6 are used to calculate BIBIs. Fish sampling is done only periodically to reduce stress to the naturally reproducing trout populations inhabiting these streams. REF-009B was confirmed in 2008 as a replacement site for original reference site REF-009, which is no longer sampled due to loss of landowner permission. The new site is located downstream of REF-009 on Prettyboy Reservoir Watershed property.

All reference sites have had BIBI values in the Good range in at least some years since sampling began (Figure 9-19). Sites exhibited their greatest variability in 2003. Over the entire 6-year record, median BIBI values have been Fair to Good, although four of the eight sites have had BIBI values in the Poor range (Figure 9-20).

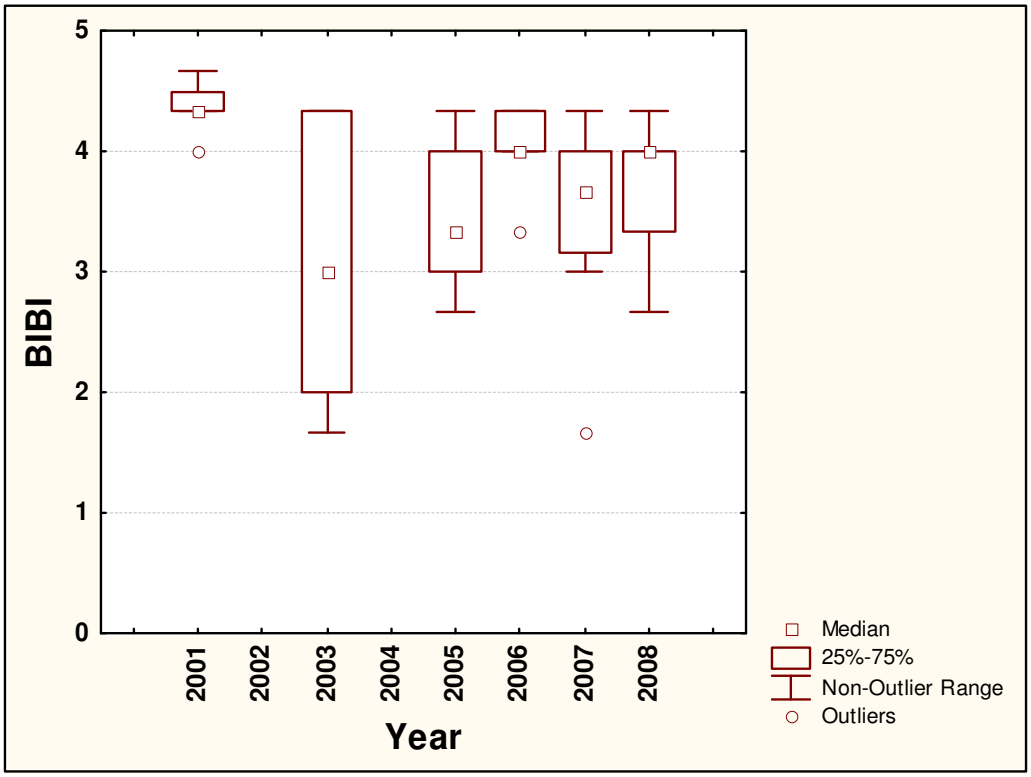


Figure 9-19: Box and Whisker Plot of Reference Site BIBI Values by Year

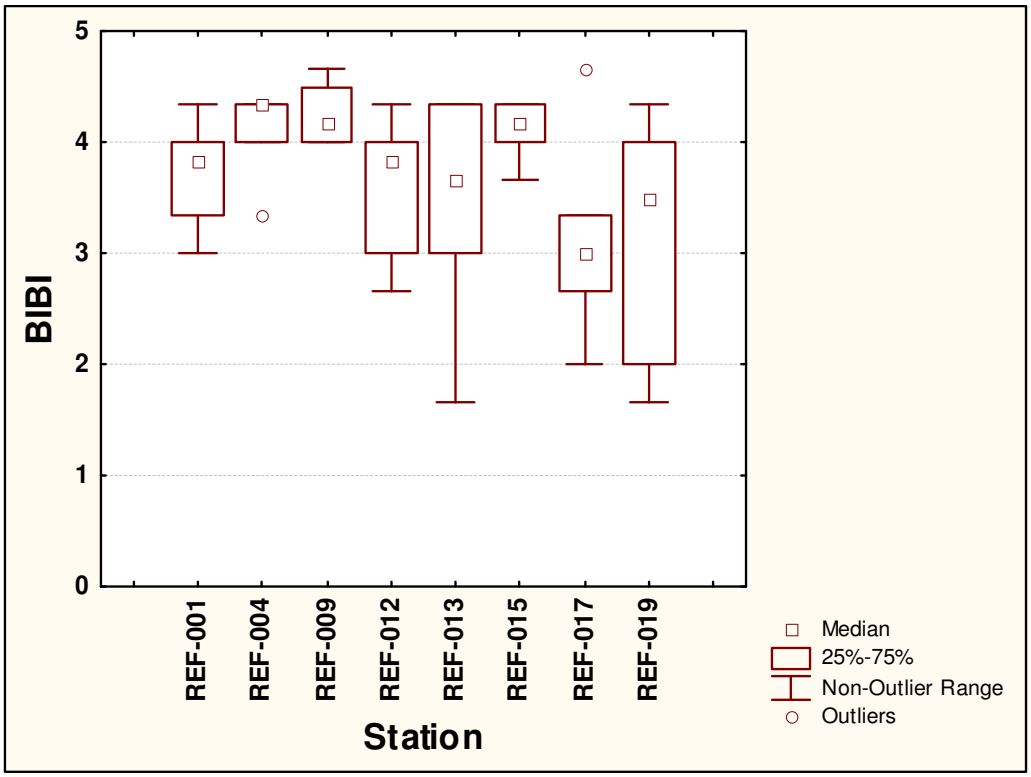


Figure 9-20: Box and Whisker Plot of Reference Site BIBI Values by Site

Of the four sites exhibiting periodically poor benthic biology, Panther Branch (REF-012) and Mingo Branch (REF-013) have impervious surface in their headwaters, which conveys pollutant-laden stormwater to the stream. Sunnyking Run (REF-017) is unique among all the other sites in that it flows through serpentine barrens at Soldiers Delight Natural Environmental Area. Finally, Fourth Mine Branch (REF-019) has the largest amount of agricultural land use among the reference sites.

Stream physical habitat was assessed following Maryland Save Our Streams protocols in 2001-2003 and MBSS protocols since 2005. In the previous NPDES report, an attempt was made to standardize the different protocols to report habitat conditions since 2001. In this report, the MBSS Physical Habitat Index will be reported for data recorded since 2005. Minimally degraded sites have PHI scores of 81-100, partially degraded sites have PHI scores of 66-80, degraded sites have PHI scores of 51-65, and severely degraded sites have PHI scores of 0-50. Figure 9-21 shows mean PHI scores for reference sites since 2005. On average, all sites have partially degraded habitat, except for REF-012, Panther Branch, which is minimally degraded. REF-013 (Mingo Branch), REF-017 (Sunnyking Run), and REF-019 (Fourth Mine Branch) had lower and more variable PHI scores than the other reference sites. The differences in physical habitat condition at these sites are likely related to the upstream land use, as mentioned in the discussion of benthic community condition at these sites.

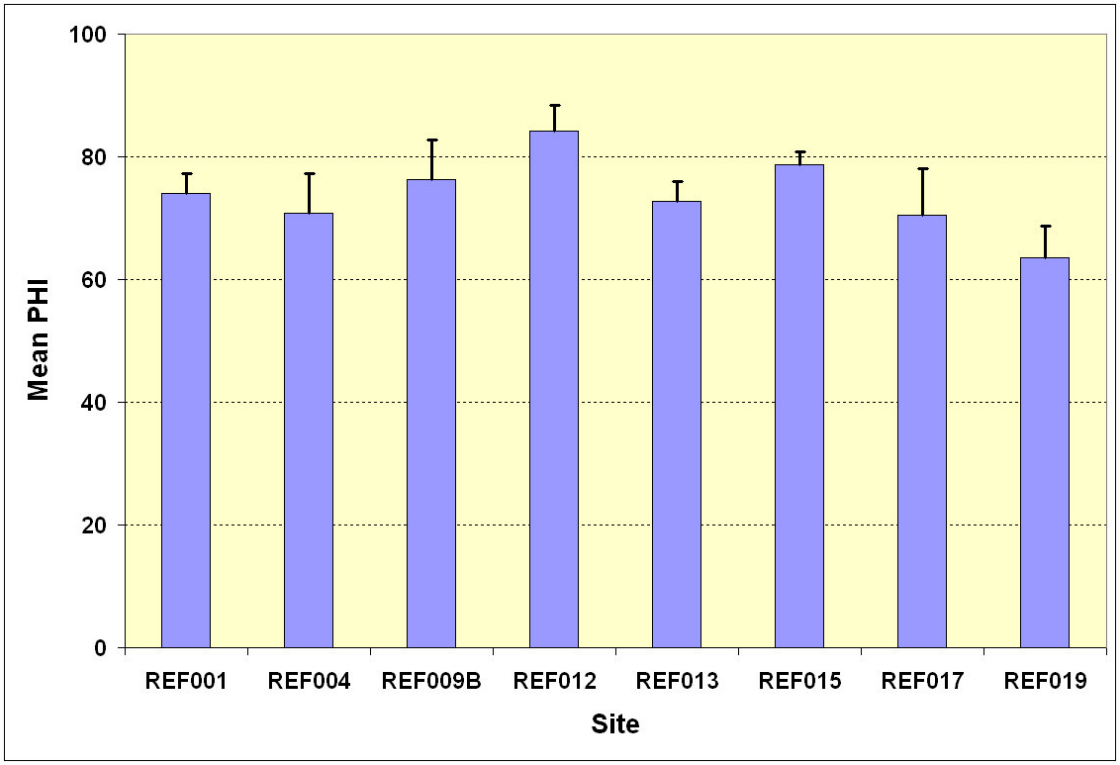


Figure 9-21: Mean and One Standard Deviation of PHI Scores for Reference Stations Since 2005.

To examine how the reference sites might be used to gage the performance of other Baltimore County assessment sites, BIBI and PHI scores of reference sites and WDVL-1 (the restored site for the Wood Valley stream restoration project) are shown in Figure 9-22. Biological and physical habitat conditions are clearly better at the reference sites, but Figure 9-22 also shows that BIBI scores were slightly higher in 2008 then they were in 2007 at both the reference sites

and Wood Valley. Physical habitat conditions have been relatively constant at the reference sites, while physical habitat gradually improved between 2005 and 2007, with a slight decrease in condition between 2007 and 2008 at Wood Valley. These observations suggest that benthos were responding to patterns of climate or precipitation, rather than to changes in physical habitat condition. Thus, it appears that the reference sites are performing their intended function, that is, providing a benchmark with which to compare stream biological condition in other, anthropogenically-affected streams. Benthic macroinvertebrate communities of the reference sites seem to be responding to physical and climactic influences in predictable ways, and should prove useful in assessing human-induced changes to other Baltimore County streams.

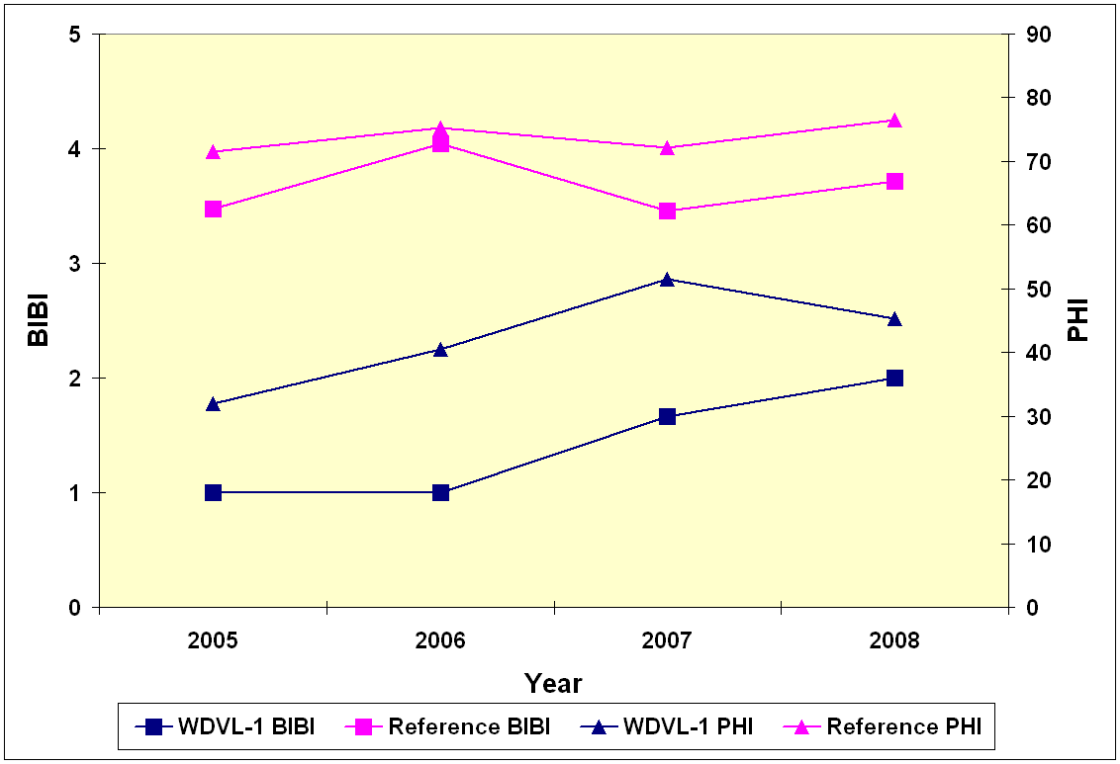


Figure 9-22: BIBI and PHI values for WDVL-1 and Reference Sites

9.4.4 Submerged Aquatic Vegetation Monitoring Program

Baltimore County has conducted Submerged Aquatic Vegetation monitoring since 1989 on certain waterways. With the advent of water quality standards for submerged aquatic vegetation, reporting on the monitoring results commenced in the 2006 NPDES Annual Report. During the last Water Quality Standards Triennial Review Maryland Department of the Environment adopted standards for tidal water submerged aquatic vegetation and water clarity, among other standards also adopted. The standards are based on water quality segments that are derived from the Chesapeake Bay Program model. There are a total of seven segments in Baltimore County tidal waters. Three of the segments (MIDOH, GUNOH1, and BACOH) are entirely within Baltimore County tidal waters. Four other segments have tidal waters that extend to other jurisdictions. Two of these segments (CB2OH and CB3MH) are Chesapeake Bay mainstem segments and extend to the eastern shore of Maryland. The Chesapeake Bay Program draft document *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2006 Addendum* provides guidance on

assessing the attainment of the SAV acreage criteria. The document states "the shallow-water bay grass designated use is considered in attainment if there are sufficient acres of SAV observed within the segment or there are enough acres of shallow-water habitat meeting the applicable water clarity criteria to support restoration of the desired acres of SAV for that segment." The recommended procedure is to use the **single best year SAV acreage** based on the most recent three-year period of available data. The criteria may also be met by attaining water clarity acres for the most recent three-year period of available data. The water clarity depth varies by tidal segment (see Table 9-13). Water clarity data is currently not collected in Baltimore County, so only the SAV acreage will be used.

The draft 2009 Triennial Review of Water Quality Standards, currently open for public comment, proposes several changes that affect the SAV criteria. First, the tidal segment BACOH, which covers tidal Back River, has had a change in the target SAV acreage goal from 0 to 340 acres. Secondly, credit for meeting water clarity standards in areas with no SAV have changed from an acre by acre basis to 2.5 acres per acre basis. In other words, using Back River as an example, if no SAV were present in Back River, water clarity standards would have to be met for 850 acres (340 acres SAV goal X 2.5).

Baltimore County monitors SAV distributions in the spring and summer of each year in accordance with the US Fish and Wildlife methodologies. There are currently 29 waterways in the County that are monitored. In order to assess the total acres of yearly coverage for the creeks surveyed, the data for the spring and summer were analyzed for overlap in SAV distribution between the two seasons. The total SAV coverage for each year is calculated by the following formula:

$$\textbf{Total SAV}_{\textbf{acres}} = (\textbf{Spring SAV}_{\textbf{acres}} - \textbf{Overlap}_{\textbf{acres}}) + (\textbf{Summer}_{\textbf{acres}}\ \textbf{SAV} - \textbf{Overlap}_{\textbf{acres}}) + \textbf{Overlap}_{\textbf{acres}}$$

To estimate the progress in meeting the SAV goal for each tidal segment the Total SAV_{acres} are divided by the SAV goal for that segment. Only two of the seven segments are totally within Baltimore County jurisdiction and therefore can be assessed for SAV criteria attainment. However, these two segments are not intirely surveyed for SAV coverage and so, like the other five segments this analysis will only provide a conservative estimate of SAV criteria attainment.

Table 9-13 presents the SAV water quality standard for each segment and the results of the last three years of SAV monitoring. The yellow highlighted water quality segments lie entirely within Baltimore County. The red highlighted cells are the highest percent attainment for each water quality segment based on the last three years of data.

Table 9-13: SAV Standards and Baltimore County SAV Monitoring Results (2006-2008)

Water Quality Segment	SAV Goal (Acres)	Water Clarity Depth (m)	2006		2007		2008	
			Acres	% of Goal	Acres	% of Goal	Acres	% of Goal
MIDOH	879	2.0	234	26.7	240.7	27.3	518.0	58.9
GUNOH1	1,860	0.5	**	**	**	**	**	**
GUNOH2	572	2.0	84	14.7	194.4	33.9	187.7	32.8
BACOH	340	0.5	5	1.5	6.3	1.9	0	0
PATMH	389	1.0	5	1.3	9.0	2.3	6.1	1.6
CB2OH	705	0.5	152	21.6	133.8	19.0	197.9	28.1
CB3MH	1,370	0.5	55	4.0	44.3	3.2	77.4	5.6
Total SAV Acres			**535.0**		**628.5**		**987.1**	

** No monitoring conducted by Baltimore County in this segment.

The Middle River segment (MIDOH) has consistently the highest acreage of SAV coverage each year. In 2004 Middle River attained 54.9% of the SAV criteria. 2008 saw a resurgence of SAV in Middle River with a total of 518 acres representing ~59% of the goal. Back River has the least amount of SAV coverage over the three-year period and is far from meeting the new draft criteria of 340 acres of SAV coverage. Overall, the SAV coverage has increased in each of the last three years of monitoring, with almost 1,000 acres of coverage in 2008. Since not all of the county tidal waters are monitored through this program, the numbers represent a conservative estimate of progress in meeting the SAV goals. The Gunpowder segment (GUNOH1) is not monitored by Baltimore County.

Figure 9-23 displays the trends in SAV coverage over 20 years of monitoring. The figure displays the percent of the area survey that was covered by SAV. As can be seen from the figure there is a generally increasing trend in the percent of the area surveyed that is covered by SAV from a low in 1989 of 0.37% to a high of 27.4% in 2008. While there is a certain degree of variability, possibly related to climatic events (record wet year in 2003 with reduced % coverage) the overall trend is improved coverage.

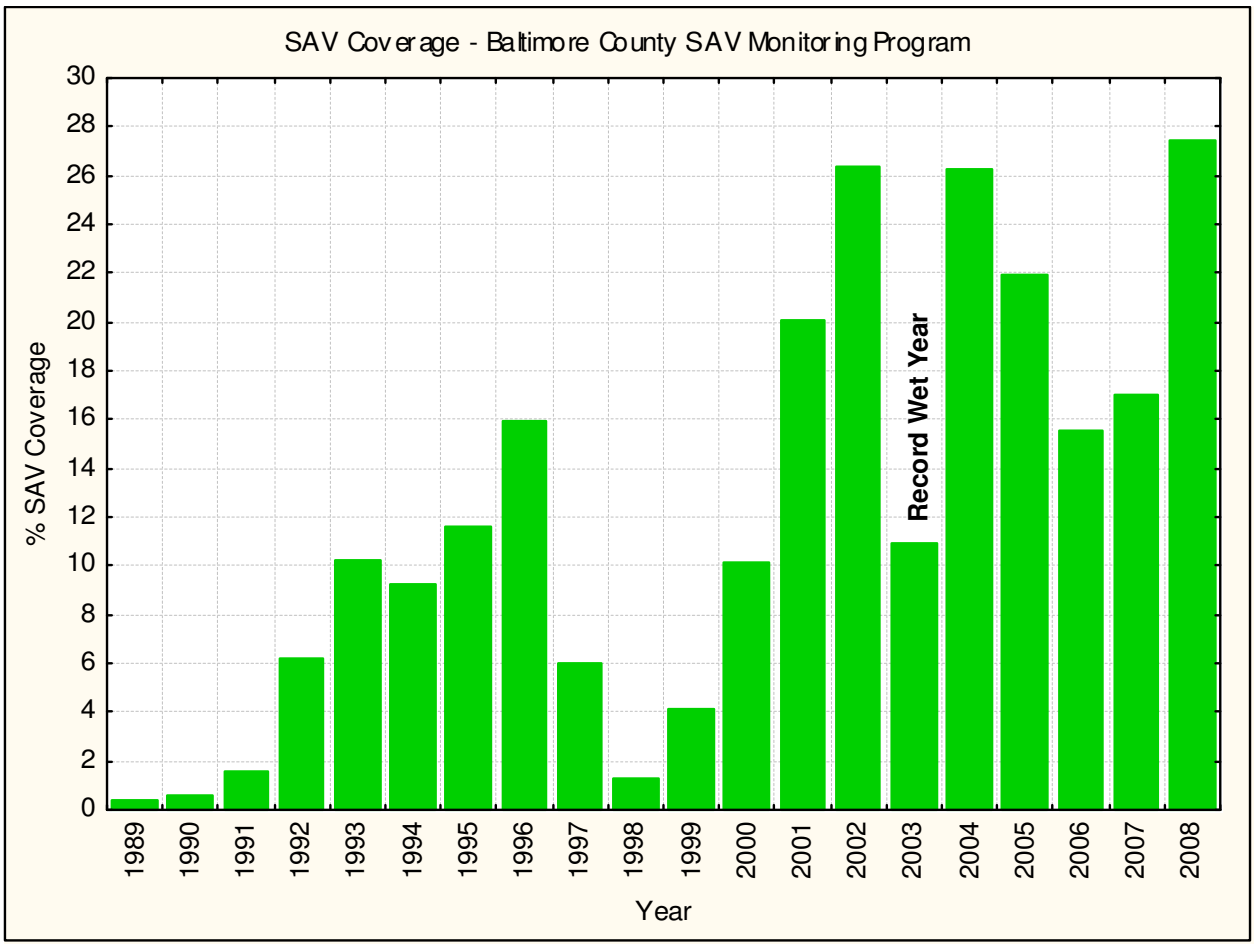


Figure 9-23: Baltimore County SAV Monitoring Program – Trends in % Coverage

9.5 Status of Brook Trout in the Prettyboy Reservoir Watershed

9.5.1 Introduction

The plight of wild brook trout (*Salvelinus fontinalis*) in Maryland streams has been documented in increasing detail in recent years. Brook trout have disappeared from streams and entire watersheds as a result of various land uses that have disrupted stream functions vital to their survival. Elevated water temperature is the most frequent result of anthropogenic activities that influence the distribution of brook trout. Brook trout require suitable water temperature regimes for optimal feeding, growth, and reproduction. The Code of Maryland Regulations established a water temperature threshold of 20 °C for naturally reproducing trout streams, while the United States Environmental Protection Agency established a maximum weekly average temperature threshold of 24 °C for brook trout (US EPA, 1986).

The Maryland Department of Natural Resources (MD DNR) has listed brook trout as a Species of Greatest Conservation Need in its Wildlife Diversity Conservation Plan. Recently, the Prettyboy Reservoir Watershed Restoration Action Strategy (WRAS) was completed. The WRAS was a cooperative effort among citizen-based organizations and state and local government agencies. The goal of the WRAS was to develop a plan of action that promotes the overall (aquatic and terrestrial) ecological health of the Prettyboy Watershed. The plan includes restoration, education, and monitoring actions. This report presents first-year results in support of one of the monitoring actions of the WRAS: to monitor brook trout population trends in streams draining Prettyboy Reservoir. The work was a joint venture among MD DNR Fisheries Service, Baltimore City Reservoir Natural Resources Section (BC RNR), Carroll County Bureau of Resource Management (CC BRM), and Baltimore County Department of Environmental Protection and Resource Management (BC DEPRM).

The overall goal of this study is to assess the current extent of wild brook trout in the Prettyboy Reservoir watershed. The brook trout population data, as well as water temperature and physical habitat data, will also be used to establish fixed sampling stations where the variability/long-term stability of brook trout populations may be evaluated. Physical habitat and riparian zone conditions will be examined to isolate streams where habitat improvement measures may bolster brook trout populations. Therefore, the objectives of the study were to (1) determine brook trout distribution and abundance, (2) measure air and water temperature regimes, (3) assess physical habitat quality, and (4) document brook trout spawning activity.

9.5.2 Methods

Historical brook trout sampling data from MD DNR and BC DEPRM were reviewed to identify streams which had not been previously sampled for brook trout, or which had not been sampled for brook trout for longer than 3-5 years. Brook trout distribution and density data were also used to select streams for thermal monitoring. We attempted to include streams that had high, medium, and low densities of brook trout. We originally selected 19 stations for thermal monitoring and brook trout sampling (Table 9-14), with the understanding that the number of stations might increase or decrease, depending upon staff and time availability and landowner permission for private property. Ultimately, 24 stations were monitored for air temperature, water temperature, or brook trout. Figure 9-24 shows the location of the monitoring stations.

Water temperature was measured at 19 stations using Onset HOBO® Pendant continuously recording thermometers. Thermometers were deployed between April 11 and April 29, 2008 by

attaching them with cable ties to stable instream structures (tree roots, for example). Thermometers were set deep enough below the stream surface so that they would not be exposed to the air during low summer stream flow. At each station, the serial number of each thermometer, latitude, longitude, and time of deployment were recorded. A Maryland Biological Stream Survey (MBSS) Spring Index Period physical habitat assessment was completed at each station. On May 7, 2008, Onset HOBO® Water Temp Pro continuously recording thermometers were deployed at ten stations to measure air temperature. Air temperature was not measured at all stations due to limited availability of temperature sensors. Thermometers were recovered between November 12 and 20, 2008.

Several stream reaches were examined for the presence of brook trout redds and spawning pairs of brook trout on days when thermometers were recovered. These observations were an initial attempt to develop a reasonable technique to standardize redd counts and gage the amount of spawning activity. Only gravel in the classic "pit and mound" formation was counted.

Electrofishing was conducted between June 19 and September 19, 2008. At minimum, a 75-m reach was sampled at each station, using the two-pass removal method with Smith-Root® LR12 backpack electrofishing units. All fish species were identified, counted, and weighed. Brook trout young-of-year and brook trout adults were counted and weighed separately. Non-trout fish species were weighed in aggregate. In the case of wider streams (average width >5m), or in reaches where sufficient adult brook trout habitat was not present in 75-m, longer reaches were sampled. "Sufficient adult brook trout habitat" was defined as at least one pool within the reach with depth > 0.5 m and containing overhead cover (i.e., stable boulders, logs, or undercuts). The length beyond 75-m sampled was based on the best professional judgment of the sampling crew. At these longer stations, only brook trout were collected beyond the first 75-m. The MBSS Fish Index of Biotic Integrity (FIBI) was calculated for each station. An MBSS Summer Index Period physical habitat assessment was completed at each station. Physical habitat data were converted to physical habitat index (PHI) scores.

Data analyses were exploratory and consisted of comparisons of water temperature, trout abundance and biomass, FIBI, and PHI among stations, although two relationships were statistically tested. Linear regression was used to test for relationships between percent watershed forest cover and maximum daily water temperature, and percent watershed forest cover and PHI. This was done primarily because of the limited data set. More rigorous statistical testing will be done after a second field season of data from a wider geographic area has been collected.

9.5.3 Results and Discussion

Brook trout were found at 12 of the 19 stations surveyed (Table 9-15). No individuals of any fish species were collected at station BC-09. The highest density of adult brook trout was found at BC-05 (476 trout/ha). The presence and abundance of brook trout was not reflected in FIBI values (Tables 9-15 and 9-16). The stations with the highest FIBI values (BC-06 and BC-13) had moderate (BC-06) or absent (BC-13) brook trout populations. Non-brook trout fish species were present at all stations except BC-09 (Table 9-18). The number of species ranged from one (BC-08) to 15 (BC-12).

Of the 19 water temperature sensors deployed, two (BC-06 and BC-10) were not found. Therefore, water temperature data is presented for 17 stations (Table 9-17). Station BC-11 had the highest maximum daily temperature (28.5 °C); 45.9% of all station readings at BC-11 were

greater than 20 °C. Four stations had temperature readings greater than 24 °C (Table 9-17). Interestingly, the only station with no fish present (BC-09) also had no water temperatures exceeding 20 °C. Northern Baltimore County experienced an extreme drought between 2001 and 2002. It is likely that this stream went dry and was never re-populated by fish. A significant relationship was found between percent forest cover and maximum daily water temperature ($p < 0.05$). As percent forest cover increased, maximum daily water temperature decreased. Of stations sampled for both brook trout and water temperature, the stations where brook trout were present had lower mean and maximum daily temperatures and lower proportions of readings greater than 20 °C than stations where brook trout were absent.

Figure 9-25 shows graphs of maximum daily air and water temperatures, for stations where both air and water temperatures were measured. Water temperatures generally remained stable relative to air temperature. One exception was station BC-11, where air temperature appeared to have a greater influence over water temperature than at other stations. BC-11 had the most agriculture and least forest cover of all stations surveyed. It is also possible that there is less groundwater influence in this stream than in the others surveyed.

As noted in Table 9-15, no brook trout were collected from station CC-03 during the survey. Angler reports to the Maryland DNR Fisheries service suggest a small, seasonal population of brook trout in this reach of Gunpowder Falls (M. Staley, personal communication). Qualitative sampling was done in the best available habitat, downstream of the station reach, in an attempt to document the presence of this population. Two adult brook trout were found in one deep pool. Water temperatures in this reach of Gunpowder Falls were already routinely greater than 20 °C prior to the survey date (June 19). It is likely that brook trout use this and similar pools as thermal refuge, as water temperatures at the bottom of the pool were probably several degrees colder than water temperatures throughout the reach. This would be due to the depth, the presence of a stream bottom spring or seep, or a lateral spring or seep from the stream bank. It is also likely that other brook trout had migrated to small, cold-water tributaries to escape the already warm temperatures. Seasonal, temperature-induced migration of salmonids is a well-documented phenomenon.

Physical habitat data were converted to physical habitat index (PHI) scores and rated using criteria from Southerland et al (2005). Minimally degraded stations had PHI scores of 81-100, partially degraded stations had PHI scores of 66-80, degraded stations had PHI scores of 51-65, and severely degraded stations had PHI scores of 0-50. Physical habitat was minimally degraded at 4 stations, partially degraded at 7 stations, degraded at 6 stations, and severely degraded at one station (Table 9-16). In general, remoteness was the lowest rated habitat parameter at each station, reflecting an extensive network of roads, even in this less developed portion of Baltimore County. Fifteen of 17 stations had sub-optimal or lower remoteness scores. Half of the stations had shading of 90% or greater. Epifaunal substrate and instream fish habitat averaged in the high sup-optimal category. Values for the number of pieces of instream wood and instream root wads were generally low (mean=2.0). Bank stability averaged optimal, while riffle quality was sub-optimal. Nine stations had embeddedness ratings of 50% or greater, which suggests that sedimentation is a significant factor in overall habitat quality. There was no relationship between PHI and the percentage of forest cover. The PHI and individual habitat parameters generally did not differ between stations where brook trout were present and stations where brook trout were absent, with two exceptions. Stations where brook trout were absent had twice as much instream wood as stations where brook trout were present. Stations where brook trout

were present had greater watershed forest cover (46%) than stations where brook trout were absent (39%, Table 9-19).

Brook trout redd counts revealed that spawning activity was limited to short stream reaches and consisted of only a small number of redds (Table 9-20). The procedures used during the first year of the study will be used to construct a more rigorous, standardized method to characterize brook trout spawning effort. These observations highlight the extremely fragile nature of wild brook trout populations in the Prettyboy watershed.

Our initial data show that brook trout are widely distributed in streams of the Prettyboy watershed, with variable population sizes. The stability of water temperature relative to air temperature suggests that groundwater may play a major role in providing suitable temperatures for brook trout, but more data are needed to discriminate between influence of groundwater and riparian tree canopy. Although riparian and instream physical habitat are significantly altered, brook trout are able to exploit the available habitat. High population densities in several of the sampled streams shows that despite hundreds of years of landscape alteration in the piedmont of Central Maryland, wild brook trout are still able to thrive, given the proper physical and chemical conditions.

9.5.4 References

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US EPA. 1986. Quality criteria for water: 1986. EPA 440/5-86-001. U. S. Environmental Protection Agency, Office of Water Regulations and Standards. Washington, D. C.

Table 9-14: Prettyboy Reservoir brook trout and thermal monitoring stations.

Station	Stream	Location	Electrofishing	Water Temperature	Air Temperature
BC-01	Gunpowder Falls	Downstream of Gunpowder Rd	X	X	
BC-02	Walker Run	Gunpowder Rd		X	
BC-03	Silver Run	Hoffmanville Rd		X	
BC-04	UNT	Clipper Mill Rd	X	X	X
BC-04B	UNT	Hoffmanville Rd	X		
BC-05	UNT	Clipper Mill Rd	X	X	X
BC-06	UNT	Kidds Schoolhouse Rd	X	X	X
BC-06B	UNT	Bulls-Sawmill Rd	X		
BC-06W	UNT	West of BC-06	X		

BC-07	Frog Hollow	Spook Hill Rd	X	X	X
BC-08	UNT	Armacost Rd	X	X	
BC-09	UNT	Prettyboy Dam Rd	X	X	X
BC-10	UNT Prettyboy Branch	Traceys Store Rd	X	X	X
BC-11	Prettyboy Branch	Traceys Store Rd	X	X	X
BC-12	Compass Run	Gunpowder Rd	X	X	X
BC-13	Grave Run	Gunpowder Rd	X	X	X
BC-14	Poplar Run	Gunpowder Rd		X	X
BC-16	UNT	Cotter Rd	X		
BC-17	UNT	Cotter Rd	X		
CC-01	UNT			X	
CC-02	UNT			X	
CC-03	Gunpowder Falls	Upstream of Gunpowder Rd	X	X	
CC-04	Grave Run	Millers Station Rd	X	X	
CC-05	UNT			X	

Table 9-15: Prettyboy Reservoir brook trout population data.

Station	Adult trout Kg/ha	Adult trout/ha	Young-of-year/ha
BC-01	1	5	0
BC-04	4	125	1313
BC-04B	8	167	1083
BC-05	29	476	476
BC-06	6	120	160
BC-06B	2	54	514
BC-06W	0	0	929
BC-07	0	0	93
BC-08	0	0	0
BC-09	0	0	0
BC-10	0	0	0
BC-11	0	0	0
BC-12	0	0	0
BC-13	0	0	0
BC-16	6	120	40
BC-17	13	167	333
CC-03*	0	0	0
CC-04	0	0	67

*Two adult brook trout were captured downstream from the station during qualitative sampling. No lengths or weights were recorded.

Table 9-16: Fish Index of Biotic Integrity (FIBI) and Physical Habitat Index (PHI) Scores

Station	FIBI	Condition	PHI	Condition
BC-01	2.67	Poor	85.38	Minimally Degraded
BC-04	2.67	Poor	65.94	Degraded
BC-04B	1.67	Very Poor	69.29	Partially Degraded
BC-05	1.33	Very Poor	84.05	Minimally Degraded
BC-06	4.33	Good	65.03	Degraded
BC-06B	3.33	Fair	81.24	Minimally Degraded
BC-06W	3.33	Fair	71.78	Partially Degraded
BC-07	2.67	Poor	66.85	Partially Degraded
BC-08	1.00	Very Poor	71.87	Partially Degraded
BC-09	NA	NA	65.52	Degraded
BC-10	3.33	Fair	73.75	Partially Degraded
BC-11	3.67	Fair	56.58	Degraded
BC-12	3.67	Fair	70.86	Partially Degraded
BC-13	4.00	Good	75.79	Partially Degraded
BC-16	1.67	Very Poor	49.21	Severely Degraded
BC-17	1.33	Very Poor	51.07	Degraded
CC-03	3.33	Fair	90.73	Minimally Degraded
CC-04	3.67	Fair	52.48	Degraded

Table 9-17: Water Temperature Summary

Station	Mean temperature, °C	Maximum daily temperature, °C	% readings exceeding 20 °C	% readings exceeding 24 °C
BC-01*	17.8	25.3	33.5	1.0
BC-02*	16.2	21.7	5.0	NA
BC-03*	16.3	21.6	4.5	NA
BC-04	15.6	21.8	2.2	0.0
BC-05	15.0	22.6	1.1	0.0
BC-06	NA	NA	NA	NA
BC-07	15.9	21.6	4.3	0.0
BC-08	14.8	20.2	0.2	0.0
BC-09	15.0	19.8	0.0	0.0
BC-10	NA	NA	NA	NA
BC-11	18.9	28.5	45.9	9.0
BC-12	15.8	22.4	6.0	0.0
BC-13	16.4	23.7	14.8	0.0
BC-14	15.5	21.9	2.2	0.0
CC-01	16.4	22.7	6.6	0.0
CC-02	18.4	25.7	39.2	2.2
CC-03	17.8	25.2	32.8	0.7
CC-04	15.3	20.6	0.6	0.0
CC-05	17.1	23.4	17.8	0.0

* Water temperatures were measured hourly at these stations.

Table 9-18: Fish Community Composition

	Station																	
	BC-01	BC-04	BC-04B	BC-05	BC-06	BC-06B	BC-06W	BC-07	BC-08	BC-10	BC-11	BC-12	BC-13	BC-15	BC-16	BC-17	CC-03	CC-04
Blacknose dace		62	157	52	17	49	6	13	31	26	15	52	18	128	390	132	29	88
Blue Ridge Sculpin					104	115	53					131	56	147				135
Bluegill	1									5	2	2	4				7	
Bluntnose minnow					12		1	2					1					
Brook trout		23	15	20	7		12	3							4	6		1
Brown bullhead										1	5	14	3					
Central stoneroller	4				1					3	29	6					30	
Common shiner																	13	
Creek chub		4	16		4	10	2			27	20	14		3	33		2	45
Cutlips minnow																	3	
Fantail darter												4						
Golden shiner					1													
Green sunfish												1	1		2			
Largemouth bass	1	3			11	7	1	3		3	8	3	16					
Longnose dace	14							2		72	78	9	4	17			34	
Northern hogsucker	15												4				28	
Potomac sculpin	26	1															120	
Pumpkinseed																		
Redbreast sunfish					1		2	1				3					4	
River chub													1				2	
Rosyside dace						2						13		12			1	
Smallmouth bass	4																8	
Spottail shiner					4						5							
Tesselated darter					4		3	43		13	13	14	11					
White sucker	5	16		1	5					6	4	9	6				47	
Yellow bullhead					4		2	28				54	1					

Table 9-19: Land Use by Percentage

	Land Use				
	Agriculture	Forest	Residential	Commercial	Other
BC-04	47.7	46.1	6.2	0.0	0.0
BC-04B	60.8	30.5	8.7	0.0	0.0
BC-05	49.5	33.1	17.3	0.0	0.0
BC-06	29.5	55.8	14.0	0.7	0.0
BC-06B	28.2	54.0	17.0	0.8	0.0
BC-06W	29.5	59.5	11.0	0.0	0.0
BC-07	33.2	42.6	23.2	0.4	0.6
BC-08	44.1	55.2	0.7	0.0	0.0
BC-09	0.0	67.4	32.6	0.0	0.0
BC-10	61.1	31.3	7.6	0.0	0.0
BC-11	71.7	13.0	11.8	0.0	3.5
BC-12	46.6	26.4	27.0	0.0	0.0
BC-13	39.1	45.8	15.1	0.0	<0.1
BC-14	30.8	30.8	20.4	0.0	17.9
BC-16	58.7	32.5	7.3	0.8	0.7
BC-17	46.7	50.3	3.0	0.0	0.0

Table 9-20: Brook Trout Redd Counts

Stream	Date	Length of Reach (m)	Number of redds
Clipper Mill Road Tributary	11/14/08	900	0
Silver Run	11/05/08	450	4
Walker Run	11/05/08	400	2
	11/14/08	300	3

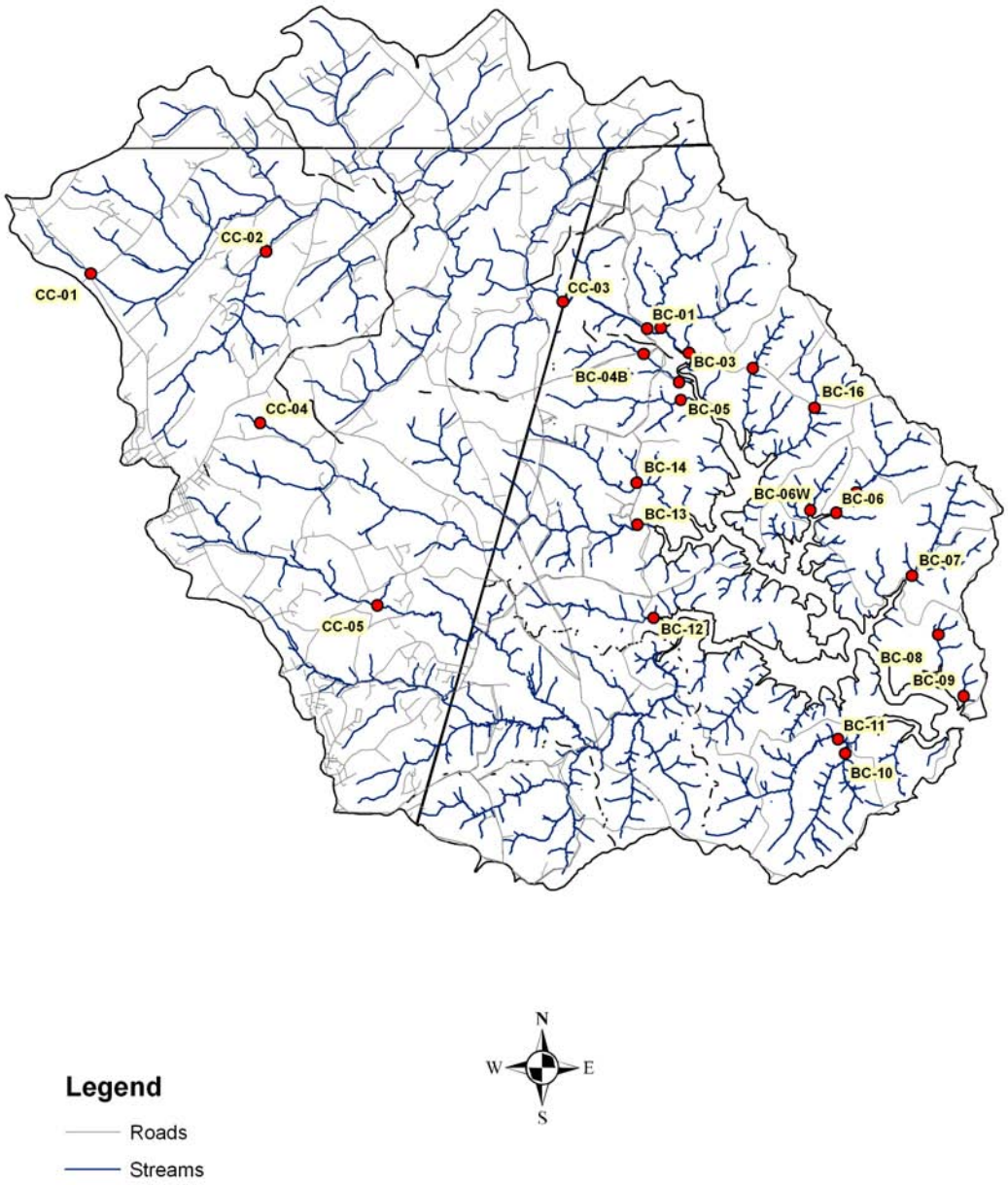
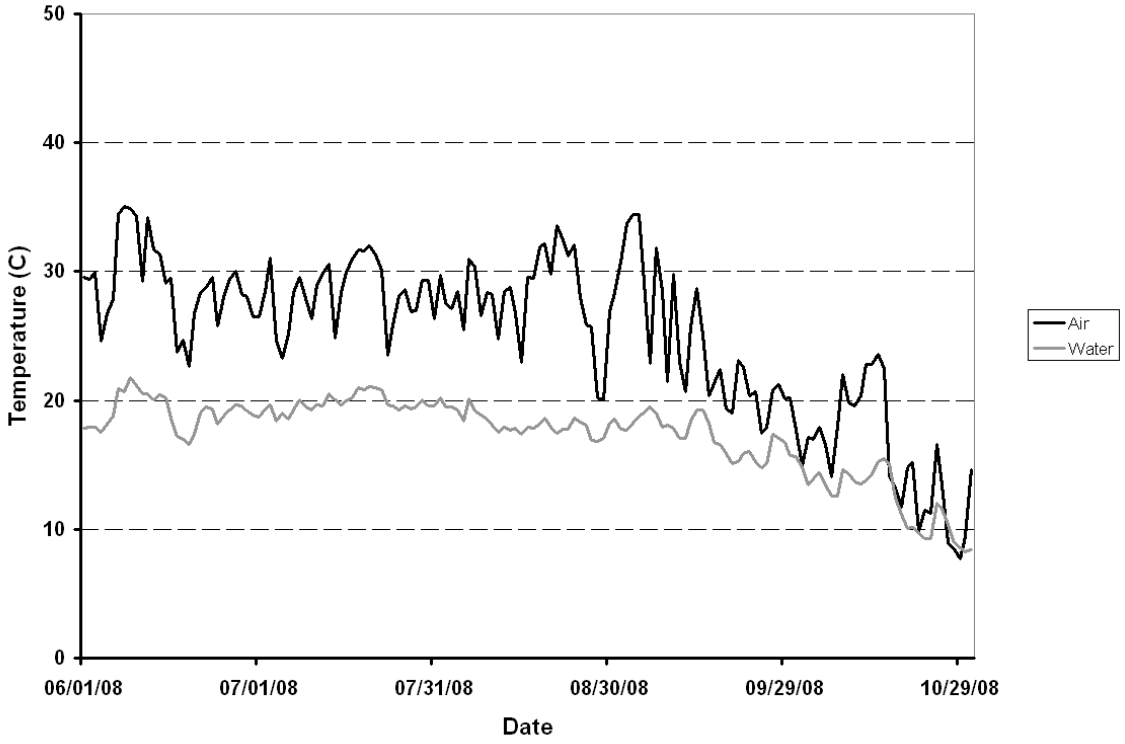
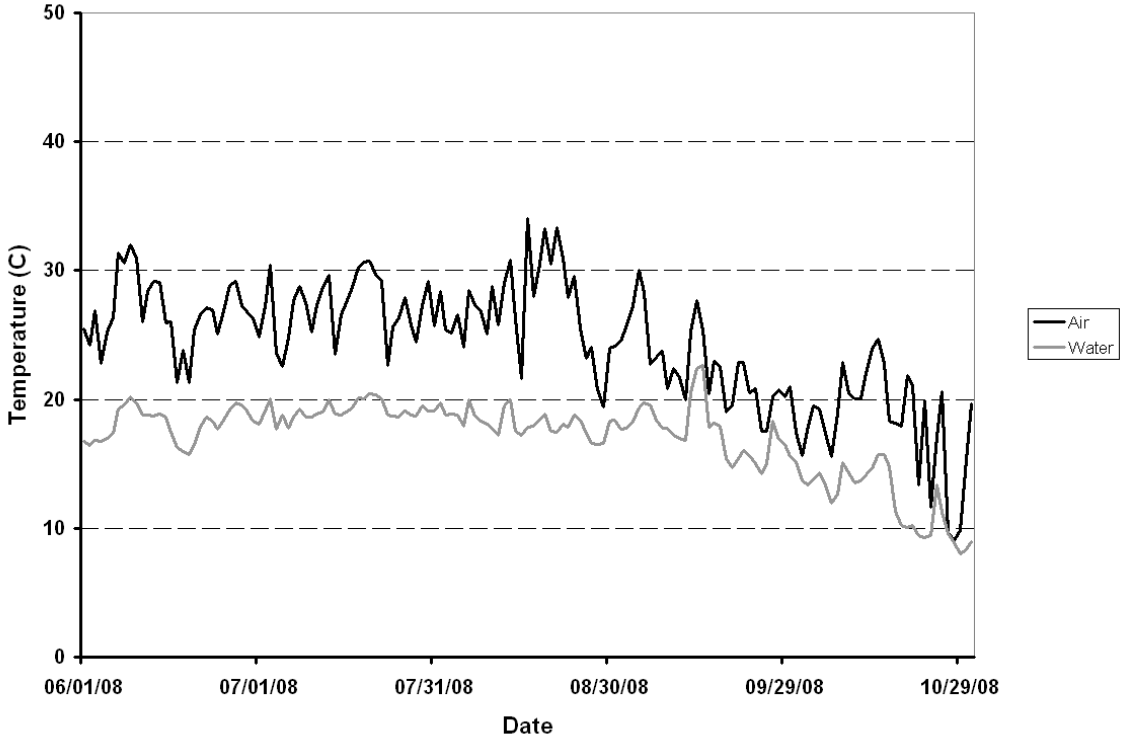


Figure 9-24: Locations of Prettyboy Reservoir Watershed Monitoring Sites.

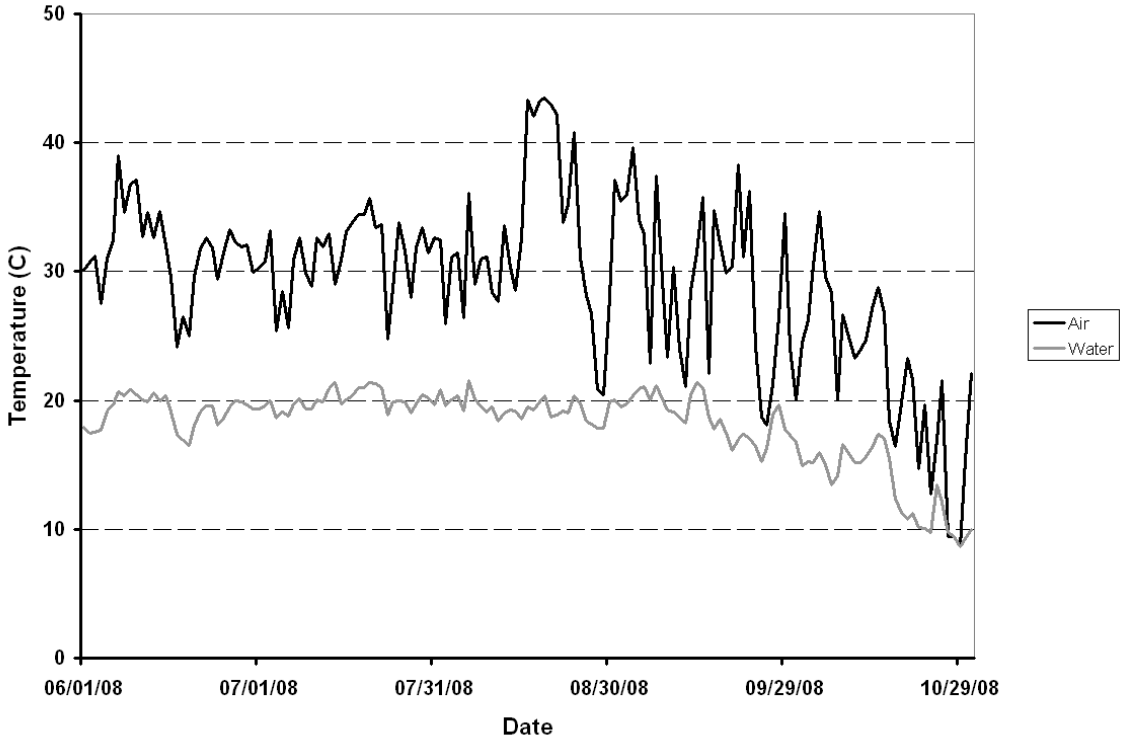


BC-04

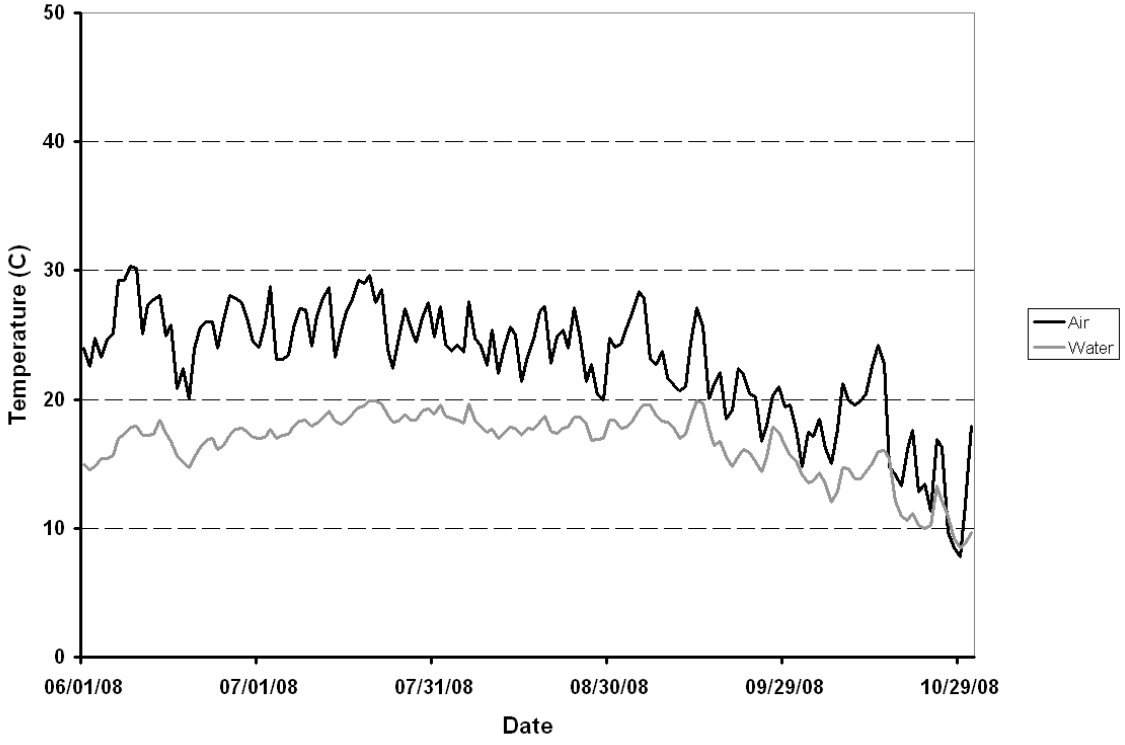


BC-05

Figure 9-25: Maximum Air and Water Temperatures at Prettyboy Stations.

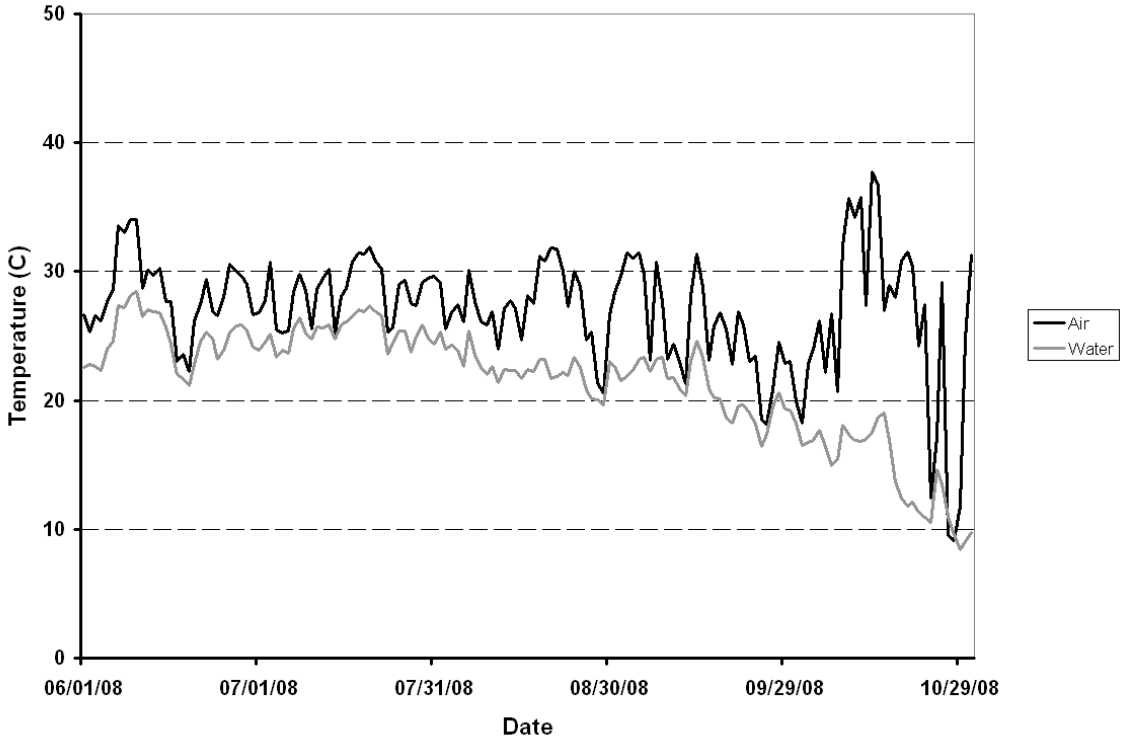


BC-07

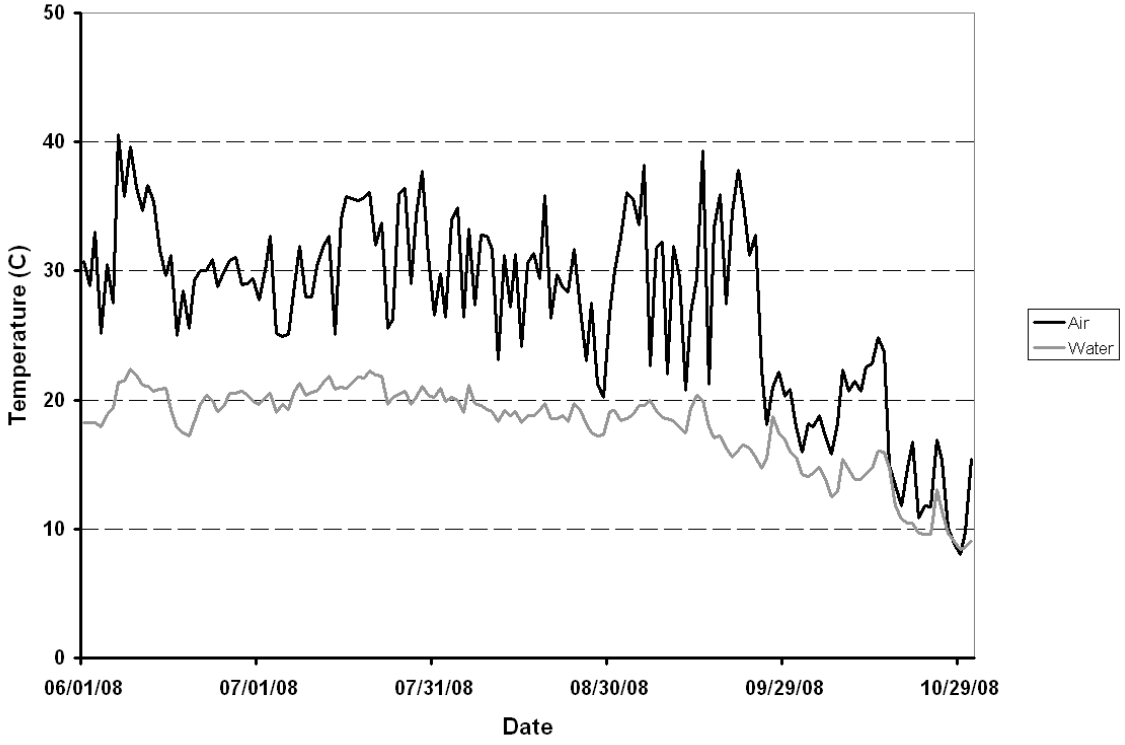


BC-09

Figure 9-25 (cont.).

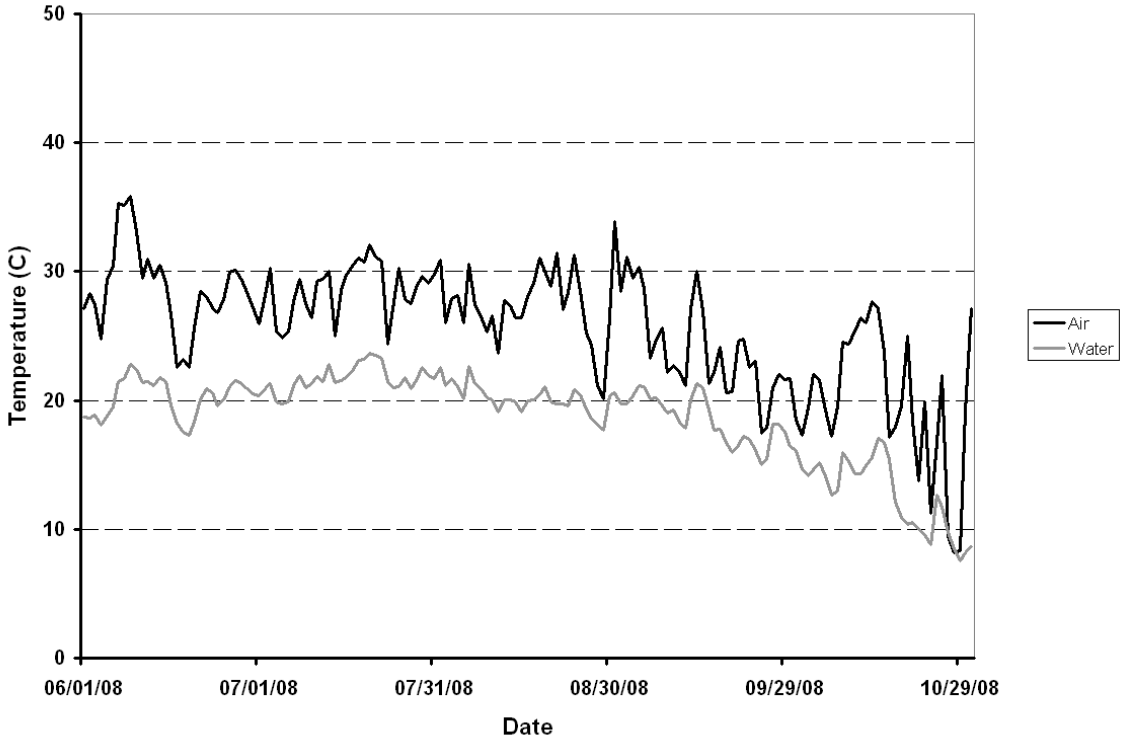


BC-11

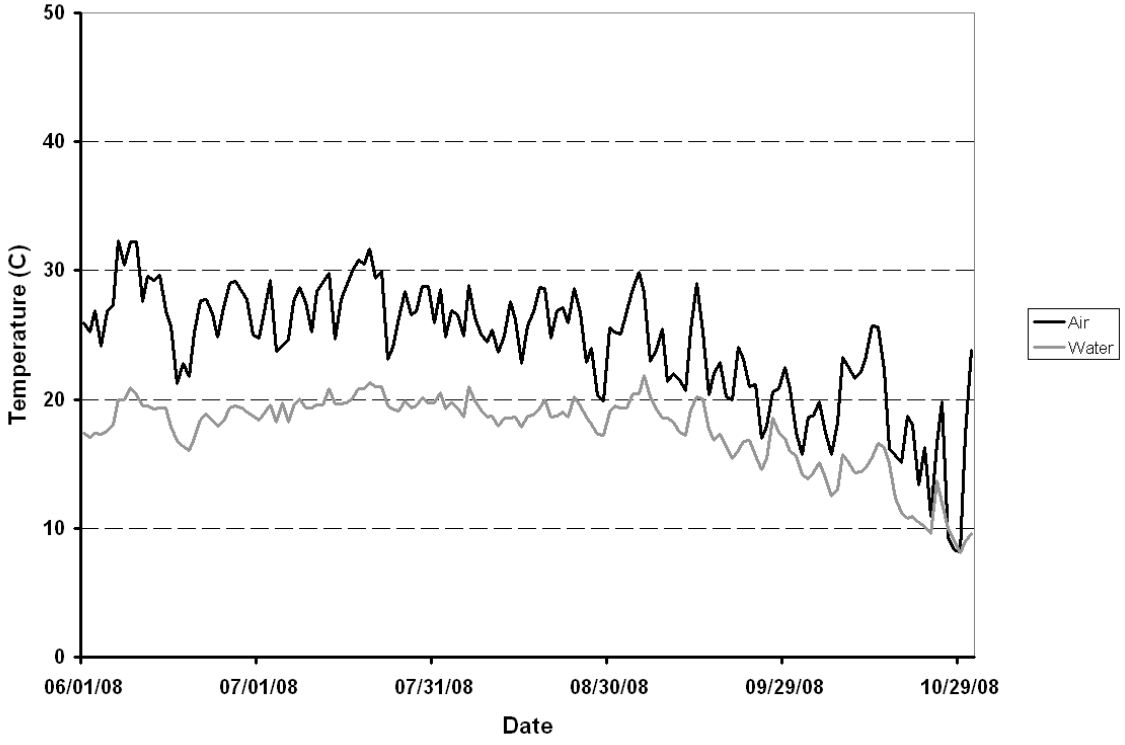


BC-12

Figure 9-25 (cont.).



BC-13



BC-14

Figure 9-25 (cont.).

9.6 Stream Corridor Assessment

9.6.1 Introduction

In 1998, the Maryland Clean Water Action Plan identified the Prettyboy Reservoir watershed as one of the State's water bodies that did not meet water quality requirements. In response to this finding, the Maryland Department of Environment (MDE) and Baltimore County formed a partnership to develop a Watershed Restoration Action Strategy (WRAS) for the Prettyboy Reservoir watershed. This Stream Corridor Assessment (SCA) survey is a result of recommendations that came out of the WRAS. It was recommended that the remaining sub-watersheds be surveyed that had not been completed prior to the completion of the WRAS. In Baltimore County this includes Direct Drainage 1, 2, 3, and 4, Gunpowder Falls, Muddy Creek and Indian Creek. These will be completed over a five-year schedule. Direct Drainage 3 and 4 were the first of this group to be surveyed and were completed in Winter 2009 (Figure 9-26).

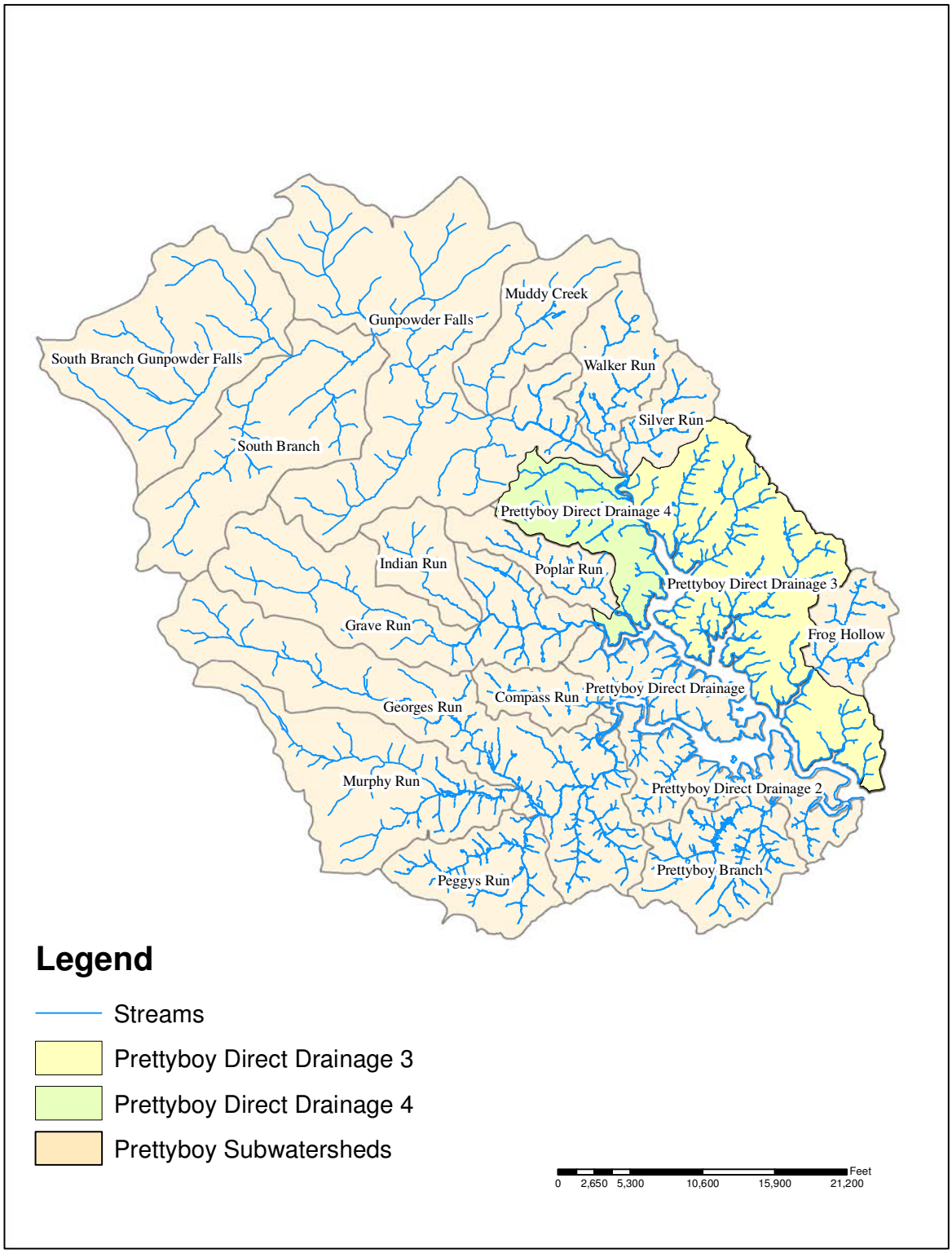


Figure 9-26 Map of Prettyboy Subwatersheds

The SCA survey provides descriptive and positional data for potential environmental problems along a watershed's non-tidal stream network. Developed by DNR's Watershed Services, the survey is a watershed management tool to identify environmental problems and helps prioritize restoration opportunities on a watershed basis. As part of the survey, specially trained personnel walk a watershed's streams and record data for several potential environmental problems that can be easily observed within the stream corridor. Each potential problem site is ranked on a scale of one to five for its severity, correctability, and access for restoration work.

9.6.2 Summary of Results

The Stream Corridor Assessment crew surveyed 40.8 miles of streams in the two sub-watersheds (Figure 9-27 and Table 9-21). They identified 76 potential environmental problems. At the time of the survey, the most frequently observed potential problem sites were erosion, reported at 30 sites. Other potential environmental problems recorded during the survey included: 6 fish barriers, 12 inadequate buffers, 6 pipe outfalls, 8 unusual conditions, 1 in or near streams construction and 13 trash dumping sites. Additionally, crews recorded descriptive habitat condition data at 60 representative sites.

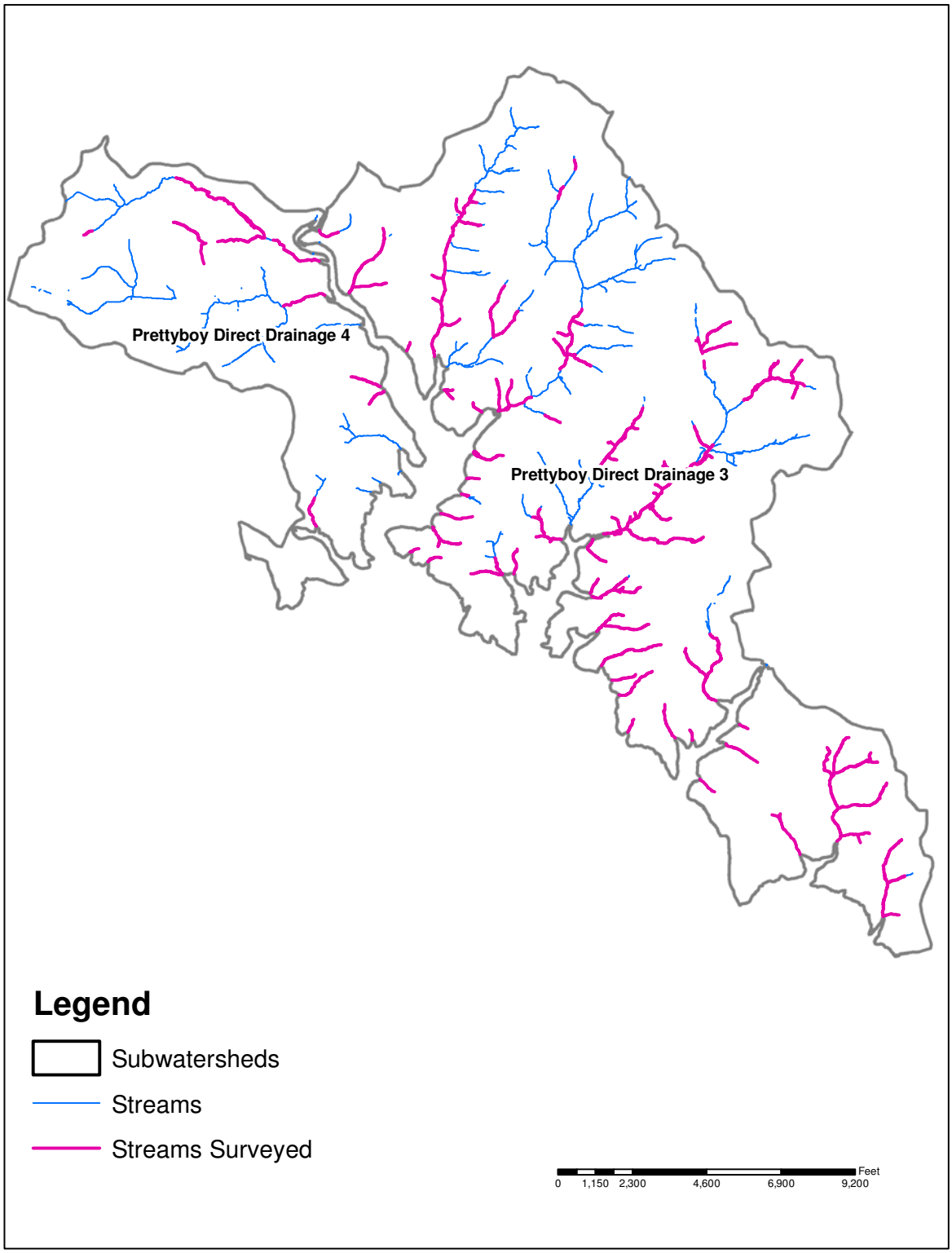


Figure 9-27 Map of the Streams Surveyed for the Two Subwatersheds.

Table 9-22 and 9-23 presents a summary of survey results by problem type by sub-watershed. Figure 9-28 provdies a histogram of potential problems found by sub-watershed. Table 9-24 provides a listing of information by site number. In Table 9-25, the data are presented by problem type and lists the collected descriptive data. Presenting the data by problem type allows the reader to see which problems are rated as most severe or easiest to correct within each category. Result categories are discussed further in order of those with the greatest number of sites to those with the least. As mentioned earlier, the number of potential problem sites is not the only measure of the overall extent of the problem, but is used here to order the data.

Table 9-21 Total Stream Miles and Stream Miles Surveyed, by Subwatershed

Subwatershed	Total Stream Miles	Miles Surveyed	Percentage
Prettyboy Direct Drainage 3	31.6	18.5	58.5 %
Prettyboy Direct Drainage 4	9.2	2.9	31.5 %
Total	40.8	21.4	52.5 %

Table 9-22 Summary of Results From Prettyboy Direct Drainage 3 Subwatershed

Potential Problems Identified	Number	Estimated Length	Very Severe	Severe	Moderate	Low Severity	Minor
Erosion	24	25,963 ft (4.9 mi)	3	2	2	17	0
Trash Dumping	11		0	1	1	3	6
Inadequate Buffer	8	4,907.9 ft (0.9 mi)	0	3	2	2	1
Unusual Condition or Comment	8		1	3	2	1	1
Fish Barrier	5		0	4	0	1	0
Pipe Outfall	2		0	0	1	0	1
In or Near Stream Construction	1		0	1	0	0	0
Channel Alteration	0		0	0	0	0	0
Exposed Pipe	0		0	0	0	0	0
Total	59		4	14	8	24	9
Representative Sites	53						

Table 9-23 Summary of results from Prettyboy Direct Drainage 4 Subwatershed

Potential Problems Identified	Number	Estimated Length	Very Severe	Severe	Moderate	Low Severity	Minor
Erosion	6	7270.8 ft (1.4 mi)	0	2	2	2	0
Trash Dumping	2		0	0	1	1	0
Inadequate	4	1189.2 ft	0	1	0	3	0

Buffer		(0.4 mi)					
Unusual Condition or Comment	0		0	0	0	0	0
Fish Barrier	1		1	0	0	0	0
Pipe Outfall	4		0	0	0	3	1
In or Near Stream Construction	0		0	0	0	0	0
Channel Alteration	0		0	0	0	0	0
Exposed Pipe	0		0	0	0	0	0
Total	17		1	3	3	9	1
Representative Sites	7						

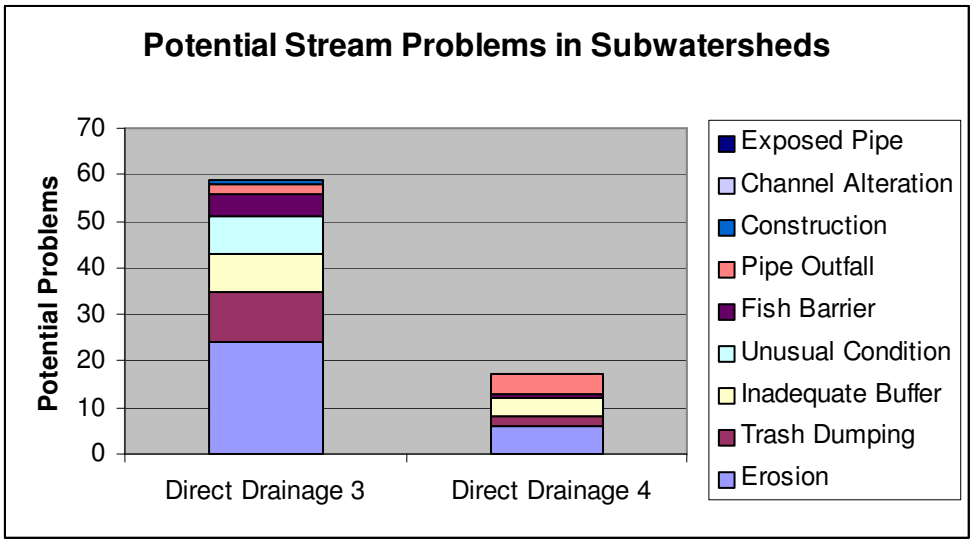


Figure 9-28 Potential Stream Problems By Subwatershed

9.6.3 Summary of Erosion

The survey teams reported 30 eroding stream banks that totaled 33,233.8 feet or 6.3 miles (29% of the 21.4 miles surveyed). Figure 9-29 shows the severity distribution of these sites, and Figure 9-30 shows their location and severity. In this survey, unstable eroding streams are defined as areas where the stream banks are almost vertical, and the vegetative roots along the stream are unable to hold the soil onto the banks. The severity rating of the site is based on the length and height of the eroding streambank. An erosion site was rated as very severe if it was a long section of stream (>1000 ft.) with unstable banks on both sides; a site was ranked as minor if it was a short section of stream (<300 ft.) with limited bank instability. While survey teams are asked to visually assess whether the stream was down cutting, widening, or headcutting at a specific site, the only way to evaluate the full significance of the erosion processes at a specific site is to do more detailed monitoring over time.

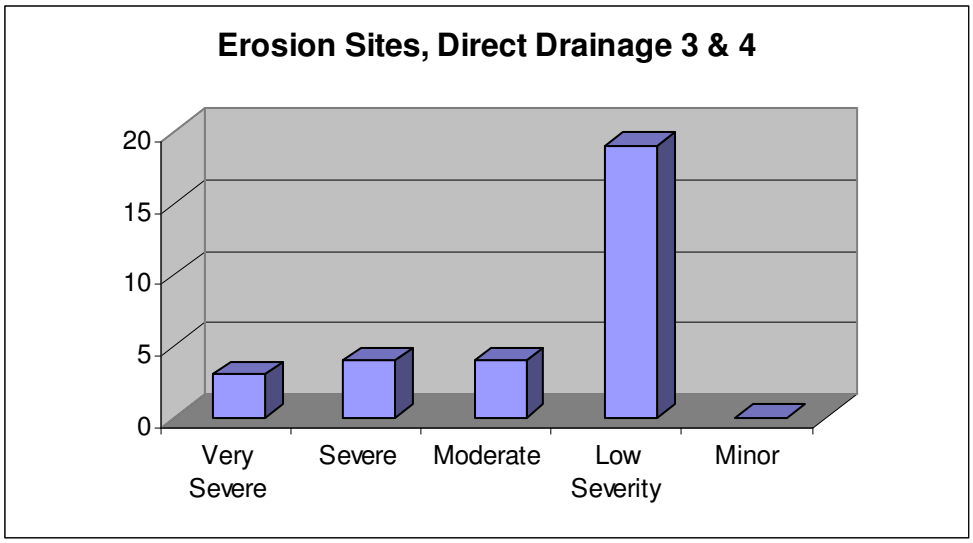


Figure 9-29 Severity Distribution of Sites

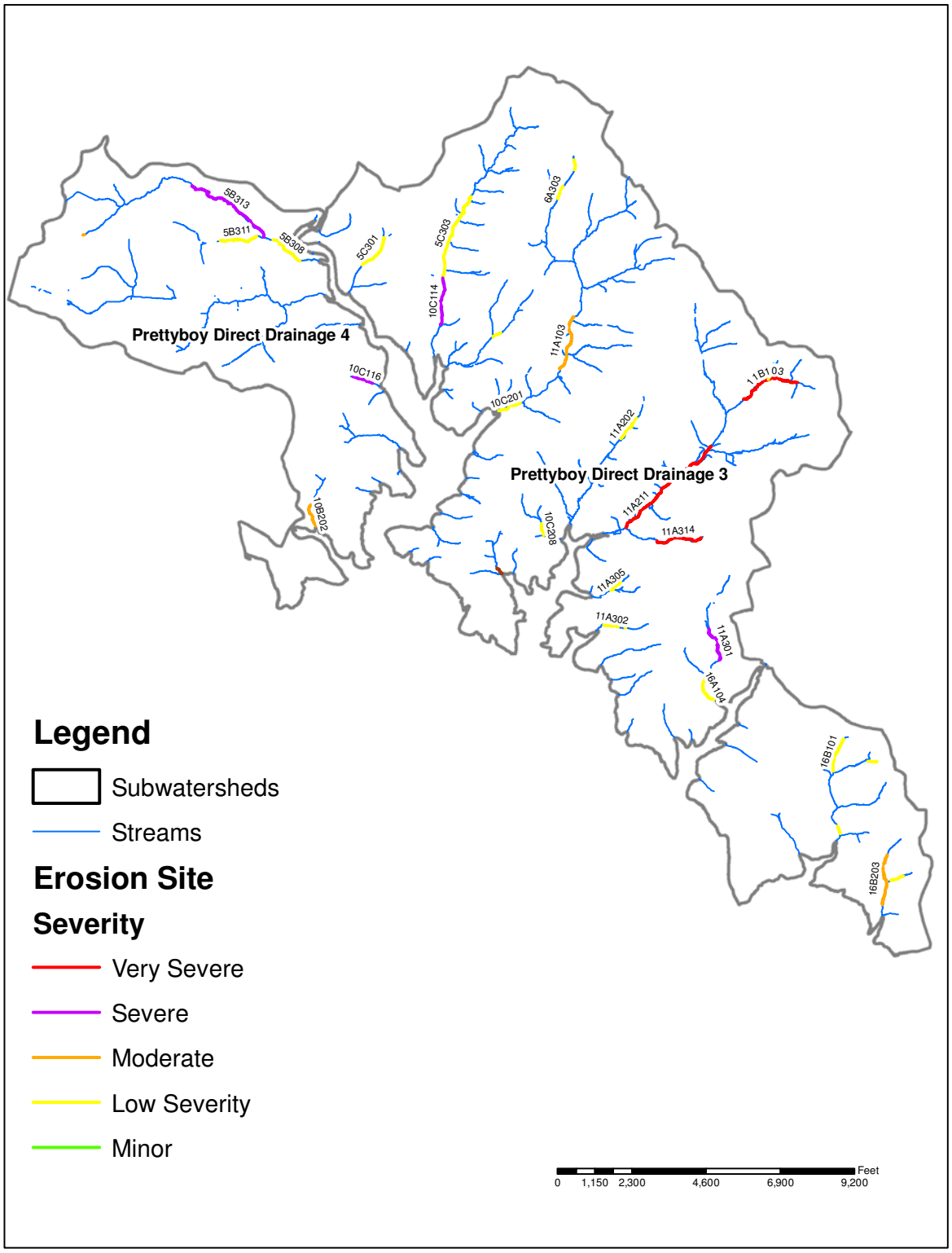


Figure 9-30 Map of Erosion Severity and Location

9.6.4 Summary of Trash Dumping

Survey crews documented 13 trash-dumping sites, and placed 1 site in the severe category, 2 in moderate, 4 in low severity, and 6 in minor (Figure 9-31). Eight of the trash-dumping sites were residential, 2 consisted of flotables, and 2 consisted primarily of tires. Figure 9-32 shows the location and severity of each site. Trash dumps are rated as being of very high severity when there is a large amount of trash spread over a very large and inaccessible area. A site is rated as minor if it is a small amount of trash located inside a park with easy access.

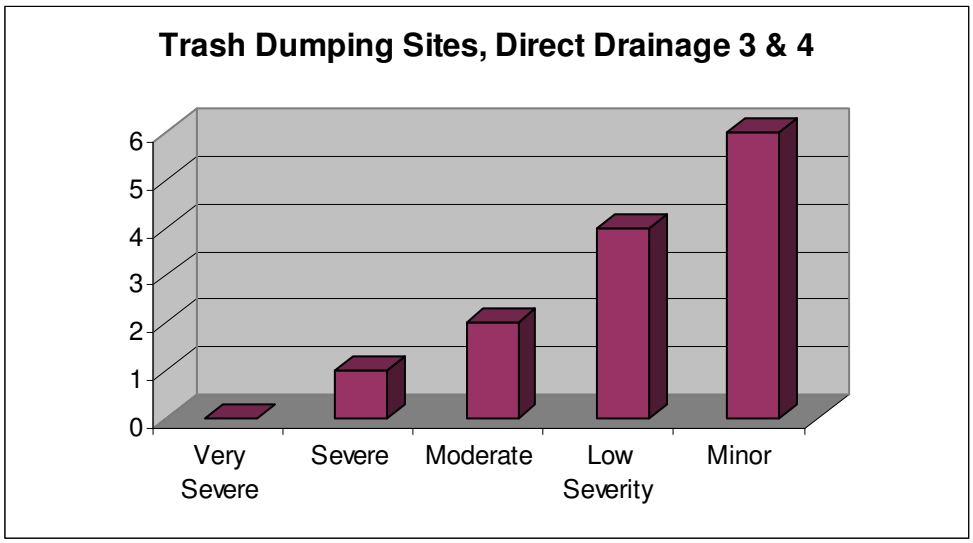


Figure 9-31 Severity Distribution of Sites

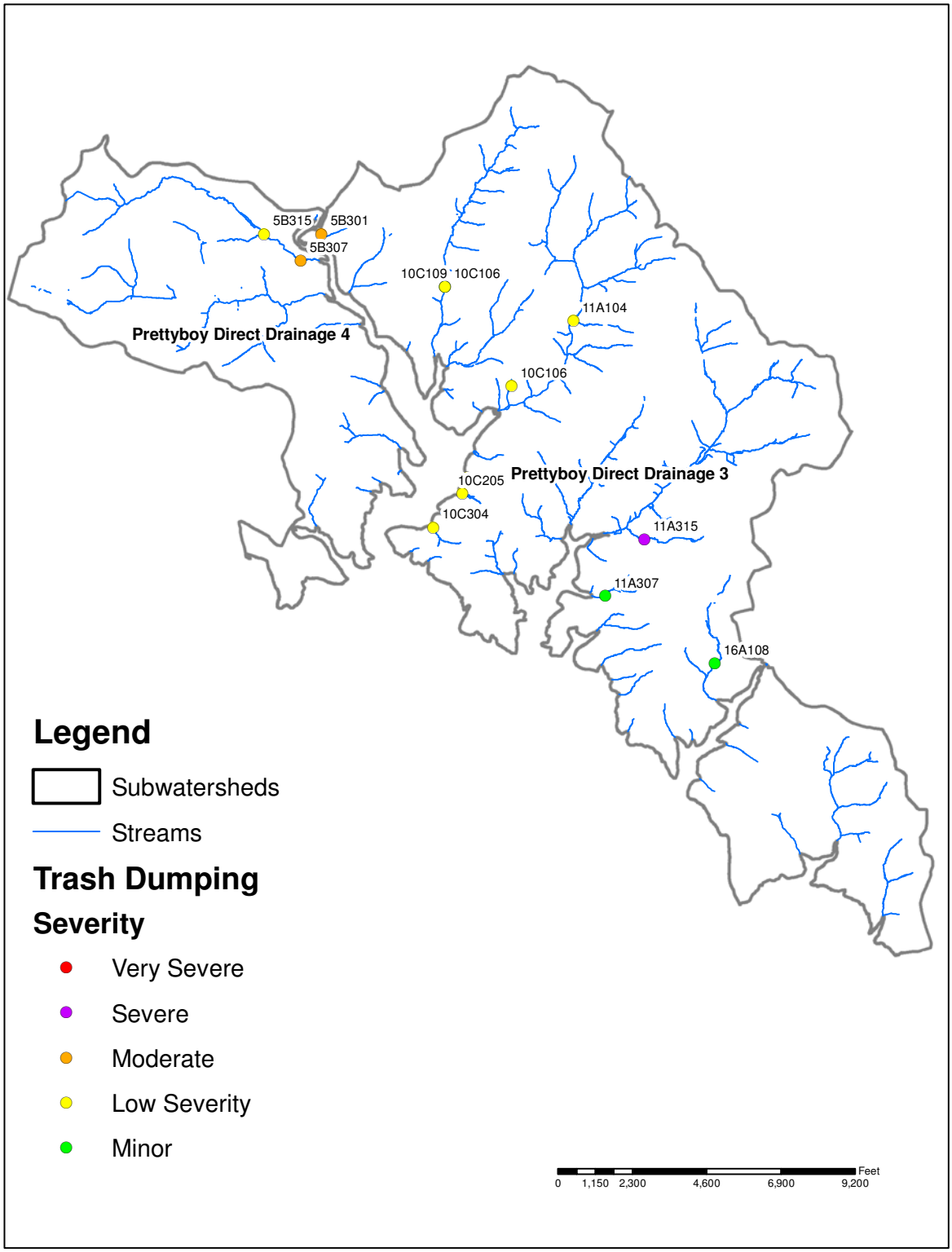


Figure 9-32 Map of Trash Dumping Severity and Location

9.6.5 Summary of Inadequate Buffer

The Baltimore County survey teams identified 12 inadequate buffers in the study area, with a total length of 6,097.1 ft (1.2 miles). This accounted for approximately 5.6% of the 21.4 miles surveyed. The severity distribution of these inadequate buffers is shown in Figure 9-33, and their location and severity are shown in Figure 9-34. While there is no single minimum standard for how wide a stream buffer should be in Maryland, for the purposes of this study a forest buffer is considered inadequate if it is less than 50 feet wide, measured from the edge of the stream. The severity of inadequate forest buffers is based on both the length and width of the site. Those sites over 1,000 feet long with no forest on either side of the stream rank as the most severe. Four of the 12 sites had inadequate buffers on both sides of the stream, while the other 8 were forested on one side. One of the inadequate buffer sites had livestock present, primarily cattle or horses. Livestock in riparian areas are associated with elevated inputs of nutrients and sediment in the associated streams. Land use in the buffers was approximately evenly distributed between forests, lawns and pastures.

Because the inadequate buffer measure is cumulative along the stream segment, the number of inadequate buffers observed is not necessarily the best indication of the level of the problem. One alternative is to examine the most severe potential problems. A ranked order of the severity of potential problems (Figure 9-33) shows 4 in severe, 2 in moderate, 5 in low severity, and 1 in minor.

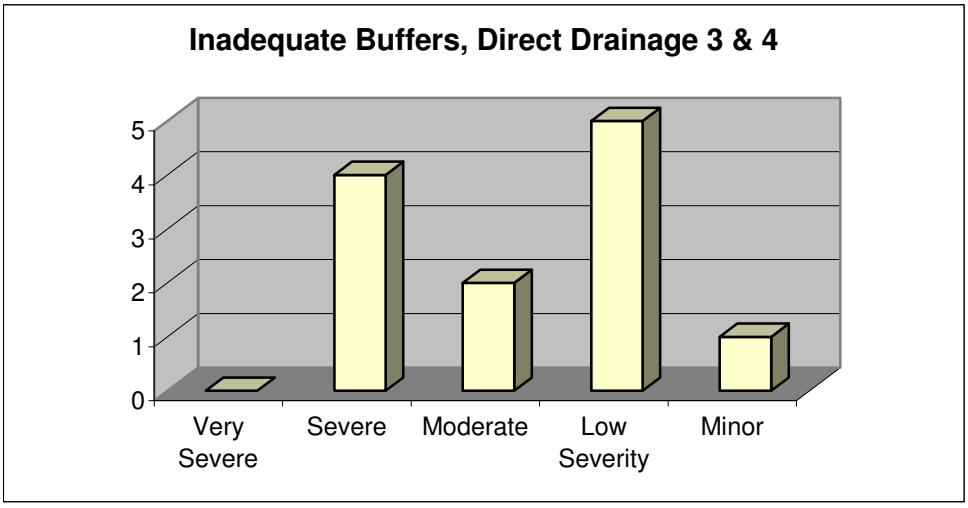


Figure 9-33 Severity Distribution of Sites

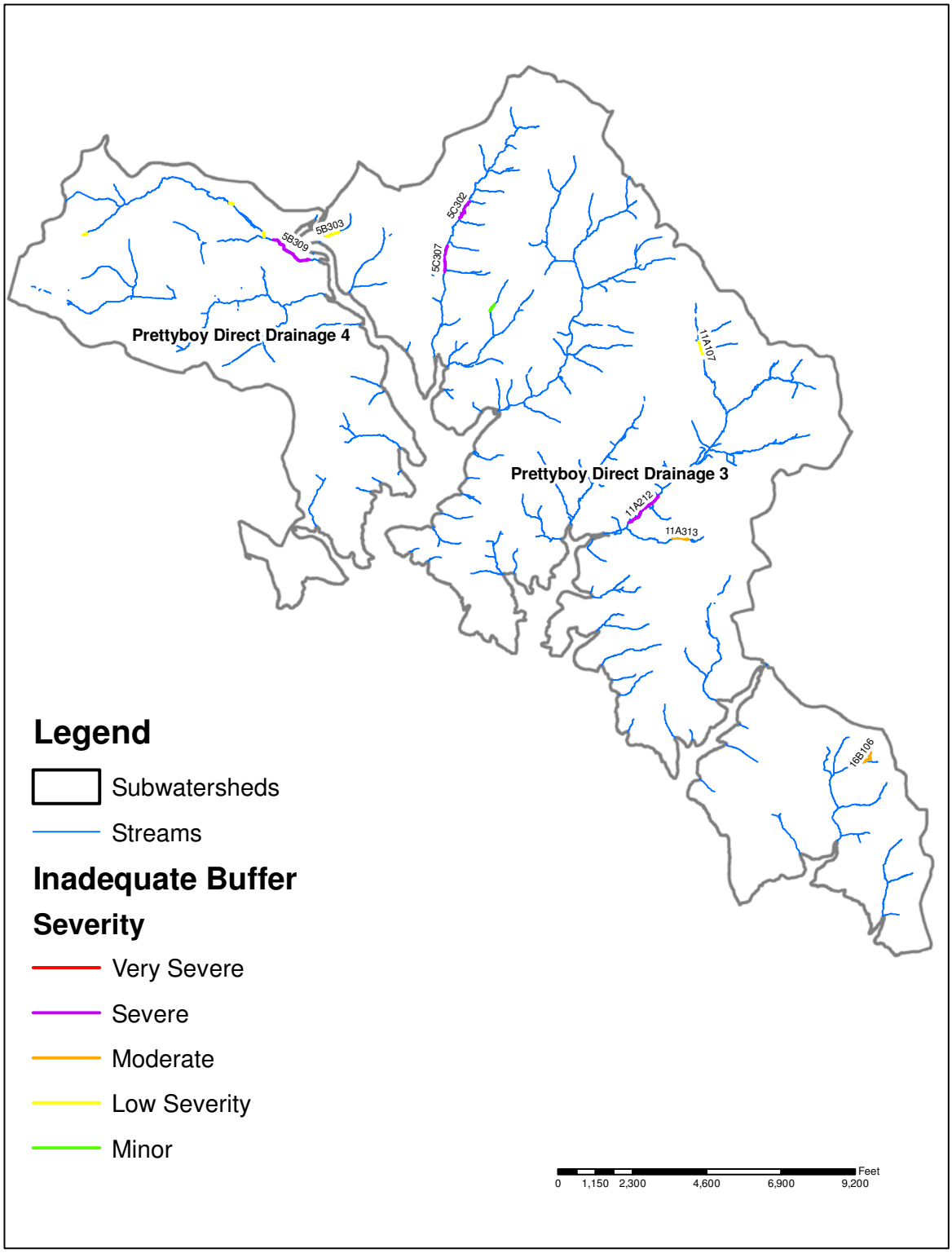


Figure 9-34 Map of Inadequate Buffer Severity and Location

9.6.6 Summary of Unusual Conditions and Comments

The Baltimore County SCA teams documented a total of 8 unusual conditions and comments. The most common unusual conditions were excessive growth of multi-flora rose, found at 5 sites, and mowed riparian areas, documented at 2 sites. Figure 9-35 shows the severity distribution of the unusual condition sites, and Figure 9-36 shows their location and severity. An unusual condition site was ranked as very severe if the survey crew judged that the potential problem would have a direct and wide-reaching impact on the stream's aquatic resources, and was among the worst that field teams would expect to observe. A site was ranked of minor severity if it was a potential problem that did not appear to have a significant impact on aquatic resources. One site was ranked as being very severe, and four sites were ranked as severe. Field crews also assessed the possible causes for the unusual conditions. In some cases, the causes are apparent. For example, at the sites with excessive multi-flora rose, the cause is most likely due to disturbances such as deer.

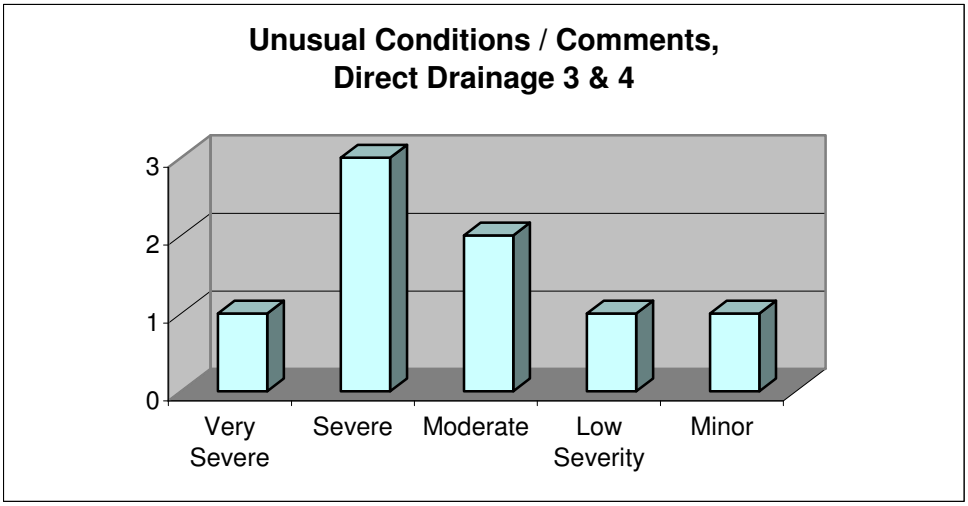


Figure 9-35 Severity Distribution of Sites

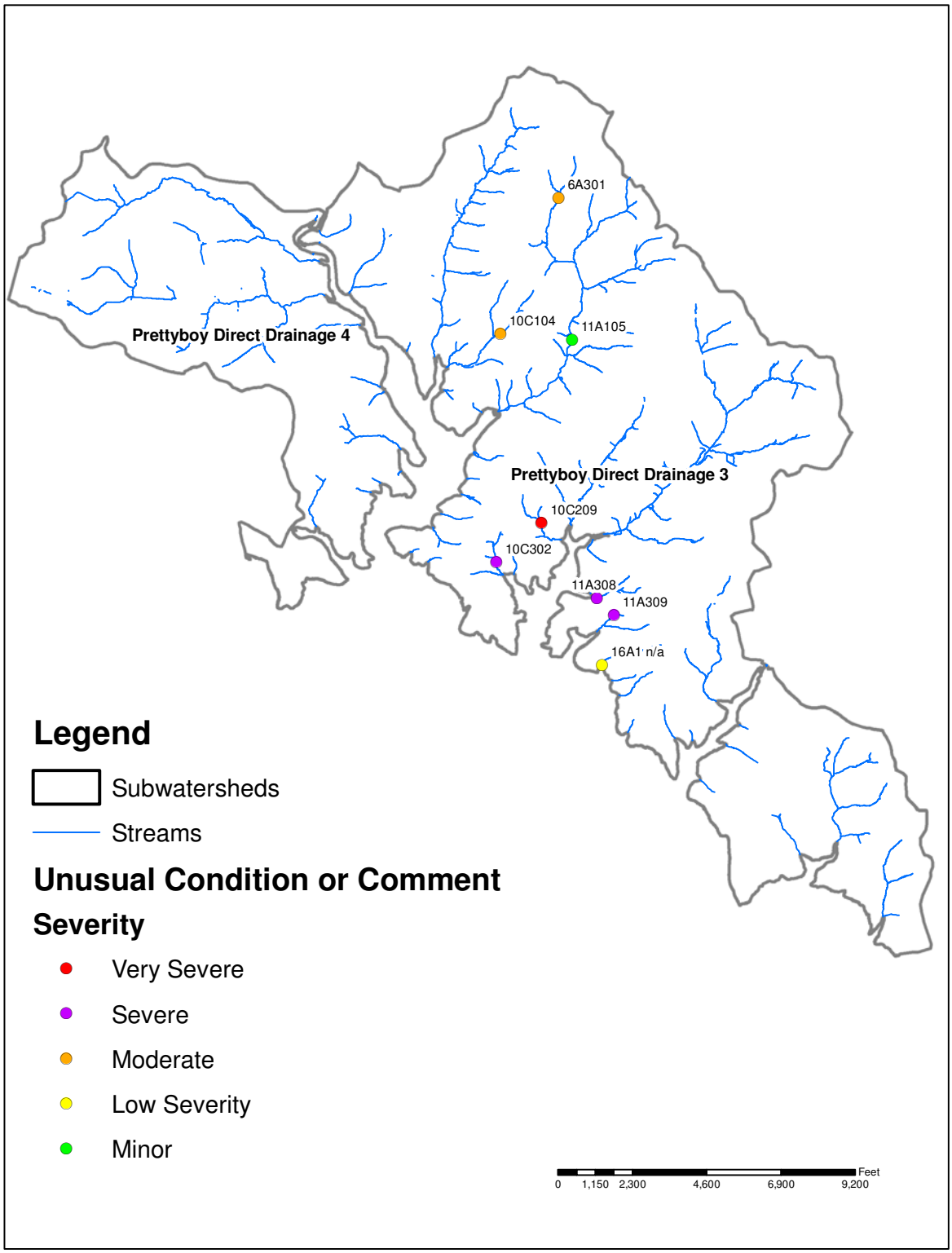


Figure 9-36 Map of Unusual Condition/Comment Severity and Location

9.6.7 Summary of Fish Barrier

The Baltimore County SCA team identified 6 barriers to fish migration. Figure 9-37 shows the severity distribution of these barriers, and figure 9-38 shows their location and severity. Most of these barriers are caused by road crossing culverts that result in water that is too shallow or drops that are too high for fish to pass. Other causes include man-made dams, natural falls, and beaver dams. A fish barrier is rated very severe when it is a structure that totally blocks a large stream or river, and is considered minor when it is a temporary barrier that blocks very little in-stream habitat. Most observed fish barriers were high severity problems with 1 ranking as very severe, 4 as severe, and 1 as low severity.

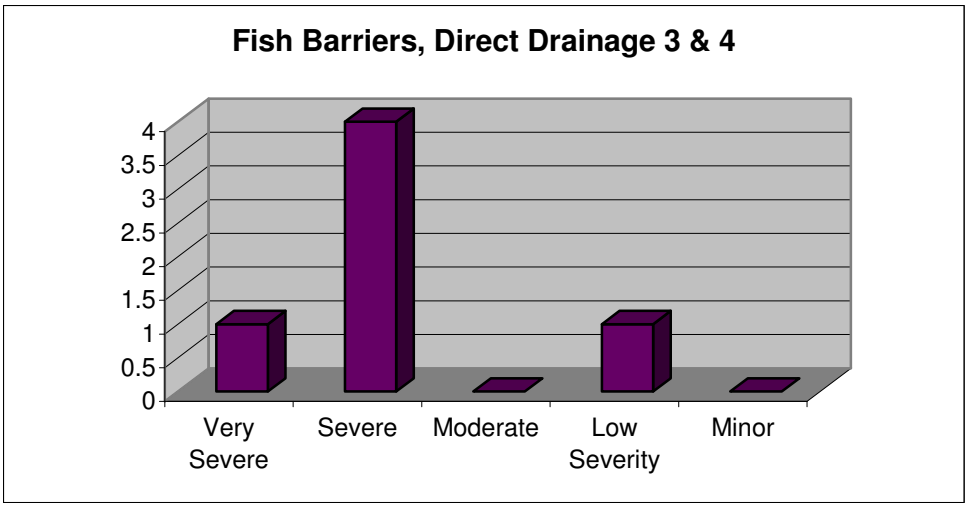


Figure 9-37 Severity Distribution of Sites

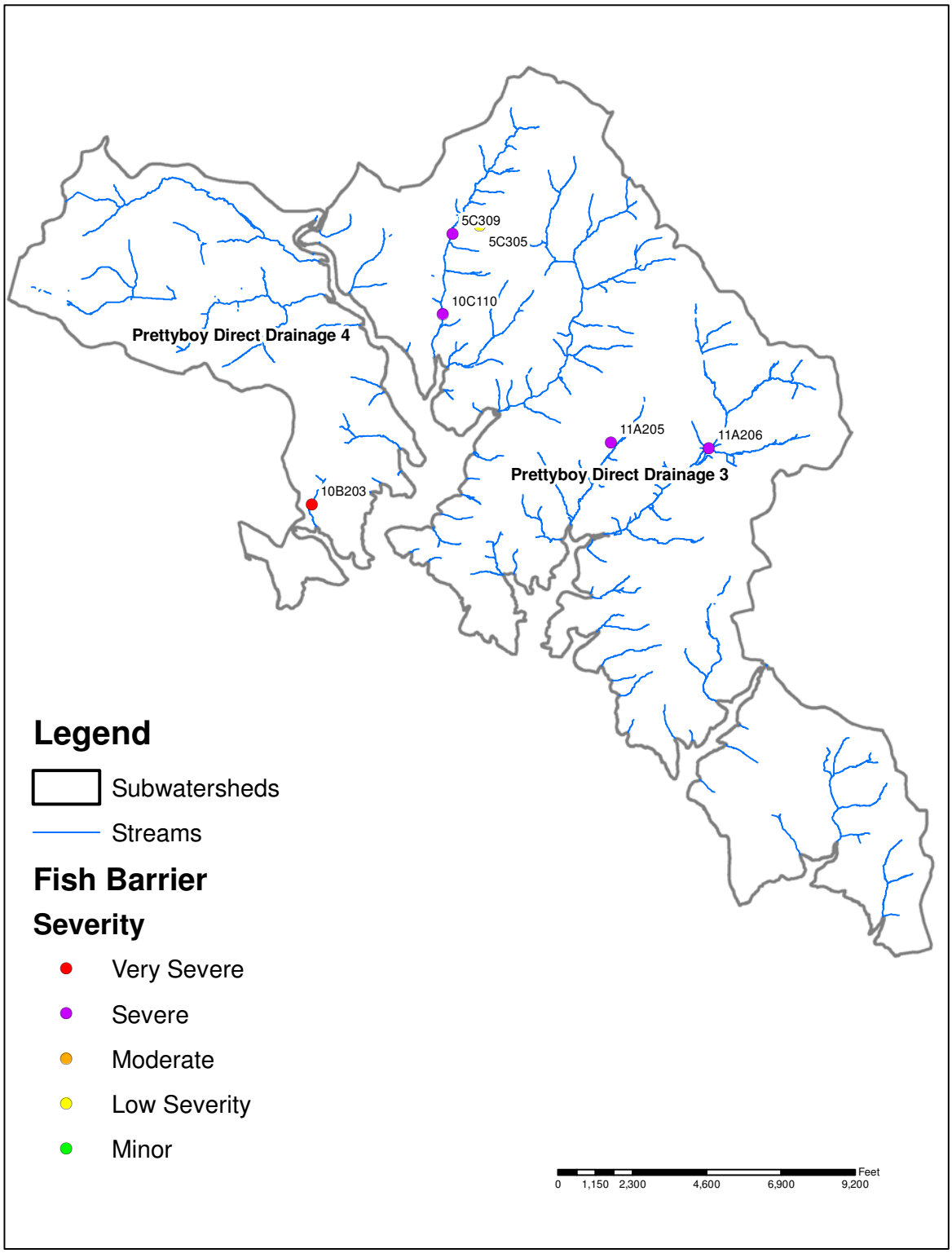


Figure 9-38 Map of Fish Barrier Severity and Location

9.6.8 Summary of Pipe Outfall

Survey crews identified 6 pipe outfalls. The severity distribution of these outfalls is shown in Figure 9-39. Figure 9-40 shows the location and severity of representative pipe outfall sites. The labels on this and all subsequent maps refer to the unique site number assigned to each potential problem. Four of the pipe outfalls had a clear discharge, and 2 had no discharge. A pipe outfall warrants a very severe rating when it has a strong discharge and a distinct color or odor, and a minor rating when it is a storm water outfall with no dry weather discharge. Most of the pipe outfalls serve as pond overflow, and have a moderate to minor severity ranking.

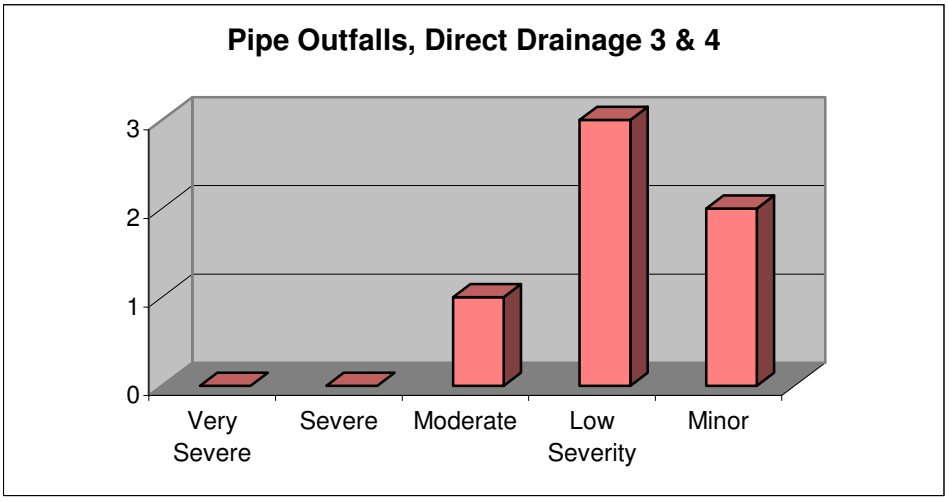


Figure 9-39 Severity Distribution of Sites

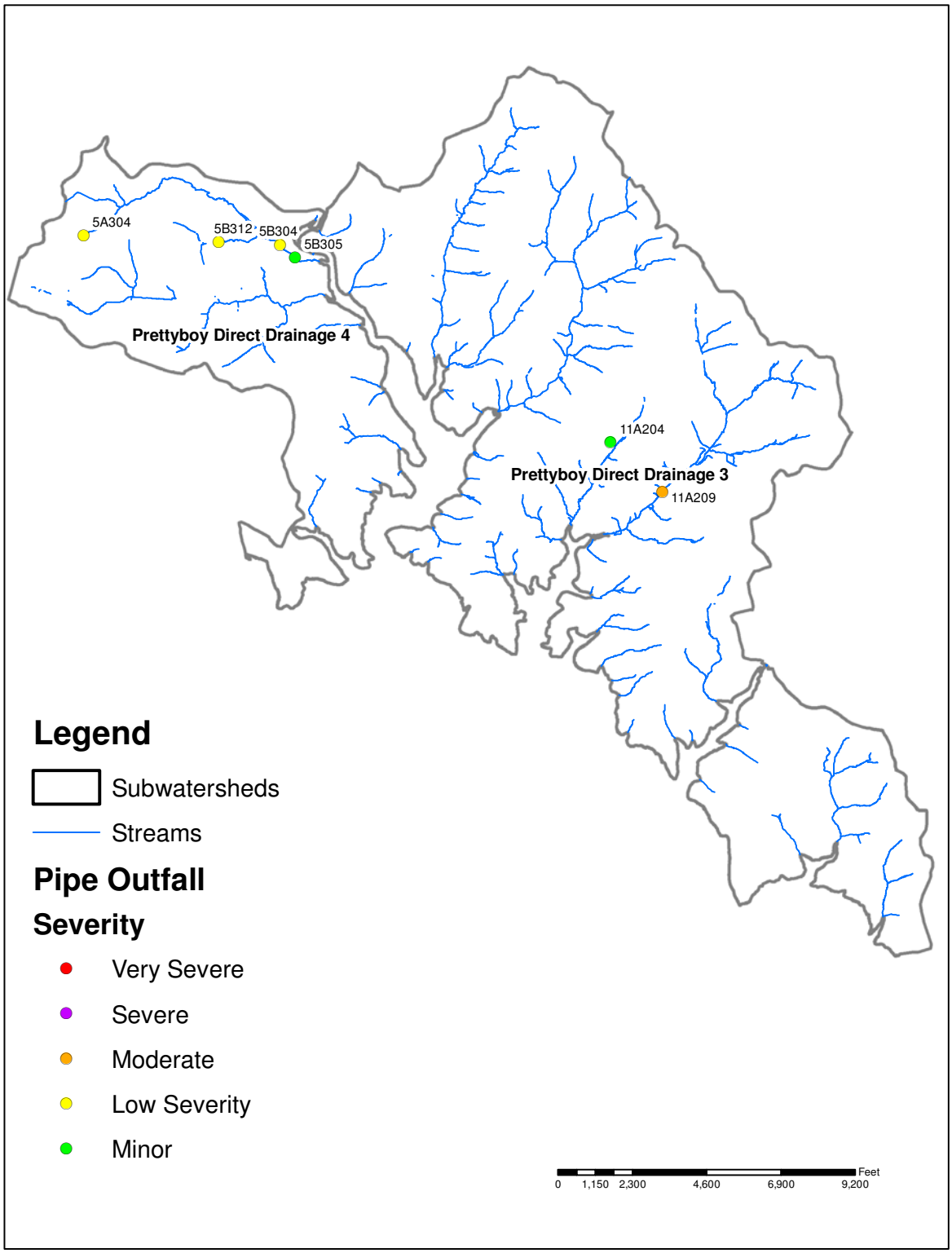


Figure 9-40 Map of Pipe Outfall Severity and Location

9.6.9 Summary of In or Near Stream Construction

The survey team identified only one in-stream construction site, which rated severe because of inadequate sediment control. The severity distribution of the site is shown in Figure 9-41, and figure 9-42 shows its location and severity.

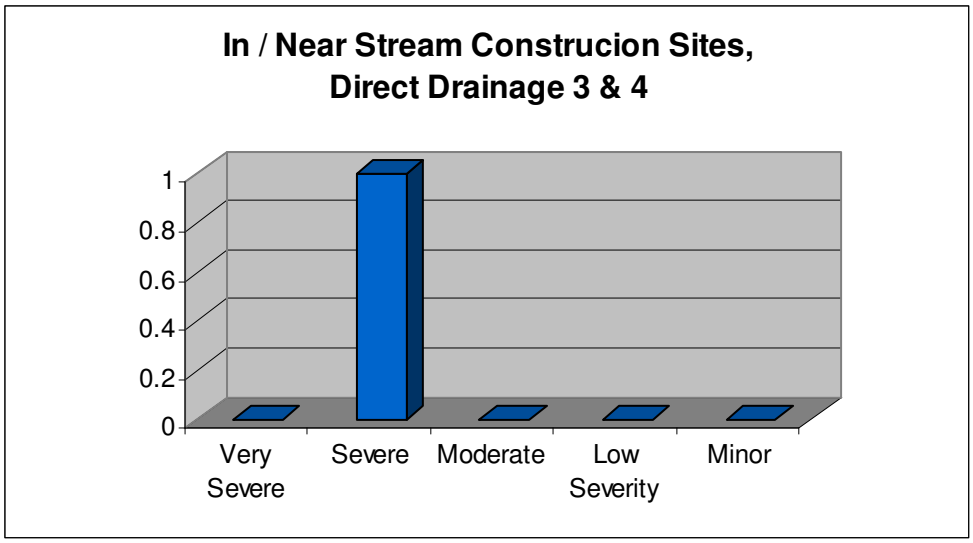


Figure 9-41 Severity Distribution of Sites

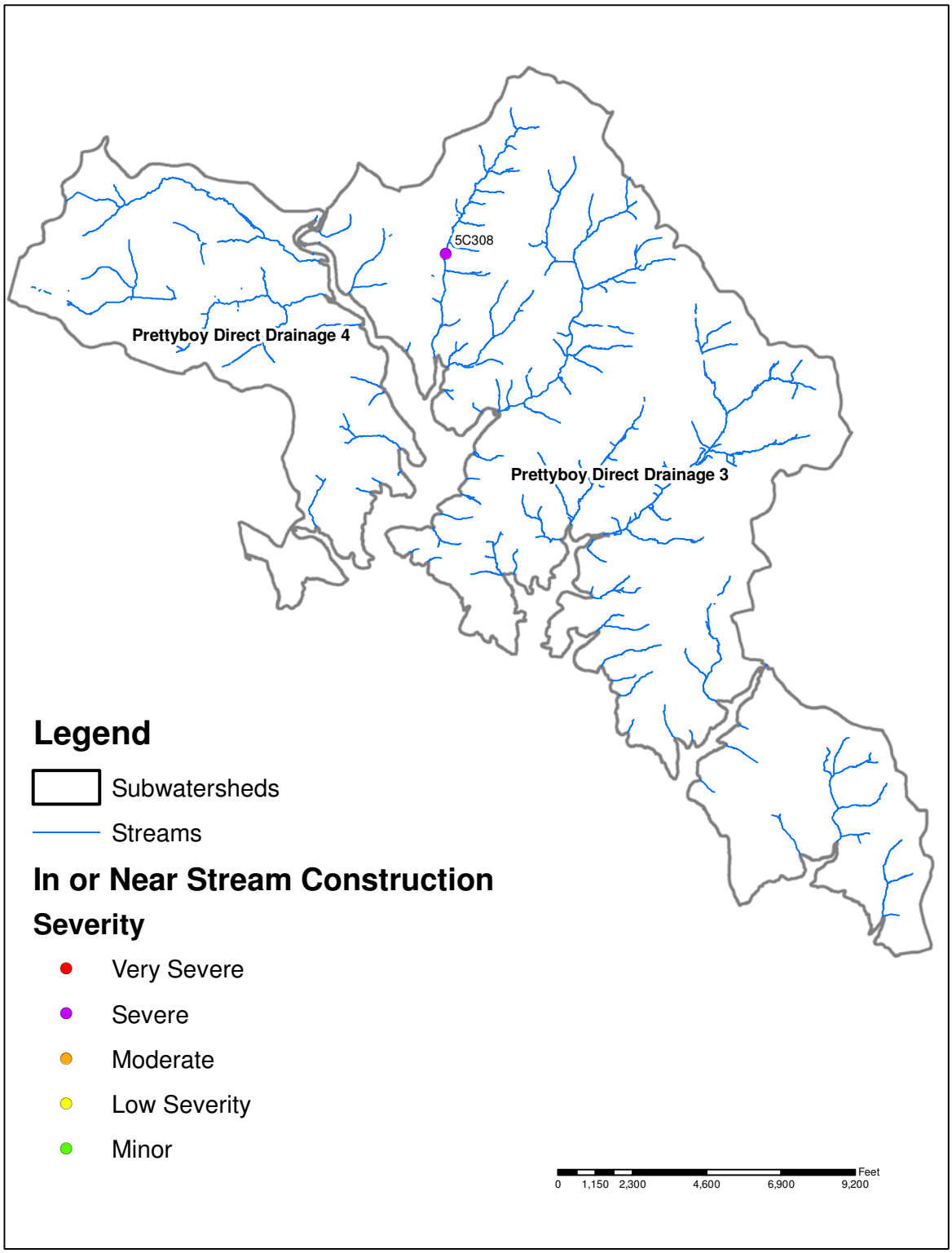


Figure 9-42 Map of In or Near Stream Construction Severity and Location

9.6.10 Summary of Representative Sites

Representative sites are used to document the general condition of both in-stream habitat and the adjacent riparian corridor (including and up to 50 feet beyond the stream bank). The SCA survey's representative site evaluations are based on the habitat assessment procedures outlined in EPA's rapid bioassessment protocols (Plafkin, et. al., 1989), and they are very similar to the habitat evaluations of Maryland Save-Our-Stream's Heartbeat Program. At each representative site, the following 10 separate categories related to stream habitat health are evaluated: Attachment Sites for Macroinvertebrates; Embeddedness; Shelter for Fish; Channel Alteration; Sediment Deposition; Velocity and Depth Regime; Channel Flow Status; Bank Vegetation Protection; Condition of Banks; and Riparian Vegetative Zone Width.

Under each category, field crews base a rating of optimal, suboptimal, marginal or poor on established grading criteria developed to reflect ideal wildlife habitat for rocky bottom streams. In addition to the habitat ratings, teams collect data on the stream's wetted width and pool depths at both runs and riffles at each representative site. Depth measurements are taken along the stream thalweg (main flow channel). At representative sites, field crews also indicate whether the bottom sediments are primarily silt, sand, gravel, cobble, boulder, or bedrock.

Representative sites are located at approximately ½- to one-mile intervals along the stream. Baltimore County survey teams evaluated stream conditions at 60 representative sites. Figure 9-43 shows the location of these sites. Substrate conditions for macroinvertebrates averaged suboptimal, with eight of the sites rating poor. Some sites were moderately embedded by sediment, however, the average embeddedness of all sites was optimal-suboptimal. Shelter conditions for fish showed wide variability, with most sites ranking marginal or poor. It is important to note that many of the streams were small springs and would not normally be expected to have the conditions that would put them in the optimal categories. None of the sites showed channel alteration. Sediment deposition conditions averaged optimal-suboptimal, with very few sites rating poor. Velocity/depth characteristics of the sites averaged marginal, with no sites rating optimal. Channel flow conditions averaged optimal-suboptimal and no sites rated poor. The teams reported no sites with poor stream bank vegetation, and the majority of the sites were optimal. There was some stream bank erosion, and most sites were rated optimal or suboptimal, while only one site rated poor. Riparian vegetation conditions showed mostly optimal conditions, with only 5 sites rating suboptimal or marginal, and none rating poor.

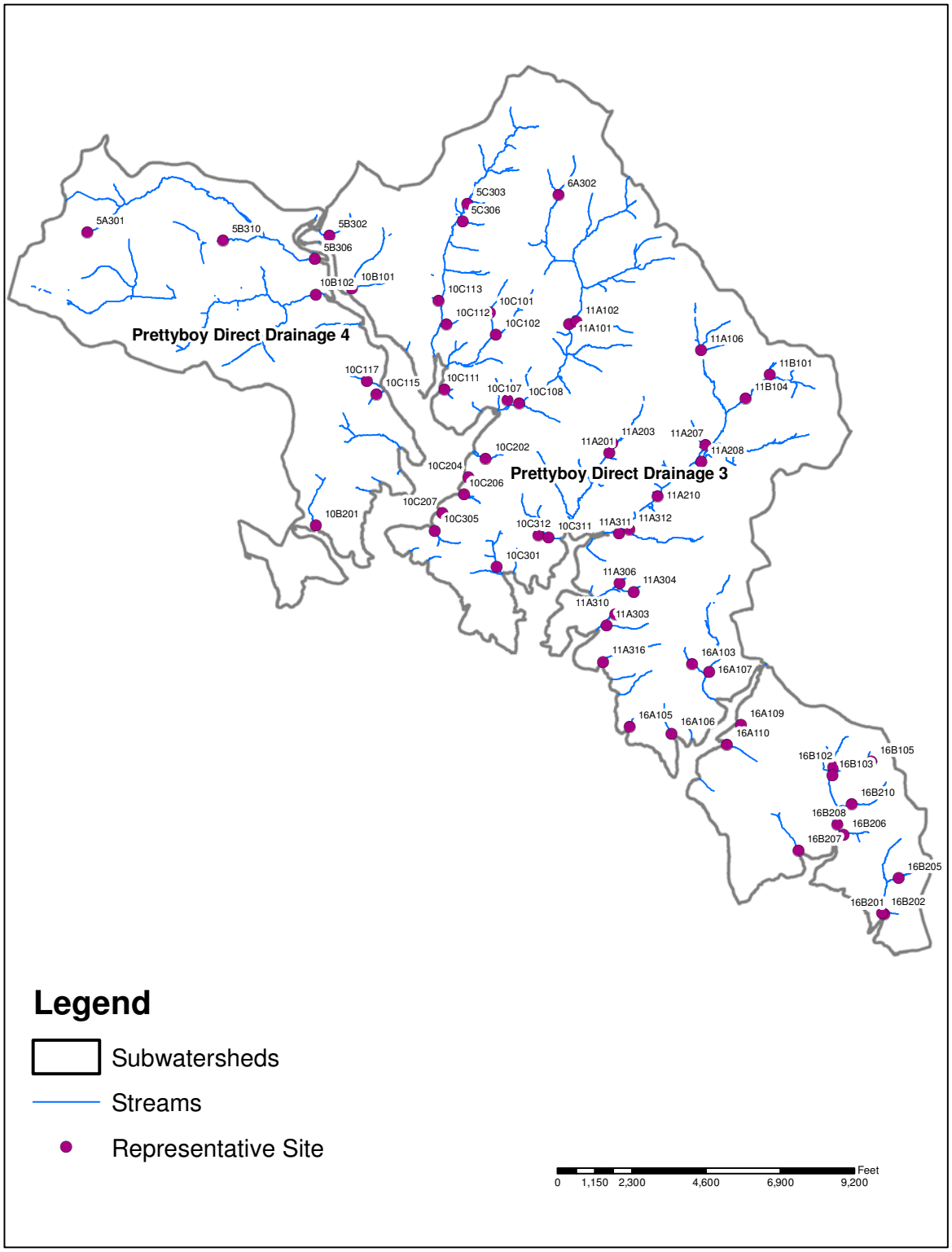


Figure 9-43 Map of Representative Site Locations

9.6.11 Discussion

The results of the Prettyboy Reservoir SCA survey list, summarize, and show the location of the observable environmental problems along the stream corridor network in this watershed. Each potential problem site has a corresponding ranking for severity, correctibility, and access and a photograph of the site. The data from this effort can be used to target future restoration efforts. After this list of potential problem sites is compiled and distributed, county planners, resource managers, and others can initiate a dialog to cooperatively set the direction and goals for the watershed's management and plan future restoration work at specific problem sites. In addition, this data can be combined with other GIS data and local information to prioritize areas for restoration.

Projects can be further targeted to restoring areas where rare or threatened species, gaps in continuous forest or the state's Green Infrastructure, or quality fish and wildlife habitat are found. In addition, sites can be prioritized for restoration based on their location in headwater areas, streams that deposit directly into the Chesapeake Bay, areas of specific local interest, or sites where the surrounding land use is particularly suited to restoration projects. The values of the present survey is its help in placing individual stream problems into their watershed context and its potential common use among resource managers and land-use planners to cooperatively and consistently prioritize future restoration work. Results of the present survey will be given to the Prettyboy Reservoir Watershed WRAS committee, which is in the implementation phase of the Watershed Restoration Action Strategy for the Prettyboy Reservoir.

Table 9-24 Listing of Information by Site

Site	Category	Severity	Correctability	Access
05A301	Representative Site			
05A302	Inadequate Buffer	4	2	1
05A303	Erosion Site	3	4	1
05A304	Pipe Outfall	4	5	1
05B301	Trash	3	2	1
05B302	Representative Site			
05B303	Inadequate Buffer	4	1	1
05B304	Pipe Outfall	5	1	1
05B305	Pipe Outfall	5	1	1
05B306	Representative Site			
05B307	Trash	3	2	1
05B308	Erosion Site	4	3	1
05B309	Inadequate Buffer	2	2	1
05B310	Representative Site			
05B311	Erosion Site	4	3	3
05B312	Pipe Outfall	4	3	2
05B313	Erosion Site	2	4	5
05B314	Inadequate Buffer	4	1	1
05B315	Trash	4	2	1
05B316	Inadequate Buffer	4	1	1
05C301	Erosion Site	4	3	3

05C302	Inadequate Buffer	2	2	1
05C303	Representative Site			
05C304	Erosion Site	4	3	2
05C305	Fish Barrier	4	3	1
05C306	Representative Site			
05C307	Inadequate Buffer	2	3	2
05C308	In or near stream construction	2	n/a	n/a
05C309	Fish Barrier	2	4	1
06A301	Unusual Condition or Comment	3	1	1
06A302	Representative Site			
06A303	Erosion Site	4	3	1
10B101	Representative Site			
10B102	Representative Site			
10B201	Representative Site			
10B202	Erosion Site	3	3	4
10B203	Fish Barrier	1	3	2
10C101	Representative Site			
10C102	Representative Site			
10C103	Erosion Site	4	2	3
10C104	Unusual Condition or Comment	2	3	3
10C105	Inadequate Buffer	5	3	1
10C106	Trash	4	2	2
10C107	Representative Site			
10C108	Representative Site			
10C109	Trash	5	3	2
10C110	Fish Barrier	2	2	2
10C111	Representative Site			
10C112	Representative Site			
10C113	Representative Site			
10C114	Erosion Site	2	5	4
10C115	Representative Site			
10C116	Erosion Site	2	4	5
10C117	Representative Site			
10C201	Erosion Site	4	3	5
10C202	Representative Site			
10C203	Trash	4	2	3
10C204	Representative Site			
10C205	Trash	4	2	3
10C206	Representative Site			
10C207	Representative Site			
10C208	Erosion Site	4	3	2
10C209	Unusual Condition or Comment	1	4	2

10C301	Representative Site			
10C302	Unusual Condition or Comment	2	5	5
10C304	Trash	4	2	3
10C305	Representative Site			
10C311	Representative Site			
10C312	Representative Site			
11A101	Representative Site			
11A102	Representative Site			
11A103	Erosion Site	3	4	3
11A103	Representative Site			
11A104	Trash	4	2	2
11A105	Unusual Condition or Comment	5	1	1
11A106	Representative Site			
11A107	Inadequate Buffer	4	2	1
11A201	Representative Site			
11A202	Erosion Site	4	3	4
11A203	Representative Site			
11A204	Pipe Outfall	5	1	3
11A205	Fish Barrier	2	4	1
11A206	Fish Barrier	2	1	1
11A207	Representative Site			
11A208	Representative Site			
11A209	Pipe Outfall	3	4	5
11A210	Representative Site			
11A211	Erosion Site	1	5	5
11A212	Inadequate Buffer	2	2	1
11A301	Erosion Site	2	4	5
11A302	Erosion Site	4	2	5
11A304	Erosion Site	4	2	4
11A304	Representative Site			
11A305	Erosion Site	4	3	5
11A306	Representative Site			
11A307	Trash	5	1	1
11A308	Unusual Condition or Comment	2	3	1
11A309	Unusual Condition or Comment	2	5	5
11A310	Representative Site			
11A311	Representative Site			
11A312	Representative Site			
11A313	Inadequate Buffer	3	3	5
11A314	Erosion Site	1	5	5
11A315	Trash	2	4	5
11B101	Representative Site			

11B102	Erosion Site	4	3	5
11B103	Erosion Site	1	5	5
11B104	Representative Site			
16A101	Representative Site			
16A102	Representative Site			
16A103	Representative Site			
16A104	Erosion Site	4	2	5
16A105	Representative Site			
16A106	Representative Site			
16A107	Representative Site			
16A108	Trash	5	1	5
16A109	Representative Site			
16A110	Representative Site			
16A1n/a	Unusual Condition or Comment	4	1	5
16B101	Erosion Site	4	4	5
16B102	Representative Site			
16B103	Representative Site			
16B104	Erosion Site	4	2	2
16B105	Representative Site			
16B106	Inadequate Buffer	3	3	1
16B201	Representative Site			
16B202	Representative Site			
16B203	Erosion Site	3	4	5
16B204	Erosion Site	4	3	5
16B205	Representative Site			
16B206	Representative Site			
16B207	Representative Site			
16B208	Representative Site			
16B209	Erosion Site	4	3	5
16B210	Representative Site			

Table 9-25 Listing of Sites by Problem Category

Erosion Sites

Site	Type	Possible Cause	Length (ft)	Height (ft)	Land use left	Land use right	Infrastructure Threatened?	Severity	Correctability	Access
05A303	Widening	pond	60	2	Lawn	Lawn	No	3	4	1
05B311	Widening	Land use change upstream	1000	2.5	Forest	Forest	No	4	3	3
05B308	Widening	unknown	900	3	Forest	Lawn	No	4	3	1
05B313	Widening	unknown	2600	3.75	Forest	Forest	No	2	4	5
05C301	Widening	unknown	1000	2.75	Forest	Forest	No	4	3	3
05C304	Widening	unknown	650	2.5	Forest	Forest	No	4	3	2

06A303	Widening	Land use change upstream	740	2	Lawn	Lawn	No	4	3	1
10B202	Widening	Land use change upstream	630	4	Forest	Forest	No	3	3	4
10C103	Widening	Unknown	160	4	Forest	Forest	No	4	2	3
10C114	Widening	Land use change upstream	2500	2.25	Forest	Forest	No	2	5	4
10C116	Widening	unknown	600	2	Forest	Forest	No	2	4	5
10C201	Widening	unknown	600	2.75	Forest	Forest	No	4	3	5
10C208	Downcutting	unknown	575	3	Multiflora Rose	Multiflora Rose	No	4	3	2
11A103	Widening	Land use change upstream	1300	5.5	Forest	Forest	No	3	4	3
11A211	Widening	Land use change upstream	2900	3	Forest	Forest	No	1	5	5
11A202	Widening	unknown	625	2	Forest	Forest	No	4	3	4
11A301	Widening	Land use change upstream	1400	6	Forest	Forest	No	2	4	5
11A302	Widening	drainage from road?	500	3.25	Forest	Forest	No	4	2	5
11A304	Headcutting	Drainage from road?	20	5	Forest	Forest	No	4	2	4
11A35	Widening	unknown	400	2	Forest	Forest	No	4	3	5
11A314	Widening	unknown	2000	3	Forest	Forest	No	1	5	5
11B103	Widening	unknown	1900	4.5	Forest	Forest	No	1	5	5
11B102	Widening	Land use change upstream	150	3.5	Forest	Forest	No	4	3	5
16A104	Widening	Unknown	900	2.5	Forest	Forest	No	4	2	5
16B104	Widening	unknown	200	1.75	Forest	Forest	No	4	2	2
16B101	Widening	Land use change upstream	975	3	Forest	Forest	No	4	4	5
16B204	Widening	Pond at headwaters	528	3.25	Forest	Forest	No	4	3	5
16B203	Widening	Other	1600	3	Forest	Forest	No	3	4	5
16B209	Widening	Land use change upstream	325	4	Forest	Forest	No	4	3	5

Trash Dumping Sites

Site	Type	Truckloads	Other measure	Extent	Volunteer Project?	Owner Type	Owner Name	Severity	Correctability	Access
05B301	Yard waste, Tires	9		Single Site	Yes	Public	Prettyboy Reservoir	3	2	1

05B307	Residential	4.5		Large Area	Yes	Public	Prettyboy Reservoir	3	2	1
05B315	Residential	2		Single Site	Yes	Public	Prettyboy Reservoir	4	2	1
10C106	Residential	3.5		Single Site	Yes	Private		4	2	2
10C109	Residential	0.25		Single Site	No	Private		5	3	2
10C203	Floatables		4.5 trash bags	Single Site	Yes	Public	Prettyboy Reservoir	4	2	3
10C205	Floatables		5 trash bags	Single Site	Yes	Public	Prettyboy Reservoir	4	2	3
10C304	Residential	1		Single Single	Yes	Public	Prettyboy Reservoir	4	2	3
11A104	Residential	0.125		Single Site	Yes	Private		4	2	2
11A307	Residential	1		Single Site	Yes	Public	Prettyboy Reservoir	5	1	1
11A315	Tires	1		Large Area	Yes	Private		2	4	5
16A108	Residential	1		Single Site	Yes	Public	Prettyboy Reservoir	5	1	5

Inadequate Buffers

Site	Sides	Unshaded	Width Left (ft)	Width Right (ft)	Length Left (ft)	Length Right (ft)	Land Use Left	Land Use Right	Recently established	Livestock	Severity	Correctability	Access	Wetland
05A302	Left	Right		0		150	Forest	Lawn	No	No	4	2	1	3
05B309	Right	Neither		10		1400	Forest	Lawn	No	No	2	2	1	5
05B303	Left	Neither	17		440		Lawn	Forest	No	No	4	1	1	5
05B316	Left	Left			150		Lawn	Forest	No	No	4	1	1	4
05B314	Both	Both	0	0	150	150	Lawn	Lawn	No	No	4	1	1	3
05C302	Both	Neither	20	20	550	550	Forest	Forest	No	No	2	2	1	3
05C307	Both	Neither	5	7	750	750	Pasture	Pasture	No	No	2	3	2	3
10C105	Right	Neither		13.5		160	Forest	Lawn	No	No	5	3	1	4
11A107	Right	Right		10		295	Other	Other	No	No	4	2	1	1
11A212	Both	Both	5	5	800	550	Lawn	Lawn	Yes	No	2	2	1	3
11A313	Right	Right		6.5		450	Forest	Lawn	No	No	3	3	5	5
16B106	Right	Right		12.5		500	Forest	Lawn	No	No	3	3	1	3

Unusual Conditions

Site	Type	Description	Potential Cause	Severity	Correctability	Access
06A301	Comment	Stream has some mature trees, but stream is unshaded partly & owner mows around trees to edge of stream. Kept as lawn.		3	1	1
10C104	Unusual Condition	Excessive multiflora		2	3	3
10C209	Unusual Condition	EXCESSIVE multiflora & invasive vines. Smothering all other vegetation.		1	4	2
10C302	Unusual Condition	Excessive multi-flora rose and excessive stilt grass.	Invasive species and deer.	2	5	5

11A105	Comment	A few mature trees present, area around them is kept as lawn.		5	1	1
11A308	Unusual Condition	Excessive growth of multi-flora rose that is blocking a path to the stream.	Invasive species.	2	3	1
11A309	Unusual Condition	Excessive multi-flora rose and excessive stilt grass.	Invasive species and deer.	2	5	5
16A1n/a	Comment	Excessive amount of bottles floating at bottom of stream where it meets the reservoir.	Trash could be from the reservoir or could have floated down from the road.	4	1	5

Fish Barriers

Site	Blockage	Type	Reason	Drop (In)	Depth (In)	Severity	Correctability	Access
05C305	Total	Road crossing	Too high	15		4	3	1
05C309	Total	Road crossing	Too high	7		2	4	1
10B203	Total	Pipe crossing	Too shallow		2	1	3	2
10C110	Total	Dam	Too high	14		2	2	2
11A205	Total	Road crossing	Too high	7		2	4	1
11A206	Total	Other	Too shallow		0.25	2	1	1

Pipe Outfalls

Site	Outfall Type	Pipe Type	Location of Pipe	Diameter (in)	Discharge	Color	Odor	Severity	Correctability	Access
05A304	Pond Overflow	Smooth Metal Pipe	Head of stream	8	Yes	Clear	None	4	5	1
05B312	Pond Outfall	Corrugated Metal	Head of stream	15.6	Yes	Clear	None	4	3	2
05B304	Stormwater	Concrete Pipe	Right Bank	18	No			5	1	1
05B305	Stormwater	Concrete Pipe	Right bank	19.2	No			5	1	1
11A204	pond	Smooth Metal Pipe	Head of stream	6	Yes	Clear	None	5	1	3
11A209	unknown - old drainage?	Smooth Metal Pipe	Right bank	3	Yes	Clear	None	3	4	5

In or Near Stream Construction

Site	Type of Activity	Sediment Control	Why, if inadequate	Excess Sediment?	Length	Company	Location	Severity
05C308	Other	Inadequate	None, sediment fence is absent.	No	10	n/a	property on cotter	2

Representative Sites

Site	Subst-rate	Embed-dedness	Shelter for Fish	Channel Alteration	Sediment Deposition	Velocity/ Depth	Flow	Veget-ation	Bank Condition	Riparian Vegetation	Width Riffle	Width Run	Width Pool	Depth Riffle	Depth Run	Depth Pool	Bottom Type
05A301	2	2	1	3	2	1	3	2	2	2	50.4	43.2		3	3.6		Sand
05B302	3	2	2	3	3	2	3	2	3	2	24	43		1.5	2.25		Sand
05B310	3	2	0	3	2	1	3	3	1	3	72			4.5			Sand
05B306	3	2	1	3	0	1	1	2	2	3	72	55		4.5	6.5		Cobble
05C303	2	2	1	3	1	1	3	3	3	3	55		42	4		5	Gravel
05C306	2	2	0	3	3	1	3	3	2	3	43	18		2.5	2		Sand
06A302	2	1	2	3	1	1	3	2	1	2	67	64		2	4.5		Silt
10B101	3	3	2	3	3	2	3	3	2	3	54	48		3	3.5		Boulder
10B102	3	2	3	3	3	2	3	3	3	3	80.4	136.8	144	5.4	4.8	10.8	Gravel
10B201	2	2	1	3	2	1	2	2	2	3	32	40		1	4		Sand
10C117	2	2	2	3	2	1	3	3	2	3	57.6			1.08			Sand
10C113	2	2	1	3	3	1	2	3	3	3	50	56		2	2		Gravel
10C101	2	3	1	3	3	1	3	3	2	1	67		72	2		54	Boulder
10C102	2	2	3	3	2	1	3	3	1	3	69			3			Boulder
10C107	0	1	0	3	2	1	1	3	3	3	9.5	6		0.75	1		Gravel
10C108	3	3	3	3	1	1	3	3	2	3	132	116	67	7	7	11	Boulder
10C111	1	2	0	3	2	0	1	3	3	3		24			1.8		Sand
10C112	2	3	1	3	3	1	2	3	3	3	30	2.9		2	1		Gravel
10C115	2	2	1	3	3	1	3	3	3	3	31.2			0.6			Sand
10C204	2	3	1	3	3	1	3	3	3	3							
10C206	1	3	1	3	3	1	3	3	3	3	34			2			Sand
10C202	3	3	2	3	3	1	3	3	3	3	33			0.75			Sand
10C207	3	3	1	3	3	1	3	3	3	3		27			2		Sand
10C312	2	2	2	3	2	1	2	1	1	3	26			1			Silt
10C311	1	1	2	3	1	1	3	2	3	3	19			1.5			Silt
10C301	2	1	2	3	1	2	3	3	3	3	30	30		1.5	2.5		Sand
10C305	0	1	0	3	2	1	3	3	3	3	18	30		0.75	1.5		Sand
11A103	2	3	0	3	3	1	3	3	1	3	31	36	47	2.25	1.5	8.5	Gravel
11A101	3	1	2	3	2	1	3	3	2	3	130	130		7	9		Cobble
11A102	1	2	1	3	3	1	3	3	2	3	29	42		2	3		Gravel
11A106	0	1	0	3	3	1	3	1	3	1		24			12		Silt
11A207	2	2	1	3	2	1	2	3	2	3	13.2		55.2	1.5		6	Gravel
11A208	1	0	2	3	1	1	2	3	2	3	27.4			2			Silt
11A210	2	1	2	3	1	2	3	3	2	3	150.5			5			Gravel
11A201	3	3	2	3	3	1	3	3	3	3	70			1.5			Gravel
11A203	2	2	1	3	2	1	3	3	3	3	43	26		2	4.25		Silt
11A312	2	2	1	3	2	1	3	3	1	3	61	45		2	4		Gravel
11A311	2	3	2	3	3	2	3	3	1	3	68	59		5	8		Gravel
11A310	1	2	1	3	2	1	2	3	2	3	25	24		2.5	2.5		Sand
11A304	2	3	1	3	3	1	2	2	3	3	39			1.5			Sand
11A306	2	2	1	3	3	1	2	2	3	3	46	35		1	3		Sand
11B104	2	2	1	3	2	1	2	3	0	3	75.2	75.2		3	3		Gravel
11B101	1	2	0	3	2	1	2	2	1	3	55.2		81.6	1.5		4.5	Gravel
16A101	3	2	2	3	2	1	3	3	3	3	39	22	44	3.25	3.5	4.5	Gravel

16A102	1	0	0	3	0	1	2	3	3	3	36	48		2.5	2.5		Sand
16A103	2	3	0	3	3	1	3	3	3	3	45			2.5			Sand
16A105	2	3	0	3	3	1	2	3	3	3	31	17		3	4		Sand
16A106	1	3	0	3	3	1	2	3	3	3	21	17		2	3		Sand
16A107	2	2	1	3	3	1	2	3	3	3	43.5	42	50	4	7	10	Sand
16A109	3	3	1	3	3	1	3	3	3	3	37			2.5			Gravel
16A110	3	2	2	3	1	1	3	3	2	3	33	23		2	3		Gravel
16B105	0	3	0	3	3	0	3	2	2	3		31.2			2		Gravel
16B103	1	2	1	3	2	1	3	3	3	3	78	50.4		3.5	3.75		Gravel
16B102	0	3	1	3	2	1	2	3	3	3		34.4			4		Gravel
16B210	2	2	2	3	3	1	3	2	2	3	18.2	68.6	80.5	2	2.5	10.5	Gravel
16B208	3	2	1	3	3	1	3	3	3	3	62.4	103		4.5	5		Gravel
16B201	0	1	0	3	2	1	3	3	3	3	13	28		2	2		Sand
16B202	1	0	1	3	1	1	3	3	3	3	44	61	64	2	2.5	8.25	Gravel
16B205	0	0	1	3	1	1	3	3	3	3	31	22		1.5	2		Sand
16B206	0	1	1	3	1	1	3	3	3	3	12	17		1	2.5		Gravel
16B207	1	1	1	3	1	1	3	3	3	3	30	34.8		1.75	2.25		Sand

Appendix 9-1: Baseflow Monitoring Sites by Watershed

Site ID	Subwatershed	Site ID	Subwatershed
Liberty Reservoir – 6 Sites			
LI-01	Cliffs Branch	LI-09	Timber Run
LI-02	Glen Falls Run	LI-10	Locust Run
LI-03	Keysers Run		
LI-04	Norris Run		
Patapsco River – 5 Sites			
PA-04	Ben's Run	PA-12	Brice Run
PA-06	Cooper Branch	PA-13	West Branch
PA-09	Soapstone Branch		
Gwynns Falls – 6 Sites			
GW-01	Gwynns Falls – Glyndon	GW-05	Horsehead Branch
GW-03	Holly Branch	GW-07	Gwynn's Falls Trib.
GW-04	Red Run	GW-10	Dead Run – Mainstem
Jones Falls – 8 Sites			
JF-01	Western Run	JF-08	Shaughterhouse Run
JF-04	Dipping Pond Run	JF-09	Moores Run
JF-05	Deep Run	JF-10	Towson Run
JF-07	Roland Run	JF-11	Jones Falls
Back River – 10 Sites			
HR-01	West Branch – Herring Run	BR-02	Brians Run
HR-02	West Branch – Herring Run	BR-03	Redhouse Run
HR-03	East Branch – Herring Run	BR-04	Redhouse Run
HR-04	East Branch – Herring Run	BR-05A	Stemmers Run
BR-01	Bread and Cheese Creek	BR-06	Stemmers Run
Deer Creek – 4 Sites			
DC-01	Harris Mill	DC-03	Deer Creek – mainstem
DC-02	Ebaughs Creek	DC-04	Plumtree Branch
Prettyboy Reservoir – 8 Sites			
PR01	Walker Run	PR05A	Prettyboy Branch (Left facing US)
PR02	Gunpowder Falls above Prettyboy	PR05B	Prettyboy Branch (Right)
PR03	Grave Run	PR06	Frog Hollow Run
PR04	George's Run		

Loch Raven Reservoir – 32 Sites			
LR-02	Fitzhugh Run	LR-23	Charles Run
LR-03	Dulaney Valley Branch	LR-24	Little Falls
LR-10 (LQ3)	Long Quarter Branch	LR-27	Third Mine Branch
LR-13 (BR1)	Beaver Dam Run – York Road	LR-28	Owl Branch
LR-14	Baisman Run	LR-30	Beetree Run
LR-15	Beaver Dam Run – Rises Court	LR-31	Mingo Branch
LR-17 (WR1)	Western Run	LR-32	Black Rock Run – Western Run
LR-18	Green Branch	LR-34	McGill Run
LR-19 (OR1)	Overshot Run	LR-35	Piney Run
LR-20	Carroll Branch	LR-36	Piney Run
LR-21	Piney Creek	LR-38	Delaware Run
LR-22 (GF1)	Gunpowder Falls - Glencoe		
Lower Gunpowder Falls – 7 Sites			
GU-01	Bean Run	GU-06	Cowen Run
GU-03	Haystack Branch	GU-07	Jennifer Branch
GU-04	Long Green Creek – Hydes Rd.	GU-08	Minebank Run
GU-05	Long Green Creek – Hartley Mill		
Little Gunpowder Falls – 7 Sites			
LG-01	Nelson Branch	LG-05	Little Gunpowder Falls
LG-02	Parker Branch	LG-07	Little Gunpowder Falls
LG-03	Sawmill Branch	LG-09	Frannklinville Channel.
LG-04	Little Gunpowder Falls		
Bird River – 5 Sites			
BI-01	Windlass Run	BI-04	North Fork
BI-02	Honeygo Run	BI-05	Whitemarsh Run – Mainstem
BI-03	Whitemarsh Run - Headwaters		

Appendix 9-2: Baseflow Water Quality Data by Site

Site	Pollutant Parameter					
	pH			TSS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Deer Creek						
DC-01	7.48	3	0.15	1.0	3	0.9
DC-02	7.14	3	0.07	1.7	3	2.0
DC-03	7.17	3	0.45	3.7	3	5.5
DC-04	6.81	3	0.17	2.3	3	3.2
Prettyboy Reservoir						
PR-01	6.33	3	0.29	1.0	3	0.9
PR-02	6.63	4	0.48	0.5	4	0.0
PR-03	6.38	4	0.25	0.5	4	0.0
PR-04	6.25	4	0.29	0.5	4	0.0
PR-05A	6.50	3	0.50	1.0	3	0.9
PR-05B	6.83	3	1.04	0.5	3	0.0
PR-06	6.67	3	0.58	0.5	3	0.0
Loch Raven Reservoir						
LR-02	7.39	3	0.49	0.5	3	0.0
LR-03	7.56	3	0.49	19.0	3	32.0
LR-10	7.93	3	0.34	0.5	3	0.0
LR-13	7.89	3	0.47	1.0	3	0.9

LR-14	6.92	3	0.39	3.7	3	5.5
LR-15	6.84	3	0.49	0.5	3	0.0
LR-17	7.26	5	0.40	7.0	5	8.9
LR-18	7.29	4	0.35	0.5	4	0.0
LR-19	6.90	4	0.29	0.9	4	0.8
LR-20	6.92	4	0.27	6.9	4	12.8
LR-21	7.73	4	0.28	1.9	4	2.8
LR-22	7.42	4	0.27	0.5	4	0.0
LR-23	7.26	3	0.10	4.3	3	6.6
LR-24	7.37	4	0.12	3.4	4	5.8
LR-27	6.93	3	0.47	0.5	3	0.0
LR-28	6.73	3	0.48	0.5	3	0.0
LR-30	7.43	3	0.46	0.5	3	0.0
LR-31	7.02	3	0.40	1.7	3	2.0
LR-32	7.55	4	0.39	0.5	4	0.0
LR-34	7.27	2	0.09	0.5	2	0.0
LR-35	7.65	3	0.34	0.5	3	0.0
LR-36	7.61	4	0.29	0.5	4	0.0
LR-38	7.90	3	0.25	0.5	3	0.0
Site	**Pollutant Parameter**					
	pH			**TSS**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Lower Gunpowder Falls						
GU-01	7.52	3	0.53	29.5	3	43.9
GU-03	8.30	4	0.48	0.9	4	0.8
GU-04	7.77	4	0.52	0.9	4	0.8
GU-05	8.15	4	0.54	2.9	4	4.8
GU-06	8.28	4	0.66	0.5	4	0.0
GU-07	7.77	4	0.18	0.5	4	0.0
GU-08	7.25	3	0.16	0.5	3	0.0
Little Gunpowder Falls						
LG-01	7.24	3	0.44	0.5	3	0.0
LG-02	7.01	3	0.25	0.5	3	0.0
LG-03	7.02	3	0.31	5.5	3	4.8
LG-04	7.02	4	0.14	0.9	4	0.8
LG-05	7.25	3	0.24	0.5	3	0.0
LG-07	7.22	4	0.31	2.9	4	4.8
LG-09	7.46	3	0.26	0.5	3	0.0
Bird River						
BI-01	6.45	4	0.60	3.4	4	5.8
BI-02	6.78	4	0.26	1.8	4	1.7
BI-03	7.33	4	0.32	0.9	4	0.8
BI-04	7.34	4	0.11	0.5	4	0.0
BI-05	7.48	4	0.14	0.5	4	0.0
Site	**Pollutant Parameter**					
	TS			**TKN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	115	3	21.9	0.10	3	0.0
DC-02	106	3	40.6	0.14	3	0.1
DC-03	108	3	61.0	0.18	3	0.1
DC-04	116	3	25.1	0.14	3	0.1

Prettyboy Reservoir						
PR-01	119	3	33.0	0.16	3	0.1
PR-02	92	4	46.7	0.10	4	0.0
PR-03	63	4	22.3	0.10	4	0.0
PR-04	142	4	36.1	0.16	4	0.1
PR-05A	141	3	48.0	0.35	3	0.1
PR-05B	127	3	71.7	0.29	3	0.2
PR-06	99	3	22.1	0.26	3	0.3
Loch Raven Reservoir						
LR-02	103	3	25.8	0.10	3	0.0
LR-03	207	3	90.0	0.34	3	0.2
LR-10	509	3	98.8	0.10	3	0.0
LR-13	369	3	62.9	0.10	3	0.0
LR-14	75	3	65.1	0.29	3	0.3
LR-15	120	3	12.2	0.16	3	0.1
LR-17	160	5	25.0	0.13	5	0.1
LR-18	169	4	5.0	0.25	4	0.1
LR-19	155	4	26.7	0.26	4	0.2
LR-20	120	4	42.5	0.36	4	0.5
LR-21	226	4	75.2	0.16	4	0.1
LR-22	108	4	50.1	0.21	4	0.2
LR-23	123	3	28.1	0.10	3	0.0
LR-24	114	4	86.3	0.16	4	0.1
LR-27	101	3	25.0	0.13	3	0.1
LR-28	127	3	51.9	0.10	3	0.0
LR-30	103	3	60.3	0.13	3	0.1
LR-31	314	3	87.1	0.10	3	0.0
LR-32	142	4	15.4	0.10	4	0.0
LR-34	180	2	2.8	0.29	2	0.3
LR-35	146	3	7.2	0.14	3	0.1
LR-36	181	4	110.7	0.15	4	0.1
LR-38	202	3	19.1	0.10	3	0.0
Lower Gunpowder Falls						
GU-01	58	3	100.2	0.28	3	0.3
GU-03	240	4	47.5	0.10	4	0.0
GU-04	177	4	44.3	0.10	4	0.0
GU-05	196	4	65.5	0.16	4	0.1
GU-06	259	4	42.7	0.10	4	0.0
GU-07	251	4	55.9	0.13	4	0.1
GU-08	411	3	77.4	0.10	3	0.0
Little Gunpowder Falls						
LG-01	109	3	54.9	0.10	3	0.0
LG-02	81	3	34.1	0.10	3	0.0
LG-03	160	3	40.6	0.16	3	0.1
LG-04	179	4	51.6	0.14	3	0.1
LG-05	84	3	73.9	0.13	3	0.1
LG-07	248	4	46.7	0.37	4	0.3
LG-09	242	3	54.8	0.18	3	0.1
Bird River						
BI-01	117	4	43.7	0.47	4	0.1
BI-02	244	4	55.0	0.13	4	0.1
BI-03	341	4	138.3	0.19	4	0.1
BI-04	303	4	52.6	0.58	4	0.5

BI-05	338	4	75.6	0.36	4	0.5
Site	**Pollutant Parameter**					
	NO_2-NO_3			**TP**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	4.20	3	4.9	0.05	3	0.0
DC-02	3.79	3	4.0	0.05	3	0.0
DC-03	3.19	3	3.2	0.04	3	0.0
DC-04	4.14	3	2.2	0.03	3	0.0
Prettyboy Reservoir						
PR-01	2.47	3	0.5	0.02	3	0.0
PR-02	2.46	4	1.0	0.04	4	0.0
PR-03	4.08	4	3.6	0.04	4	0.0
PR-04	3.69	4	1.2	0.04	4	0.0
PR-05A	3.02	3	0.3	0.03	3	0.0
PR-05B	2.53	3	0.6	0.04	3	0.0
PR-06	1.72	3	0.5	0.03	3	0.0
Loch Raven Reservoir						
LR-02	1.75	3	0.8	0.02	3	0.0
LR-03	2.13	3	0.8	0.04	3	0.1
LR-10	0.70	3	0.7	0.12	3	0.2
LR-13	1.40	3	0.5	0.03	3	0.0
LR-14	1.33	2	0.3	0.05	3	0.1
LR-15	1.65	2	0.5	0.03	3	0.0
LR-17	3.77	4	2.1	0.04	5	0.0
LR-18	1.19	3	0.1	0.03	4	0.0
LR-19	2.35	3	0.3	0.04	4	0.0
LR-20	1.19	3	0.3	0.08	4	0.0
LR-21	2.94	4	0.8	0.03	4	0.0
LR-22	1.78	4	0.2	0.03	4	0.0
LR-23	0.89	3	0.2	0.06	3	0.0
LR-24	2.32	4	0.3	0.04	4	0.0
LR-27	2.62	3	0.1	0.04	3	0.0
LR-28	3.27	3	2.9	0.03	3	0.0
LR-30	2.26	3	0.3	0.02	3	0.0
LR-31	0.96	3	0.2	0.02	3	0.0
LR-32	1.99	4	0.4	0.01	4	0.0
LR-34	3.46	2	0.0	0.03	2	0.0
LR-35	3.78	3	0.4	0.04	3	0.0
LR-36	4.09	4	1.2	0.05	4	0.0
LR-38	2.67	3	0.4	0.03	3	0.0
Lower Gunpowder Falls						
GU-01	0.99	3	0.5	0.09	3	0.1
GU-03	3.81	4	0.6	0.03	4	0.0
GU-04	4.03	4	0.4	0.04	4	0.0
GU-05	2.87	4	0.4	0.06	4	0.0
GU-06	1.55	4	0.3	0.11	4	0.0
GU-07	1.08	4	0.2	0.02	4	0.0
GU-08	1.06	3	0.2	0.02	3	0.0
Little Gunpowder Falls						
LG-01	0.96	3	0.1	0.03	3	0.0
LG-02	1.43	3	0.2	0.02	3	0.0
LG-03	2.33	3	0.4	0.02	3	0.0

LG-04	1.50	4	1.4	0.03	3	0.0
LG-05	1.61	3	0.2	0.03	3	0.0
LG-07	3.33	4	1.0	0.04	4	0.0
LG-09	1.60	3	0.5	0.02	3	0.0
Bird River						
BI-01	0.27	4	0.2	0.06	4	0.0
BI-02	0.84	4	0.4	0.04	4	0.0
BI-03	0.30	4	0.2	0.04	4	0.0
BI-04	0.40	4	0.3	0.04	4	0.0
BI-05	0.55	4	0.2	0.03	4	0.0
Site	**Pollutant Parameter**					
	Cd			**Cd-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	0.001	3	0.0	0.001	3	0.0
DC-02	0.001	3	0.0	0.001	3	0.0
DC-03	0.001	3	0.0	0.001	3	0.0
DC-04	0.001	3	0.0	0.001	3	0.0
Prettyboy Reservoir						
PR-01	0.001	3	0.0	0.001	3	0.0
PR-02	0.001	4	0.0	0.001	4	0.0
PR-03	0.001	4	0.0	0.001	4	0.0
PR-04	0.001	4	0.0	0.001	4	0.0
PR-05A	0.001	3	0.0	0.001	3	0.0
PR-05B	0.001	3	0.0	0.001	3	0.0
PR-06	0.001	3	0.0	0.001	3	0.0
Loch Raven Reservoir						
LR-02	0.001	3	0.0	0.001	3	0.0
LR-03	0.001	3	0.0	0.001	3	0.0
LR-10	0.001	3	0.0	0.001	3	0.0
LR-13	0.001	3	0.0	0.001	3	0.0
LR-14	0.001	3	0.0	0.001	3	0.0
LR-15	0.001	3	0.0	0.001	3	0.0
LR-17	0.001	5	0.0	0.001	5	0.0
LR-18	0.001	4	0.0	0.001	4	0.0
LR-19	0.001	4	0.0	0.001	4	0.0
LR-20	0.001	4	0.0	0.001	4	0.0
LR-21	0.001	4	0.0	0.001	4	0.0
LR-22	0.001	4	0.0	0.001	4	0.0
LR-23	0.001	3	0.0	0.001	3	0.0
LR-24	0.001	4	0.0	0.001	4	0.0
LR-27	0.001	3	0.0	0.001	3	0.0
LR-28	0.001	3	0.0	0.001	3	0.0
LR-30	0.001	3	0.0	0.001	3	0.0
LR-31	0.001	3	0.0	0.001	3	0.0
LR-32	0.001	4	0.0	0.001	4	0.0
LR-34	0.001	2	0.0	0.001	2	0.0
LR-35	0.001	3	0.0	0.001	3	0.0
LR-36	0.001	4	0.0	0.001	4	0.0
LR-38	0.001	3	0.0	0.001	3	0.0
Lower Gunpowder Falls						
GU-01	0.001	3	0.0	0.001	3	0.0
GU-03	0.001	4	0.0	0.001	4	0.0

GU-04	0.001	4	0.0	0.001	4	0.0
GU-05	0.001	4	0.0	0.001	4	0.0
GU-06	0.001	4	0.0	0.001	4	0.0
GU-07	0.001	4	0.0	0.001	4	0.0
GU-08	0.001	3	0.0	0.001	3	0.0
Little Gunpowder Falls						
LG-01	0.001	3	0.0	0.001	3	0.0
LG-02	0.001	3	0.0	0.001	3	0.0
LG-03	0.001	3	0.0	0.001	3	0.0
LG-04	0.001	4	0.0	0.001	4	0.0
LG-05	0.001	3	0.0	0.001	3	0.0
LG-07	0.001	4	0.0	0.001	4	0.0
LG-09	0.001	3	0.0	0.001	3	0.0
Bird River						
BI-01	0.001	4	0.0	0.001	4	0.0
BI-02	0.001	4	0.0	0.001	4	0.0
BI-03	0.001	4	0.0	0.001	4	0.0
BI-04	0.001	4	0.0	0.001	4	0.0
BI-05	0.001	4	0.0	0.001	4	0.0
Site	**Pollutant Parameter**					
	Cu			**Cu-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	0.003	3	0.0	0.001	3	0.0
DC-02	0.003	3	0.0	0.001	3	0.0
DC-03	0.003	3	0.0	0.001	3	0.0
DC-04	0.002	3	0.0	0.001	3	0.0
Prettyboy Reservoir						
PR-01	0.001	3	0.0	0.001	3	0.0
PR-02	0.002	4	0.0	0.001	4	0.0
PR-03	0.002	4	0.0	0.001	4	0.0
PR-04	0.002	4	0.0	0.001	4	0.0
PR-05A	0.001	3	0.0	0.001	3	0.0
PR-05B	0.001	3	0.0	0.001	3	0.0
PR-06	0.002	3	0.0	0.001	3	0.0
Loch Raven Reservoir						
LR-02	0.004	3	0.0	0.002	3	0.0
LR-03	0.007	3	0.0	0.002	3	0.0
LR-10	0.004	3	0.0	0.001	3	0.0
LR-13	0.005	3	0.0	0.002	3	0.0
LR-14	0.008	3	0.0	0.003	3	0.0
LR-15	0.012	3	0.0	0.003	3	0.0
LR-17	0.009	5	0.0	0.005	5	0.0
LR-18	0.021	4	0.0	0.004	4	0.0
LR-19	0.023	4	0.0	0.005	4	0.0
LR-20	0.022	4	0.0	0.005	4	0.0
LR-21	0.004	4	0.0	0.002	4	0.0
LR-22	0.006	4	0.0	0.002	4	0.0
LR-23	0.009	3	0.0	0.002	3	0.0
LR-24	0.010	4	0.0	0.003	4	0.0
LR-27	0.001	3	0.0	0.001	3	0.0
LR-28	0.001	3	0.0	0.001	3	0.0
LR-30	0.002	3	0.0	0.001	3	0.0

LR-31	0.003	3	0.0	0.001	3	0.0
LR-32	0.004	4	0.0	0.002	4	0.0
LR-34	0.007	2	0.0	0.003	2	0.0
LR-35	0.004	3	0.0	0.001	3	0.0
LR-36	0.002	4	0.0	0.001	4	0.0
LR-38	0.008	3	0.0	0.003	3	0.0
Lower Gunpowder Falls						
GU-01	0.004	3	0.0	0.003	3	0.0
GU-03	0.004	4	0.0	0.002	4	0.0
GU-04	0.005	4	0.0	0.002	4	0.0
GU-05	0.004	4	0.0	0.002	4	0.0
GU-06	0.007	4	0.0	0.003	4	0.0
GU-07	0.006	4	0.0	0.002	4	0.0
GU-08	0.009	3	0.0	0.004	3	0.0
Little Gunpowder Falls						
LG-01	0.005	3	0.0	0.001	3	0.0
LG-02	0.005	3	0.0	0.001	3	0.0
LG-03	0.005	3	0.0	0.001	3	0.0
LG-04	0.004	4	0.0	0.002	4	0.0
LG-05	0.004	3	0.0	0.002	3	0.0
LG-07	0.004	4	0.0	0.002	4	0.0
LG-09	0.004	3	0.0	0.002	3	0.0
Bird River						
BI-01	0.008	4	0.0	0.002	4	0.0
BI-02	0.006	4	0.0	0.002	4	0.0
BI-03	0.004	4	0.0	0.001	4	0.0
BI-04	0.004	4	0.0	0.001	4	0.0
BI-05	0.005	4	0.0	0.001	4	0.0
Site	**Pollutant Parameter**					
	Pb			**Pb-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	0.001	3	0.0	0.001	3	0.0
DC-02	0.001	3	0.0	0.001	3	0.0
DC-03	0.001	3	0.0	0.001	3	0.0
DC-04	0.001	3	0.0	0.001	3	0.0
Prettyboy Reservoir						
PR-01	0.001	3	0.0	0.001	3	0.0
PR-02	0.001	4	0.0	0.001	4	0.0
PR-03	0.001	4	0.0	0.001	4	0.0
PR-04	0.001	4	0.0	0.001	4	0.0
PR-05A	0.001	3	0.0	0.001	3	0.0
PR-05B	0.001	3	0.0	0.001	3	0.0
PR-06	0.001	3	0.0	0.001	3	0.0
Loch Raven Reservoir						
LR-02	0.001	3	0.0	0.001	3	0.0
LR-03	0.001	3	0.0	0.001	3	0.0
LR-10	0.001	3	0.0	0.001	3	0.0
LR-13	0.001	3	0.0	0.001	3	0.0
LR-14	0.001	3	0.0	0.001	3	0.0
LR-15	0.001	3	0.0	0.001	3	0.0
LR-17	0.001	5	0.0	0.001	5	0.0
LR-18	0.002	4	0.0	0.001	4	0.0

LR-19	0.001	4	0.0	0.001	4	0.0
LR-20	0.001	4	0.0	0.001	4	0.0
LR-21	0.001	4	0.0	0.001	4	0.0
LR-22	0.001	4	0.0	0.001	4	0.0
LR-23	0.001	3	0.0	0.001	3	0.0
LR-24	0.001	4	0.0	0.001	4	0.0
LR-27	0.001	3	0.0	0.001	3	0.0
LR-28	0.001	3	0.0	0.001	3	0.0
LR-30	0.001	3	0.0	0.001	3	0.0
LR-31	0.001	3	0.0	0.001	3	0.0
LR-32	0.001	4	0.0	0.001	4	0.0
LR-34	0.001	2	0.0	0.001	2	0.0
LR-35	0.001	3	0.0	0.001	3	0.0
LR-36	0.001	4	0.0	0.001	4	0.0
LR-38	0.001	3	0.0	0.001	3	0.0
Lower Gunpowder Falls						
GU-01	0.001	3	0.0	0.001	3	0.0
GU-03	0.001	4	0.0	0.001	4	0.0
GU-04	0.001	4	0.0	0.001	4	0.0
GU-05	0.001	4	0.0	0.001	4	0.0
GU-06	0.001	4	0.0	0.001	4	0.0
GU-07	0.001	4	0.0	0.001	4	0.0
GU-08	0.001	3	0.0	0.001	3	0.0
Little Gunpowder Falls						
LG-01	0.001	3	0.0	0.001	3	0.0
LG-02	0.001	3	0.0	0.001	3	0.0
LG-03	0.001	3	0.0	0.001	3	0.0
LG-04	0.001	4	0.0	0.001	4	0.0
LG-05	0.001	3	0.0	0.001	3	0.0
LG-07	0.001	4	0.0	0.001	4	0.0
LG-09	0.001	3	0.0	0.001	3	0.0
Bird River						
BI-01	0.001	4	0.0	0.001	4	0.0
BI-02	0.001	4	0.0	0.001	4	0.0
BI-03	0.001	4	0.0	0.001	4	0.0
BI-04	0.001	4	0.0	0.001	4	0.0
BI-05	0.000	4	0.0	0.001	4	0.0
Site	**Pollutant Parameter**					
	Zn			**Zn-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	0.007	3	0.0	0.002	3	0.0
DC-02	0.005	3	0.0	0.002	3	0.0
DC-03	0.006	3	0.0	0.001	3	0.0
DC-04	0.006	3	0.0	0.001	3	0.0
Prettyboy Reservoir						
PR-01	0.001	3	0.0	0.001	3	0.0
PR-02	0.007	4	0.0	0.002	4	0.0
PR-03	0.005	4	0.0	0.001	4	0.0
PR-04	0.002	4	0.0	0.001	4	0.0
PR-05A	0.001	3	0.0	0.001	3	0.0
PR-05B	0.002	3	0.0	0.001	3	0.0
PR-06	0.002	3	0.0	0.001	3	0.0

Loch Raven Reservoir						
LR-02	0.003	3	0.0	0.001	3	0.0
LR-03	0.001	3	0.0	0.001	3	0.0
LR-10	0.003	3	0.0	0.001	3	0.0
LR-13	0.010	3	0.0	0.004	3	0.0
LR-14	0.009	3	0.0	0.002	3	0.0
LR-15	0.008	3	0.0	0.002	3	0.0
LR-17	0.013	5	0.0	0.003	5	0.0
LR-18	0.030	4	0.0	0.009	4	0.0
LR-19	0.016	4	0.0	0.004	4	0.0
LR-20	0.014	4	0.0	0.004	4	0.0
LR-21	0.022	4	0.0	0.006	4	0.0
LR-22	0.021	4	0.0	0.005	4	0.0
LR-23	0.018	3	0.0	0.005	3	0.0
LR-24	0.014	4	0.0	0.003	4	0.0
LR-27	0.006	3	0.0	0.002	3	0.0
LR-28	0.003	3	0.0	0.001	3	0.0
LR-30	0.003	3	0.0	0.001	3	0.0
LR-31	0.001	3	0.0	0.001	3	0.0
LR-32	0.001	4	0.0	0.001	4	0.0
LR-34	0.001	2	0.0	0.001	2	0.0
LR-35	0.003	3	0.0	0.001	3	0.0
LR-36	0.001	4	0.0	0.001	4	0.0
LR-38	0.002	3	0.0	0.001	3	0.0
Lower Gunpowder Falls						
GU-01	0.007	3	0.0	0.002	3	0.0
GU-03	0.003	4	0.0	0.001	4	0.0
GU-04	0.007	4	0.0	0.003	4	0.0
GU-05	0.003	4	0.0	0.001	4	0.0
GU-06	0.008	4	0.0	0.003	4	0.0
GU-07	0.010	4	0.0	0.003	4	0.0
GU-08	0.011	3	0.0	0.003	3	0.0
Little Gunpowder Falls						
LG-01	0.013	3	0.0	0.003	3	0.0
LG-02	0.010	3	0.0	0.003	3	0.0
LG-03	0.010	3	0.0	0.003	3	0.0
LG-04	0.010	4	0.0	0.003	4	0.0
LG-05	0.011	3	0.0	0.003	3	0.0
LG-07	0.008	4	0.0	0.002	4	0.0
LG-09	0.008	3	0.0	0.002	3	0.0
Bird River						
BI-01	0.022	4	0.0	0.006	4	0.0
BI-02	0.011	4	0.0	0.004	4	0.0
BI-03	0.010	4	0.0	0.003	4	0.0
BI-04	0.008	4	0.0	0.002	4	0.0
BI-05	0.015	4	0.0	0.004	4	0.0
Site	**Pollutant Parameter**					
	BOD			**COD**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	1	3	0.0	9	3	5.8
DC-02	1	3	0.0	5	3	3.8
DC-03	1	3	0.0	7	3	3.9

DC-04	1	3	0.0	6	3	3.2
Prettyboy Reservoir						
PR-01	1	3	0.0	5	3	4.3
PR-02	1	4	0.0	8	4	5.9
PR-03	1	4	0.0	4	4	3.8
PR-04	1	4	0.0	4	3	2.0
PR-05A	1	3	0.0	15	3	1.0
PR-05B	1	3	0.0	15	3	3.2
PR-06	1	3	0.0	6	3	6.1
Loch Raven Reservoir						
LR-02	2	3	1.2	11	3	10.8
LR-03	2	3	1.2	15	3	7.5
LR-10	1	3	0.0	13	3	10.8
LR-13	1	3	0.0	14	3	11.3
LR-14	1	3	0.0	11	3	4.2
LR-15	1	3	0.0	11	3	7.1
LR-17	1	5	0.0	8	5	6.8
LR-18	1	4	0.0	8	4	6.5
LR-19	1	4	0.0	6	4	3.5
LR-20	1	4	0.0	9	4	5.9
LR-21	1	4	0.0	5	4	4.0
LR-22	1	4	0.0	7	4	5.4
LR-23	1	3	0.0	8	3	5.3
LR-24	1	4	0.0	6	4	4.5
LR-27	1	3	0.0	11	3	10.8
LR-28	1	3	0.0	10	3	5.5
LR-30	1	3	0.0	9	3	9.5
LR-31	1	3	0.0	7	3	7.8
LR-32	1	4	0.0	10	4	8.7
LR-34	1	2	0.0	11	2	11.7
LR-35	1	3	0.0	15	3	10.7
LR-36	1	4	0.0	11	4	9.7
LR-38	1	3	0.0	13	3	8.7
Lower Gunpowder Falls						
GU-01	1	3	0.0	11	3	3.5
GU-03	1	4	0.0	5	4	3.3
GU-04	1	4	0.0	5	4	4.3
GU-05	1	4	0.0	7	4	8.3
GU-06	1	4	0.0	6	4	5.0
GU-07	1	4	0.0	7	4	3.3
GU-08	1	3	0.0	3	3	0.0
Little Gunpowder Falls						
LG-01	1	3	0.0	9	3	3.0
LG-02	1	3	0.0	8	3	0.6
LG-03	1	3	0.0	7	3	3.9
LG-04	1	4	0.0	5	4	3.2
LG-05	1	3	0.0	8	3	2.0
LG-07	1	4	0.0	8	4	6.4
LG-09	1	3	0.0	10	3	5.8
Bird River						
BI-01	1	4	0.5	24	4	6.2
BI-02	1	4	0.0	10	4	5.4
BI-03	1	4	0.0	7	4	3.6

BI-04	1	4	0.0	13	4	6.8
BI-05	1	4	0.0	6	4	3.8
Site	**Pollutant Parameter**					
	Cl			**TN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	79.49	3	45.9	4.30	3	4.9
DC-02	36.82	3	14.8	3.92	3	3.9
DC-03	41.74	3	14.9	3.37	3	3.1
DC-04	45.93	3	21.2	4.28	3	2.3
Prettyboy Reservoir						
PR-01	25.92	3	5.6	2.63	3	0.5
PR-02	16.58	4	3.7	2.56	4	1.0
PR-03	31.34	4	24.9	4.18	4	3.6
PR-04	37.23	4	10.2	3.84	4	1.4
PR-05A	25.66	3	6.8	3.37	3	0.3
PR-05B	24.55	3	6.4	2.82	3	0.5
PR-06	25.44	3	3.5	1.97	3	0.5
Loch Raven Reservoir						
LR-02	31.28	3	13.7	1.85	3	0.8
LR-03	46.25	3	22.0	2.47	3	0.6
LR-10	79.43	3	73.0	0.80	3	0.7
LR-13	74.95	3	38.9	1.50	3	0.5
LR-14	64.37	2	37.9	1.71	2	0.7
LR-15	81.54	2	61.7	1.75	2	0.5
LR-17	37.51	4	14.0	3.87	4	2.1
LR-18	52.02	3	2.1	1.44	3	0.2
LR-19	73.40	3	4.9	2.53	3	0.2
LR-20	17.88	3	0.4	1.29	3	0.3
LR-21	73.18	4	17.3	3.09	4	0.8
LR-22	31.54	4	6.6	1.99	4	0.3
LR-23	22.86	3	0.6	0.99	3	0.2
LR-24	32.63	4	4.0	2.48	4	0.4
LR-27	26.14	3	1.3	2.75	3	0.1
LR-28	102.34	3	85.3	3.37	3	2.9
LR-30	34.73	3	1.2	2.40	3	0.4
LR-31	128.90	3	6.0	1.06	3	0.2
LR-32	28.95	4	2.4	2.09	4	0.4
LR-34	36.50	2	0.5	3.75	2	0.3
LR-35	38.79	3	3.9	3.92	3	0.3
LR-36	49.23	4	7.1	4.24	4	1.2
LR-38	23.74	3	1.1	2.77	3	0.4
Lower Gunpowder Falls						
GU-01	39.59	3	9.4	1.27	3	0.2
GU-03	23.74	4	2.5	3.91	4	0.6
GU-04	36.80	4	2.3	4.13	4	0.4
GU-05	24.54	4	2.9	3.03	4	0.4
GU-06	54.94	4	14.1	1.65	4	0.3
GU-07	78.98	4	12.4	1.20	4	0.2
GU-08	115.49	3	6.2	1.16	3	0.2
Little Gunpowder Falls						
LG-01	21.06	3	1.6	1.06	3	0.1
LG-02	10.57	3	0.9	1.53	3	0.2

LG-03	53.30	3	1.8	2.49	3	0.5
LG-04	40.25	4	10.0	1.17	3	1.3
LG-05	20.23	3	2.2	1.75	3	0.2
LG-07	60.70	4	9.8	3.70	4	0.8
LG-09	43.44	3	6.8	1.78	3	0.5
Bird River						
BI-01	24.26	4	12.7	0.74	4	0.2
BI-02	99.45	4	31.3	0.97	4	0.4
BI-03	123.13	4	28.0	0.49	4	0.1
BI-04	86.55	4	30.5	0.98	4	0.6
BI-05	150.02	4	47.5	0.91	4	0.4
Site	**Pollutant Parameter**					
	Na			**Hardness**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	32.23	3	4.0	47.65	3	9.9
DC-02	16.43	3	4.8	54.85	3	11.0
DC-03	20.93	3	4.8	56.91	3	11.8
DC-04	20.80	3	3.1	48.93	3	7.4
Prettyboy Reservoir						
PR-01	17.60	3	2.5	33.45	3	3.1
PR-02	13.76	4	5.9	48.08	4	13.1
PR-03	17.18	4	3.4	40.84	4	3.0
PR-04	22.80	4	2.4	57.26	4	4.6
PR-05A	12.37	3	3.2	49.14	3	6.0
PR-05B	11.55	3	2.6	56.88	3	7.3
PR-06	23.95	3	10.5	34.09	3	3.1
Loch Raven Reservoir						
LR-02	17.98	3	7.2	45.03	3	7.5
LR-03	20.75	3	6.4	102.60	3	19.1
LR-10	81.25	3	37.8	167.72	3	79.6
LR-13	54.07	3	16.9	147.02	3	58.9
LR-14	15.78	3	10.3	35.30	3	5.0
LR-15	17.90	3	3.8	40.96	3	5.5
LR-17	19.73	5	4.2	83.12	5	23.5
LR-18	22.30	4	5.6	90.15	4	9.8
LR-19	30.60	4	4.1	65.55	4	14.0
LR-20	13.05	4	3.6	46.87	4	7.2
LR-21	30.34	4	6.0	113.32	4	30.7
LR-22	20.43	4	9.4	58.36	4	15.9
LR-23	16.85	3	5.9	44.05	3	8.4
LR-24	19.61	4	5.4	49.49	4	9.0
LR-27	13.40	2	1.9	45.93	3	5.5
LR-28	25.15	2	4.9	48.23	3	9.7
LR-30	16.75	2	5.0	50.09	3	7.6
LR-31	31.53	2	24.2	70.25	3	15.0
LR-32	14.86	4	6.1	70.11	4	16.1
LR-34	24.93	2	0.4	62.01	2	0.6
LR-35	25.00	3	2.4	68.40	3	18.9
LR-36	46.48	4	8.9	68.20	4	15.8
LR-38	12.60	3	4.3	141.16	3	48.4
Lower Gunpowder Falls						
GU-01	23.75	3	3.6	99.03	3	27.7

GU-03	11.81	4	2.6	117.16	4	48.1
GU-04	15.53	4	5.1	112.23	4	39.8
GU-05	11.06	4	2.3	111.58	4	43.3
GU-06	27.19	4	9.7	175.05	4	102.9
GU-07	35.63	4	6.6	128.51	4	81.4
GU-08	52.83	3	2.5	265.48	3	175.8
Little Gunpowder Falls						
LG-01	10.87	3	2.4	44.31	3	3.9
LG-02	7.77	3	3.3	31.86	3	4.2
LG-03	27.00	3	6.1	45.73	3	3.8
LG-04	20.40	4	2.9	48.90	4	6.0
LG-05	12.58	3	2.1	45.45	3	4.3
LG-07	29.05	4	9.2	60.17	4	7.5
LG-09	20.38	3	5.7	73.48	3	6.4
Bird River						
BI-01	27.29	4	18.9	36.63	4	3.9
BI-02	71.93	4	60.7	99.44	4	17.9
BI-03	87.41	4	45.5	141.45	4	40.0
BI-04	77.44	4	40.9	171.13	4	54.9
BI-05	97.64	4	42.8	191.43	4	65.1
Site	**Pollutant Parameter**					
	Mg			**Ca**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Deer Creek						
DC-01	4.07	3	1.9	12.37	3	0.8
DC-02	4.06	3	1.9	15.28	3	1.4
DC-03	4.17	3	2.1	15.92	3	1.2
DC-04	3.92	3	1.7	13.13	3	0.2
Prettyboy Reservoir						
PR-01	3.03	3	0.1	8.40	3	1.1
PR-02	2.86	4	0.1	14.54	4	5.0
PR-03	2.84	4	0.1	11.60	4	1.0
PR-04	3.00	4	0.1	17.99	4	1.8
PR-05A	3.04	3	0.1	14.67	3	2.2
PR-05B	3.03	3	0.1	17.79	3	2.7
PR-06	2.99	3	0.1	8.72	3	1.1
Loch Raven Reservoir						
LR-02	3.85	3	1.8	11.68	3	0.5
LR-03	5.69	3	4.5	31.71	3	3.9
LR-10	13.66	3	17.8	44.64	3	8.7
LR-13	10.76	3	12.9	41.14	3	5.8
LR-14	3.72	3	1.7	7.99	3	0.9
LR-15	3.86	3	1.8	10.04	3	1.2
LR-17	7.58	5	4.2	20.78	5	7.3
LR-18	8.16	4	5.8	22.64	4	7.4
LR-19	5.83	4	3.2	16.63	4	2.4
LR-20	4.04	4	1.6	12.07	4	1.5
LR-21	9.97	4	7.9	28.94	4	1.7
LR-22	3.95	4	1.6	16.86	4	7.1
LR-23	4.16	3	2.4	10.78	3	0.6
LR-24	4.16	4	2.5	12.97	4	1.1
LR-27	2.81	2	0.1	12.59	2	1.4
LR-28	2.93	2	0.0	12.32	2	1.6

LR-30	3.01	2	0.2	13.37	2	0.6
LR-31	3.35	2	0.1	19.21	2	1.8
LR-32	4.38	4	2.4	20.87	4	9.0
LR-34	5.38	2	3.2	15.97	2	5.5
LR-35	4.47	3	2.4	20.02	3	10.4
LR-36	3.10	4	0.1	22.21	4	6.3
LR-38	7.66	3	7.4	43.90	3	8.0
Lower Gunpowder Falls						
GU-01	5.88	3	3.6	29.96	3	9.5
GU-03	6.39	4	6.5	36.38	4	8.7
GU-04	9.13	4	7.6	28.00	4	10.6
GU-05	5.60	4	5.0	36.15	4	10.6
GU-06	10.90	4	10.0	52.13	4	24.8
GU-07	7.82	4	9.5	38.57	4	17.1
GU-08	13.77	3	18.3	83.60	3	44.7
Little Gunpowder Falls						
LG-01	2.99	3	0.1	12.78	3	1.4
LG-02	2.67	3	0.2	8.36	3	1.3
LG-03	3.22	3	0.2	13.00	3	1.3
LG-04	3.17	4	0.2	14.35	4	2.5
LG-05	3.14	3	0.2	13.02	3	1.5
LG-07	3.28	4	0.3	18.69	4	2.6
LG-09	3.41	3	0.3	23.83	3	2.2
Bird River						
BI-01	4.53	4	1.5	7.12	4	3.0
BI-02	9.54	4	4.3	23.70	4	8.3
BI-03	9.98	4	4.5	40.22	4	10.7
BI-04	11.35	4	5.4	49.82	4	17.3
BI-05	13.95	4	7.3	53.67	4	14.6

Appendix 9-3: Tidal Waters Chemical Monitoring Results

Site	TSS			TS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	133.4	16	162.3	7385.3	16	3567.7
BD	30.5	31	25.5	828.8	31	1078.6
BR	55.0	31	61.9	2505.7	31	2312.8
DD	69.4	15	99.3	3197.4	15	2941.4
GR	50.6	14	64.8	2527.7	14	2497.7
HM	50.2	11	92.1	3570.2	11	2633.6
MR	55.5	14	78.2	3643.0	14	3005.8
MS	79.5	15	103.8	4492.6	15	3316.3
ORB	130.5	15	169.5	6895.5	15	4045.8
PR	137.1	16	188.0	8359.0	16	4012.5
PSF	9.6	17	24.2	219.2	17	59.8
PSE	70.7	17	85.1	4710.4	17	3544.4
Site	**TKN**			**NO_2-NO_3**		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	1.1406	17	0.4648	0.3727	15	1.0606
BD	0.9519	31	0.3801	0.1130	27	0.2559
BR	1.7087	31	0.6934	0.3659	27	0.5805
DD	0.4227	15	0.1673	0.0600	13	0.0000
GR	0.3736	14	0.1674	0.0575	12	0.0087

HM	0.4900	11	0.1281	0.1500	8	0.2546
MR	0.3857	14	0.1582	0.1233	12	0.1480
MS	0.3673	15	0.1209	0.1015	13	0.1498
ORB	0.7319	16	0.3443	0.2964	14	0.7920
PR	0.8753	17	0.4465	0.1040	15	0.1051
PSF	0.4029	17	0.2643	0.8221	14	0.5158
PSE	0.6841	17	0.2286	0.2667	15	0.2785
Site	**TP**			**Cu**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.1362	17	0.0856	0.0109	17	0.0126
BD	0.1377	31	0.0533	0.0082	31	0.0085
BR	0.2158	31	0.1079	0.0073	31	0.0091
DD	0.0653	15	0.0188	0.0054	15	0.0070
GR	0.0871	14	0.0414	0.0088	14	0.0075
HM	0.0536	11	0.0441	0.0045	11	0.0062
MR	0.0707	14	0.0279	0.0053	14	0.0049
MS	0.0573	15	0.0198	0.0047	15	0.0048
ORB	0.0803	16	0.0397	0.0096	16	0.0099
PR	0.0856	17	0.0462	0.0060	17	0.0053
PSF	0.0735	17	0.0741	0.0077	17	0.0078
PSE	0.0812	17	0.0369	0.0090	17	0.0106
Site	**Cu-dissolved**			**Pb**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.0033	17	0.0034	0.0011	17	0.0010
BD	0.0026	31	0.0026	0.0008	31	0.0006
BR	0.0023	31	0.0027	0.0009	31	0.0007
DD	0.0020	15	0.0021	0.0009	15	0.0005
GR	0.0029	14	0.0027	0.0008	14	0.0005
HM	0.0019	11	0.0023	0.0009	11	0.0006
MR	0.0016	14	0.0014	0.0008	14	0.0004
MS	0.0015	15	0.0014	0.0008	15	0.0004
ORB	0.0031	16	0.0026	0.0010	16	0.0009
PR	0.0020	17	0.0016	0.0008	17	0.0006
PSF	0.0026	17	0.0026	0.0009	17	0.0005
PSE	0.0029	17	0.0028	0.0009	17	0.0006
Site	**Pb-dissolved**			**Zn**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.0007	17	0.0004	0.0191	17	0.0252
BD	0.0005	31	0.0002	0.0137	31	0.0110
BR	0.0006	31	0.0002	0.0137	31	0.0144
DD	0.0006	15	0.0002	0.0135	15	0.0125
GR	0.0006	14	0.0002	0.0109	14	0.0072
HM	0.0005	11	0.0002	0.0163	11	0.0165
MR	0.0005	14	0.0001	0.0125	14	0.0105
MS	0.0005	15	0.0001	0.0123	15	0.0075
ORB	0.0007	16	0.0004	0.0251	16	0.0395
PR	0.0006	17	0.0004	0.0180	17	0.0243
PSF	0.0005	17	0.0001	0.0181	17	0.0136
PSE	0.0006	17	0.0002	0.0151	17	0.0133
Site	**Zn-dissolved**			**BOD**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.0056	17	0.0070	6.5	17	2.5
BD	0.0037	31	0.0025	4.2	31	2.2

BR	0.0040	31	0.0037	6.5	29	2.4
DD	0.0042	15	0.0031	1.3	15	0.6
GR	0.0033	14	0.0023	1.1	14	0.5
HM	0.0046	11	0.0044	1.5	11	0.7
MR	0.0048	14	0.0032	1.5	14	0.7
MS	0.0039	15	0.0024	1.1	15	0.5
ORB	0.0067	16	0.0094	2.5	16	1.4
PR	0.0044	17	0.0046	3.6	17	2.3
PSF	0.0052	17	0.0034	1.0	17	0.0
PSE	0.0048	17	0.0033	2.3	17	2.1
Site	**COD**			**CL**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	30.5	17	17.4	4132.3	15	2859.7
BD	13.5	31	8.2	538.2	27	1034.8
BR	23.2	31	14.3	1373.4	27	1532.3
DD	13.0	15	8.2	2285.4	14	2275.0
GR	11.2	14	7.8	1579.4	11	1695.5
HM	16.3	11	8.7	1681.8	8	1743.8
MR	16.2	14	12.5	1951.5	13	1971.1
MS	16.8	15	15.5	2990.3	14	3145.3
ORB	24.0	16	17.7	3917.1	14	2709.6
PR	28.4	17	19.4	4834.6	15	3242.5
PSF	8.1	17	6.9	40.5	15	21.1
PSE	18.1	17	9.2	2528.7	15	2239.3
Site	**Fl**			**SO_4**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.3	16	0.1	611.3	15	391.2
BD	0.2	27	0.0	72.1	26	115.8
BR	0.3	27	0.3	205.1	27	217.9
DD	0.3	14	0.1	328.4	14	284.4
GR	0.3	12	0.1	234.9	11	231.1
HM	0.3	9	0.3	285.2	9	251.9
MR	0.3	13	0.3	281.0	13	278.6
MS	0.3	14	0.3	406.2	14	344.0
ORB	0.3	14	0.0	582.9	14	383.7
PR	0.3	15	0.1	683.3	15	418.7
PSF	0.3	15	0.1	13.0	15	6.5
PSE	0.3	15	0.1	370.8	15	322.5
Site	**TN**					
	Mean	**N**	**Std.Dev**			
BC	1.5400	15	1.2020			
BD	1.0767	27	0.4166			
BR	2.1019	27	0.7623			
DD	0.4638	13	0.1698			
GR	0.4250	12	0.1780			
HM	0.6250	8	0.2237			
MR	0.4958	12	0.2039			
MS	0.4585	13	0.1612			
ORB	1.0293	14	0.8705			
PR	0.9133	15	0.3939			
PSF	1.2164	14	0.3726			
PSE	0.9373	15	0.3224			

Appendix 9-4: Results of 2008 Probabilistic Monitoring

Station ID	Subwatershed	DNR 12 Digit Subsheds	Benthic Index of Biotic Integrity Score	Rating
Prettyboy Reservoir				
0204014	Prettyboy Direct Drainage-A	0313	4.00	Good
0204033	Georges Run	0314	3.67	Fair
0208001	Gunpowder Falls	0316	4.00	Good
0208005	Walker Run	0316	4.33	Good
0208006	Grave Run	0315	4.00	Good
0208009	Gunpowder Falls	0316	3.67	Fair
0208012	Peggy's Run	0314	3.33	Fair
0208013	Prettyboy Branch	0313	3.67	Fair
0208018	Prettyboy Branch	0313	4.00	Good
0208019	Peggy's Run	0314	2.33	Poor
0208022	Frog Hollow	0313	4.33	Good
0208036	Grave Run	0315	4.00	Good
0208038	Peggy's Run	0314	3.67	Fair
Loch Raven Reservoir				
0304021	Fourth Mine Branch	0309	4.33	Good
0304084	Piney Run	0308	4.33	Good
0304121	Blackrock Run	0307	4.00	Good
0304197	Baisman Run	0302	4.00	Good
0304208	Goodwin Run	0302	1.00	Very Poor
0304214	Merryman's Branch	0300	2.67	Poor
0308007	Piney Creek	0305	3.67	Fair
0308016	Blackrock Run	0307	4.00	Good
0308018	First Mine Branch	0309	2.00	Poor
0308028	Beetree Run	0311	4.00	Good
0308036	Gunpowder Falls	0306	4.00	Good
0308042	Little Falls	0312	4.00	Good
0308044	Loch Raven Reservoir-E	0300	3.33	Fair
0308046	Deadman's Run	0303	4.00	Good
0308048	Little Falls	0312	4.00	Good
0308049	Goodwin Run	0302	1.67	Very Poor
0308050	Slade Run	0303	4.67	Good
0308055	McGill Run	0308	4.00	Good
0308061	Indian Run-Loch Raven	0307	4.33	Good
0308064	Overshot Run	0301	4.33	Good
0308068	Western Run-Loch Raven-A	0303	3.33	Fair
0308072	Little Falls	0312	4.33	Good
0308078	Buffalo Creek	0305	4.33	Good
0308083	Blackrock Run	0307	3.67	Fair
0308086	Beaver Dam Run	0302	4.00	Good

0308092	Bush Cabin	0306	4.67	Good
0308093	Gunpowder Falls	0304	2.00	Poor
0308095	Fitzhugh Run	0300	4.00	Good
0308097	Piney Run	0308	4.00	Good
0308102	Second Mine Branch	0309	4.33	Good
0308107	Loch Raven Reservoir-F	0300	3.33	Fair
0308109	Little Falls	0312	4.00	Good
0308112	Indian Run-Loch Raven	0307	4.67	Good
0308115	Piney Run	0308	3.00	Fair
0308117	Little Piney Run	0308	3.00	Fair
0308118	Oregon Run	0302	2.00	Poor
0308120	Piney Creek	0305	3.33	Fair
0308128	Bush Cabin	0306	4.00	Good
0308139	Indian Run-Loch Raven	0307	3.33	Fair
0308144	Dulaney Valley Branch	0300	4.00	Good
0308146	Piney Run	0308	3.33	Fair
0308152	Little Falls	0312	3.33	Fair
0308157	Beetree Run	0311	4.67	Good
0308160	Bush Cabin	0306	4.00	Good
0308164	Bush Cabin	0306	4.67	Good
0308165	Gunpowder Falls	0306	4.00	Good
0308174	Blackrock Run	0307	4.00	Good
Deer Creek				
0404001	Harris Mill	0332	4.33	Good
0404006	Plumtree Branch	0332	3.67	Fair
0408023	Deer Creek-A	0332	4.00	Good
0408024	Deer Creek-A	0332	4.00	Good
0408026	Deer Creek-A	0332	2.67	Poor
0408029	Harris Mill	0332	2.67	Poor
0408030	Ebaughs Creek	0332	3.33	Fair
0408032	Harris Mill	0332	1.67	Very Poor
0408036	Deer Creek-A	0332	4.00	Good
0408041	Ebaughs Creek	0332	3.67	Fair
0408042	Harris Mill	0332	1.33	Very Poor
0408044	Ebaughs Creek	0332	3.33	Fair
Little Gunpowder Falls				
0904008	Parker Branch	0299	3.67	Fair
0908001	Little Gunpowder Falls-C	0298	3.67	Fair
0908002	Little Gunpowder Falls-A	0298	4.33	Good
0908003	Little Gunpowder Falls-C	0298	4.00	Good
0908004	Sawmill Branch	0299	4.33	Good

0908005	Little Gunpowder Falls-A	0298	3.67	Fair
0908008	Little Gunpowder Falls-A	0299	3.67	Fair
0908010	Little Gunpowder Falls-A	0298	3.67	Fair
0908011	Little Gunpowder Falls-A	0299	3.67	Fair
0908014	Little Gunpowder Falls-A	0298	3.67	Fair
0908025	Sawmill Branch	0299	4.33	Good
Lower Gunpowder Falls				
1004002	Jennifer Branch	0297	1.33	Very Poor
1004029	Long Green Creek	0297	2.00	Poor
1008001	Lower Gunpowder Falls	0297	1.00	Very Poor
1008003	Lower Gunpowder Falls	0296	3.00	Fair
1008006	Lower Gunpowder Falls	0297	1.00	Very Poor
1008020	Lower Gunpowder Falls	0296	2.67	Poor
1008024	Long Green Creek	0297	1.33	Very Poor
1008029	Jennifer Branch	0297	1.33	Very Poor
1008037	Minebank Run	0297	1.67	Very Poor
1008038	Minebank Run	0297	1.00	Very Poor
1008040	Sweathouse Run	0296	4.33	Good
1008041	Sweathouse Run	0296	4.33	Good
Bird River				
1108001	Bird River-D	0294	1.67	Very Poor
1108003	Whitemarsh Run	0295	1.00	Very Poor
1108004	Whitemarsh Run (S.Fo)	0295	1.67	Very Poor
1108008	Honeygo Run	0295	1.33	Very Poor
1108016	Whitemarsh Run (S.Fo)	0295	1.67	Very Poor