9.0 Permit Requirements

F. <u>Discharge Characterization</u>

Baltimore County and 10 other municipalities in Maryland have been conducting discharge characterization monitoring since the early 1990's. From this expansive monitoring, a statewide database has been developed that includes hundreds of storms across numerous land uses. Analyses of this dataset and other research performed nationally effectively characterize stormwater runoff in Maryland for NPDES municipal stormwater purposes. To build on the existing information and to better track progress toward meeting TMDLs, better data are needed on ESD performance and BMP efficiencies and effectiveness.

Assessment of controls is critical for determining the effectiveness of the NPDES stormwater management program and progress toward improving water quality. The County shall use chemical, biological, and physical monitoring to document work toward meeting applicable WLAs developed under EPA approved TMDLs. Additionally, the County shall continue physical stream monitoring in the Windlass Run to assess the implementation of latest version of the *2000 Maryland Stormwater Design Manual*. Specific monitoring requirements are described below.

1. <u>Watershed Restoration Assessment</u>

Baltimore County shall monitor the Scotts Level Branch, or, select and submit for MDE's approval a new watershed restoration project for monitoring. Monitoring activities shall occur where the cumulative effects of watershed restoration activities can be assessed. One outfall and associated in-stream station, or other locations based on a study design approved by MDE, shall be monitored. The criteria for chemical, biological, physical monitoring are as follows:

a. <u>Chemical Monitoring</u>

i. Twelve (12) storm events shall be monitored per year at each monitoring location with at least three occurring per quarter. Quarters shall be based on the calendar year. If extended dry weather periods occur, baseflow samples shall be taken at least once per month at the monitoring stations if flow is observed;

ii. Discrete samples of stormwater flow shall be collected at the monitoring stations using automated or manual sampling methods. Measurements of pH and water temperature shall be taken;

iii. At least three (3) samples determined to be representative of each storm event shall be submitted to a laboratory for analysis according to methods listed under 40 CFR Part 136 and event mean concentrations (EMC) shall be calculated for:

Biochemical Oxygen demand (BOD_5)	Total Lead
Total Kjeldahl Nitrogen (TKN)	Total Copper
Nitrate plus Nitrite	Total Zinc
Total Suspended Solids	Total Phosphorus
Total Petroleum Hydrocarbons (TPH)	Hardness
E. coli or enterococcus	

iv. Continuous flow measurements shall be recorded at the in-stream monitoring station or other practical locations based on an approved study design. Data collected shall be used to estimate annual and seasonal pollutant loads and reductions, and for the calibration of watershed assessment models.

b. Biological Monitoring

i. Benthic macroinvertebrate samples shall be gathered each Spring between the outfall and the in-stream stations or other practical locations based on MDE approved study design; and

ii. The County shall use EPA Rapid Bioassessment Protocols (RBP), Maryland Biological Stream Survey (MBSS), or other similar method approved by MDE.

c. Physical Monitoring

i. A geomorphologic stream assessment shall be conducted between the outfall and the in-stream monitoring locations or in a reasonable area based on the approved study design. This assessment shall include an annual comparison of permanently monumented stream channel cross-sections and the stream profile.

ii. A stream habitat assessment shall be conducted using techniques defined by the EPA's RBP, MBSS, or other similar method approved by MDE; and

iii. A hydrologic and/or hydraulic model shall be used (e.g., TR-20, HEC-2, HEC-RAS, HSPF, SWMM, etc.) in the fourth year of the permit to analyze the effects of rainfall; discharge rates; stage; and, if necessary, continuous flow on channel geometry.

d. Annual Data Submittal: The County shall describe in detail its monitoring activities for the previous year and include the following:

i. EMCs submitted on MDE's long-term monitoring database as specified in PART IV below;

ii. Chemical, biological, and physical monitoring results and a combined analysis for the approved monitoring locations; and

iii. Any requests and accompanying justifications for proposed modification to the monitoring program.

2. Stormwater Management Assessment

The County shall continue monitoring the Windlass Run for determining the effectiveness of stormwater management practices for stream channel protection. Physical stream monitoring protocols shall include:

a. An annual stream profile and survey of permanently monumented cross-sections in the Windlass Run to evaluate channel stability in conjunction with surrounding and on-going commercial development;

b. A comparison of the annual stream profile and survey of the permanently monumented cross-sections with baseline conditions for assessing areas of aggradation and degradation; and

c. A hydrologic and/or hydraulic model shall be used (e.g., TR-20, HEC-2, HEC-RAS, HSPF, SWMM, etc.) in the fourth year of the permit to analyze the effects of rainfall; discharge rates; stage; and, if necessary, continuous flow on channel geometry.

9.1 Introduction

Baltimore County is required to maintain a long-term monitoring location in an approved watershed to determine the effectiveness of stormwater management practices for stream channel protection. Additionally, chemical, biological, and physical monitoring is required to assess the cumulative effects of watershed restoration activities. The permit requires the County to conduct a systematic assessment of water quality for each watershed. These watershed assessments are to include detailed water quality analyses, identifying water quality improvement opportunities, and developing and implementing restoration plans to control stormwater discharges.

Assessment of controls is critical to determine the effectiveness of the NPDES stormwater management program. Therefore, chemical, biological, and physical monitoring is required to document progress toward improving water quality and meeting applicable stormwater WLAs developed under EPA approved TMDLs. This report will present the research design and monitoring data for Scotts Level Branch (9.2), Windlass Run (9.3), and Countywide monitoring locations (9.4). The monitoring results reporting is on a calendar year basis. This report covers monitoring conducted during calendar year 2015.

9.2 Scotts Level Branch Long-Term Monitoring

Scotts Level Branch is located in the Gwynns Falls watershed in the Patapsco/Back River Basin. The Gwynns Falls has a TMDL for sediment that requires a 36.5% reduction. On December 29, 2010, the U.S. Environmental Protection Agency established the Chesapeake Bay TMDL. The Chesapeake Bay TMDL requires 29% nitrogen and 45.1% phosphorus load reductions. The Gwynns Falls TMDL for bacteria has identified a ~98% reduction for human and domestic pet sources.

The Baltimore County NPDES Municipal Stormwater Discharge Permit requires monitoring of restoration effectiveness. For the first two rounds of the 5-year permit, the Spring Branch subwatershed had been monitored to determine the effectiveness of the stream restoration in promoting stream stability, reduction in pollutant loads, and improvement in the benthic macroinvertebrate community. Using the experience gained in monitoring Spring Branch, a more effective monitoring program has been designed for the Scotts Level Branch subwatershed, as detailed below.

While the Spring Branch study monitored the effectiveness of one large restoration project, the Scotts Level Branch monitoring is designed on the basis that a number of restoration projects will be implemented within the subwatershed over a period of time. The ability to detect effects of individual restoration projects will be dependent on the size of the restoration project in relation to the total subwatershed size. Therefore each restoration project will be monitored for project effectiveness, dependent on staff availability. The cumulative effects of restoration will be measured at the long-term in-stream monitoring site. In order to assess restoration progress in the Scotts Level Branch subwatershed, a before-after design concept will be used.

9.2.1 Monitoring Design

9.2.1.1 Flow Monitoring

Scotts Level Branch has a gage installed and operated by the US Geological Survey (SL-01) (Figure 9-1). USGS provides the rating curve and annual data for the gage. A 36" outfall near the headwater of Scotts Level Branch is being monitored for discharge and chemistry (SL-09). A weir was installed to permit continuous flow monitoring with a water level sensor installed and operated by Baltimore County. This outfall has a drainage area of 15.0 acres with ~35% impervious cover. The land use is ~88% medium residential and therefore representative of the major land use in each of the subwatersheds.

The flow monitoring will be used in conjunction with the chemical monitoring (described below) to determine pollutant loads and in relation to the geomorphological monitoring. Over time the flow data will be assessed for any changes in relation to restoration work that is conducted in the subwatersheds.

9.2.1.2 Chemical Monitoring

The chemical monitoring will include both storm event and baseflow monitoring components. The standard list of chemicals detailed in the permit requirements will be analyzed. Figure 9-1 displays the location of the chemical monitoring sites in Scotts Level Branch by type.

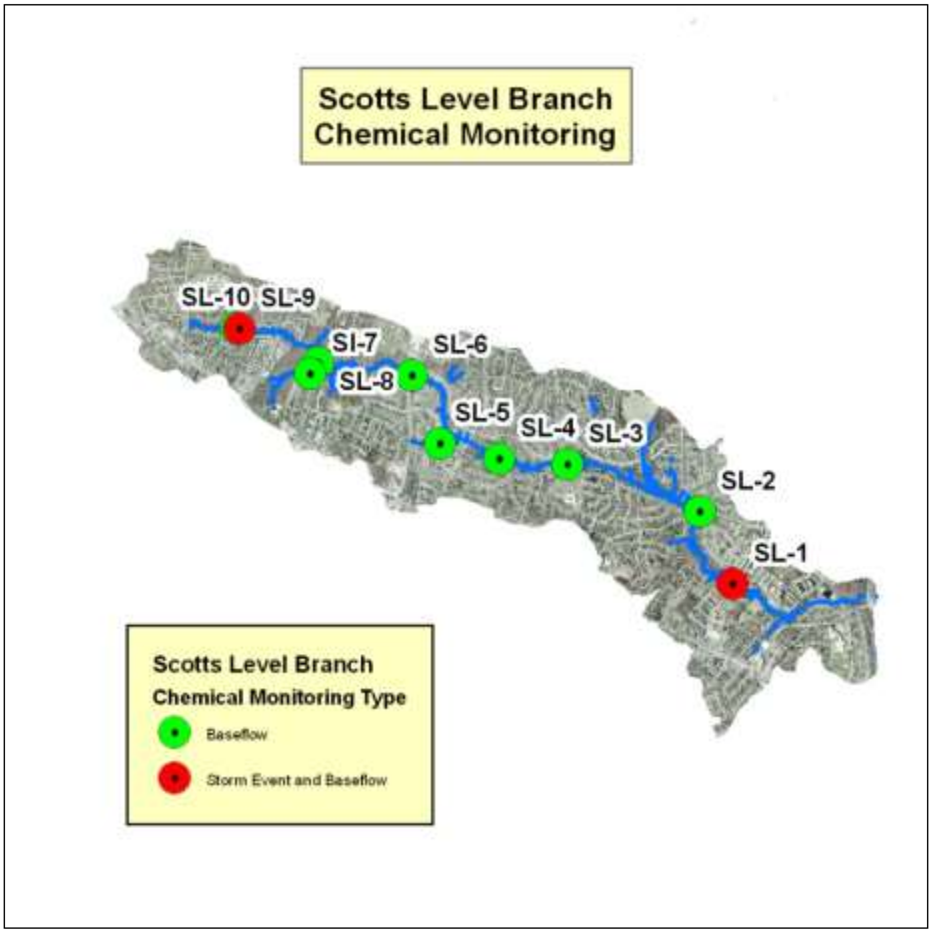


Figure 9-1: Scotts Level Branch Chemical Monitoring Locations

9.2.1.3 Storm Event Monitoring

Storm event monitoring occurs at the USGS gage site and at the outfall. The two Scotts Level Branch storm event monitoring sites (SL-1 in-stream, and SL-9 outfall) will be monitored for 12 storms each calendar year seeking to acquire samples for the entire hydrograph. The data will be analyzed using regression analysis to determine the relationship between discharge and pollutant concentration. These relationships will then be used in conjunction with the flow data collected from the USGS operated gage and the water level sensor operated by EPS. The results and subsequent analysis following restoration will be used to determine annual loads and any load reductions due to restoration activities.

The pollutant load data collected from the Scotts Level Branch outfall will be used to estimate the wash load (the load derived from the land surface). The pollutant load estimate derived from the Scotts Level Branch in-stream site will estimate the watershed load, which includes both the wash load and the load derived from stream bank erosion. The geomorphological analysis (see below) will attempt to determine the stream channel erosion component via changes in the channel cross-section and analysis of the pollutant concentration of the stream bank and bed. Thus the wash load (derived from the outfall data) plus the stream erosion load (derived from the geomorphological data) should equal the watershed load (derived from the in-stream monitoring data). These data should provide an estimate of the relative proportions of pollutants derived from the land surface and the stream corridor. This will have important implications for restoration efforts in urban settings. If, as the literature suggests, a large component of the sediment and total phosphorus load is derived from the stream channel, then in order to meet sediment and phosphorus load reduction requirements for TMDLs and the Chesapeake Bay Program additional effort will need to be focused on stream restoration.

Additional storm event monitoring will be associated with the restoration activities to determine the effectiveness of the restoration in reducing pollutant loads. These will also use a before-after design with installation of the monitoring equipment and collection of data occurring as far in advance of the restoration site as possible to collect the before data.

9.2.1.4 Baseflow Monitoring

Scotts Level Branch baseflow monitoring will occur at the outfall (SL-9), two tributary locations, and six mainstem locations for a total of 10 baseflow monitoring sites (Figure 9-1). The baseflow sites in Scotts Level Branch will be monitored quarterly during baseflow conditions (preceded by a minimum of 72 hours dry weather).

Analysis of baseflow pollutants is especially important in relation to nitrogen. Research work conducted by the County, indicates that ~50% of the nitrogen load occurs during dry weather. The baseflow sampling will be used in conjunction with the storm event sampling to partition the annual discharge and pollutant load between baseflow (dry weather) conditions and storm event conditions.

9.2.1.5 Geomorphic Monitoring

The geomorphic monitoring is intended to provide an estimate of stream erosion and deposition rates, and an estimate of the pollutant load derived from stream channel erosion. In addition, it is intended over time to provide an estimate of the effects of restoration on stream stability on both a project basis and over the entire subwatershed.

In order to assure unbiased selection of cross-section locations, Scotts Level Branch and Powder Mill Run were divided into 30 equal length stream segments, 20 in Scotts Level Branch (Figure 9-2) and 10 in Powder Mill Run (Figure 9-3). Within each segment a point was randomly selected, using a GIS subroutine, for location of permanent cross sections. These cross sections are monitored annually, usually in the fall or winter seasons with the results overlaid to provide an assessment of the amount of channel change. Two longitudinal profile reaches were selected in Scotts Level Branch for annual assessment.

In the summer of 2016 stream bank and bed core samples were collected in Scotts Level in the vicinity of nineteen permanent cross sections for laboratory analysis of bulk density, particle size distribution, total nitrogen, and total phosphorus. These were one-time sample collections, however additional samples should be collected to provide an analysis of annual variability. Based on the annual and long term change, and the results of the core samples, the estimated annual sediment, total nitrogen, and total phosphorus loads will be calculated for comparison with the chemical monitoring results derived from the in-stream monitoring site.

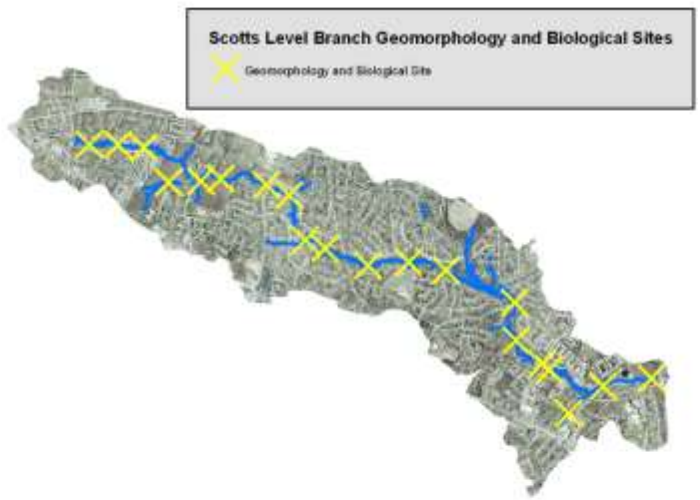


Figure 9-2: Scotts Level Branch Geomorphic and Biological Monitoring Site Locations

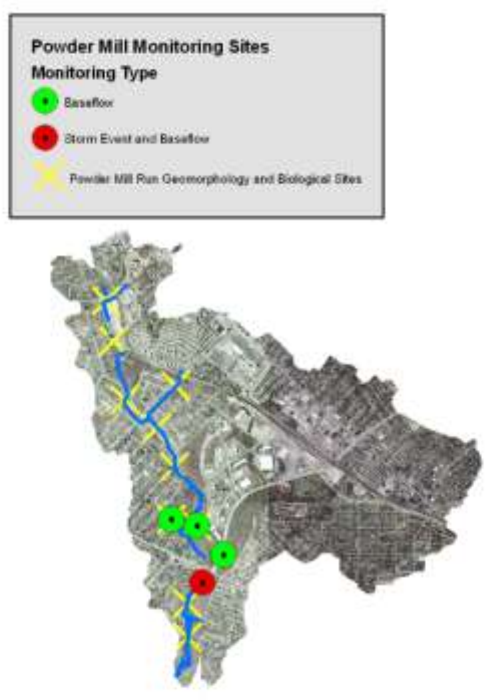


Figure 9-3: Powder Mill Run Chemical, Geomorphic and Biological Monitoring Sites

9.2.1.6 Biological Monitoring

Benthic macroinvertebrate and fish sampling is conducted annually at ten fixed stations on Scotts Level Branch and two fixed stations on Powder Mill Run, during the appropriate index periods (March-April for macroinvertebrates, June-September for fish). Maryland Biological Stream Survey (MBSS) methods are followed. Macroinvertebrate identification is to the Genus taxonomic level or the lowest practical identification level. At the time of sample collection, the appropriate MBSS stream habitat assessment is conducted. The biological monitoring data are integrated with the cross sectional and habitat data to produce an overall assessment of conditions in the subwatersheds.

9.2.2 Scotts Level Branch Long-Term Site Monitoring Results

9.2.2.1 Chemical Monitoring Results

The data analysis for chemical monitoring includes three components, storm event monitoring, baseflow monitoring, and the calculation of pollutant loads.

9.2.2.1.1 Storm Event Monitoring Results

The chemical results from the storm event monitoring at the Scotts Level Branch in-stream (SL-01) and outfall (SL-09) monitoring sites were analyzed in conjunction with the discharge data.. Eight storms were monitored for the instream site (SL-01) and twelve were monitored at the outfall site (SL-09). Baseflow conditions were monitored twice during 2015. Attachment A of this document contains a table of these storms with calculated EMCs. Fewer storms were captured at the instream site due to a variety of factors, including a more variable response to precipitation than the outfall monitoring site. The county's laboratory also had intermittent availability and data issues, including being unavailable for the last two weeks of December 2015. Both the chemical and the discharge data were $\log_{10}$ transformed before regression analysis and all available data were used to determine the regression equations. The data for the regression equations was censored by removing any chemical data that was below the detection limit for any constituent. The regression equations were used to calculate the chemical concentrations for each 15-minute interval for recorded discharge. Regression equations were determined for Total Suspended Solids, TKN, Nitrate/Nitrite, Total Nitrogen, and Total Phosphorus. The results are displayed in Table 9-1 and Table 9-2 and an example regression graph is shown in Appendix 9-3.

Table 9-1: SL-01 Regression Equations Relationship Between Discharge (CFS) and Pollutant Concentrations

Parameter	Regression Equation
Total Suspended Solids	0.83725+0.53574*(log cfs)
Total Kjeldahl Nitrogen	-0.4125+0.23279*(log cfs)
Nitrate/Nitrite	-0.1806-0.1317*(log cfs)
Total Nitrogen	0.02911+0.08733*(log cfs)
Total Phosphorus	-1.243+0.26737*(log cfs)

Table 9-2: SL-09 Regression Equations Relationship Between Discharge (CFS) and Pollutant Concentrations

Parameter	Regression Equation
Total Suspended Solids	1.3149+0.18394*(log cfs)
Total Kjeldahl Nitrogen	0.02504-0.0018*(log cfs)
Nitrate/Nitrite	-0.4012-0.1835*(log cfs)
Total Nitrogen	0.22653-0.0919*(log cfs)
Total Phosphorus	-0.8396-0.0127*(log cfs)

For SL-01, Total Suspended Solids, TKN, and Total Phosphorus exhibited moderately positive relationships with discharge. The Nitrate/Nitrite relationship with discharge was weak and negative, while Total Nitrogen's (TKN+Nitrate/Nitrite Nitrogen) relationship to discharge was weak and positive.

For SL-09, Total Suspended Solids exhibited a weak positive correlation to discharge, while Nitrate/Nitrite relationship was weak and negative. TKN and TP exhibited a very weak, negative correlation to discharge.

9.2.2.1.2 Baseflow Monitoring Results

Scotts Level Branch baseflow monitoring occurred at the outfall (SL-9), two tributary locations, and six mainstem locations for a total of 10 baseflow monitoring sites (Figure 9-1). Within Powder Mill Run baseflow monitoring will take place at the USGS gage and two up-stream sites that are representative of each major branch (one in the County and one in the City). Baseflow monitoring in Upper Gwynns Falls will occur only at the USGS gage site. The baseflow sites in Scotts Level Branch, Powder Mill Run, and Upper Gwynns Falls will be monitored quarterly during baseflow conditions (preceded by a minimum of 72 hours dry weather).

Analysis of baseflow pollutants is especially important in relation to nitrogen. Research conducted by the County indicates that ~50% of the nitrogen load occurs during dry weather conditions. The baseflow sampling will be used in conjunction with the storm event sampling to partition the annual discharge and pollutant load between baseflow (dry weather) conditions and storm event conditions.

Pollutant loads were examined for each of the baseflow sites. Total Suspended solids were excluded from the baseflow analyses because limited conclusions can be drawn from this parameter during a baseflow sample. Many factors can affect the total suspended solids including small construction projects and car washing. These factors may only affect the stream for the limited time the sample is taken and can be misleading if extrapolated for a longer period of time. The results obtained were standardized to both daily pollutant load for drainage area and a daily load per acre and are shown in Table 9-3.

Table 9-3: 2015 Mean Daily Baseflow Pollutant Loads for Scott's Level Branch Sites

Site	Acres	TKN (mg/L)	TKN Daily Load (#s)	TKN Daily Load (#s per acre)	NO_2/NO_3 (mg/L)	NO_2/NO_3 Daily Load (#s)	NO_2/NO_3 Daily load (#s per acre)
SL-01	2,186	0.1*	n/a	n/a	1.21	9.16	0.0042
SL-02	1,908	0.25	0.91	0.0005	1.23	5.95	0.0031
SL-03	1,434	0.37	0.75	0.0005	1.19	3.51	0.0024
SL-04	1,167	0.22	0.59	0.0005	1.14	3.03	0.0026
SL-05 – Trib.	202	0.34	0.14	0.0007	3.27	1.16	0.0057
SL-06	742	0.24	0.45	0.0006	0.96	1.79	0.0024
SL-07 – Trib.	62	0.34	0.03	0.0005	1.27	0.11	0.0018
SL-08	451	0.23	0.24	0.0005	0.97	1.05	0.0023
SL-09 -outfall	15	0.20	0.15	0.0010	4.30	2.78	0.1853
SL-10	265	0.25	0.21	0.0008	1.17	0.97	0.0037
Site	**Acres**	**TN (mg/L)**	**TN Daily Load (#s)**	**TN Daily Load (#s per acre)**	**TP (mg/L)**	**TP Daily Load (#s)**	**TP Daily Load (#s per acre)**
SL-01	2,186	1.31	9.91	0.0045	0.025*	n/a	n/a
SL-02	1,908	1.41	6.71	0.0035	0.025*	n/a	n/a
SL-03	1,434	1.43	4.08	0.0028	0.025*	n/a	n/a
SL-04	1,167	1.36	3.61	0.0031	0.025*	n/a	n/a
SL-05 Trib.	202	3.49	1.24	0.0062	0.025*	n/a	n/a
SL-06	742	1.20	2.24	0.0030	0.025*	n/a	n/a
SL-07 Trib.	62	1.49	0.13	0.0021	0.025*	n/a	n/a
SL-08	451	1.20	1.30	0.0029	0.025*	n/a	n/a
SL-09 -outfall	15	4.45	2.88	0.1921	0.88	0.49	0.0329
SL-10	265	1.42	1.18	0.0045	0.11	0.03	0.0001

*- denotes values below detection limit,

9.2.2.1.3 Pollutant Load Calculations

Data from the USGS gage was recorded at 15-minute intervals from October 1, 2005 through June 4, 2013. Starting June 5, 2013, the intervals were changed to 5 minutes. There were 580,539 individual discharge readings. Discharge data from the Win-situ probe installed at the outfall recorded 209,893 15-minute intervals from January 1, 2010 to December 31, 2015. The regression equations determined above from the storm event samples, relating pollutant concentration to discharge, were used to determine the pollutant concentration for each 15-

minute interval. From this data the load was calculated for each 15-minute interval using the following formula:

$P_L = (P_C * .000008345)*(CFS*448.8*I)$, where

P_L = Pollutant Load,

P_C = Pollutant Concentration,

.000008345 = Conversion factor to convert mg/L to pounds per gallon,

CFS = Cubic feet per second,

448.8 = Conversion factor to convert cubic feet per second to gallons per minute

I = number of minutes in the interval (5 or 15).

The results obtained by the above formula were standardized to both an annual pollutant load for the drainage area and an annual pollutant load per acre (Table 9-4).

Table 9-4: Pollutant Load Characteristics for USGS gaged in-stream site (SL-01) calendar year 2015

Parameter	Pounds/ Year	Pounds/year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event lbs.	% Load as Storm Flow	Baseflow lbs.	% Load as Baseflow
TSS								
Fall	163,080	133,690	74.60	32.3%	161,130	98.8%	1,950	1.2%
Winter	98,888	81,067	45.24	19.6%	95,237	96.3%	3,651	3.7%
Spring	121,684	99,754	55.67	24.1%	117,247	96.4%	4,437	3.6%
Summer	120,937	99,142	55.32	24.0%	118,647	98.1%	2,290	1.9%
Total	**504,589**	**413,652**	**331.75**		**492,261**	**97.6%**	**12,328**	**2.4 %**
TKN								
Fall	2,723	2,233	1.02	32.8%	2,617	96.1%	106	3.9%
Winter	2,132	1,748	0.80	25.7%	1,988	93.2%	144	6.8%
Spring	1,867	1,530	0.70	22.5%	1,654	88.6%	213	11.4%
Summer	1,583	1,298	0.59	19.1%	1,460	92.3%	123	7.7%
Total	**8,305**	**6,809**	**3.11**		**7,719**	**92.9%**	**586**	**7.1%**
NO_2/NO_3								
Fall	1,487	1,219	0.56	31.7%	1,312	88.3%	175	11.7%
Winter	1,397	1,145	0.52	29.8%	1,231	88.1%	166	11.9%
Spring	1,025	840	0.38	21.9%	721	70.3%	305	29.7%
Summer	781	640	0.29	16.6%	575	73.7%	205	26.3%
Total	**4,689**	**3,844**	**1.76**		**3,839**	**81.9%**	**851**	**18.1%**
TN								
Fall	4,210	3,452	1.58	32.4%	3,929	93.3%	281	6.7%
Winter	3,529	2,893	1.32	27.2%	3,219	91.2%	310	8.8%
Spring	2,892	2,370	1.08	22.2%	2,375	82.1%	518	17.9%
Summer	2,364	1,938	0.88	18.2%	2,035	86.1%	328	13.9%
Total	**12,995**	**10,653**	**4.89**		**11,558**	**88.2%**	**1,437**	**11.8%**
TP								
Fall	456	374	0.17	32.8%	440	96.6%	16	3.4%
Winter	348	286	0.13	25.0%	326	93.6%	22	6.4%
Spring	315	259	0.12	22.7%	283	89.8%	32	10.2%
Summer	272	223	0.10	19.5%	254	93.3%	18	6.7%
Total	**1,392**	**1,141**	**0.52**		**1,304**	**93.7%**	**88**	**6.3%**

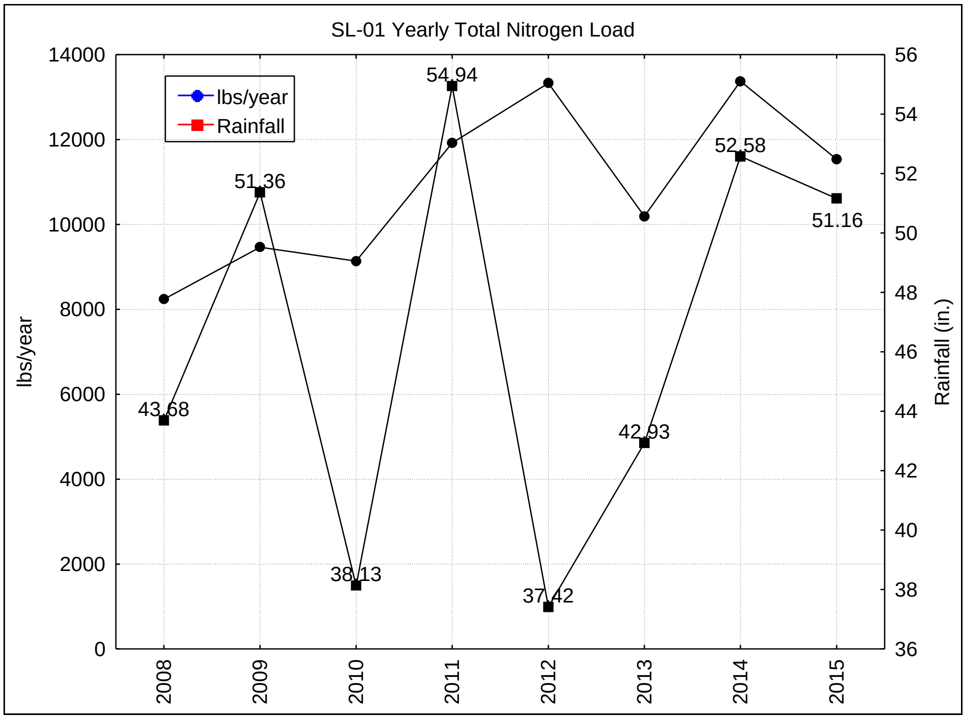
Table 9-5: Pollutant Load Characteristics for Outfall site (SL-09) calendar year 2015

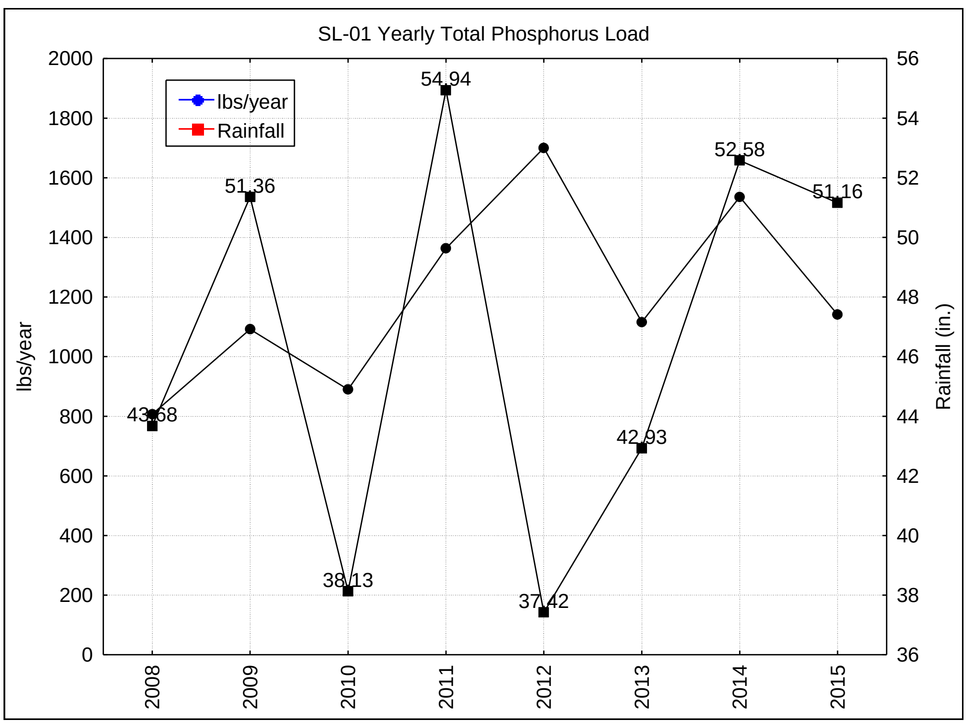
Parameter	Pounds/ Year	Pounds/year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event lbs.	% Load as Storm Flow	Baseflow lbs.	% Load as Baseflow
TSS								
Fall	1,826	1,497	99.81	19.7%	1,206	66.0%	620	34.0%
Winter	3,820	3,131	208.75	41.2%	3,047	79.8%	772	20.2%
Spring	1,825	1,496	99.74	19.7%	1,006	55.1%	819	44.9%
Summer	1,791	1,468	97.89	19.3%	1,184	66.1%	607	33.9%
Total	**9,262**	**7,593**	**506.20**		**6,443**	**69.6%**	**2,819**	**30.4%**
TKN								
Fall	89	73	4.88	20.4%	47	52.8%	42	47.2%
Winter	173	142	9.44	39.4%	125	72.3%	48	27.7%
Spring	95	78	5.20	21.7%	42	44.2%	53	55.8%
Summer	81	66	4.43	18.5%	39	48.1%	42	51.9%
Total	**438**	**359**	**23.94**		**253**	**57.5%**	**185**	**42.5%**
NO_2/NO_3								
Fall	45	37	2.46	21.4%	19	41.2%	26	57.8%
Winter	76	62	4.16	36.2%	49	64.2%	27	35.8%
Spring	49	40	2.68	23.3%	17	35.2%	32	64.8%
Summer	40	33	2.19	19.1%	13	32.5%	27	67.5%
Total	**210**	**172**	**11.50**		**98**	**43.3%**	**112**	**56.7%**
TN								
Fall	134	110	7.34	20.7%	66	49.3%	68	51.7%
Winter	249	204	13.60	38.4%	174	69.9%	75	30.1%
Spring	144	118	7.88	22.2%	59	41.0%	85	59.0%
Summer	121	99	6.62	18.6%	52	43.0%	69	57.0%
Total	**648**	**531**	**35.44**		**351**	**54.2%**	**297**	**45.8%**
TP								
Fall	14	11	0.75	20.4%	7	51.7%	7	48.3%
Winter	27	22	1.45	39.3%	19	71.8%	7	28.2%
Spring	15	12	0.80	21.8%	6	43.3%	8	56.7%
Summer	12	10	0.68	18.5%	6	47.2%	7	52.8%
Total	**68**	**55**	**3.69**		**38**	**56.9%**	**29**	**43.1%**

There are distinct seasonal differences in the delivery of nutrient and total suspended solids pollutant loads at SL-01. For Suspended Solids at SL-01, winter was observed to be the season of reduced loading. Nutrients had reduced loading during the summer. SL-09 showed higher loading during the winter than the other seasons for all parameters.

Figure 9-4 shows pollutant loads for TN, TP and TSS at the SL-01 gage throughout the year. This data is adjusted for average annual rainfall. In 2015, the total annual rainfall was 51.16 inches, compared to the average annual rainfall of 41.94 inches. As can be seen from the graphs, rainfall loosely follows pollutant load. A regression analysis shows that the total pollutant load for all three pollutants had a moderately to strongly positive correlation to rainfall. Pollutant loads adjusted for average annual rainfall had weak to very weak correlation to rainfall amounts.

However, factors such as intensity of rainfall and length of storm event may account for the variability.





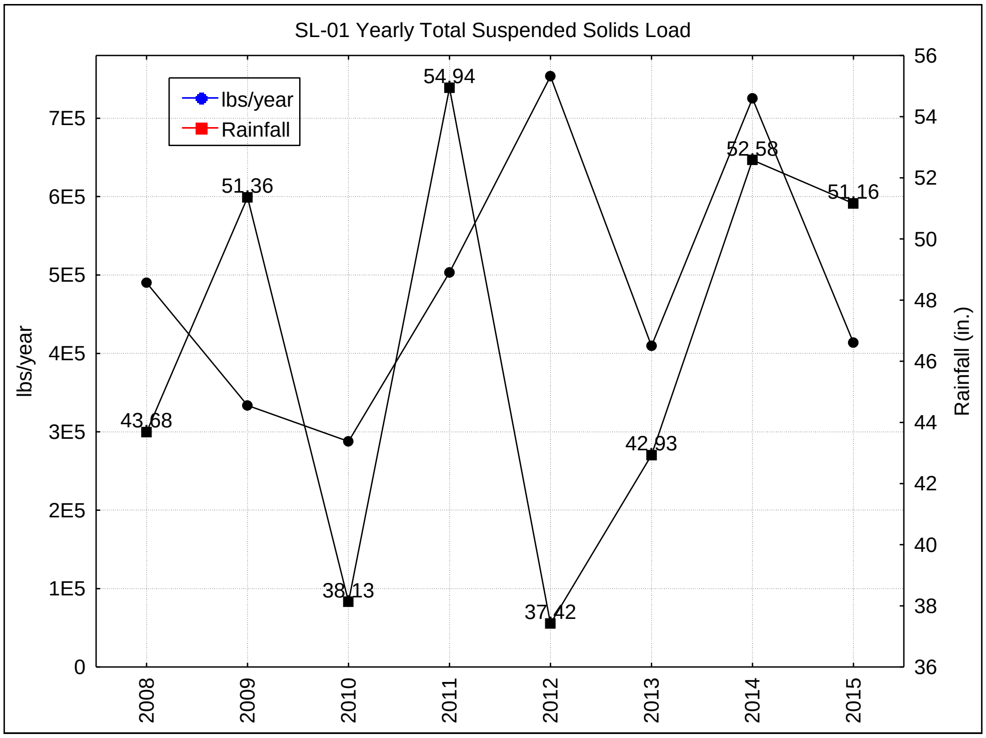


Figure 9-4: Scotts Level Branch pollutant loads at SL-01 gage from 2007-2015 (adjusted for average annual rainfall)

9.2.2.2 Geomorphic Monitoring Results

Streambank Soil Sampling: Nineteen sets of Scott's Level stream bank and bed core samples were collected in 2016 in the vicinity of the permanent cross sections for laboratory analysis of bulk density, particle size distribution, total nitrogen, and total phosphorus and other constituents. The data from each cross section will allow either positive or negative loading estimates to be made for the cross sections. These estimates, if extended to represent their respective stream segments, may provide information helpful in understanding the sediment and chemical flux of the stream system. Based on the annual and long term change, and the results of the core samples, the estimated annual sediment, total nitrogen, and total phosphorus loads will be calculated for comparison with the chemical monitoring results derived from the in-stream monitoring site.

9.2.2.2.1 Scotts Level Branch Geomorphic Monitoring Results

The morphology of 17 cross sections was examined to show changes that occurred in fall and winter of 2015/2016 and the changes over the period of 2006 through 2016. Figure 9-5 shows an overlay of CX #1 for 2015 and 2016. Table 9-6 presents the amount of aggradation (filling) or degradation (cutting) within the active channel, and Table 9-7 (listed from upstream to downstream) summarizes Table 9-6. Data in Table 9-6 were annualized by multiplying the cut/fill value by 365 over the number of days between measurements to standardize the aggradation and degradation estimates. The data files and plots are included on the CD accompanying this report. SL-18, SL-12, and SL-4 cross sections were not sampled. Both left and right bank pins for SL-18 could not be located. The pins for SL-12 were removed during stream restoration construction. The contractor, EA Engineering Science, will take future cross sectional data within the restoration site. SL-4 is lacking property owner permission, so this cross section was not sampled. A majority of cross sectional reaches showed minor adjustments in channel morphology between 2015 and 2016. SL-19, SL-11, SL-9, SL-6, SL-2, and SL-1 were more active (cut/fill > ± 4.0 cubic feet) than the rest of the cross sections. SL-1 is on a straight, low-gradient reach following a series of high-gradient, alternating riffles and short pools. As the stream slows at the gradient break, it deposits sands and silts along the stream banks. However, in 2015 numerous storms removed the sand deposits on the right bank.

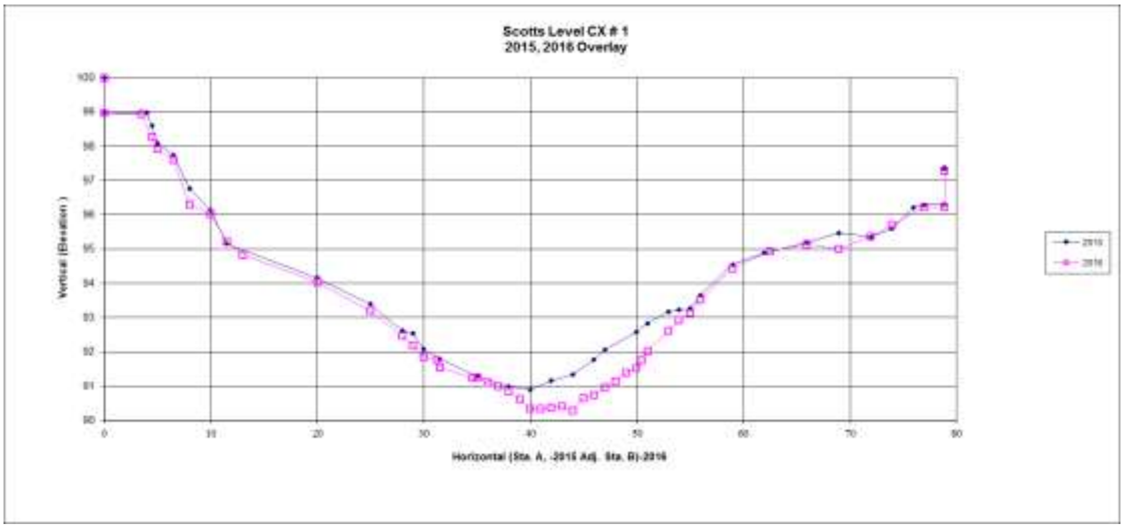


Figure 9-5: Scotts Level Branch Geomorphic Cross Section 1 Overlay showing differences in channel morphology between the 2015 and 2016 surveys.

Impervious land cover influences the majority of the Scotts Level Branch hydrology. Therefore the sediment fluxes within the stream channel are most likely part of the process of the stream reworking its surrounding legacy flood plain sediments and ultimately transporting them into the Gwynns Falls mainstem and beyond. The baseline data will be useful in evaluating the stream restoration project at McDonogh Road. The project stabilized the stream channel and reconnected the stream to the floodplain.

Table 9-6: Scotts Level Branch Cross Sections - Annualized Cut and Fill Amounts

SL20: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL10: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-0.5	-0.2	Total Cut	-2.0	-0.2
Total Fill	1.9	0.3	Total Fill	0.9	0.2
Total Change	2.4	0.5	Total Change	2.9	0.5
Net Change	1.4	0.0	Net Change	-1.0	0.0
SL19: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL9: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-11.0	-0.5	Total Cut	-6.7	-1.0

Total Fill	0.0	0.8	Total Fill	0.0	0.0
Total Change	11.1	1.3	Total Change	6.7	1.0
Net Change	-11.0	0.3	Net Change	-6.7	-1.0
SL18: Change (cu ft)*	**Period: 2015-2016**	**Period: 2006-2016**	**SL8: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	NA	NA	Total Cut	-2.7	-0.5
Total Fill	NA	NA	Total Fill	1.4	0.2
Total Change	NA	NA	Total Change	4.1	0.6
Net Change	NA	NA	Net Change	-1.2	-0.3
SL17: Change (cu ft)	**Period: 2015-2016**	**Period: 2012-2016**	**SL7: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-3.2	-0.3	Total Cut	-3.2	-0.5
Total Fill	2.7	0.3	Total Fill	0.8	0.8
Total Change	5.9	0.6	Total Change	4.0	1.3
Net Change	-0.5	-0.1	Net Change	-2.3	0.3
SL16: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL6: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-0.7	-0.4	Total Cut	-11.1	-0.3
Total Fill	2.0	0.3	Total Fill	0.1	0.2
Total Change	2.7	0.7	Total Change	11.2	0.5
Net Change	1.3	-0.1	Net Change	-11.0	-0.1
SL15: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL5: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-2.8	-0.2	Total Cut	-3.0	-1.1
Total Fill	0.6	0.0	Total Fill	0.7	0.0
Total Change	3.4	0.2	Total Change	3.7	1.1
Net Change	-2.2	-0.2	Net Change	-2.3	-1.0
SL14: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL4: Change (cu ft) ****	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-2.8	-1.4	Total Cut	NA	NA
Total Fill	3.4	0.3	Total Fill	NA	NA
Total Change	6.2	1.7	Total Change	NA	NA
Net Change	0.6	-1.0	Net Change	NA	NA

SL13: Change (cu ft)	Period: 2015-2016	Period: 2006-2016	SL3: Change (cu ft)	Period: 2015-2016	Period: 2006-2016
Total Cut	-1.4	-1.2	Total Cut	-0.8	-0.1
Total Fill	2.8	0.4	Total Fill	0.2	0.3
Total Change	4.2	1.6	Total Change	-0.6	0.4
Net Change	1.4	-0.7	Net Change	1.0	0.2
SL12: Change (cu ft)* **	**Period: 2015-2016**	**Period: 2006-2016**	**SL2: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	NA	NA	Total Cut	-2.5	-0.3
Total Fill	NA	NA	Total Fill	3.4	0.2
Total Change	NA	NA	Total Change	0.9	-0.2
Net Change	NA	NA	Net Change	5.9	0.5
SL11: Change (cu ft)	**Period: 2015-2016**	**Period: 2006-2016**	**SL1: Change (cu ft)**	**Period: 2015-2016**	**Period: 2006-2016**
Total Cut	-11.6	-0.9	Total Cut	-22.9	-1.0
Total Fill	2.8	0.4	Total Fill	0.1	1.2
Total Change	14.4	1.2	Total Change	23.0	2.2
Net Change	-8.7	-0.5	Net Change	-22.7	0.2

*SL-18 Right pin could not be located. New set of pins will be set in 2016

** SL-4 was not sampled in 2014. Permission from private property owners for SL 4 has not been obtained and will not be sampled.

*** SL-12 was not sampled in 2014 and was removed during stream restoration construction.

Table 9-7: Scotts Level Branch Stream Channel Changes Over Time.

SL #	CX 2015-2016	CX 2006-2016
20	a	nc
19	d	a
18	*	*
17 (Trib.)	d	d^
16	a	d
15	d	d
14	a	d
13	a	d
12	**	**

SL #	CX 2015-2016	CX 2006-2016
11	d	d
10	d	d
9	d	d
8	d	d
7	d	a
6	d	d
5	d	d^^
4	***	***
3	a	a
2	a	a
1	d	a

Symbols: a: aggradation, d: degradation, nc: no change

* The right pin monument for SL 18 could not be located. Annual and historic comparisons could not be made. New pins were set, and both comparisons will continue in the 2016 report.

** SL-12 was not sampled in 2014 and was removed during stream restoration construction.

*** SL-4 was not sampled in 2014. Permission from private property owners for SL 4 has not been obtained and will not be sampled.

^ SL-17 historically compared from 2012-2015 due to resetting of pin

^^ SL-5 historically compare from 2012-2015 due to resetting of pin

9.2.2.2.2 Powder Mill Run Geomorphic Monitoring Results

Cross-sectional measurements for the fall and winter of 2015/2016, and the period of 2006 through 2016, were compared to determine changes in bedload movement. The data files and plots are included on the CD accompanying this report. Table 9-8 presents cubic feet of aggradation (filling) and degradation (cutting) within the active channel of each cross section. Table 9-9 summarizes Table 9-8. The Powder Mill Run channel remained active. Similar to Scotts Level Branch, this most downstream station is on a relatively low-gradient reach, just downstream of a high-gradient riffle-pool section. The imperviousness of the upstream channel likely concentrates high flows and causes downstream channel instability.

Table 9-8: Powder Mill Run Cross Sections - Cut and Fill Amounts

PM 10:Change (cu ft)	Period:2015-2016	Period: 2006-2016		PM 5:Change (cu ft)	Period:2015-2016	Period: 2006-2016
Total Cut	-0.4	-0.2		Total Cut	-12.6	-2.1
Total Fill	5.3	1.0		Total Fill	1.8	0.4
Total Change	5.7	1.2		Total Change	14.4	2.4

Net Change	4.9	0.9		Net Change	-10.7	-1.7
PM 9:Change (cu ft)	**Period:2015-2016**	**Period: 2006-2016**		**PM 4:Change (cu ft)**	**Period:2015-2016**	**Period: 2006-2016**
Total Cut	-2.8	-0.2		Total Cut	-9.2	-1.2
Total Fill	3.9	0.8		Total Fill	4.1	1.3
Total Change	6.7	1.2		Total Change	13.3	2.5
Net Change	1.1	0.4		Net Change	-5.1	0.0
PM 8:Change (cu ft)	**Period:2015-2016**	**Period: 2006-2016**		**PM 3:Change (cu ft)**	**Period:2015-2016**	**Period: 2006-2016**
Total Cut	-4.6	-0.8		Total Cut	-0.8	-0.3
Total Fill	2.2	0.2		Total Fill	0.8	0.2
Total Change	6.8	0.9		Total Change	1.6	0.5
Net Change	-2.4	-0.6		Net Change	0.0	-0.2
PM 7:Change (cu ft)	**Period:2015-2016**	**Period: 2006-2016**		**PM 2:Change (cu ft)**	**Period:2015-2016**	**Period: 2006-2016**
Total Cut	-3.9	-0.3		Total Cut	-2.7	-0.4
Total Fill	0.2	0.1		Total Fill	8.3	0.8
Total Change	4.1	0.4		Total Change	10.9	1.2
Net Change	-3.7	-0.2		Net Change	5.6	0.4
PM 6:Change (cu ft)	**Period:2015-2016**	**Period: 2006-2016**		**PM 1:Change (cu ft)**	**Period:2015-2016**	**Period: 2006-2016**
Total Cut	-1.4	-0.3		Total Cut	-4.9	-1.5
Total Fill	4.6	0.6		Total Fill	5.4	1.6
Total Change	6.0	1.0		Total Change	10.4	3.1
Net Change	3.3	0.3		Net Change	0.5	0.1

Table 9-9: Powder Mill Run, 2014-2015 and 2006-2015 Stream Channel Changes

PM #	CX 2015-2016	CX 2006-2016
10	a	a
9	a	a
8	d	d
7	d	d
6	a	a
5	*	d**
4	*	nc*
3	a	d
2	*	a**
1	*	a**

Symbols: a: aggradation, d: degradation, nc: no change
***Not sampled for 2015**
****2006-2015**

9.2.2.3 Biological Monitoring Results

Benthic macroinvertebrate and fish sampling were conducted as per MBSS protocols. Benthic macroinvertebrates were sampled between March 3rd and April 30th, 2015 and fish were sampled between June 2nd and September 30th, 2015. Scotts Level Branch was sampled for benthos and fish at SL-1 SL-6, SL-9, SL-11, SL-11a, SL-12, SL-12a, SL-13, SL-14, and SL-18. Powder Mill Run was sampled at PM-1 and PM-4. The Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) were calculated using metrics developed by MBSS for Piedmont streams. The BIBI and FIBI scoring criteria are: 1.00-1.99 (Very Poor), 2.00-2.99 (Poor), 3.00-3.99 (Fair), and 4.00-5.00 (Good). Stream physical habitat was assessed when macroinvertebrates and fish were collected using the MBSS Physical Habitat Index. The protocol measured components of stream physical habitat, including fish habitat quality, macroinvertebrate habitat quality, stream depth and velocity diversity, riffle quality, pool quality, the percentage of sediment surrounding stream bottom substrates, and the percentage of shading in the stream reach. Each parameter was estimated on a scale of 0-20, except for sediment and shading, which were percentage estimates. 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.

The IBI scores are shown in Figure 9-6. All Scotts Level and Powder Mill BIBIs were in the Very Poor or Poor condition category. The BIBI and FIBI scores for all sites in Scotts Level and Powdermill were Poor or Very Poor. The following sites sampled for fish will be discussed in the McDonogh Road restoration section: SL-11, SL-11a, SL-12, SL-12a, and SL-13. Fish in Scotts Level Branch are able to survive the acute and chronic water quality problems within both streams than benthic macroinvertebrates. The mobility of fish likely allows them to better exploit good habitat and avoid such episodic events as high storm flows. The PHI scores are shown in Figure 9-7. Scotts Level Branch physical habitat condition was degraded at SL-6. SL-9. SL-14 and SL-18 were severely degraded. SL-1 was degraded.

The benthic and fish communities of Scotts Level Branch and Powder Mill Run show the effects of environmental stress. Both are low in diversity and are primarily composed of pollution tolerant organisms. The stream habitat is degraded and provides poor living space for both benthos and fish. As reported in previous Baltimore County NPDES reports, these results have been consistent since monitoring began in 2005, i.e., BIBI and FIBI ratings of Poor or Very Poor annually. The biological community of Scotts Level Branch is so impaired that it does not respond to fluctuations in precipitation and water temperature the way healthy streams do.

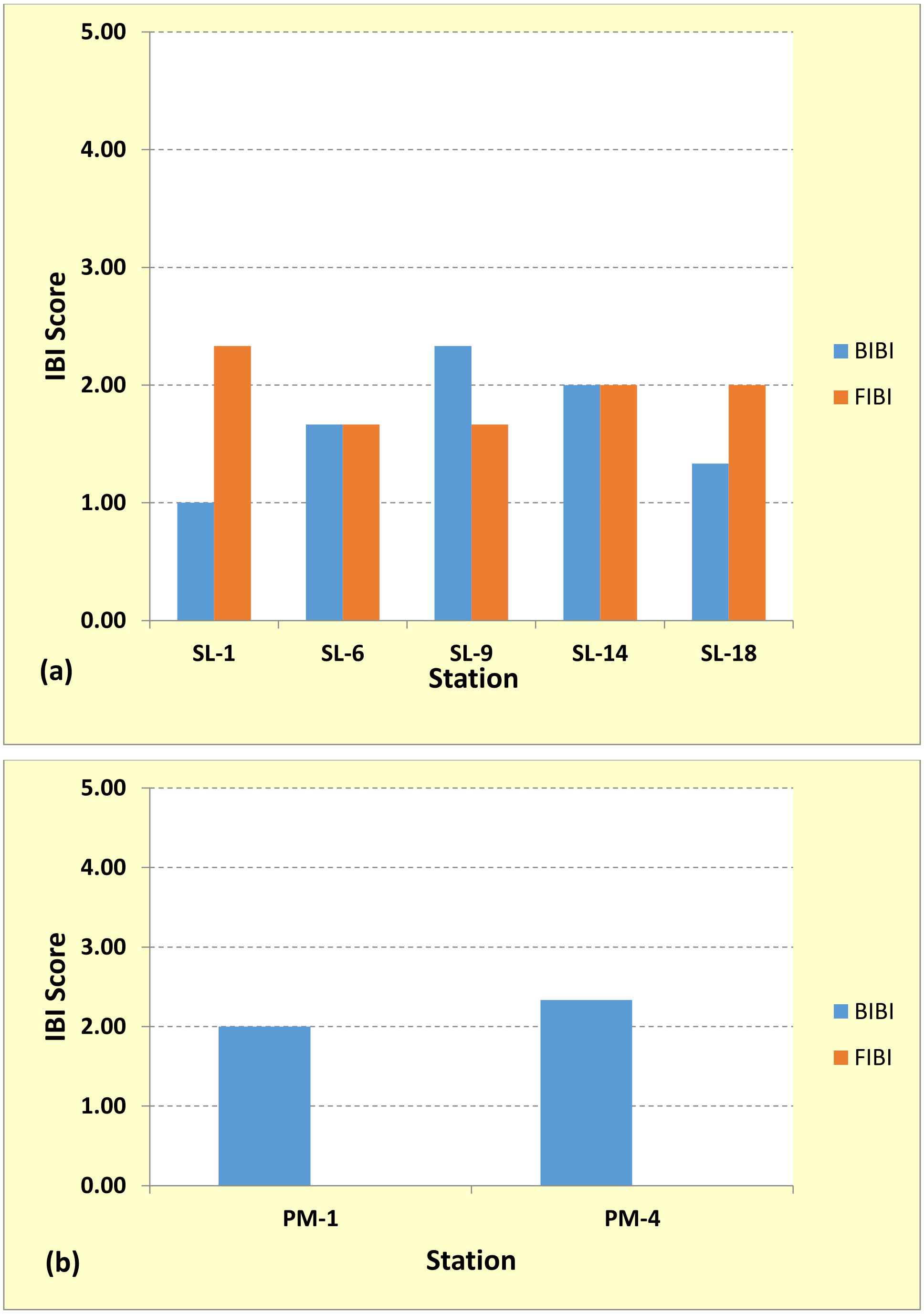


Figure 9-6: (a) Scotts Level Branch and (b) Powder Mill Run IBI Scores, 2015.

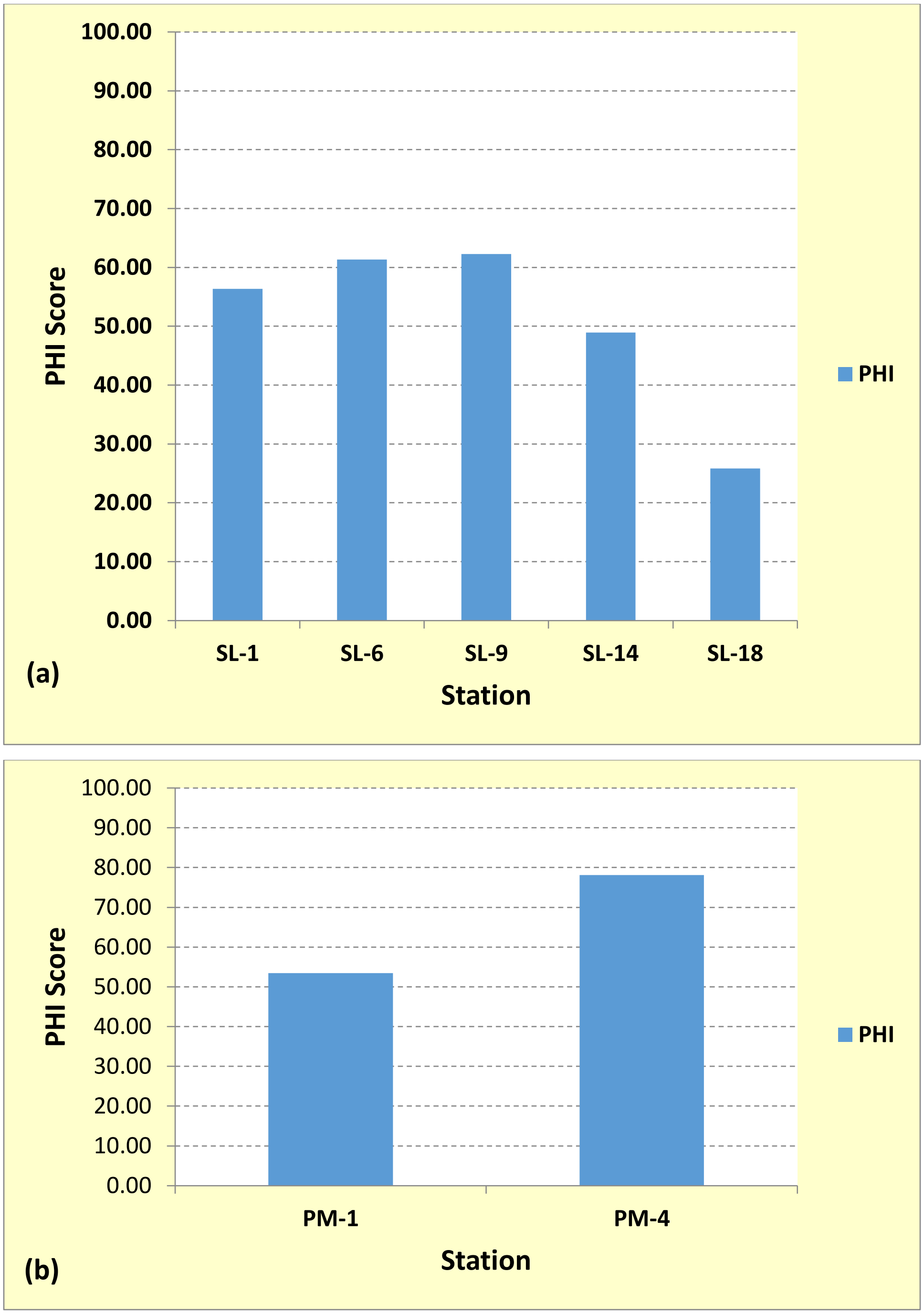


Figure 9-7: (a) Scotts Level Branch and (b) Powder Mill Run Physical Habitat Index 2015.

9.2.2.4 Scotts Level Branch Pollutant Load Calculations

Integrating geomorphology, stream bank soil chemistry, and water chemistry data, allows examination of pollutant loads for various components of the Scotts Level Branch watershed. The three components of the field model are in-stream water quality loads measured at SL-01, stream bank soil loads measured at the geomorphology cross-sections, and watershed wash-off loads measured at outfall SL-09. The model expectation is that in-stream water quality estimates are equal to the sum of stream bank and watershed wash-off estimates.

9.2.2.4.1 Stream Erosion Loads

The calculations for the stream erosion loads are based on the stream channel changes measured by the annual cross-sections and the mean concentration of TKN, NO_3, and TP determined by stream bank and bed chemical analysis. The net change at a particular cross-section was applied to a stream length based on the midpoints between cross-sections to determine the cubic feet of change for the stream reach. The load for each reach was then calculated based on the average bulk density of stream bank and bed samples, the chemical concentrations of nitrogen species, and total phosphorus. The numbers used in this analysis were:

- Mean Bulk Density = 86.86 lbs/ft^3
- Mean TKN Concentration = 0.0005495 lbs/lb sediment
- Mean NO_3 Concentration = 0.0000026 lbs/lb sediment
- Mean TP Concentration = 0.0001454 lbs/lb sediment

The following formulas were applied to determine the stream channel erosion loads for sediment, TKN, TP, NO_3, and TN

Sediment Load = Net Change Cross-section (ft^2) x reach length (ft) x Bulk Density (lbs/ft^3) (9.2)

Total TKN Load = Sediment Weight (lbs) x Mean TKN Concentration (9.3)

Total NO_3 Load = Sediment Weight (lbs) x Mean NO_3 Concentration (9.4)

Total TP Load = Sediment Weight (lbs) x Mean TP Concentration (9.5)

Total TN Load = Total TKN Load + Total NO_3 Load (9.6)

Table 9-10 shows load calculations derived from the geomorphology measurements for the calendar year 2015.

Table 9-10: 2015 Pollutant Load Estimates and Calculations for Stream Bank Soil Sediment and Nutrients

Site	Stream Length (ft)	Distance Between Sites	Adjusted Stream Length[1]	Net Cut/Fill at Site (cu ft)[2]	Cut/Fill Adjusted for Stream Length (cu ft)[3]	Sediment Weight (lbs)[4]	TKN (lbs)[5]	TP (lbs)[6]	NO_3 (lbs)[7]	TN (lbs)[8]
20	885	* [9]	1,643	1.4	2,301	199,838	109.8	29.06	0.52	110.3
19	2,402	1,517	1,351	-11.0	-14,861	-1,290,826	-709	-188	-3.36	-712.7
18	3,587	1,185	3,434	0	0	0	0	0	0	0
17	2,782	* [10]	3,662	-0.5	-1831	-159,041	-87.4	-23.1	-0.41	-87.8
16	12,932	5,683	3,918	1.3	5,093.5	442,424	243.1	64.3	1.15	244.3
15	15,085	2,153	2,269	-2.2	-4,992	-433,588	-238.3	-63.1	-1.1	-239.4
14	17,470	2,385	1,738	0.6	1,043	90,552	49.8	13.2	0.24	49.9
13	18,560	1,090	3,070	1.4	4,297	373,264	205.1	54.3	0.97	206.1
12	1,575	* [10]	1,601	0	0	0	0	0	0	0
11	25,210	5,049	3,764	-8.7	-32,743	-2,844,009	-1,563	-414	-7.4	-1,571
10	27,688	2,478	2,400	-1.0	-2,400	-208,464	-115	-30	-0.5	-1570

Site	Stream Length (ft)	Distance Between Sites	Adjusted Stream Length[1]	Net Cut/Fill at Site (cu ft)[2]	Cut/Fill Adjusted for Stream Length (cu ft)[3]	Sediment Weight (lbs)[4]	TKN (lbs)[5]	TP (lbs)[6]	NO_3 (lbs)[7]	TN (lbs)[8]
9	30,010	2,322	2,562	-6.7	-17,165	-1,490,987	-819.3	-217	-3.9	-823
8	32,812	2,802	6,845	-1.2	-8,213	-713,416	-392	-104	-1.85	-394
7	43,699	10,887	6,922	-2.3	-15,919	-1,382,763	-760	-201	-3.6	-763
6	46,655	2,956	2,612	-11	-28,732	-2,495,662	-1,371	-363	-6.5	-1,378
5	48,923	2,268	1,318	-2.3	-3,031	-263,307	-145	-38.3	-0.7	-145
Total Load (lbs)	--	--	--	--	--	-6,423,634		-934		-3,547
Total Load, Normalized for Rainfall (lbs)	--	--	--	--	--	**-7,726,859**		**-1,124**		**-4,266**

1 Stream length upstream of cross-section plus one-half the distance between cross-sections
2 As calculated from geomorphic cross-section measurements
3 Geomorphic cut/fill multiplied by adjusted stream length
4 Cut/fill adjusted for stream length multiplied by 86.86 lb/cu ft (mean bulk density of Scotts Level soils)
5 Weight of sediment in lbs multiplied by 0.0005495 (mean soil TKN in lb/lb sediment)
6 Weight of sediment in lbs multiplied by 0.0001454 (mean soil TP in lb/lb sediment)
7 Weight of sediment in lbs multiplied by 0.0000026 (mean soil NO_3 in lb/lb sediment)
8 TKN (lbs) plus NO_3 (lbs)
9 Upstream limit of study. "Distance between sites" does not apply.
10 Tributary. "Distance between sites" does not apply.

9.2.2.4.2 Watershed Load

The land surface pollutant load was calculated for 2015 using water chemistry data and discharge measurements from the outfall (SL-09). A flow-rating curve developed by the United States Geological Survey aided in calculating watershed wash-off loads at the SL-09 outfall. The calculated per acre loading rates from the outfall SL-09 were used to calculate the watershed load. The load was determined by placing the watershed acreage (watershed determined by drainage area to SL-01) into four categories:

- Acreage of urban land draining untreated to outfalls,
- Acreage of urban land draining to stormwater management facilities and receiving some treatment,
- Acreage of urban land that did not flow to a storm drain system (considered sheet flow to buffer), and
- Acreage in forest cover based on MDP 2007 land use and CBP Watershed Model 5.3 loading from forest.

Using the pollutant loading information provided in Table 9-5 on the standardized per acre loading rates (standardization based on average annual rainfall), the watershed per acre loads for Total Nitrogen, Total Phosphorus, and Total Suspended Solids were calculated. The respective loading rates were:

- 45.14 lbs/acre Total Nitrogen
- 3.69 lbs/acre Total Phosphorus
- 506.2 lbs/acre Total Suspended Solids

The acreages, nutrient loads, and sediment load by landscape category are shown in Table 9-11.

Table 9-11: Calculated Watershed Loads Delivered Based on SL-09 Monitoring Data

Landscape Category	Acres	TN Load	TP Load	Sediment Load
Untreated Outfalls	1,510.9	68,202	5,575	764,818
Stormwater Management	249.4	1,791	287	18,518
Sheet Flow to Buffer	127.1	184	19	820
Forest Cover	298.3	829	12	24,511
Total	**2,185.7**	**71,006**	**5,893**	**808,667**

The bulk of the nutrient and sediment loads from the watershed are delivered untreated directly to the stream through storm drain outfalls, and a smaller portion of the drainage receives some treatment from stormwater management facilities.

The calculated watershed loads (Table 9-11) were combined with estimated stream erosion loads (Table 9-10) to provide an estimate of the total load delivered to the in-stream monitoring site SL-01. The estimated total load was compared to the calculated (based on discharge and pollutant concentration) load from the monitoring data at SL-01 for 2015. The differences between the two loads were then calculated on both a pound and percentage basis. All loads are standardized to an average precipitation year. The results are displayed in Table 9-12.

Table 9-12: 2015 Watershed Pollutant Load Estimates Compared to Water Quality Monitoring at SL-01

Year	Component	Parameter		
		TN	TP	Sediment
2015	**Geomorphology Pollutant Load (lbs/yr)**	4,266	1,124	7,726,859
	Land Surface Pollutant Load (lbs/yr)	71,006	5,893	808,667
	Total Estimated Watershed Load to SL-01	**75,271**	**7,016**	**8,535,526**
	In-stream Water Quality Pollutant Load (lbs/yr) SL-01 – Measured	11,537	1,141	413,652
	Difference Between Estimated Load and Measured	63,734	5,875	8,121,874
	Percent Underestimate by In-stream Monitoring	**85%**	**84%**	**95%**

The in-stream monitoring site SL-01 measured pollutant loads were 84% - 95% less than the calculated loads based on the geomorphological and the outfall monitoring, site SL-09.

Several explanations may account for why the in-stream monitoring, and stream erosion estimates and land surface (based on outfall SL-09 monitoring) pollutant loads are out of balance. Suggestions for future avenues of investigation are provided for several of the points below.

- The estimates may not be accurate due to inadequate data. The estimates should become more refined as more data are collected annually. This is the sixth year for the pollutant load estimates and with additional water chemistry data we should get closer to a better estimate of the in-stream pollutant load.
- The outfall is not representative of each outfall in the watershed. This outfall has groundwater input whereas many of the other outfalls are dry. There are 18 major outfalls upstream from SL-01, which have 4.98 acres of drainage. Additional outfalls have been selected for comparative sampling to determine if the data is adequate.

- Geomorphology estimates are based on once-annual cross-sectional measurements. Although the loads are annualized, they are point-in-time estimates and may not accurately characterize the amount of material being moved through the channel in each study reach over the entire year. In future, more frequent cross-sectional measurements should be made to determine what, if any, effect this has on sediment and nutrient loads originating from the Scotts Level Branch stream banks.
- Randomly selected cross-sections may not accurately reflect nutrient and sediment fluxes within the Scotts Level Branch watershed. Targeted cross-sections should be considered, in areas where stream bank and floodplain indicators suggest frequent shaping of the active channel by storm events.
- Field-measured pollutant loads do not fully integrate stormwater management reductions. Samples for this analysis are collected during storm-flow. Stormwater management facilities retain water for treatment, so that the water wouldn't be released and flow past the gage until several days after sampling.
- The field-collected data may underestimate the in-stream pollutant loads, or the land surface pollutant loads may be overestimated. There may be a component of the in-stream load that our current monitoring is missing. For example, we may not be getting enough peak flow water quality data or we may be missing bed load, or large organic matter. The land surface loads may be overestimated because the SL-09 outfall is not representative of all outfalls in the watershed, as explained above.
- Scotts Level Branch benthic and fish communities are impaired, as shown in past EPS NPDES reports. Nutrient uptake by stream organisms is probably less than in a healthy, functional stream. However, it is likely that some ecosystem function such as, denitrification, floodplain deposition and in-stream biological uptake is maintained and may account for some of the difference between the in-stream measured loads and the estimated loads.
- The ISCO sampler at the in-stream site may not be collecting the entire sediment load. Therefore, the bank- and bedloads may be undersampled. We will do a comparison study between the ISCO sampler and manual grab samples to determine the validity of this statement.
- The County is currently funding a sediment loading study on Scotts Level Branch, which was started in 2015. USGS has been monitoring continuous turbidity levels with concurrent grab samples to develop a rating curve that will give us a better estimate of the sediment load.

9.2.2.4.3 Comparison of Scotts Level Pollutant Loads with the Chesapeake Bay Watershed Model Computed Loads

To aid in understanding the field-collected data, pollutant loads were calculated using a Chesapeake Bay model which incorporates loading rates for urban pervious, urban impervious, crop, pasture, and forested land use. The model also considers load reductions due to stormwater management measures. Table 9-13 shows the loading rates and acreages for each land use and the results of the computations for nitrogen, phosphorus, and sediment. These results are compared to the estimated watershed load for Scotts Level Branch. As can be seen from Table 9-13, the CBP Watershed Model underestimates the nitrogen, sediment and phosphorus loads in comparison to the data collected in Scotts Level Branch (Table 9-12). It should be noted that the in-stream measurements at SL-01 are closer to the CBP Watershed Model numbers than the estimated loads calculated for Scotts Level Branch.

Table 9-13: Land Use and CBP Watershed Model 5.3 Loading Rates for SL-01 Drainage Area and Calculated Loads

Land Use	Acres	Loading Rate N (lbs/ac/yr)	N Load (lbs/yr)	Loading Rate P (lbs/ac/yr)	P Load (lbs/yr)	Loading Rate TSS (lbs/ac/yr)	Sed Load (lbs/yr)
Urban Pervious	1,360.5	11.55	15,714	0.30	408	280.43	381,525
Urban Impervious	526.0	17.34	9,121	1.51	794	2,056.95	1,081,956

Crop	0.56	23.07	13	1.32	1	1,422.32	796
Pasture	0.37	7.97	3	0.74	0	307.45	114
Forest	298.3	2.78	829	0.04	12	82.17	24,511
CBP Total Load	**2,185.7**		**25,680**		**1,215**		**1,488,902**
In-stream SL-01 Measured Load			**11,537**		**1,141**		**413,652**
Scotts Level Estimated Load			**73,913**		**6,659**		**6,074,641**

9.2.2.4.4 *Summary*

This analysis has begun to show patterns of nutrient and sediment loading to Scotts Level Branch. Continued water quality and stream bank soil sampling, along with estimates of loads from the outfall, should provide more refined estimates of the relative contribution of each of these components to the pollutant loads within the watershed, as well as estimates of export from the watershed. These data will allow EPS to more accurately determine the contribution of the various flow components to overall pollutant load estimates, and will form the basis for more accurate determination of benefits from future stream restoration.

9.2.3 McDonogh Road Stream Restoration

Figure 9-8: Scotts Level Branch McDonogh Road Restoration Water Chemistry Monitoring Locations

Restoration work in the Scotts Level Branch was started in 2014 with the completion of the McDonogh Road site. Pre restoration monitoring data has been collected since 2005 and post restoration monitoring data was started in the fall of 2014. Figure 9-8 shows the location of the three water chemistry monitoring sites for the McDonogh Road restoration project. All three sites are outside the restoration project, with SL-05 being the Allenswood tributary site along with SL-12 (Meadow Heights) and SL-13 (McDonogh) being the main stem sites above and below restoration. The monitoring will consist of flow monitoring, chemical monitoring, geomorphological monitoring, and biological monitoring as described below.

Stream restoration and riparian enhancement began in December 2013 on approximately 1600 linear feet of stream channel and 4 acres of land surface in Scotts Level Branch, upstream of McDonogh Road. To investigate potential gains in water quality resulting from the restoration, EPS will complete pre- and post-restoration monitoring. Pre-restoration monitoring began in 2011. Stream restoration was completed in late Spring 2014. Stream chemistry is monitored at three stations within the project reach. Both baseflow (quarterly) and stormflow (12 storms per year) are sampled. A rating curve will be constructed to determine the relationship between discharge and pollutant loads. Benthos and fish are monitored at five stations within the reach. Changes in biological stream condition will be determined using the Maryland Benthic and Fish IBIs. Changes in fish species composition and biomass will also be examined. Pre-Restoration geomorphic monitoring has concluded. The cross section monuments were removed during the construction of the Restoration project. Baltimore County EPS will receive cross-sectional, longitudinal profiles, and pebble count data at each station within the restoration project from a consultant for the next 3 years. Post-Restoration cross section monuments were replaced within the restoration near the old Pre-Restoration monuments. For each monitoring component, there are stations upstream, within, and downstream of the restoration reach. Currently, Baltimore County EPS is expecting the consultant to provide the geomorphic data after this report is published. The geomorphic data will be compared in next year's report.

9.2.3.1 <u>McDonogh Road Geomorphic Monitoring Results</u>

Pre-Restoration monitoring consisted of three existing cross-sections (SL-11, SL-12, and SL-13) in Scotts Level Branch near McDonogh Road. A cross-section that was within the reach to be restored (CS 5) was added. Longitudinal profiles (20 bankfull widths long) and pebble counts were completed in each reach. SL-11 is downstream of the restoration, SL-13 is upstream of the restoration, CS 5 is within the restoration, and SL-12 is located on a tributary to Scotts Level Branch above the restoration site. A consultant will be monitoring geomorphic sites within the restoration. Baltimore County will monitor sites that are upstream and downstream of the restoration.

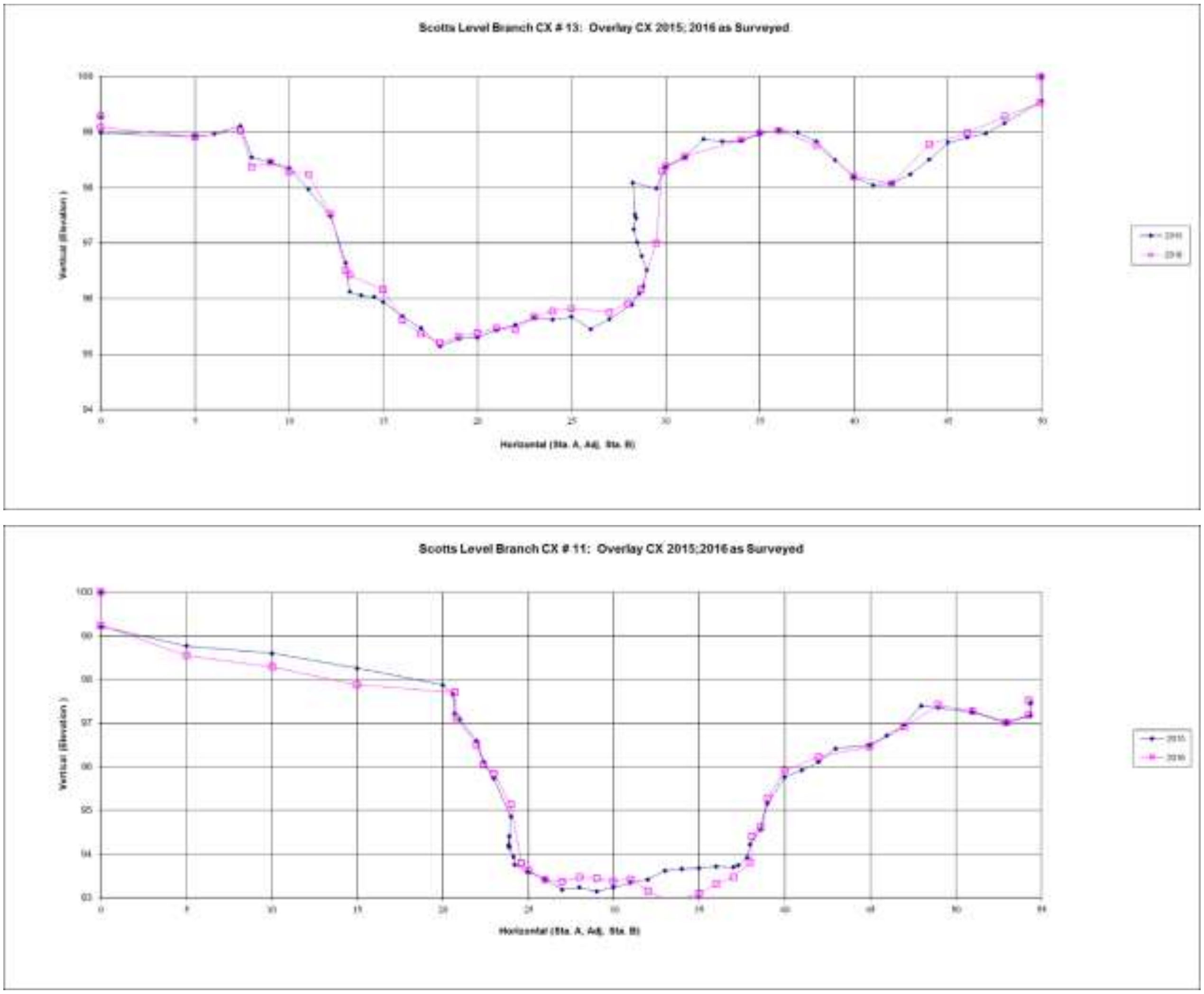


Figure 9-9: McDonogh Road 2015 and 2016 cross-section overlays.

Cross sectional data was collected in the early winter of 2015 and late winter of 2016. The data collected each year, represents the previous year's addition or subtraction of sediment from the cross section. ie. 2016 represents 2015. The 2015-2016 cross-section overlays for (Figure 9-9) show that each reach is typical of urbanized streams: incised and widened channels, and perched floodplains. Both cross sections of the restoration (SL-13 and SL-11) saw changes than the downstream cross section (SL-11). SL-13 gained 1.4 cubic feet of fill. SL-11 lost 8.7 cubic feet of sediment from the cross section. More data will be collected determine the potential benefit of the Scotts Level restoration on stream channel stabilization.

9.2.3.2 <u>McDonogh Road Biological Monitoring Results</u>

Scotts Level Branch was sampled for benthos and fish at SL-11, SL-11a, SL-12, SL-12a, and SL-13. Five stations were monitored to establish pre-restoration biological condition: SL-11 (downstream of restoration), SL-11a (on main stem within restoration), SL-12 (tributary upstream of confluence to main stem, within restoration), SL-12a (tributary, upstream of restoration and SL-12), and SL-13 (Scotts Level Branch, upstream of restoration). Table 9-14 shows BIBI, FIBI and PHI values for pre-restoration (2011-2013) and post restoration (2014 &

2015). All stations had biological communities' characteristic of urban streams. However BIBI scores did show a significant increase between pre and post restoration with scores going from a Very Poor to Poor Category at all but one site. (Table 9-15). All sites' 2015 FIBI scores decreased into the Very Poor category. Taxonomic diversity was low, and the organisms present were pollution tolerant. Habitat was degraded or severely degraded.

Table 9-14: BIBI, FIBI and PHI values for McDonogh Road restoration biological monitoring stations

Station	Status – Stream Restoration	Year	BIBI	FIBI	PHI
S-11 Mainstem Downstream of Restoration	Pre	2011	1.33	1.67	58
	Pre	2012	1.00	2.00	53
	Pre	2013	1.00	1.67	59
	Post – 0 Year	2014	2.33	2.00	59
	Post – 1 Year	2015	2.00	1.67	57
S-11a Mainstem Within Restoration	Pre	2011	1.33	1.67	52
	Pre	2012	1.00	1.67	55
	Pre	2013	1.00	2.00	58
	Post – 0 Year	2014	2.33	2.00	58
	Post – 1 Year	2015	2.33	1.67	57
SL-12 Tributary Within Restoration	Pre	2011	1.33	1.67	54
	Pre	2012	1.00	2.00	46
	Pre	2013	1.00	1.33	56
	Post – 0 Year	2014	NA	2.00	56
	Post – 1 Year	2015	2.67	1.33	47
SL-12a Tributary Upstream of Restoration	Pre	2011	2.00	1.33	40
	Pre	2012	1.33	1.00	25
	Pre	2013	1.00	1.33	43
	Post – 0 Year	2014	2.00	1.33	43
	Post – 1 Year	2015	2.00	*	44
SL-13 Upstream of Restoration	Pre	2011	2.00	1.33	52
	Pre	2012	1.00	1.67	55
	Pre	2013	1.67	1.67	66
	Post – 0 Year	2014	1.66	2.00	66
	Post – 1 Year	2015	2.00	1.33	45

***SL-12a = No fish were captured; unable to do FIBI Calculation**

Table 9-15: Mean BIBI, FIBI and PHI values for McDonogh Road restoration biological monitoring stations

Station	Status	Mean			BIBI Sign. Diff. <0.05
		BIBI	FIBI	PHI	
SL-11	Pre	1.11	1.78	57	Yes
	Post	2.17	1.84	58	
SL-11a	Pre	1.11	1.78	55	Yes
	Post	2.33	1.84	58	
SL-12	Pre	1.11	1.67	52	Yes
	Post	2.67	1.67	52	
SL-12a	Pre	1.44	1.22	36	Yes
	Post	2.00	1.33	44	
SL-13	Pre	1.56	1.56	58	Yes
	Post	1.83	1.67	56	

9.3 Windlass Run Monitoring – Stormwater Management Assessment

Baltimore County's National Pollutant Discharge Elimination System (NPDES) permit requires the monitoring of a subwatershed for geomorphologic impacts resulting from development under the revised Stormwater Management Design Manual (year 2000). In order to comply with this component of the permit, Baltimore County conducted a comprehensive review of the available land for development. An analysis using geographic information systems (GIS) was used for selection of the monitoring subwatershed. The characteristics for determination of the selected subwatershed were:

- 1) an area of open undeveloped land, and
- 2) an area with a zoning category that would lead to development.

Nearly all new development and redevelopment will be affected by the guidelines in the new stormwater design manual, but the denser developments are expected to show a more dramatic change to the stream system. Therefore the study area must have a zoning category of sufficient density to affect the stability of the stream system. The results of a countywide screening, followed by field verification led to the selection of Windlass Run as the monitoring subwatershed.

The Windlass Run subwatershed is 1,926 acres, and has the potential for a large amount of future development. The level of imperviousness in the subwatershed at the beginning of the study was about 3 % and is expected to increase to well over 20%. Much of the undeveloped land is zoned for manufacturing. The development in this subwatershed began after the extension of MD route 43 was completed. This roadway is the primary access to these new properties and is needed for the intense level of development expected in this subwatershed. If this high-density development is not controlled, it is expected to have a severe impact on the water quality and stability of Windlass Run. The protection provided by the new stormwater management regulations should be easily visible through monitoring of the stream conditions.

Windlass Run is a Coastal Plain stream system typified by a stable, low gradient, sinuous, unconfined, silt and sand channel within well-developed floodplains. Average Rosgen bankfull width and corresponding bankfull depths are 10 and 2 feet, respectively. The Windlass Run system is very stable, and there are no areas of moderate or severe streambank erosion. One year of stream gage data was recorded by U.S.G.S. in 1992 – 1993. Well-vegetated stream buffers surround the stream. The upper portion exhibits multiple channels, which are stable and meander through non-tidal wetlands. These conditions are reflective of those described in the Bird River watershed plan that was completed in 1995.

Monitoring in the Windlass Run watershed includes stream geomorphology and biology. The Baltimore County NPDES Municipal Stormwater Discharge Permit only requires the stream stability geomorphic monitoring.

9.3.1 Stream Geomorphic Monitoring

Six (6) monitoring sites in the Windlass Run subwatershed are shown in Figure 9-10 below. The site selection process took into consideration the location of future development and the extension of MD Route 43. Three sites are located along the mainstem: two above (WR-3, WR-5) and one below (WR-2) the crossing of MD Route 43. WR-2 has experienced additional flow of water when a nearby SWM pond is drained into a forest buffer prior to entering the mainstem. This was observed in 2015. One site (WR-4) is on a tributary within the area of proposed industrial and high-density development, and downstream of Route 43. Another cross section (WR-6) is on a tributary within the area of under current residential development. The last cross section (WR1) is a reference site on a tributary near the bottom of the subwatershed. This tributary is within an area zoned for agricultural uses and should not be affected by the other development activities in the watershed.

The geomorphic monitoring consists of a monumented channel cross-section measurement, a channel slope/profile measurement, and a Wolman pebble count. Cross sections were selected on the reach between meander bends and where the conditions best represented confined flow. Profiles were also surveyed at all of the cross section reaches and include the cross sections. The procedures outlined by D. Rosgen (1996) were used for channel classification and stability assessment. The seven cross sections and six profiles have been surveyed annually since 2002. WR-6 is located on a tributary to Windlass Run. Its forest buffer has been cleared away for future development and impervious cover has increased. .

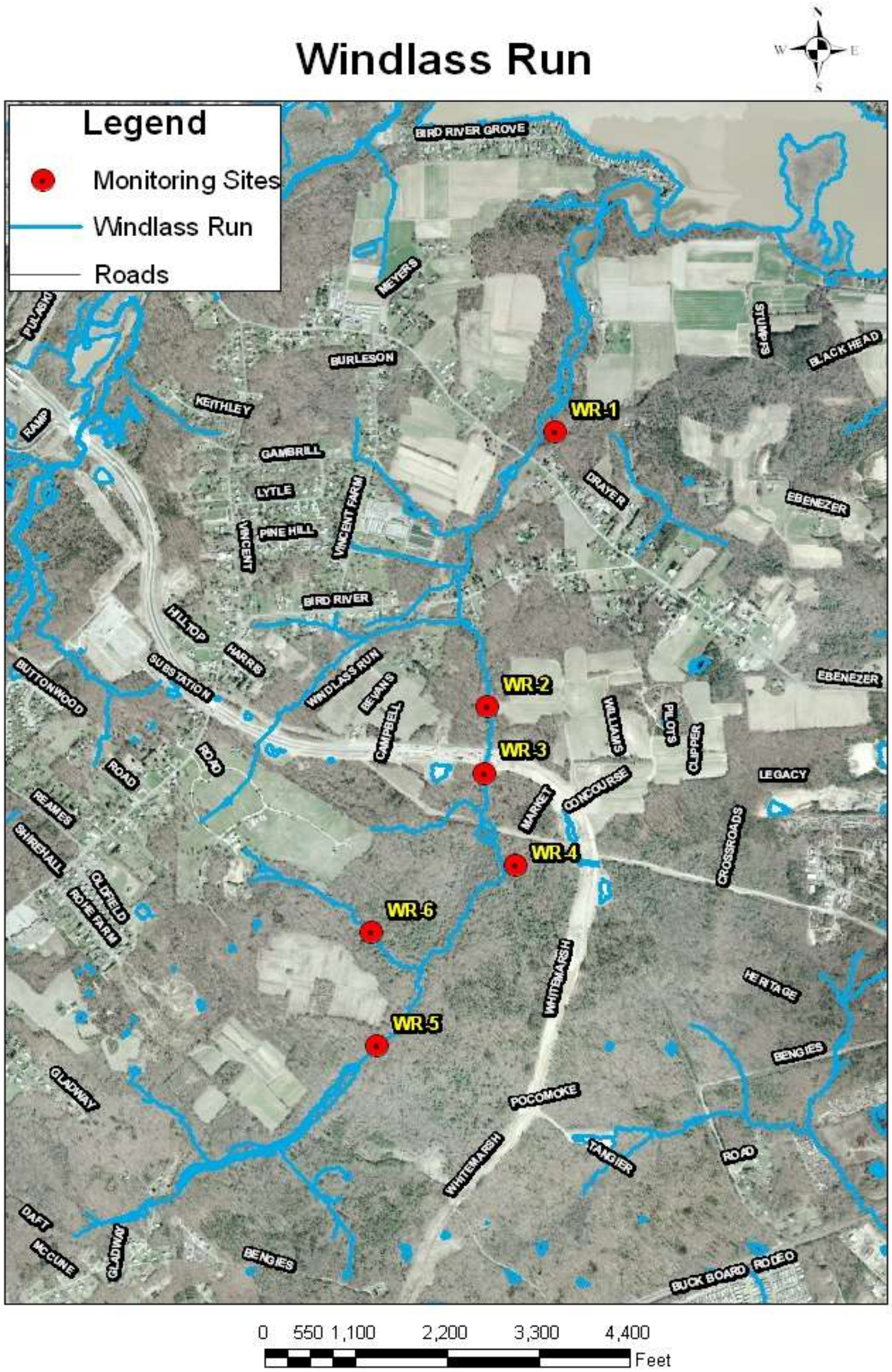


Figure 9-10: Windlass Run Aerial Photograph Showing Monitoring Station Locations.

Figure 9-11 shows the percentage of impervious land cover at each station in 2001, 2005, 2008, 2011, and 2014. Figure 9-12 through Figure 9-17 show the progression of development in Windlass Run, from 1995-2014, in years for which orthophotographs were available. Development occurring in the interval between years is summarized below. Any additional development that occur from 2014 – 2015 will be reflected in the 2016 Report, as the new orthophotograph will become available in 2016. Changes in geomorphology and biology related to the land disturbance caused by development are discussed in the results for each monitoring component.

1995 – 2002:

- A small housing development was built 2,850 feet northwest of WR-5.
- Two driveways were cleared 1,520 feet west of WR-2.

2002 – 2005:

- The roadbed for the Route 43 extension was cleared.

2005 – 2008:

- The Route 43 extension was paved.
- A roadway was cleared 2,470 feet southwest of WR-5.
- Land clearing and grading for commercial/industrial complexes occurred 1,330 feet east of WR-6, 95 feet east of WR-2, WR-3, and WR-4, and 380 feet west of WR-1.

2008 – 2011:

- A housing development was graded and built 95 feet west of WR-2.
- A convenience store was built on the previously cleared and graded area south of WR-4. Additional land was cleared and graded in this area.

2011-2014:

- Land was cleared and graded for a housing development west of WR-4.
- Land was cleared and graded for a housing development west of WR-5.

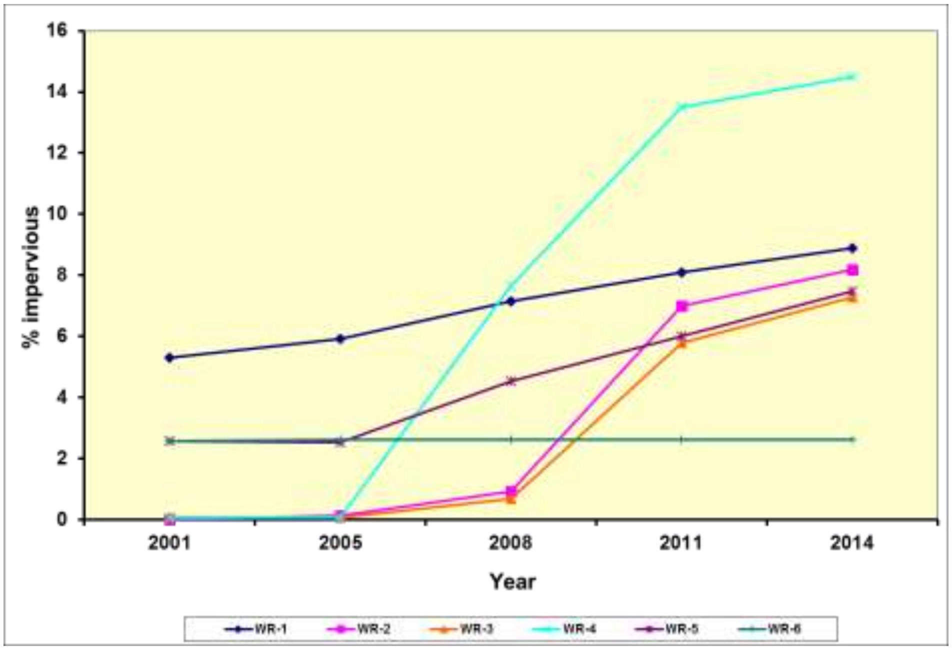


Figure 9-11: Percentage impervious cover in Windlass Run watershed 2001 through 2014

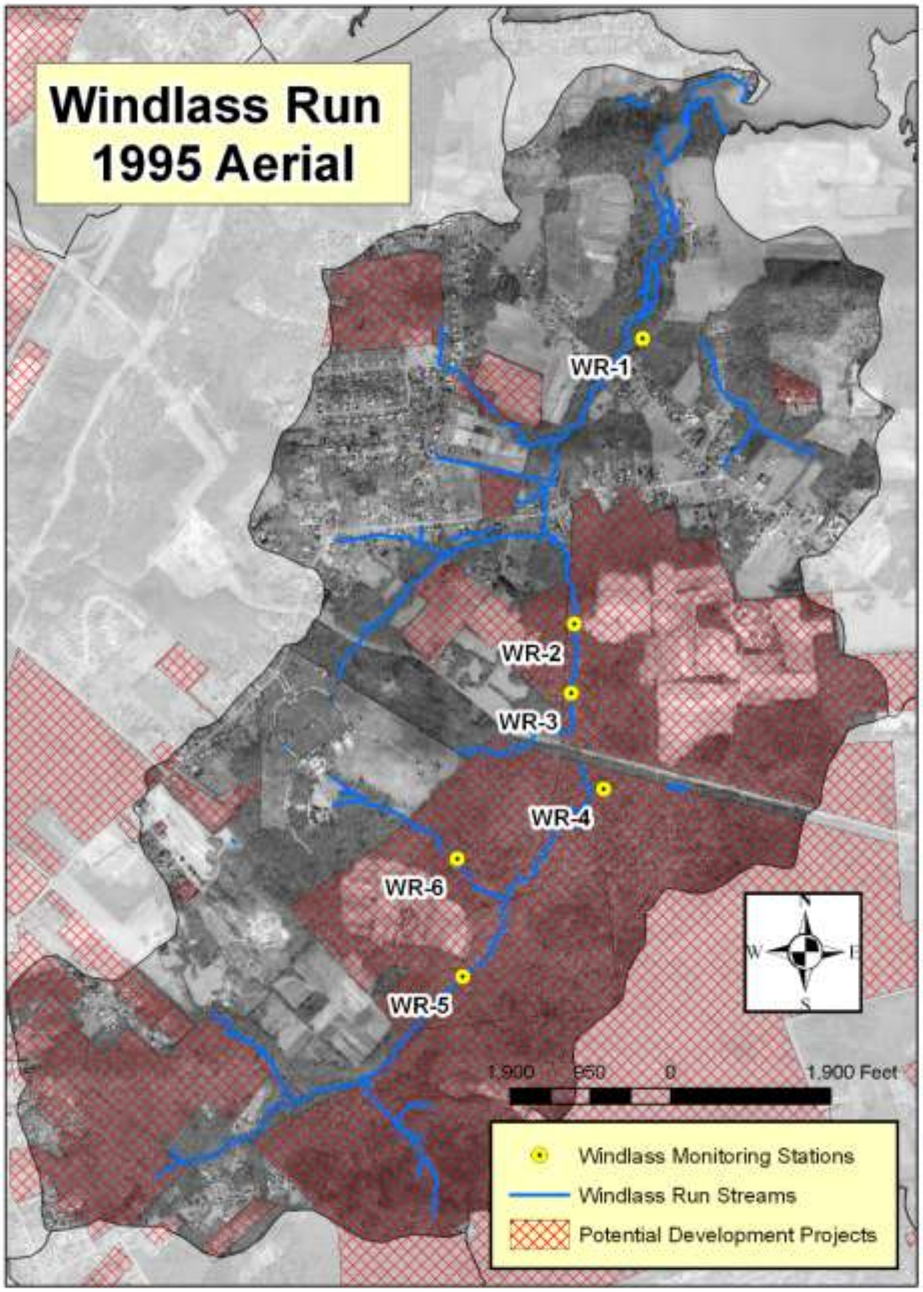


Figure 9-12: Orthophotograph of Windlass Run watershed, 1995, with potential for development highlighted in red cross-hatching.

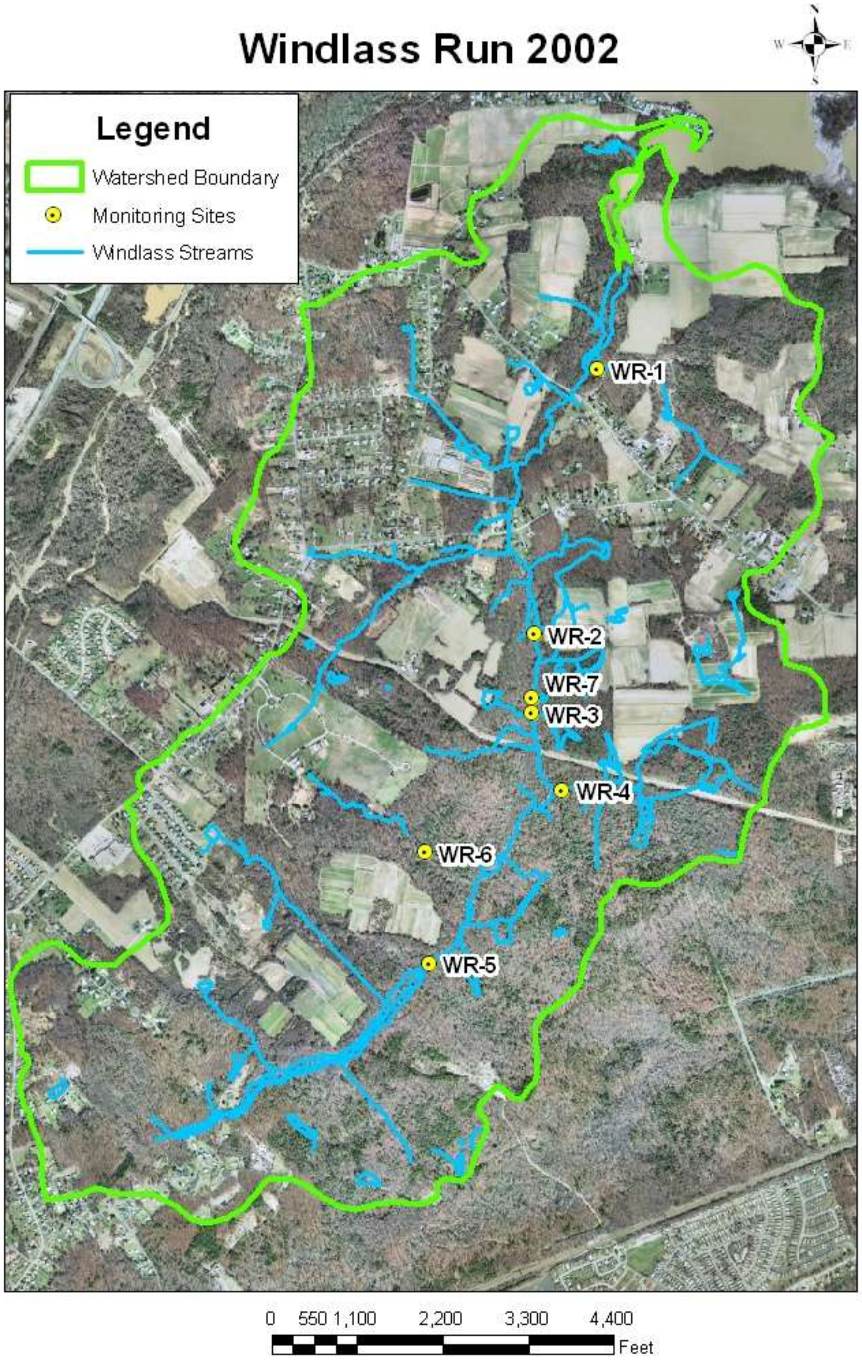


Figure 9-13: Windlass Run watershed orthophotograph, 2002.

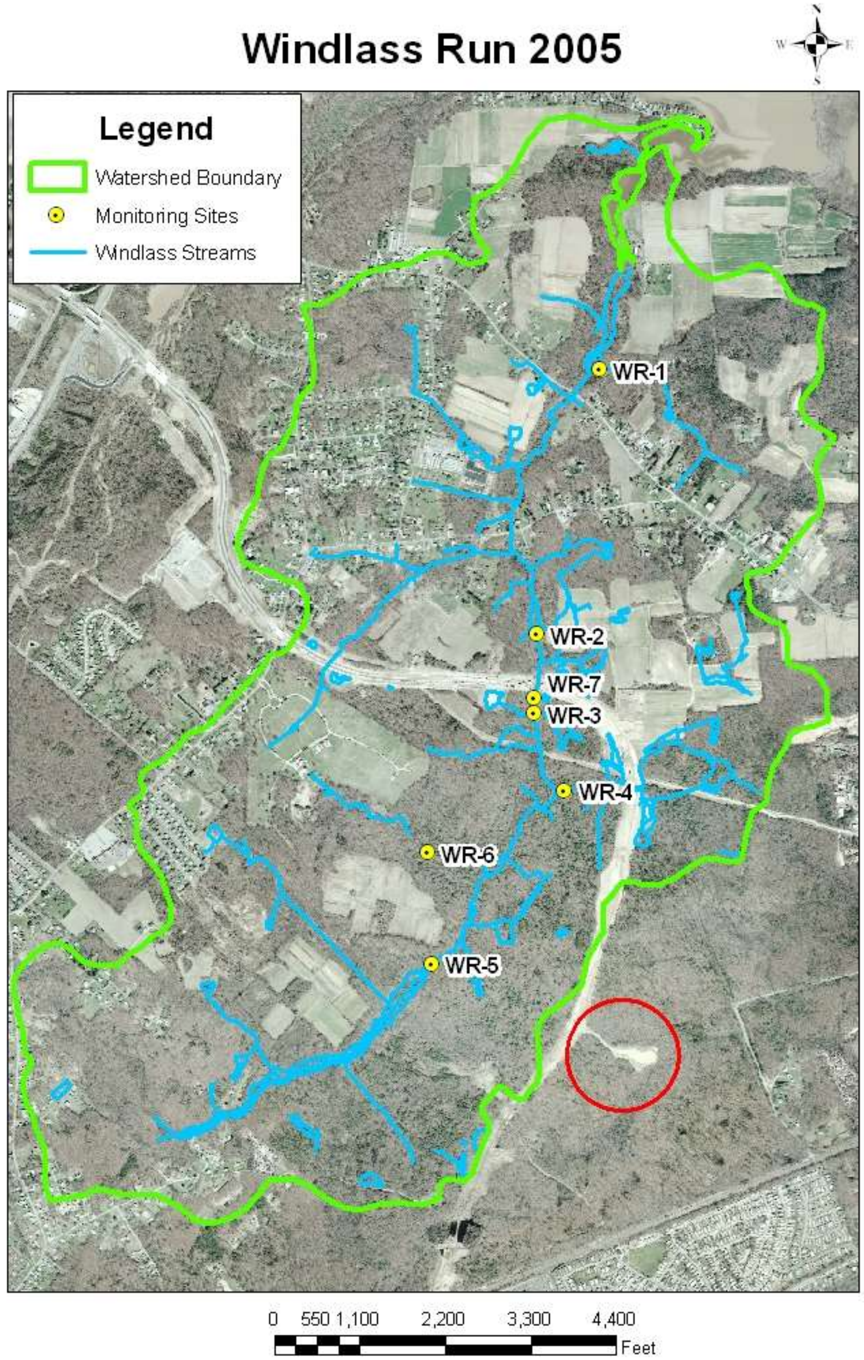


Figure 9-14: Windlass Run orthophotograph, 2005. New development/grading is circled in red.

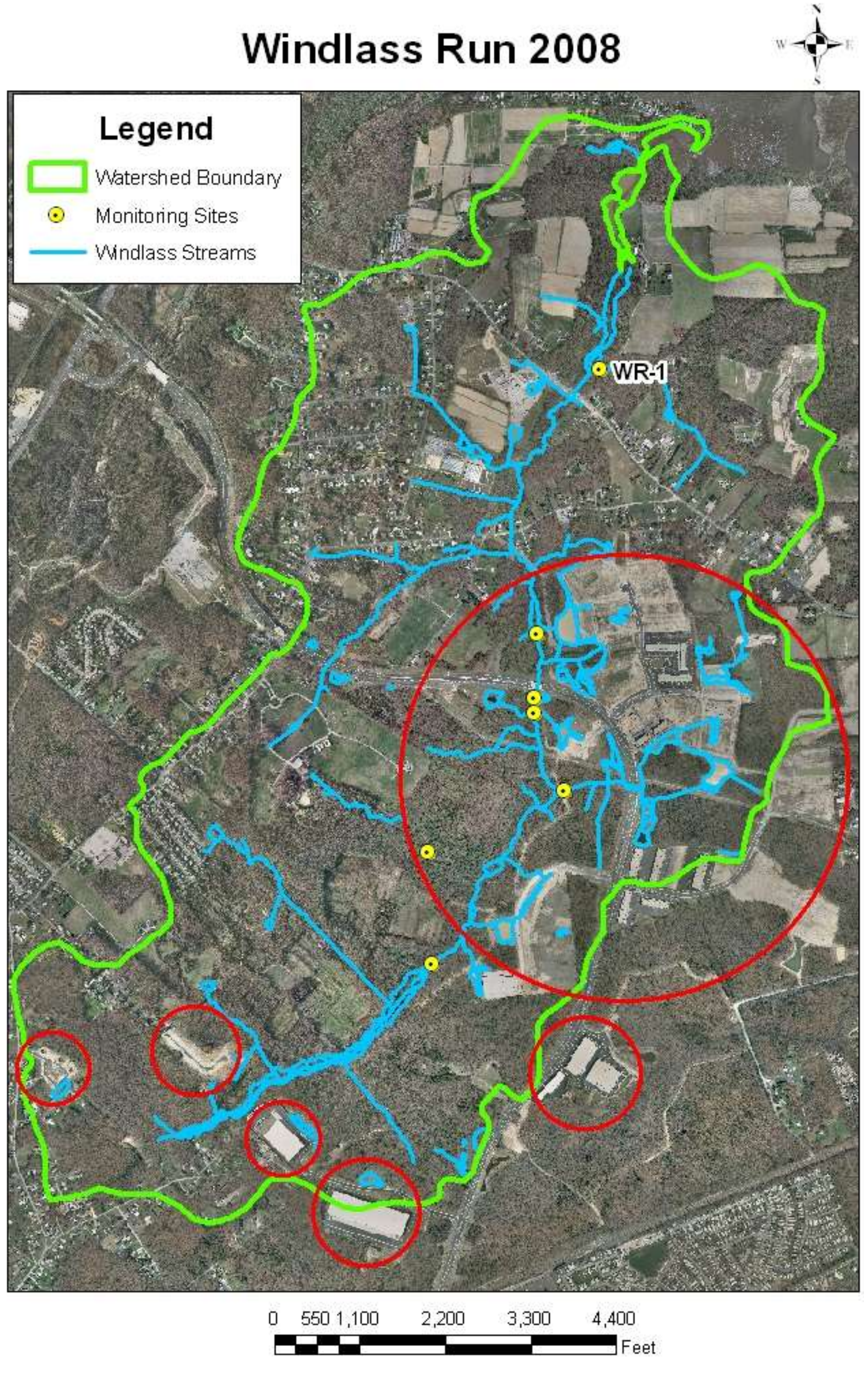


Figure 9-15: Windlass Run orthophotograph, 2008. New development/grading is circled in red.

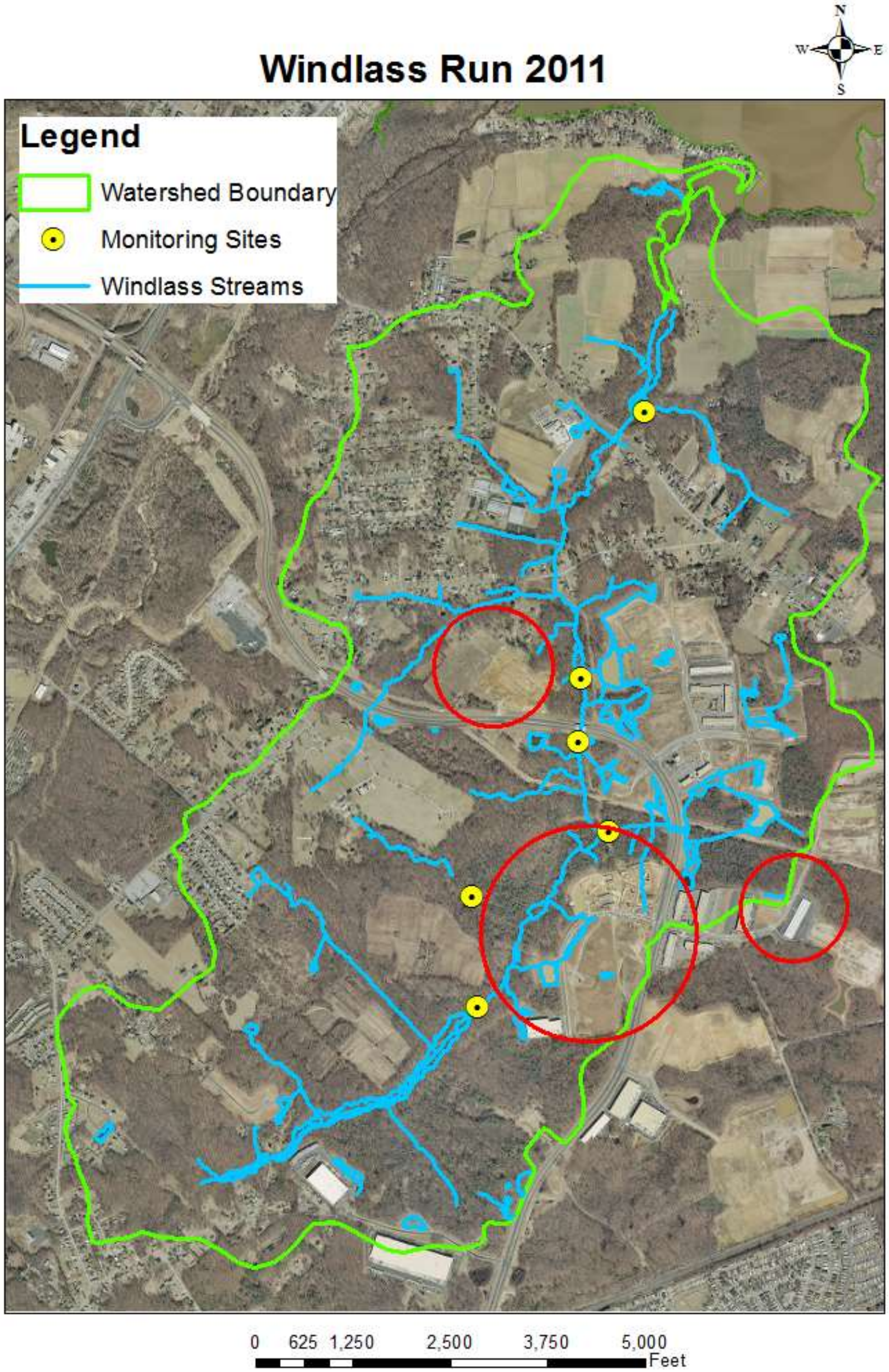


Figure 9-16: Windlass Run orthophotograph, 2011. New development/grading is circled in red.

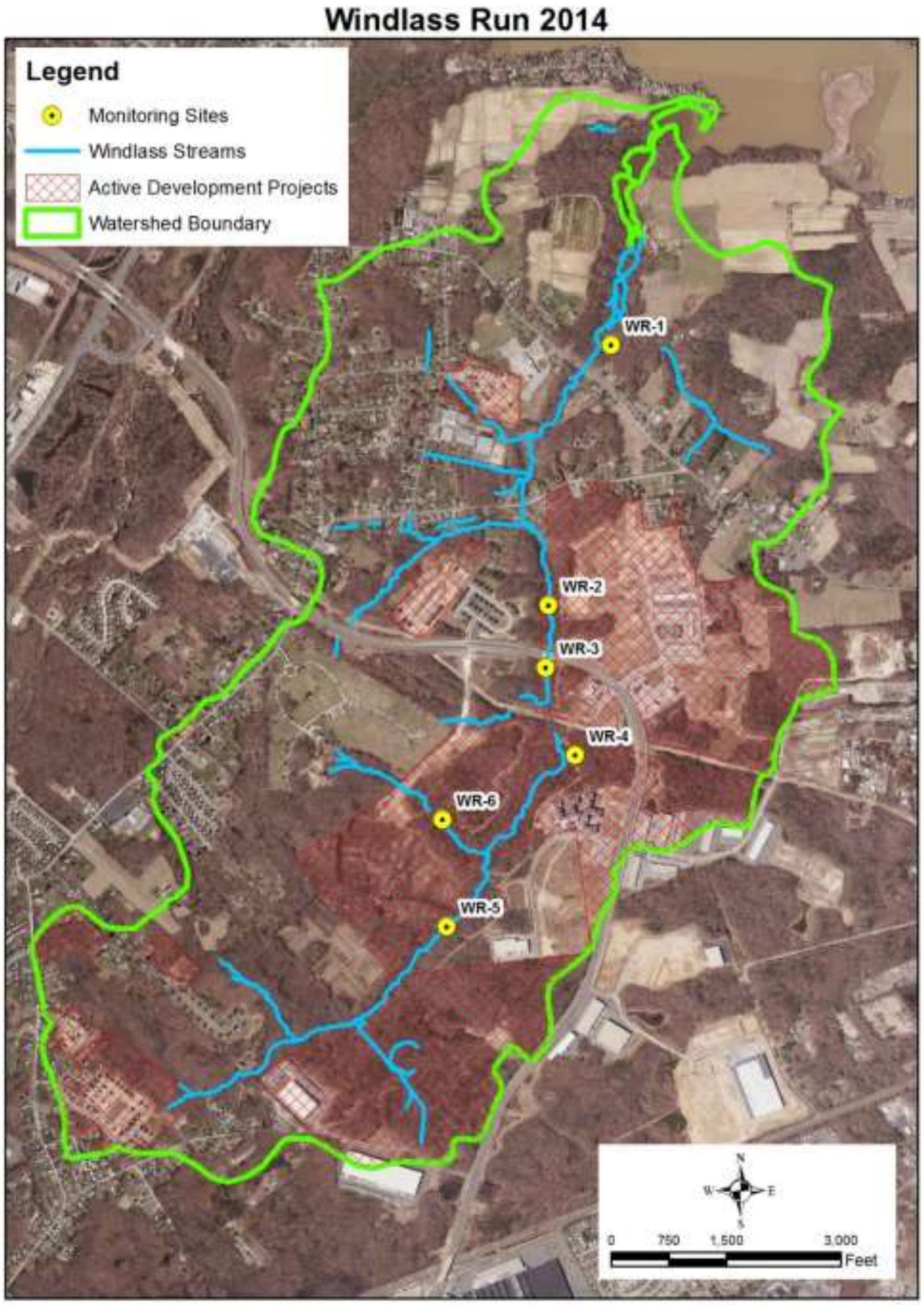


Figure 9-17: Windlass Run orthophotograph, 2014. New development/grading in red

9.3.2 Windlass Run Monitoring Results

The Windlass Run stream channels are beginning to show changes which may be related to development. The significant increases in impervious cover occurred between 2008 and 2015 at WR-2, WR-3, and WR-4. The most downstream cross section on Windlass Run, WR-2 saw the largest cut of all the cross sections (Table 9-16). There is a SWM retention pond that is located 500 meters adjacent to Windlass Run was observed being pumped into the forest buffer. The water from the SWM retention pond flows downhill creating a gully which then enters into the stream upstream of WR-2. WR-6 is located on a tributary to Windlass Run. The forest buffer within the vicinity of the WR-6 has been cleared away for future development. Despite installed silt fences lining the remaining stream buffer, the overall loss of surrounding buffer and increased run off from bare soil may have caused the tributary to alter its course over time. The tributary made a 90 degree turn whereas the left bank pin in now in the stream channel. Once the development of the area around WR-6 has been completed, new monuments will be installed. If the changes are short-term, natural responses to precipitation continued monitoring will show a return toward stability at the affected stations. If the streams in Windlass Run are adjusting to a new hydrologic regime caused by increased impervious cover, the geomorphic measurements will show increased instability. Continued monitoring is warranted to verify that these changes are being caused by development.

Table 9-16: Windlass Run Cross Sections - Annualized Cut and Fill Amounts

WR 1:Change (cu ft)	Period:2015-2016	WR 2:Change (cu ft)	Period:2015-2016	WR 3:Change (cu ft)	Period:2015-2016
Total Cut	-9.1	Total Cut	-10.8	Total Cut	-2.4
Total Fill	3.1	Total Fill	2.7	Total Fill	8.4
Total Change	12.1	Total Change	13.4	Total Change	10.8
Net Change	-6.0	Net Change	-8.1	Net Change	5.9
WR 4:Change (cu ft)	**Period:2015-2016**	**WR 5:Change (cu ft)**	**Period:2015-2016**	**WR 6 :Change (cu ft) ***	**Period:2015-2016**
Total Cut	-7.1	Total Cut	-2.3	Total Cut	0.0
Total Fill	0.1	Total Fill	1.5	Total Fill	6.6
Total Change	7.2	Total Change	3.7	Total Change	6.6
Net Change	-6.9	Net Change	-0.8	Net Change	6.6
WR 7:Change (cu ft)	**Period:2015-2016**				
Total Cut	-0.2				
Total Fill	4.6				
Total Change	4.8				
Net Change	4.4				

*WR-6 right bank pin is now located in the stream channel

9.3.2.1 Biological Monitoring

Benthic macroinvertebrates are being used as indicator organisms to monitor the effects of disturbance in the Windlass Run watershed. The condition of the benthic macroinvertebrate community before and after development will help determine the effectiveness of the new stormwater regulations at maintaining the suitability of Windlass Run for aquatic life.

Benthic macroinvertebrate sampling was conducted as per MBSS protocols. Benthic macroinvertebrates were sampled annually, during the spring index period (March 1st - April 30th), at WR-1, WR-2, WR-3, WR-4, and WR-5. WR-1 was not sampled in 2004 and 2006 because a beaver dam downstream of the station, on the Windlass Run mainstem, was causing backwater effects within the station reach. Data for WR-1 from 2005 are missing because the sorted sample had dried before it could be identified. A Benthic Index of Biotic Integrity (BIBI) was calculated using metrics developed by MBSS for Coastal Plain streams (Figure 9-18). The BIBI scoring criteria are: 1.00-1.99 (Very Poor), 2.00-2.99 (Poor), 3.00-3.99 (Fair), and 4.00-5.00 (Good). Physical habitat assessments performed during benthic sampling were converted to a physical habitat index (PHI) developed by MBSS (Figure 9-19). The PHI scoring criteria are: 81-100 (minimally degraded), 66-80 (partially degraded), 51-65 (degraded), and 50 or less (severely degraded).

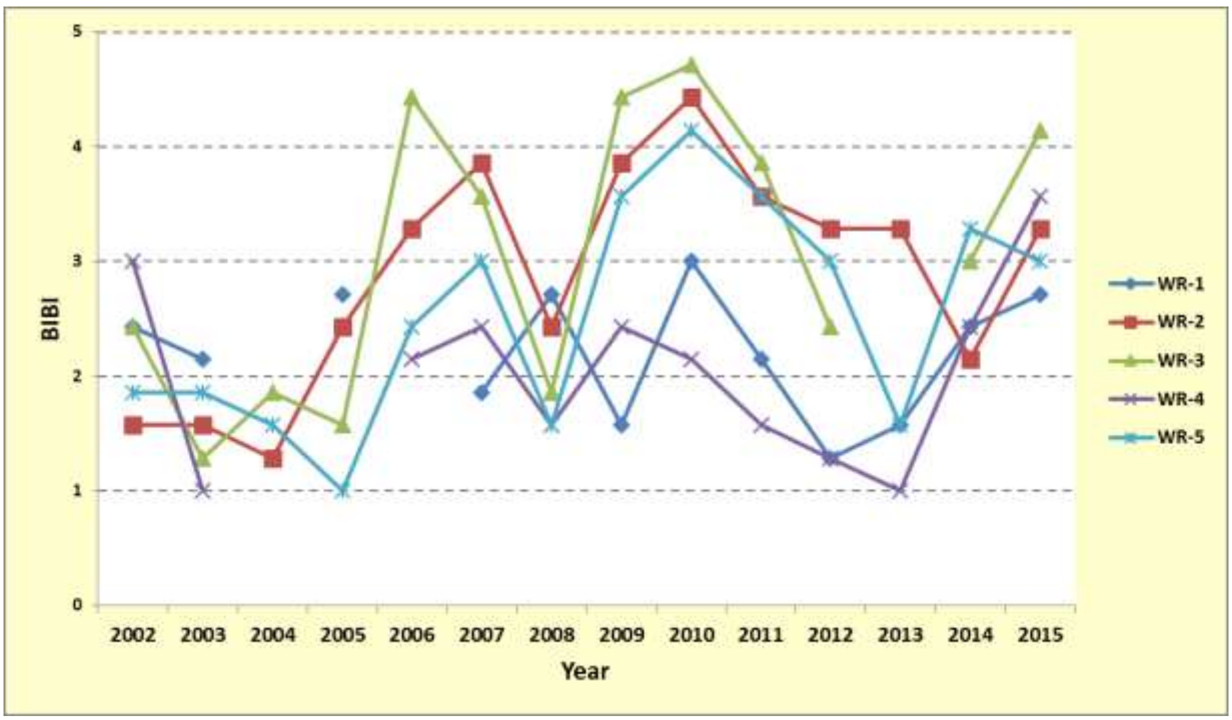


Figure 9-18: Windlass Run BIBI Scores

Figure 9-19: Windlass Run PHI Scores from 2004-2015

BIBI values continue to fluctuate between years. The BIBI score at WR-1 improved, but the score remains in the Poor Category. The BIBI scores for WR-2, WR-3, and WR-4 rebounded from the previous year. WR-2 and WR-4 BIBI scores improved from the Poor Category to the Fair Category. The only site that saw a BIBI score decrease was WR-5. Table 9-17 displays the 2015 BIBI scores compared to the 2014's BIBI score.

Table 9-17: Windlass Run BIBI Scores from 2014 and 2015

Station	Year	BIBI
WR-1	2014	2.43
	2015	2.71
WR-2	2014	2.14
	2015	3.29
WR-3	2014	3.00
	2015	4.14
WR-4	2014	2.43
	2015	3.57
WR-5	2014	3.29
	2015	3.00

9.4 Countywide Monitoring

9.4.1 Chemical Monitoring Program

In order to determine the condition of Baltimore County waters, a trend chemical monitoring program has been implemented. The trend 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 local watershed Total Maximum Daily Loads (TMDLs). These programs will partially fulfill the restoration effectiveness monitoring required under NPDES Permit section F.1 and H above.

9.4.1.1 Trend Monitoring

The Trend Monitoring Program was initiated in January 2011. Forty-one sites were selected throughout Baltimore County (Figure 9-20). Sites were primarily chosen where there are USGS gaged stations, which provides a good record of discharge at 15 minute intervals with the data QA/QC'd by experts. In watersheds where there was a lack of gages stations, sites were still selected but are measured manually for discharge. All sites are visited once a month approximately on the same day, regardless of weather. This will give us a better picture of the stream health and increase the number of samples per site to 12 per year. This sampling design will permit calculations of pollutant loads from each site. 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*. For 2015, most sites were sampled twelve times, once per month. A new site on Long Quarter Branch, named LR41, was added near the end of 2013 and its results have been added to Table 9-18.

9.4.1.2 Pollutant Load Calculations

Pollutant loads were calculated for each site. Data from the USGS gages were recorded at 5 or 15 minute intervals. If a site was not gaged a correlation was run with gaged sites within the county, and using the gage with the highest correlation coefficient, a discharge record was created. The regression equations determined from the trend samples, relating pollutant concentration to discharge, were used to determine the pollutant concentration for each interval. All below detection limit chemical data were removed before analysis. From this data the load was calculated for each 15-minute interval using the following formula:

$P_L = (P_C * .000008345) * (CFS * 448.8 * I)$, where

P_L = Pollutant Load,
P_C = Pollutant Concentration,
.000008345 = Conversion factor to convert mg/L to pounds per gallon,
CFS = Cubic feet per second,
448.8 = Conversion factor to convert cubic feet per second to gallons per minute
I = number of minutes in the interval (5 or 15).

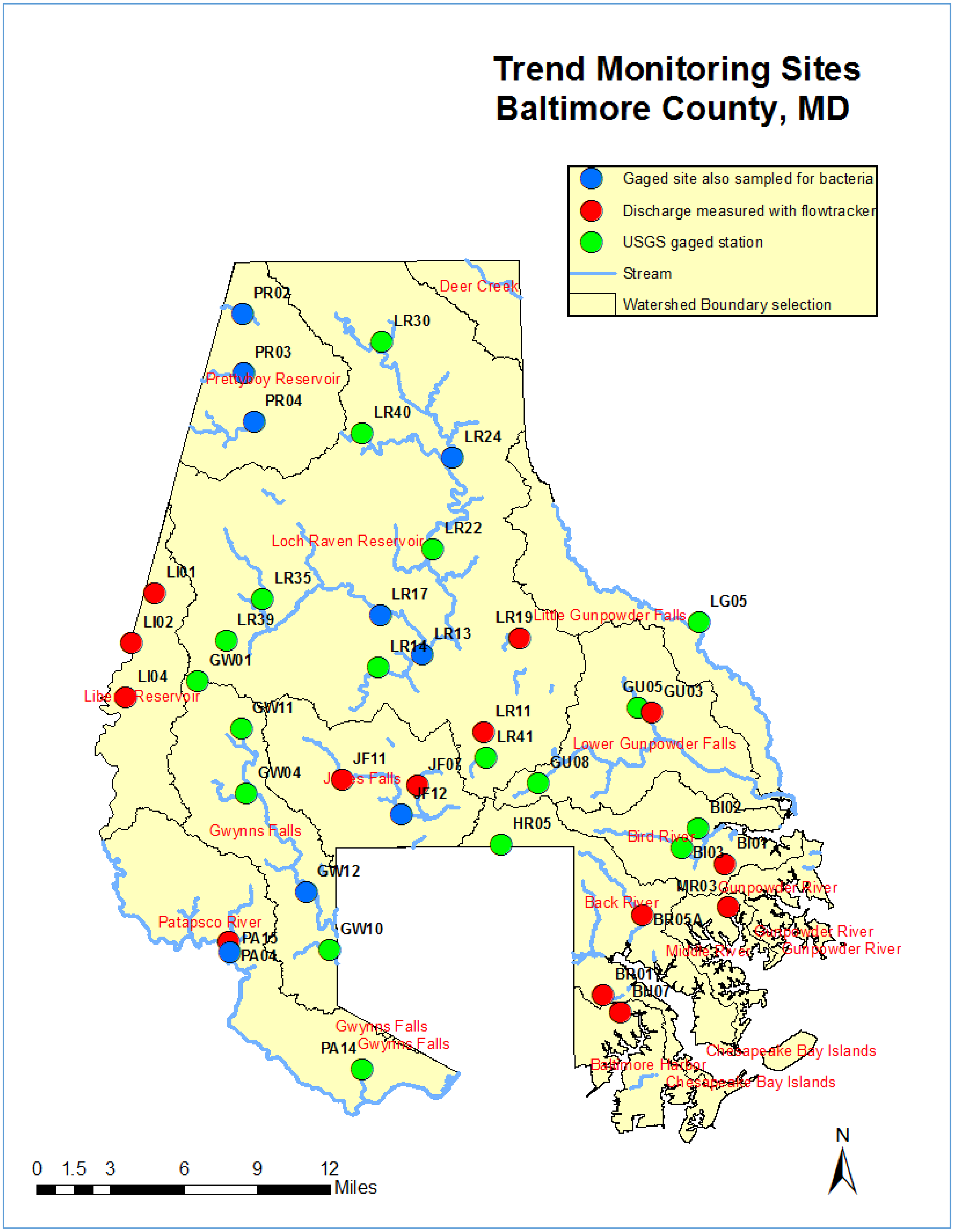


Figure 9-20: Trend Monitoring Sites

Table 9-18: Pollutant Load Analysis, Standardized by Drainage Area Acreage, 2015

Site	Drainage Area (ac)	Total Suspended Solids	Nitrate/ Nitrite	Total Nitrogen	Total Phosphorus	Chloride	Sodium
Prettyboy Reservoir							
PR02	17,528.14	95.0	9.74	10.98	0.40	67.47	31.25
PR03	4,971.14	54.7	10.02	11.03	0.55	69.38	33.42
PR04	9,995.36	71.2	2.06	14.07	0.27	117.34	54.68
Loch Raven Reservoir							
LR11	948.84	6.6	4.70	5.27	1.33	254.62	76.12
LR13	13,371.76	410.0	22.55	29.81	2.12	1,346.40	567.90
LR14	956.27	12.4	5.11	5.65	0.28	115.11	48.16
LR17	38,460.65	119.6	9.97	11.65	0.51	107.63	45.19
LR19	1,117.44	12.7	9.05	10.12	0.31	187.84	74.99
LR22	102,240.48	24.8	7.17	8.16	1.09	99.70	43.20
LR24	34,391.45	54.4	10.42	11.44	0.90	119.81	50.39
LR30	6,185.80	9.3	9.65	10.30	0.80	133.30	63.04
LR35	7,873.46	479.4	13.12	15.28	3.08	128.60	58.87
LR39	1,371.54	1,204.7	5.05	6.76	1.95	69.84	25.69
LR40	52,143.54	11.1	5.97	6.78	0.44	77.32	35.00
LR41	1,287.27	52.2	5.66	8.19	0.50	792.80	589.16
Liberty Reservoir							
LI01	1,488.66	35.3	35.3	14.90	17.05	0.82	111.24
LI02	2,058.54	78.3	78.3	5.48	6.81	0.81	180.05
LI04	1,639.56	262.8	262.8	6.03	8.47	1.97	252.90
Little Gunpowder							
LG05	23,225.29	51.2	11.73	13.86	0.79	101.48	42.55
Lower Gunpowder							
GU03	1,828.29	24.9	14.28	15.24	16.45	128.68	51.49
GU05	6,002.65	90.9	17.16	22.93	11.22	162.79	57.61
GU08	1,456.12	67.8	4.04	5.43	0.39	475.18	387.59
Gwynns Falls							
GW01	194.46	84.9	4.10	10.17	0.58	633.78	516.67
GW04	4,731.00	0.9	0.30	0.39	0.03	30.05	12.26
GW10	3,507.70	16.7	4.00	11.45	1.05	897.90	342.55
GW11	2,998.00	890.5	4.96	8.68	0.72	336.46	122.39
GW12	11,735.89	260.5	9.77	14.34	0.84	901.42	475.94
Jones Falls							
JF07	3,111.86	12.2	5.33	6.56	0.36	398.17	175.00
JF11	7,986.54	12.0	4.62	5.24	0.35	126.70	46.87
JF12	16,181.91	103.3	6.94	0.61	0.64	359.28	181.35
Bird River							
BI01	1,004.18	36.2	0.89	2.82	0.43	143.01	67.47
BI02	1,510.73	669.8	4.48	11.43	2.27	520.66	333.27
BI03	4,885.67	494.9	4.63	21.32	2.49	963.64	428.18
Back River							
BR01	403.15	20.5	5.32	7.18	1.06	377.20	187.92
BR05A	3,566.61	20.2	1.66	3.10	0.17	557.98	240.72

Site	Drainage Area (ac)	Total Suspended Solids	Nitrate/ Nitrite	Total Nitrogen	Total Phosphorus	Chloride	Sodium
HR05	1,356.27	173.9	7.66	11.34	0.45	534.66	611.06
Middle River							
MR03	194.23	54.9	4.35	10.41	0.75	1,219.78	668.01
Patapsco River							
PA04	4,529.46	6.5	2.04	2.46	0.31	141.49	58.47
PA14	1,402.65	137.3	5.42	12.06	0.99	408.15	382.46
PA15	182,430.69	38.6	4.12	5.04	0.37	81.48	39.32
Baltimore Harbor							
BH07	311.04	18.2	3.40	4.39	0.68	333.13	144.66

When adjusted to pounds per acre of drainage area, LR39 (Slade Run) had the highest loading rate for Suspended Solids, while LR13 (Beaver Dam Run) had the highest Nitrate+Nitrate Nitrogen and Total Nitrogen loading rates. Beaver Dam Run also had the highest loading rate for Chlorides, while Frog Mortar Creek in Middle River had the highest Sodium loading rate. Figure 9-21 and Figure 9-22 are maps that show the total nitrogen and total phosphorus mean concentrations. As can be seen from Figure 9-21, the highest concentrations of total nitrogen are found outside the URDL. In the rural areas these increased total nitrogen concentrations may be the result of agricultural activities, septic system inputs, or a combination of both. In the urban areas the high concentrations are most likely from fertilizer, pet waste and point sources entering the streams through outfalls. The majority of Total Phosphorus is delivered during storm events, associated with sediment. The very high Total Phosphorus at the sites outside the URDL may be associated with farming and land use change from forest to residential; the predominant land use is cropland, forest and low density residential.

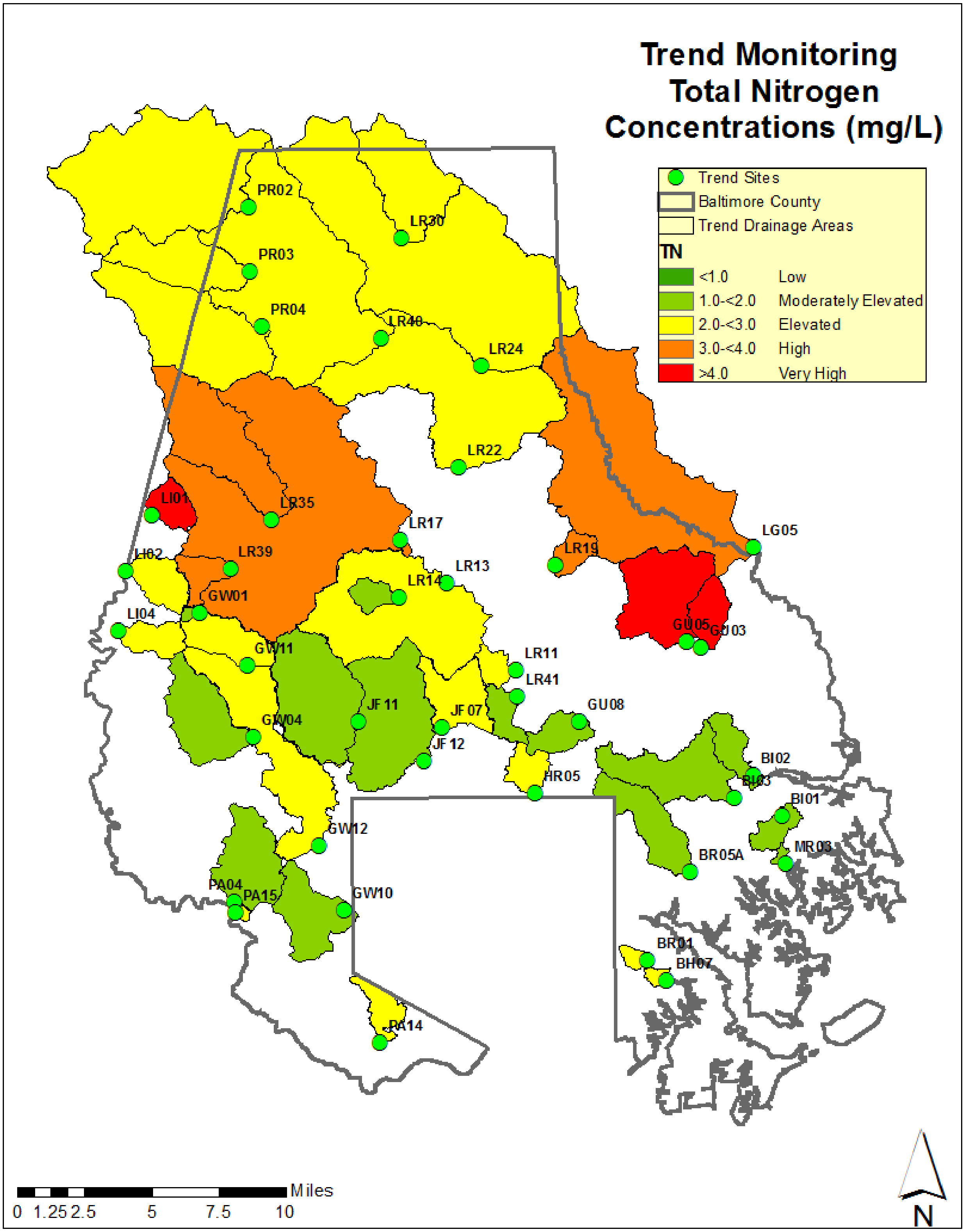


Figure 9-21: Trend Total Nitrogen Mean Concentrations for Monitoring Year 2015

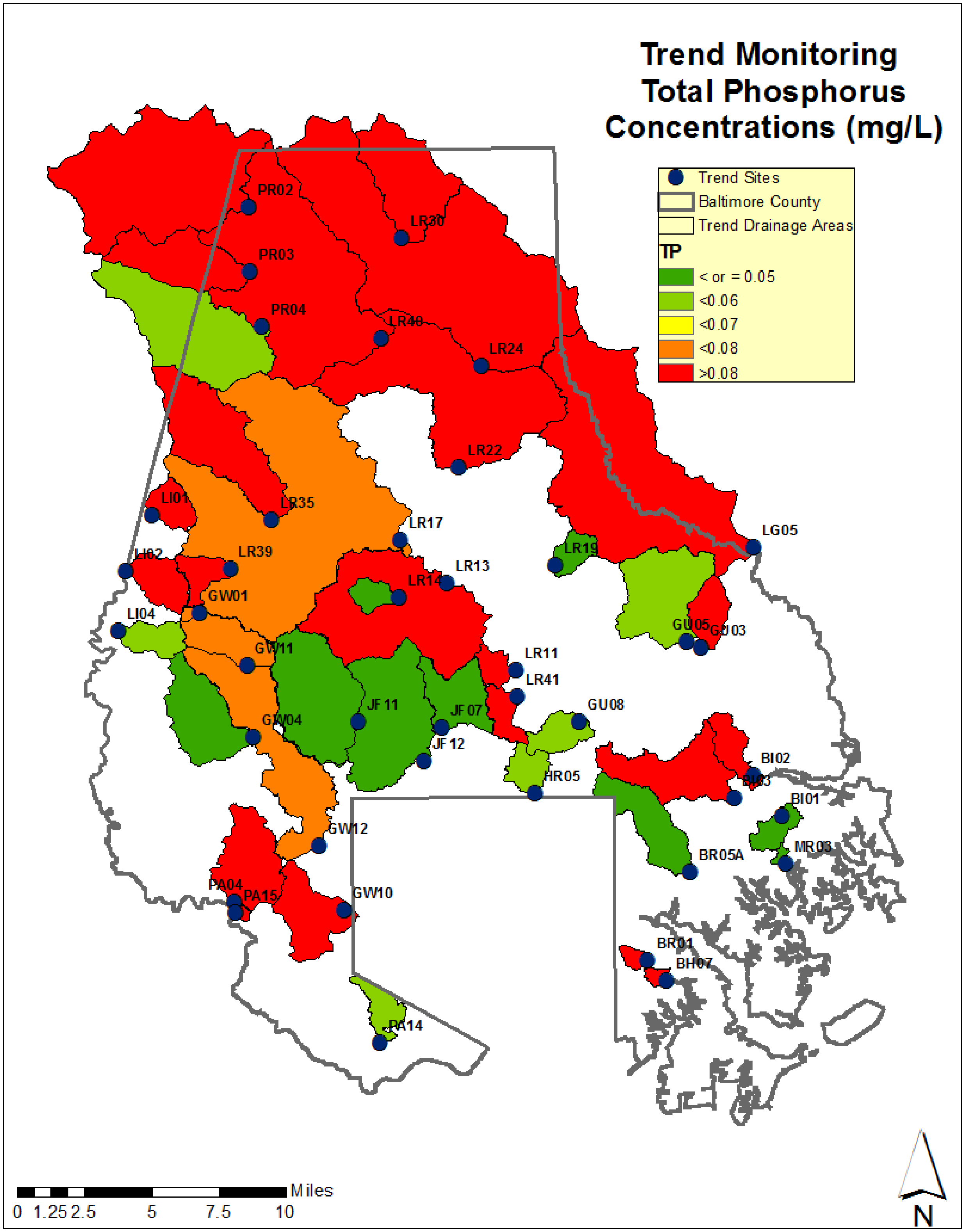


Figure 9-22: Trend Total Phosphorus Mean Concentrations for Monitoring Year 2015

9.4.2 Bacteria TMDL Monitoring

Baltimore County EPS has coordinated with Baltimore City Surface Water Management Division, and Carroll County Department of Land Use, Planning, and Development to monitor trend over time levels of bacteria at 32 monitoring locations within 1 subwatershed and 6 major watersheds. This program was developed in response to the development of bacteria TMDLs in Herring Run, Gwynns Falls, Loch Raven, Prettyboy, Jones Falls, Liberty Reservoir, and Patapsco. Bacteria monitoring began in June 2010, with 20 sites in Baltimore County, and 7 sites in Baltimore City and 5 sites in Carroll County. Figure 9-23 shows the locations of the sites. These are the sites used by Maryland Department of the Environment in developing the bacteria TMDL.

In 2014 Baltimore County developed TMDL Implementation Plans for the 7 bacteria impairments in Baltimore County waters along with 15 additional TMDL Implementation Plans for other water quality impairments. These plans were submitted along with the annual report. Revised plans are being submitted with the 2016 annual report. Future bacteria monitoring, to commence in 2015, is detailed in the bacteria TMDL Implementation Plans. The Bacteria Trend monitoring, as detailed in this report, has been expanded to add additional monitoring locations where streams cross the city/county line and for subwatersheds included in the bacteria TMDL for which there were no corresponding monitoring stations (Redhouse Run). Two additional bacteria monitoring programs will be initiated; the Bacteria Subwatershed Prioritization Program and the Reach Source Tracking Program. These programs are designed to narrow the focus to the subwatersheds exhibiting bacteria contamination and locating the bacteria sources, respectively. The results from the first year of bacteria subwatershed prioritization is reported in section 9.4.2.3 below. The Reach Source Tracking Program will follow the Bacteria Subwatershed Prioritization program, and will be based on the results collected by that program. From this point forward the results will be reported on a watershed basis.

In 2015, eight new trend sites were added to more directly assess how the portions of impacted watersheds in Baltimore County contributed to the total bacterial load observed at the bottom of the watershed located in Baltimore City. Two trend sites were added to the Gwynns Falls watershed, two to the Jones Falls, and four to the Herring Run portion of the Back River watershed. Table 9-19 lists the locations and descriptions of the new trend sites added in 2015. Additionally, seasonal monitoring of trend sites was enhanced in 2015 by sampling the 40 sites twice per month in order to develop a more accurate assessment of seasonal, low flow trends.

Table 9-19: New Bacteria Trend Sites added in 2015

Station Code	Subwatershed	Monitoring Type	Latitude	Longitude
DR-B-10	Dead Run	New Trend	39.304	-76.712
GF-B-8	Gwynns Falls – mainstem	New Trend	39.322	-76.712
JF-B-12	Western Run – East Branch	New Trend	39.373	-76.668
JF-B-13	Western Run – West Branch	New Trend	39.372	-76.708
HR-B-12	East Branch – Herring Run	New Trend	39.369	-76.574
HR-B-13	West Branch – Herring Run	New Trend	39.371	-76.583
HR-B-14	Unnamed Trib to Redhouse Run	New Trend	39.316	-76.518
HR-B-15	Redhouse Run	New Trend	39.317	-76.518

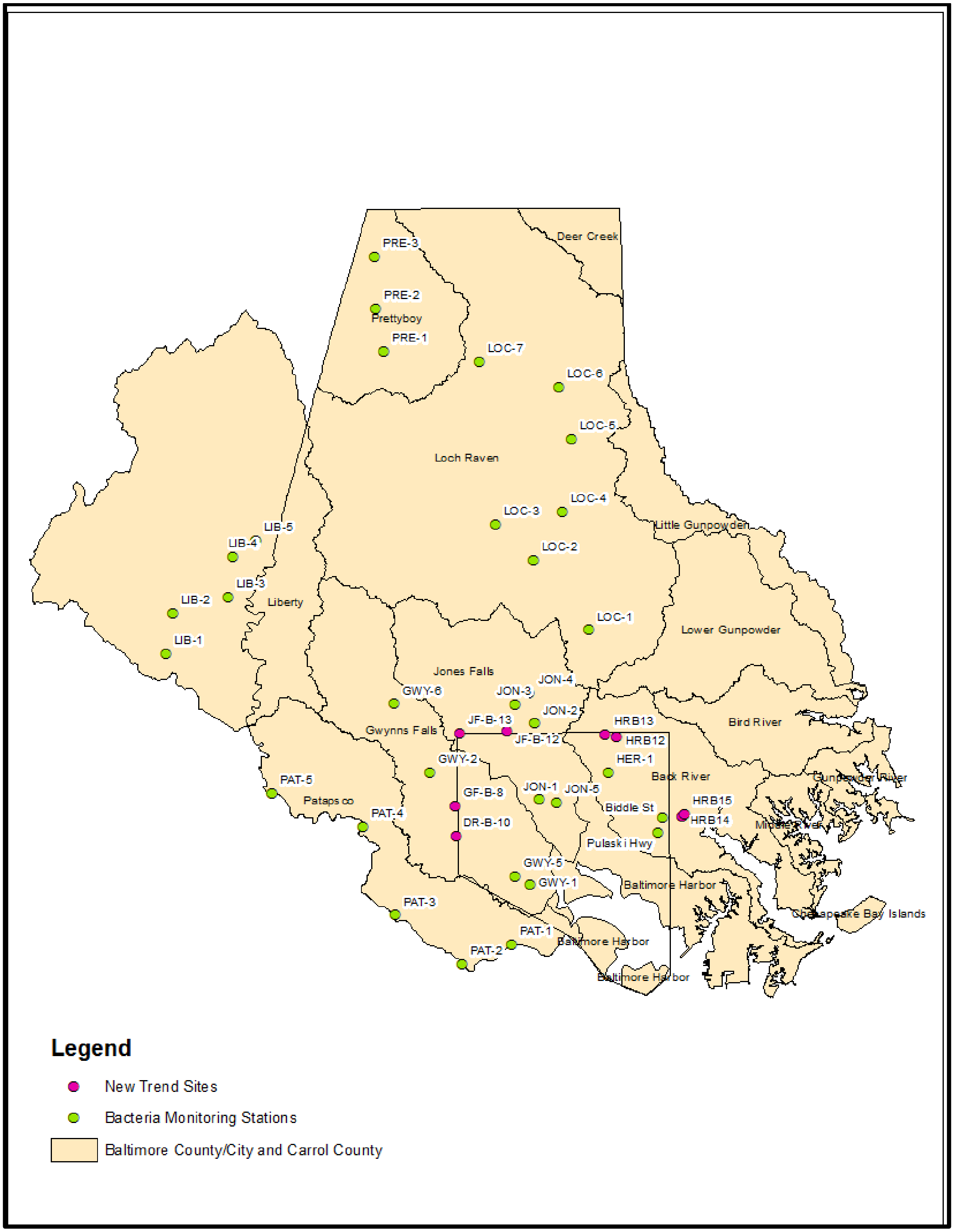


Figure 9-23: Map of Bacteria TMDL Monitoring Stations

9.4.2.1 Monitoring Protocol

Samples are collected on the first Thursday of every month, regardless of weather conditions. Using sterile sample containers containing sodium thiosulfate, 100mL of water is collected and is kept in a cooler with ice until analyzed.

The samples are analyzed for E. coli using IDEXX procedures and equipment including Colilert-18 and Quanti-Tray/2000, and are read after 18-22 hours of incubation. Results are given in Most Probable Number (MPN), a statistically determined estimate of organisms present per sample.

Dilutions are done on samples that are taken during or after heavy rains, or at sites with chronically high levels of bacteria, so that the sample reading is within the limit of detection for the analysis (between 1 MPN and 2419.6 MPN).

A high/low flow determination was made for each bacteria sample. First, a cutoff flow rate was determined using a similar methodology to those made in the Bacteria TMDL documentation. Then, each bacteria trend sampling site was assigned a USGS gage from those used in the Bacteria TMDLs, based on geographic proximity. Then, for each sampling date/time, the assigned gage was checked for flow. If the flow was greater than the predetermined cutoff, it was a 'high' flow. If it was lower, it was marked as 'low' flow. Ties were assigned 'low' flow.

9.4.2.2 Results

Prettyboy Reservoir

Table 9-20 shows the latitude/longitude locations of the current bacteria monitoring stations within the Prettyboy Reservoir watershed. The monitoring locations are on major tributaries to the Prettyboy Reservoir, with the majority of the drainage area in Carroll County.

Table 9-20: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed	Latitude	Longitude
PRE-1	GOB0042	Georges Run	39.626	-76.773
PRE-2	GRG0013	Grave Run	39.655	-76.779
PRE-3	GUN0476	Gunpowder Falls	39.689	-76.781

Table 9-21 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means that meet the water quality standard (126 MPN) are highlighted in green. These data are displayed graphically in Figure 9-24 through Figure 9-26.

Table 9-21: Prettyboy Reservoir Watershed E. coli Results on an Annual and Seasonal Basis

Annual (MPN/100 ml)											
Site	Flow Type	2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
PRE-1	High	4	585	3	222	1	1300	4	1087	4	984
	Low	8	98	9	225	9	45	8	170	13	185
	All	12	178	12	225	10	63	12	329	17	274
PRE-2	High	4	165	3	165	2	105	4	750	4	1007
	Low	8	80	9	80	9	33	8	73	13	113
	All	12	131	12	96	11	41	12	168	17	189
PRE-3	High	4	813	3	1434	3	104	4	831	4	1007
	Low	8	136	9	135	9	67	8	213	13	214
	All	12	247	12	244	12	74	12	346	17	333

Seasonal (May 1st to September 30th) (MPN/100 ml)											
Site	Flow Type	2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
PRE-1	High	2	968	1	121	1	1300	2	1293	2	841
	Low	3	254	4	546	4	127	3	294	8	331
	All	5	431	5	350	5	203	5	531	10	399
PRE-2	High	2	743	1	59	1	186	2	1151	2	631
	Low	3	163	4	198	4	44	3	140	8	167
	All	5	299	5	155	5	59	5	326	10	217
PRE-3	High	2	778	1	2420	1	326	2	2420	2	616
	Low	3	615	4	176	4	74	3	335	8	283
	All	5	676	5	298	5	99	5	740	10	331

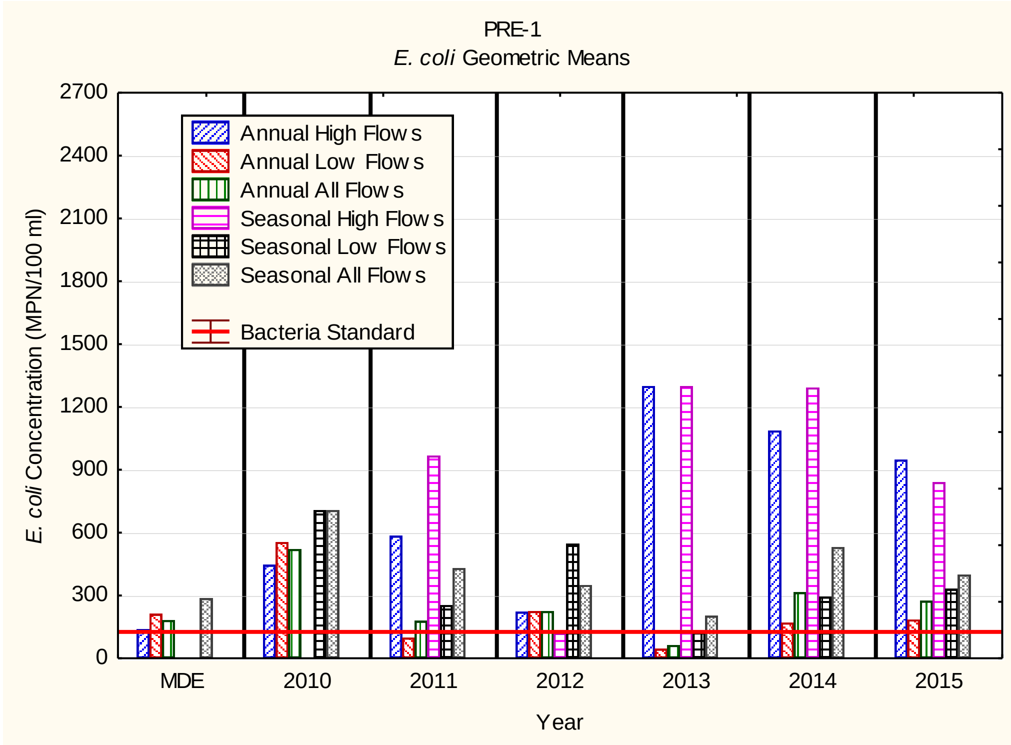


Figure 9-24: E. coli Geometric Mean Concentrations at Site PRE-1 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

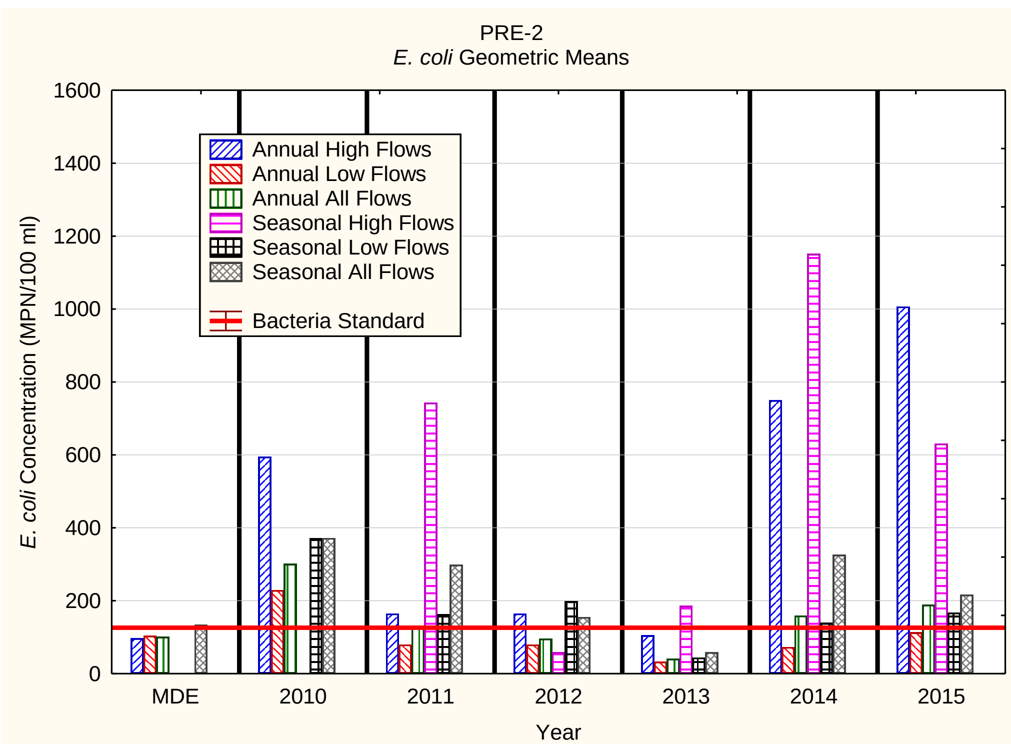


Figure 9-25: E. coli Geometric Mean Concentrations at Site PRE-2 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

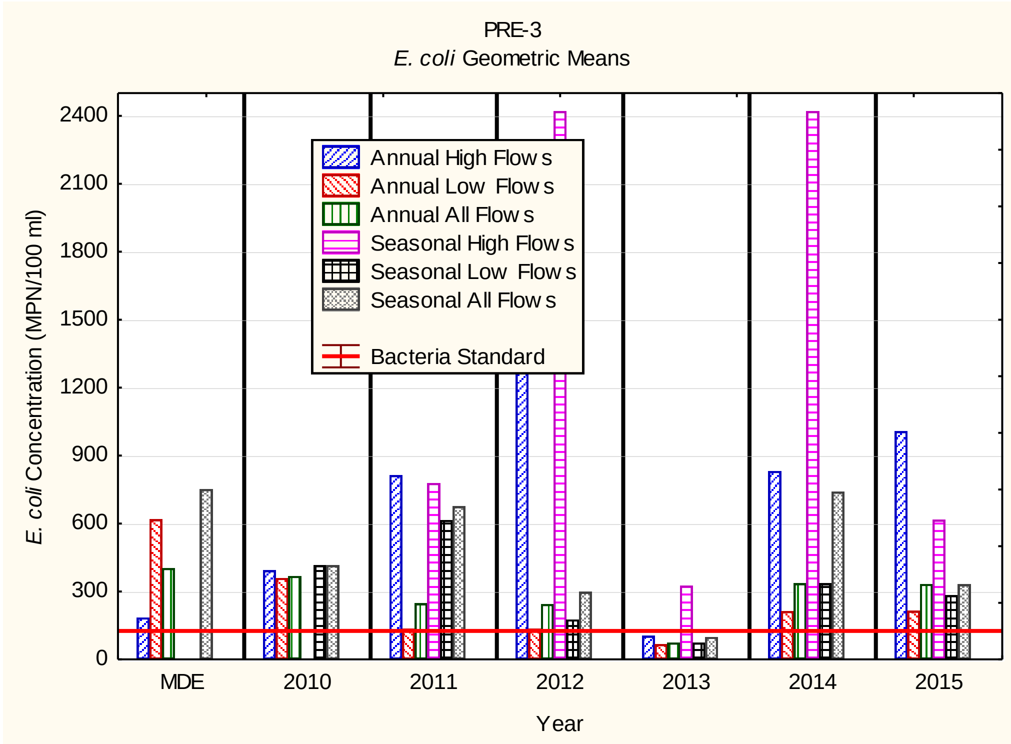


Figure 9-26: E. coli Geometric Mean Concentrations at Site PRE-3 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-22 presents the results of the analysis by station, by year and by flow regime.

Table 9-22: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
PRE-1	2011	2	3	50%	0%	50%	0%	100%	33%	100%	66.7%
	2012	1	4	0%	80%	0%	80%	0%	100%	0%	100%
	2013	1	4	100%	0%	100%	25%	100%	25%	100%	25%
	2014	2	3	100%	33%	100%	33%	100%	67%	100%	67%
	2015	2	8	100%	25%	100%	25%	100%	63%	100%	75%
	2011	2	3	50%	0%	50%	0%	50%	0%	50%	0%

PRE-2	2012	1	4	0%	0%	0%	25%	0%	25%	0%	25%
	2013	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2014	2	3	50%	0%	100%	0%	100%	0%	100%	0%
	2015	2	8	100%	13%	100%	25%	100%	25%	100%	25%
PRE-3	2011	2	3	50%	33%	50%	33%	50%	67%	50%	100%
	2012	1	4	100%	0%	100%	0%	100%	0%	100%	0%
	2013	1	4	0%	0%	0%	0%	100%	0%	100%	0%
	2014	2	3	100%	0%	100%	33%	100%	67%	100%	67%
	2015	2	8	50%	38%	50%	38%	100%	50%	100%	50%

The frequency of exceedance data shows improvement for all three monitoring sites with a general downward trend in the frequency of exceedance of the various single sample bacteria standards. 2015 seems to continue the trend first seen in 2014, with all of the sites exceeding standards at least once during any flow regime.

PRE-1 (GOB0042): This site is located on Georges Run close to where it discharges into the reservoir. It receives drainage from both Carroll County and Baltimore County, with the majority of the drainage in Carroll County. The data indicate variability over the five years of monitoring on an annual and seasonal basis; the geometric mean for low flow and all samples combined was below water quality standard of 126 MPN/100 ml for *E. coli* in 2013. The Maryland Department of the Environment (MDE) data for this site indicated a geometric mean of 287 MPN/100ml for dry weather seasonal samples based on monitoring conducted between 2003 and 2004. A weighted mean for dry weather seasonal sampling for the six years of monitoring conducted by Baltimore County resulted in a value of 310 MPN/100ml. This would indicate the conditions are degrading at this station based on the difference between the two monitoring periods. The TMDL requires a 59.0% reduction of bacteria at this site.

PRE-2 (GRG0013): This monitoring site is located on Grave Run in Baltimore County, but with the majority of drainage area in Carroll County. The Baltimore County monitoring indicated that this site has displayed continuing improvement for both low flow and high flow on an annual and a seasonal basis. It met water quality standards for all flow conditions on an annual basis, and on for low flow on a seasonal basis. The MDE data for this site indicated a seasonal dry weather geometric mean of 134 MPN/100ml for this site. The previous six years of Baltimore County data resulted in a geometric mean of 155 MPN/100 ml for the dry weather seasonal data. This would indicate that there has been no change or slight improvement at this site. The TMDL indicated a reduction of 9.5% reduction necessary for meeting bacteria water quality standards in the drainage area to this site.

PRE-3 (GUN0476): This site is located on the mainstem of Gunpowder Falls above the Prettyboy Reservoir. The Baltimore County monitoring data indicates variability in the geometric mean *E.coli* concentrations from year to year for both low flow and high flow conditions, but the data indicated a generally improving trend. The MDE data indicated a seasonal dry weather concentration of 751 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 254 MPN/100ml, indicating improvement at this site. The

TMDL indicated 85.3% reduction necessary for meeting bacteria water quality standards at this site.

Loch Raven Reservoir

Table 9-23 shows the latitude/longitude locations of the current bacteria monitoring stations within the Loch Raven watershed. There are seven bacteria trend monitoring sites in the Loch Raven Reservoir watershed.

Table 9-23: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed/ Subshed	Latitude	Longitude	Location
SBH0002	LOC-1	Spring Branch	39.440	-76.597	County
BEV0005	LOC-2	Beaverdam Run	39.487	-76.645	County
WGP0050	LOC-3	Western Run	39.511	-76.677	County
GUN0233	LOC-4	Gunpowder Falls	39.519	-76.620	County
GUN0284	LOC-5	Gunpowder Falls	39.568	-76.611	County
LIT0002	LOC-6	Little Falls	39.602	-76.622	County
GUN0387	LOC-7	Gunpowder Falls	39.619	-76.690	County

Table 9-24 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means that met the water quality standard (126 MPN) are highlighted in green. These data are displayed graphically in Figure 9-27 through Figure 9-32.

Table 9-24: Loch Raven Reservoir Watershed E. coli Results on an Annual and Seasonal Basis

Annual (MPN/100 ml)											
Site	Flow Type	2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
LOC-1	High	4	825	4	364	3	1340	4	1273	6	1328
	Low	9	89	8	123	9	117	8	547	11	315
	All	13	177	12	177	12	216	12	725	17	457
LOC-2	High	4	1064	4	345	3	524	4	634	6	1078
	Low	8	143	8	104	9	79	8	70	11	168
	All	12	279	12	156	12	127	12	146	17	292
LOC-3	High	4	576	4	861	3	190	4	1238	8	451
	Low	8	118	8	137	9	62	8	129	9	176

	All	12	200	12	253	12	83	12	275	17	274
LOC-4	High	4	477	3	498	3	161	4	888	6	547
	Low	8	77	9	138	9	42	8	75	11	276
	All	12	142	12	190	12	59	12	170	17	351
LOC-5	High	4	192	3	230	3	78	4	316	5	310
	Low	8	65	9	54	9	54	8	55	12	96
	All	12	94	12	77	12	59	12	98	17	136
LOC-6	High	2	217	3	336	3	87	4	846	5	706
	Low	6	172	9	144	9	52	8	61	12	209
	All	8	182	12	178	12	59	12	146	17	299
LOC-7	High	4	14	3	16	3	11	4	18	5	28
	Low	8	5	9	6	9	8	8	3	12	7
	All	12	7	12	8	12	8	12	5	17	10

Seasonal (May 1st to September 30th) (MPN/100 ml)											
Site	**Flow Type**	**2011**		**2012**		**2013**		**2014**		**2015**	
		N	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**
LOC-1	High	2	812	2	567	1	2420	2	1773	3	1967
	Low	3	524	3	378	4	270	3	1043	7	511
	All	5	624	5	444	5	418	5	1290	10	766
LOC-2	High	2	1405	2	613	1	1046	2	1202	3	1791
	Low	3	700	3	370	4	142	3	334	7	257
	All	5	925	5	453	5	212	5	558	10	460
LOC-3	High	2	968	2	1448	1	313	2	1493	3	1161
	Low	3	387	3	411	4	112	3	258	7	360
	All	5	558	5	680	5	138	5	521	10	512
LOC-4	High	2	727	1	691	1	387	2	863	2	1448
	Low	3	170	4	240	4	55	3	134	8	589
	All	5	304	5	296	5	81	5	282	10	705
LOC-5	High	2	178	1	219	1	260	2	469	2	460
	Low	3	149	4	112	4	53	3	121	8	223
	All	5	160	5	128	5	73	5	208	10	258
LOC-6	High	1	579	1	260	1	328	2	1850	2	824

	Low	3	661	4	263	4	78	3	85	8	372
	All	4	640	5	263	5	104	5	291	10	436
LOC-7	High	2	14	1	17	1	16	2	25	2	35
	Low	3	7	4	9	4	7	3	2	8	13
	All	5	9	5	10	5	8	5	5	10	16

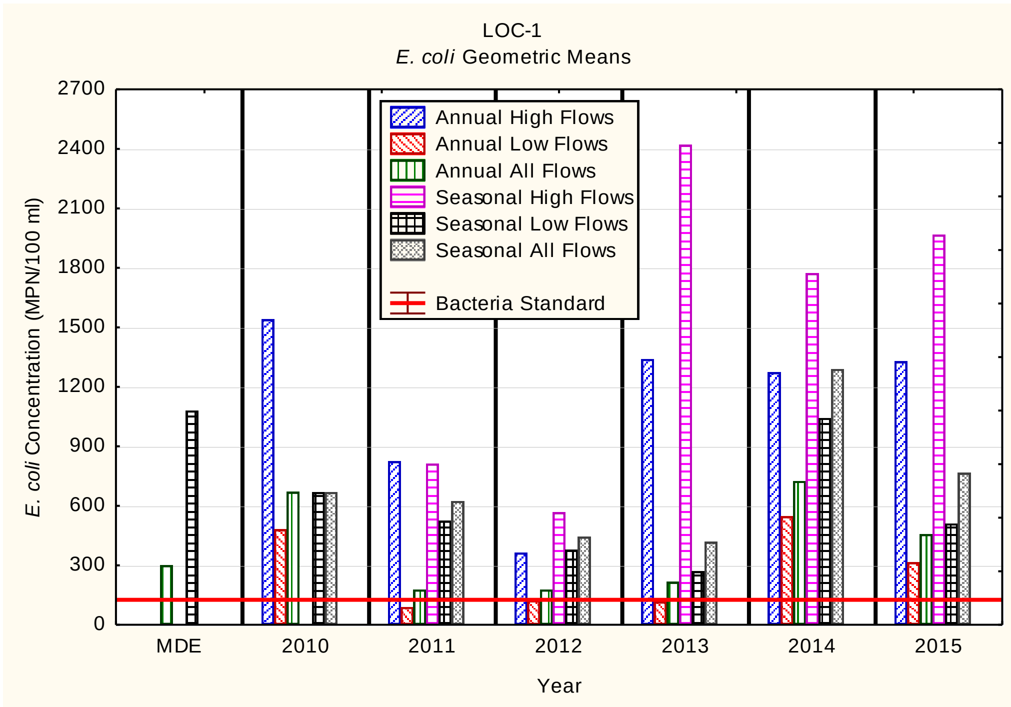


Figure 9-27: E. coli Geometric Mean Concentrations at Site LOC-1 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

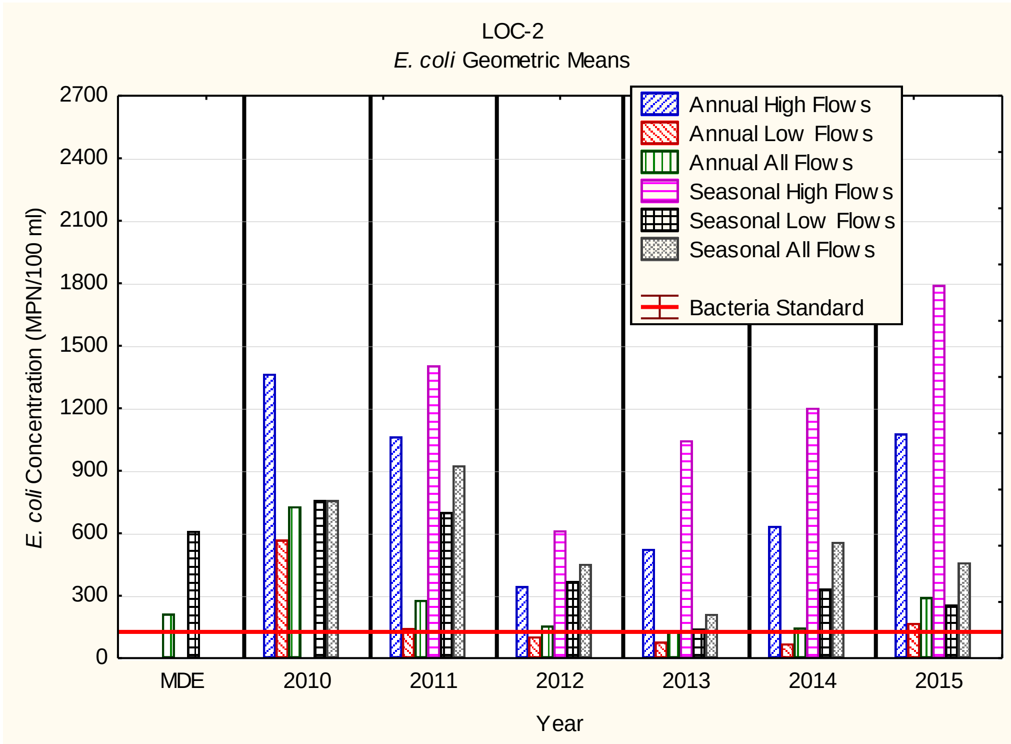


Figure 9-28: E. coli Geometric Mean Concentrations at Site LOC-2 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

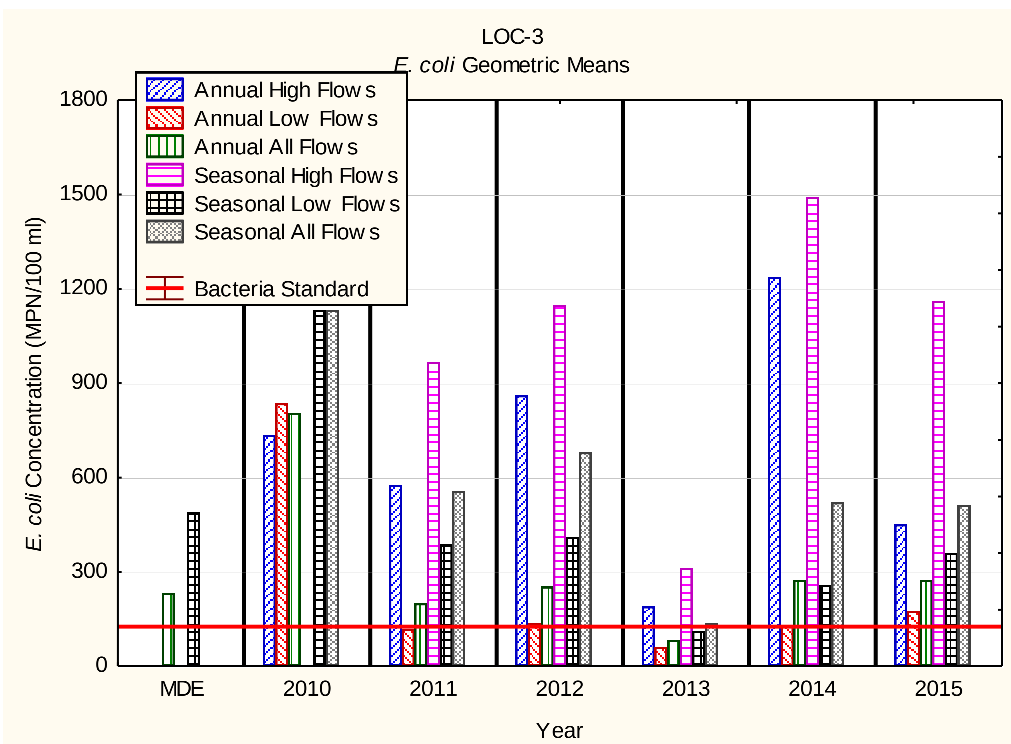
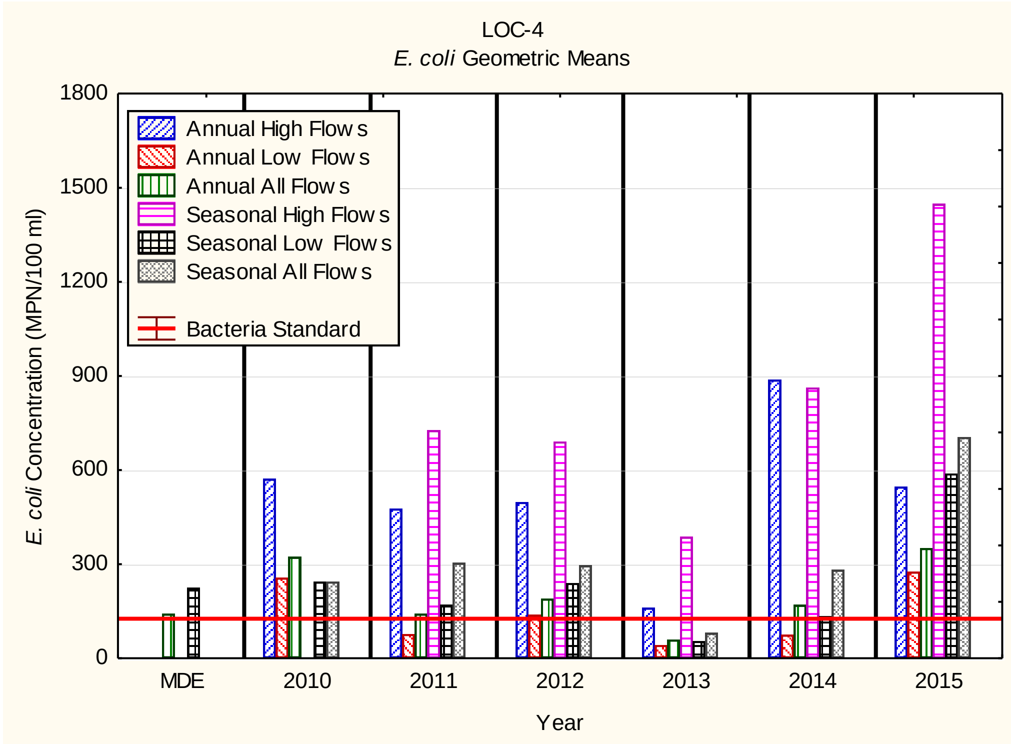


Figure 9-29: E. coli Geometric Mean Concentrations at Site LOC-3 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison



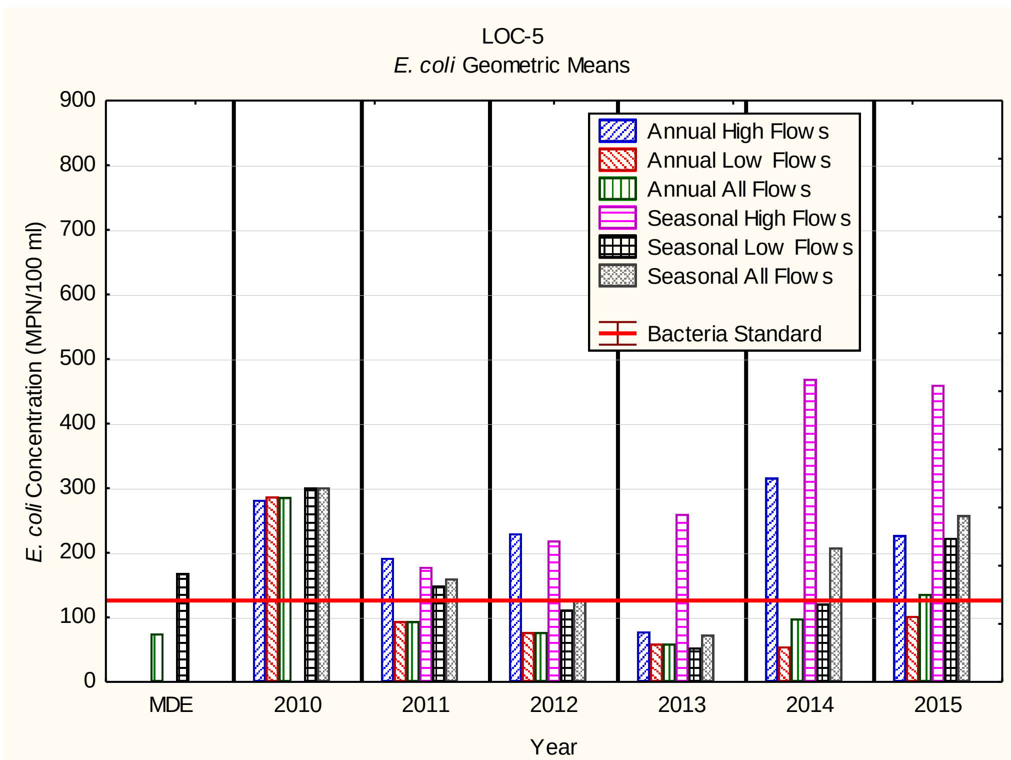


Figure 9-30: E. coli Geometric Mean Concentrations at Site LOC-5 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

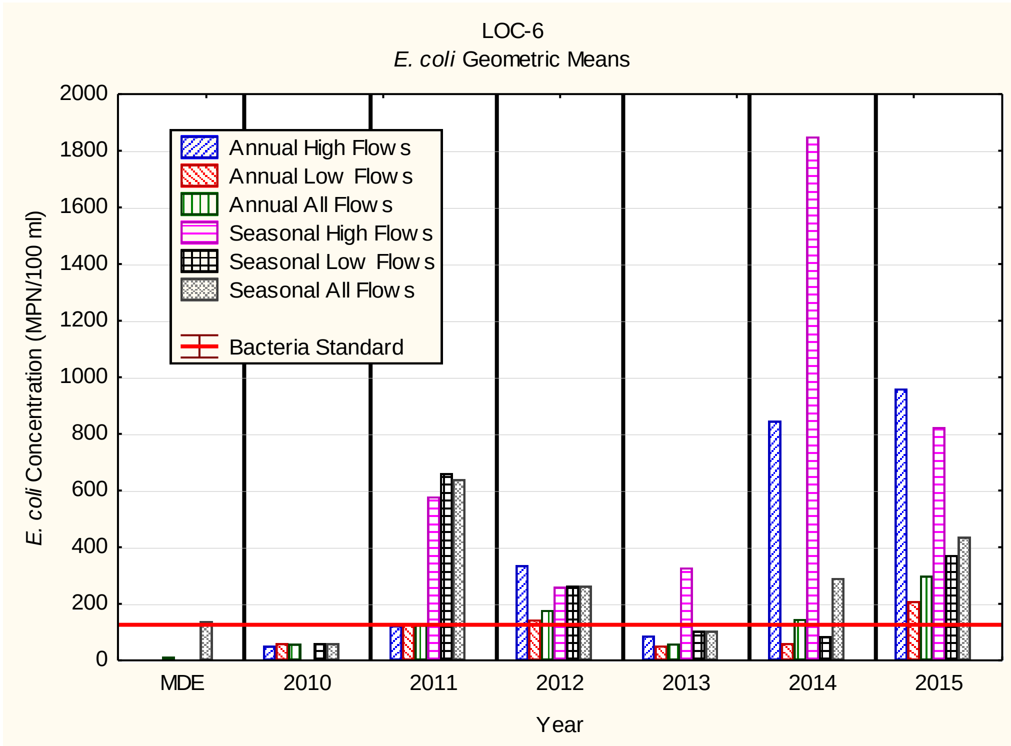


Figure 9-31: E. coli Geometric Mean Concentrations at Site LOC-6 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

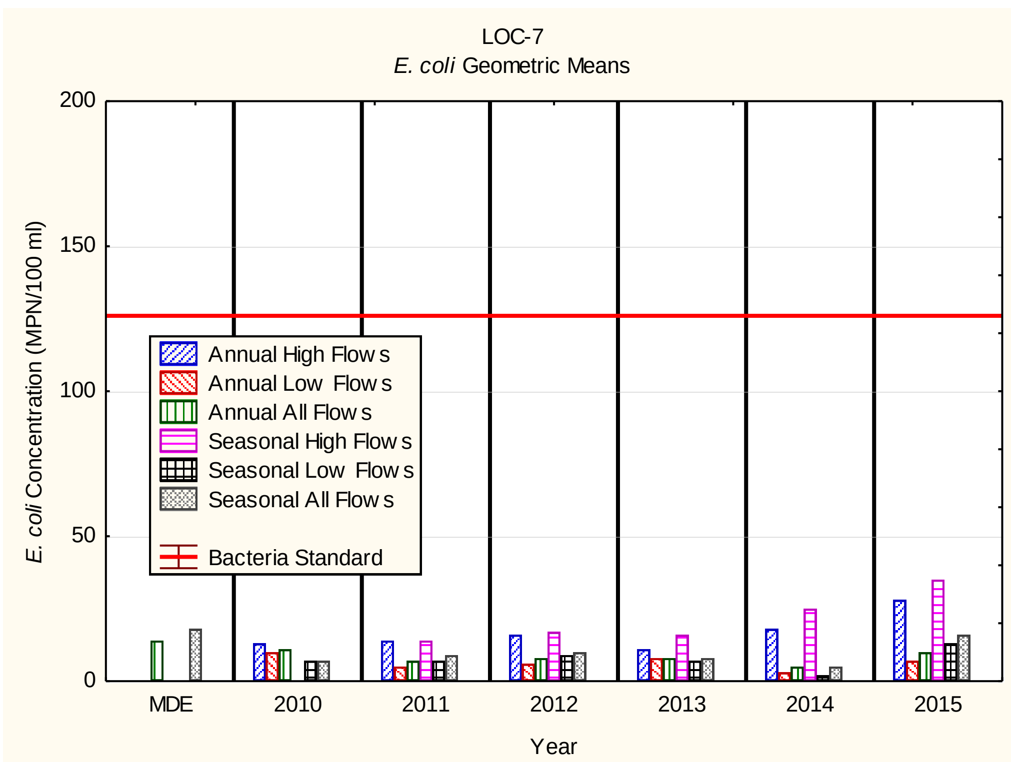


Figure 9-32: E. coli Geometric Mean Concentrations at Site LOC-7 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-25 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are highlighted in green.

Table 9-25: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
LOC-1	2011	2	3	50%	33%	50%	67%	50%	100%	100%	100%
	2012	2	3	50%	33%	50%	67%	100%	67%	100%	67%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	50%
	2014	2	3	100%	67%	100%	100%	100%	100%	100%	100%
	2015	3	7	100%	43%	100%	57%	100%	57%	100%	86%
LOC-2	2011	2	3	100%	33%	100%	67%	100%	100%	100%	100%
	2012	2	3	100%	33%	100%	33%	100%	67%	100%	67%
	2013	1	4	100%	0%	100%	0%	100%	0%	100%	25%
	2014	2	3	100%	33%	100%	33%	100%	33%	100%	67%
	2015	3	7	100%	0%	100%	29%	100%	29%	100%	57%
LOC-3	2011	2	3	50%	0%	50%	33%	100%	67%	100%	100%
	2012	1	4	100%	25%	100%	75%	100%	75%	100%	100%
	2013	1	4	0%	0%	0%	0%	100%	25%	100%	50%
	2014	2	3	100%	0%	100%	33%	100%	67%	100%	67%
	2015	3	7	100%	43%	100%	57%	100%	57%	100%	71%
LOC-4	2011	2	3	50%	0%	50%	0%	50%	0%	50%	25%
	2012	1	4	100%	0%	100%	0%	100%	0%	100%	50%
	2013	1	4	0%	0%	0%	0%	100%	0%	100%	0%
	2014	2	3	50%	0%	50%	0%	100%	0%	100%	0%
	2015	2	8	100%	50%	100%	50%	100%	50%	100%	75%

LOC-5	2011	2	3	0%	0%	0%	0%	0%	0%	50%	0%
	2012	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	0%	0%	0%	0%	0%	0%	100%	0%
	2014	2	3	50%	0%	50%	0%	50%	0%	50%	0%
	2015	2	8	0%	13%	50%	38%	100%	38%	100%	38%
LOC-6	2011	1	3	100%	33%	100%	67%	100%	67%	100%	100%
	2012	1	4	0%	0%	0%	0%	0%	25%	100%	75%
	2013	1	4	0%	0%	0%	0%	100%	0%	100%	0%
	2014	2	3	100%	0%	100%	0%	100%	0%	100%	33%
	2015	2	8	100%	38%	100%	38%	100%	75%	100%	88%
LOC-7	2011	2	3	0%	0%	0%	0%	0%	0%	0%	0%
	2012	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2014	2	3	0%	0%	0%	0%	0%	0%	0%	0%
	2015	2	8	0%	13%	0%	13%	0%	13%	0%	13%

The frequency of exceedance data for low flow conditions generally shows improvement at all monitoring sites over the first four years of monitoring, but some sites experienced regression in 2014. However, in 2015, many of those sites improved. LOC-7, having previously never exceeded the standard under any flow regime, had an exceedance above every standard for the single seasonal high flow sampled in 2015.

Based on the both the geometric mean data and the exceedance frequency data, stations LOC-1, LOC-2, and LOC-3, require additional bacteria reductions for both low flow and high flow conditions. LOC-4, LOC-5, and LOC-6 require reductions for high flow conditions. LOC-7 appears to have met all bacteria water quality standards with no additional bacteria reductions required, with the exception of the single high flow sample during the seasonal period of 2015.

LOC-1 (SBH0002): This site is the located in Baltimore County in the Spring Branch subwatershed. This subwatershed drainage area is entirely within Baltimore County and represents an urban drainage area. While the data indicate an improving trend over the four years of monitoring on an annual and seasonal basis for low flows, the data for high flows is more variable. The geometric means for the annual low flow met bacteria water quality standards for the last three years, but the seasonal low flow geometric means, while improving, are still above the standards. The geometric means for all high flows were above the standards. The Maryland Department of the Environment (MDE) data for this site indicted a geometric mean of 1,080 MPN/100ml for dry weather seasonal samples based on monitoring conducted in 2003 and 2004. A weighted geometric mean for dry weather seasonal sampling over four years of monitoring conducted by Baltimore County resulted in a value of 433 MPN/100ml. When the data from 2014 was included in the geometric mean, it jumped to 505 MPN/100ml. The data from 2015 keeps the geometric mean steady at 508 MPN/100ml. This would indicate the conditions are generally improving at this station based on the difference between the two monitoring periods. The TMDL requires an 89.8% reduction of bacteria at this site to meet bacteria water quality standards.

LOC-2 (BEV0005): This monitoring site is located on Beaverdam Run at the USGS gage where York Road crosses the stream. The entire drainage area is in Baltimore County. The Baltimore County monitoring indicated that this site has displayed continuing improvement for both low flows on both an annual and a seasonal basis, with the annual low flow meeting bacteria water quality standards during 2012 to 2014, with the annual low flow slightly exceeding the standard in 2015 at 143 MPN/100ml. None of the high flow geometric means met standards and have generally increased since 2012 for both the annual and seasonal time periods. The MDE data for this site indicated a seasonal dry weather geometric mean of 611 MPN/100ml for this site. The six years of Baltimore County data resulted in a geometric mean of 342 MPN/100 ml for dry weather seasonal data. This would indicate that there has been improvement at this site. The TMDL indicated a bacteria reduction of 80.2% is necessary for meeting bacteria water quality standards in the drainage area to this site.

LOC-3 (WPG0050): This site is located on Western Run subwatershed in Baltimore County at the USGS gage on the stream. The majority of the drainage area is in Baltimore County, with a small portion (~580 acres) from the town of Hampstead in Carroll County. This subwatershed is predominantly agricultural. The Baltimore County monitoring data indicates that the bacteria concentrations are generally improving, particularly for low flow conditions. The high flow data for both the annual and seasonal time periods has been variable and none of the high flow geometric means met the water quality standards. The MDE data indicated a seasonal dry weather concentration of 491 MPN/100ml for this site. The data gathered over six years of seasonal low flow indicated a geometric mean of 353 MPN/100ml, with the geometric mean coming down after each season’s data is incorporated. This trend indicates improvement at this site. The TMDL indicated 73.9% reduction necessary for meeting bacteria water quality standards at this site.

LOC-4 (GUN0233): This site is located in Baltimore County on mainstem of Gunpowder Falls at the Glencoe USGS gage site. The majority of the drainage is in Baltimore County, with some headwater drainage area is in York County, Pennsylvania (~2,700 acres) and a small amount of drainage from Harford County (~818 acres). The site also receives discharge from the upstream Prettyboy dam. The Baltimore County monitoring data indicates variable trends no matter the flow regime across six years of data. The MDE data indicated a seasonal dry weather concentration of 224 MPN/100ml for this site, while the Baltimore County data for the six years of monitoring resulted in a geometric mean concentration of 148 MPN/100ml; indicating improvement at this site. However, when the latest data from 2015 is included, the geometric mean jumps to 222 MPN/100ml. The TMDL indicated a 82.1% reduction in bacteria is necessary for meeting bacteria water quality standards at this site.

LOC-5 (GUN284): This site is located on the mainstem of Gunpowder Falls below the confluence with Little Falls. The majority of the drainage is in Baltimore County, with some headwater drainage area is in York County, Pennsylvania (~2,700 acres). The site also receives discharge from the upstream Prettyboy dam. The annual data, up to 2014, indicate decreasing trends across all flow regimes except seasonal high flows. However, in the last two years, there has been an increase in the geometric means across all flow regimes. The MDE data indicated a seasonal dry weather concentration of 168 MPN/100ml at this site based on monitoring in 2003-2004, while the Baltimore County data for the five years of monitoring results in a geometric mean of 126 MPN/100 ml for the seasonal dry weather samples, which increases to 148 MPN/100ml when 2015 data is included. The TMDL indicated an 88.0% reduction in bacteria is necessary for meeting bacteria water quality standards at this site.

LOC-6/LOC-6a (LIT0002): This site is located on the mainstem of Little Falls. The majority of the drainage is in Baltimore County with some headwater drainage area is in York County, Pennsylvania (~2,700 acres). Baltimore County data for six years of monitoring resulted in a geometric mean concentration for seasonal low flow samples of 221 MPN/100ml.

LOC-7 (GUN0387): This site is located a short distance downstream from the Prettyboy Reservoir dam on the mainstem of the Gunpowder River. There are few small tributaries that enter the mainstem between the dam and the monitoring site. The major source of water in the stream is release from the Prettyboy Reservoir. This is a cold water release from depth in the reservoir, which results in the low *E. coli* concentrations found at this monitoring site. The site consistently meets the bacteria water quality standards for high flow, low flow, and all flow conditions combined.

Liberty Reservoir

Table 9-26 shows the latitude/longitude locations of the current bacteria monitoring stations within the Liberty Reservoir watershed. Figure 9-23 shows the locations of the monitoring sites for the entire trend monitoring program. The monitoring locations are on major tributaries to the Liberty Reservoir, with all of the sites located in Carroll County.

Table 9-26: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed	Latitude	Longitude
LMR0015	LIB-1	Little Morgan Run	39.425	-76.961
MOR0040	LIB-2	Morgan Run	39.452	-76.955
MDE0026	LIB-3	Middle Run	39.463	-76.908
BEA0016	LIB-4	Beaver Run	39.489	-76.904
NPA0016	LIB-5	North Branch Patapsco River	39.501	-76.883

Table 9-27 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means that met the water quality standard (126 MPN) are highlighted in green. These data are displayed graphically in Figure 9-33 through Figure 9-37.

Table 9-27: Liberty Reservoir Watershed E. coli Results on an Annual and Seasonal Basis

Annual (MPN/100 ml)											
Site	Flow Type	2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
LIB-1	High	0		3	207	2	2192	3	442	3	106
	Low	0		5	98	8	40	7	39	8	111
	All	0		8	130	10	89	10	81	11	140
LIB-2	High	0		3	162	2	816	3	463	3	235
	Low	0		5	137	8	37	7	99	8	67
	All	0		8	146	10	118	10	166	11	133
LIB-3	High	0		3	683	2	1031	3	1372	6	521
	Low	0		5	464	8	169	7	325	5	337
	All	0		8	536	10	242	10	500	11	482
LIB-4	High	0		3	172	2	366	3	390	6	193
	Low	0		9	138	8	25	7	116	5	83
	All	0		8	146	10	42	10	167	11	147
LIB-5	High	0		2	380	2	115	3	524	4	604
	Low	0		6	220	9	36	7	155	7	132
	All	0		8	253	9	77	10	224	11	243

Seasonal (May 1st to September 30th) (MPN/100 ml)											
Site	Flow Type	2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
LIB-1	High	0		2	134	1	1986	1	579	0	--
	Low	0		3	163	4	105	3	86	4	133
	All	0		5	151	5	189	4	139	4	133
LIB-2	High	0		2	86	1	275	1	345	0	--
	Low	0		3	171	4	72	3	159	4	133
	All	0		5	130	5	94	4	193	4	133
LIB-3	High	0		2	495	1	1733	1	1553	0	--
	Low	0		3	687	4	260	3	554	4	629
	All	0		5	602	5	380	4	717	4	629
LIB-4	High	0		1	74	1	411	1	387	0	--
	Low	0		4	172	4	84	3	173	4	194
	All	0		5	145	5	115	4	211	4	194
LIB-5	High	0		1	156	1	770	1	613	0	--
	Low	0		4	357	3	216	3	381	4	239
	All	0		5	303	4	297	4	429	4	239

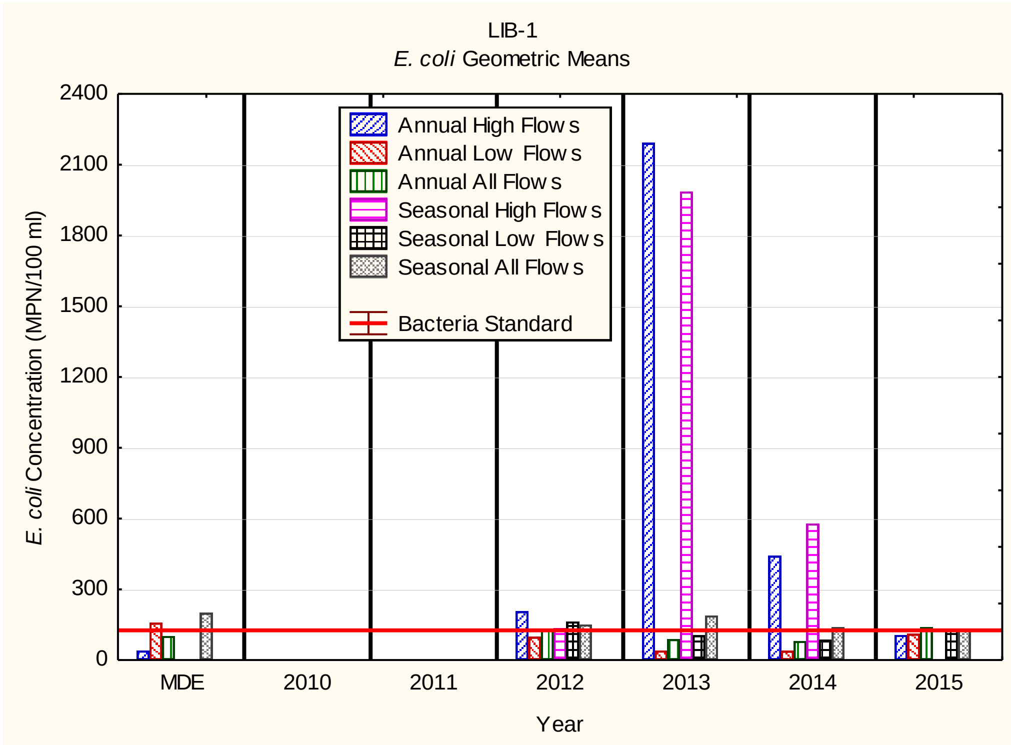


Figure 9-33: E. coli Geometric Mean Concentrations at Site LIB-1 for Both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No data for 2010 and 2011.

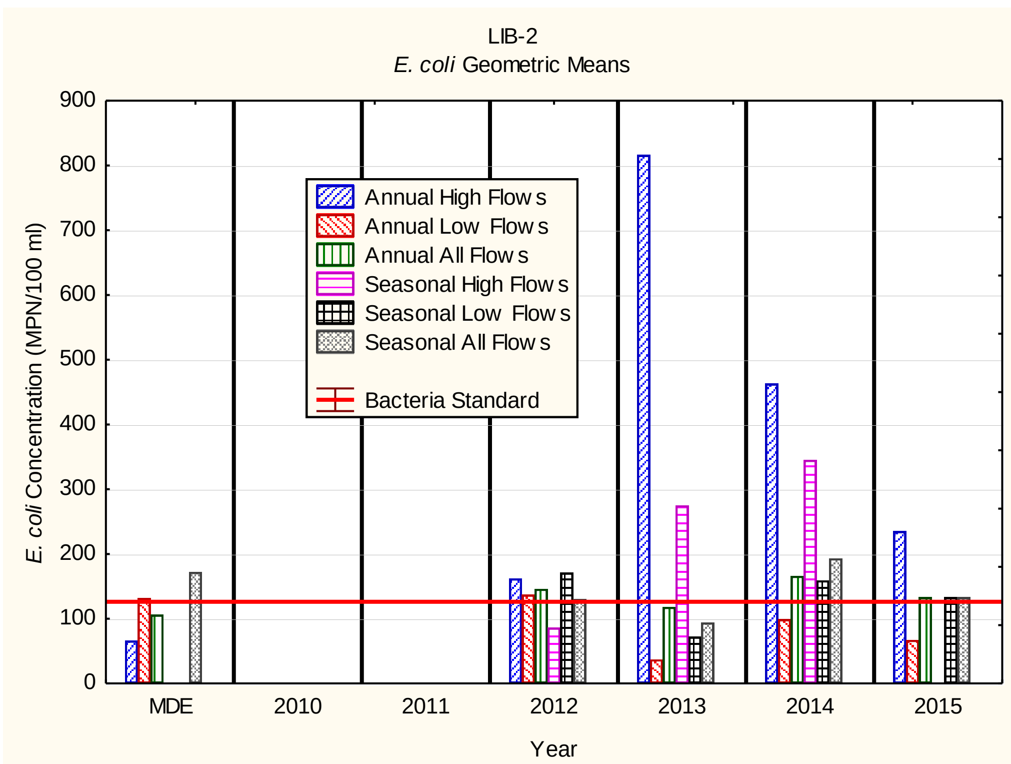


Figure 9-34: E. coli Geometric Mean Concentrations at Site LIB-2 for Both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No data for 2010 and 2011.

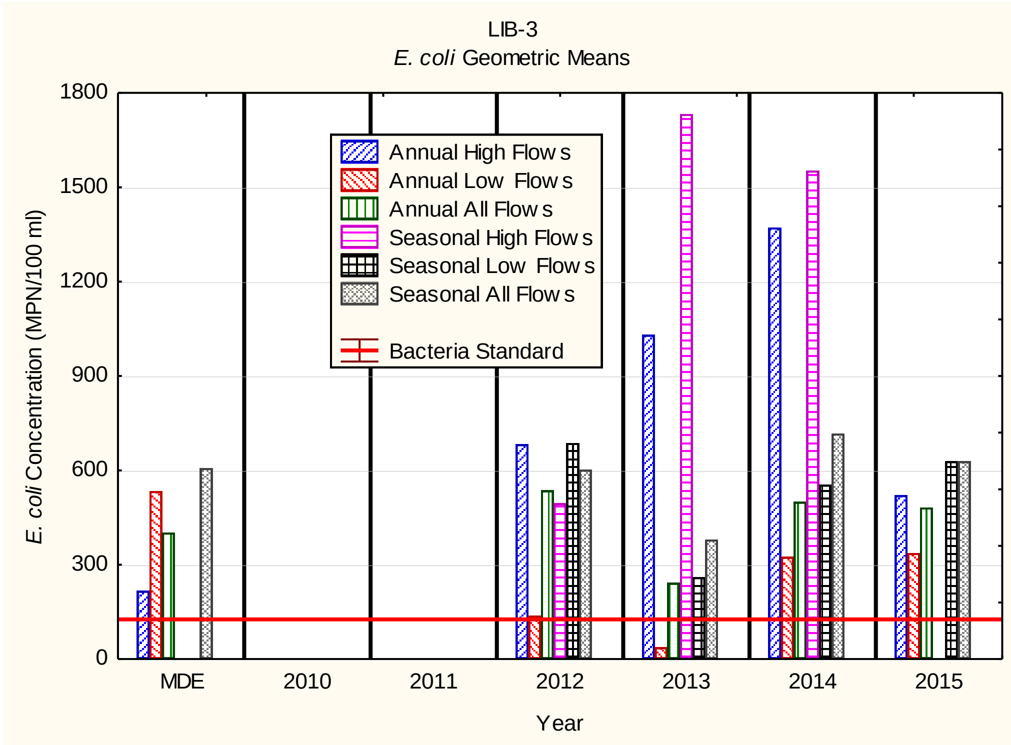


Figure 9-35: E. coli Geometric Mean Concentrations at Site LIB-3 for Both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No data for 2010 and 2011.

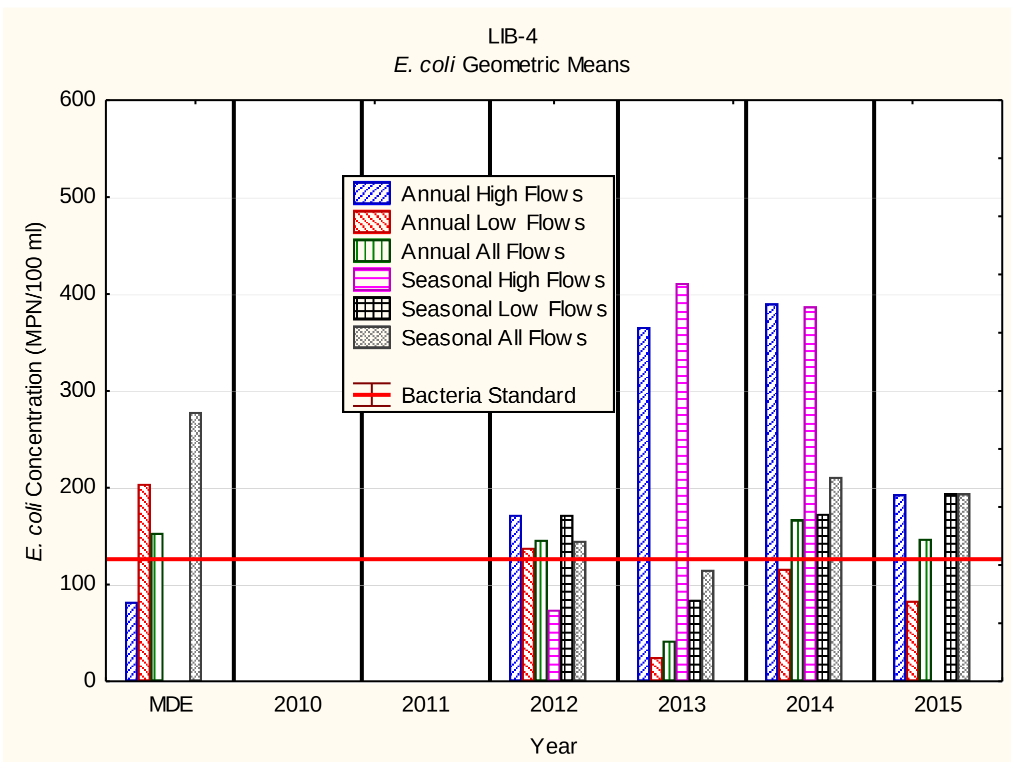


Figure 9-36: E. coli Geometric Mean Concentrations at Site LIB-4 for Both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No data for 2010 and 2011.

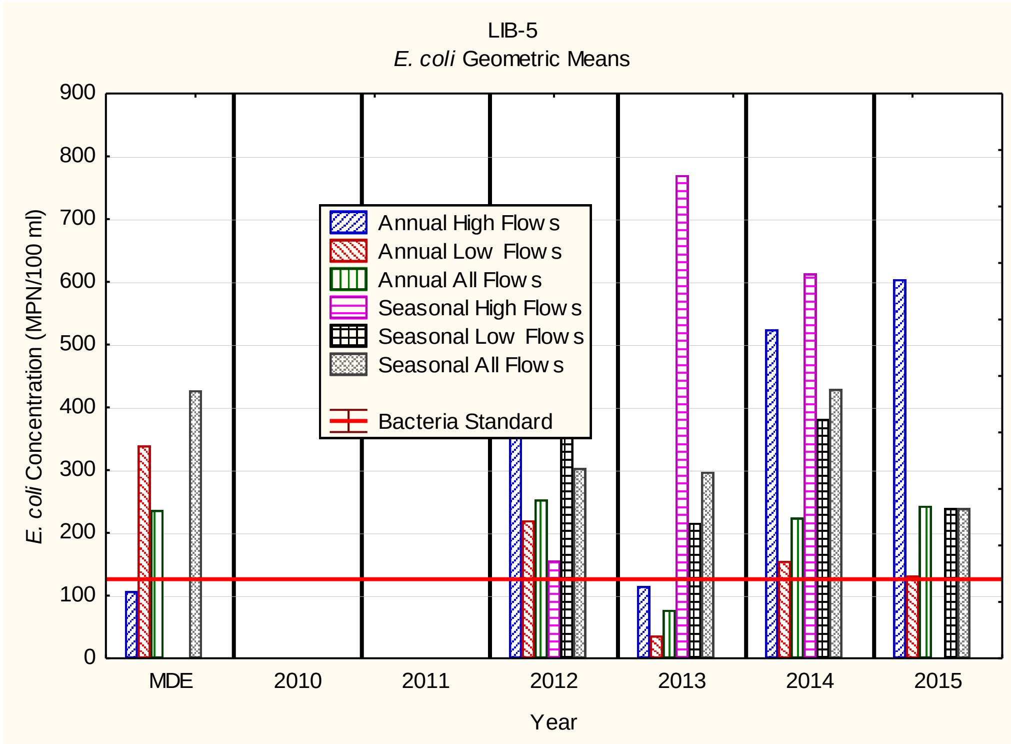


Figure 9-37: E. coli Geometric Mean Concentrations at Site LIB-5 for Both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No data for 2010 and 2011.

Given the limited amount of data collected, it is difficult to analyze the data for trends. General comments will be provided for each station.

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur.

Table 9-28 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are high-lighted in green.

Table 9-28: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
LIB-1	2011	0	0								
	2012	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	100%	0%	100%	0%	100%	0%	100%	0%
	2014	1	3	100%	0%	100%	0%	100%	0%	100%	0%
	2015	0	4		0%		0%		0%		25%
LIB-2	2011	0	0								
	2012	2	3	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	0%	0%	0%	0%	0%	0%	100%	0%
	2014	1	3	0%	0%	0%	0%	100%	0%	100%	0%
	2015	1	4		25%		25%		25%		25%
LIB-3	2011	0	0								
	2012	2	3	50%	67%	50%	100%	50%	100%	50%	100%
	2013	1	4	100%	0%	100%	0%	100%	0%	100%	0%
	2014	1	3	0%	0%	0%	0%	100%	0%	100%	33%
	2015	1	3	0%	67%	100%	67%	100%	67%	100%	100%
LIB-4	2011	0	0								
	2012	2	3	0%	0%	0%	0%	0%	0%	0%	25%
	2013	1	4	0%	0%	100%	0%	100%	0%	100%	0%
	2014	1	3	0%	0%	0%	0%	100%	0%	100%	33%
	2015	1	3	0%	0%	0%	33%	0%	33%	0%	67%
LIB-5	2011	0	0								
	2012	2	3	0%	0%	0%	25%	0%	100%	0%	100%
	2013	1	4	100%	33%	100%	33%	100%	33%	100%	33%
	2014	1	3	100%	0%	100%	33%	100%	67%	100%	100%
	2015	0	4		25%		25%		25%		50%

The frequency of exceedance data shows improvement for three monitoring sites (LIB-2, LIB-3, LIB-4) with a general downward trend in the frequency of exceedance of the various single sample bacteria standards. Site LIB-1 appears to be increasing in its exceedance frequencies; and LIB-5 is increasing at the higher single sample standards, but decreasing at the lower single sample standards.

LIB-1 (LMR0015): This site is located on Little Morgan Run in Carroll County. All of the drainage to the site is located in Carroll County. The data indicate the low flow geometric mean on an annual basis for 2013, 2014, and 2015 were below water quality standard of 126 MPN/100 ml. The Maryland Department of the Environment (MDE) data for this site indicated a geometric mean of 200 MPN/100ml for dry weather seasonal samples based on monitoring conducted between 2003 and 2004. A weighted mean for dry weather seasonal sampling for the four years of monitoring conducted by Baltimore County resulted in a value of 118 MPN/100ml. This would indicate the conditions are improving at this station based on the difference between the two monitoring periods. The TMDL requires a 40.0% reduction of bacteria at this site.

LIB-2 (MOR0040): This monitoring site is located on Morgan Run in Carroll County, with the entire drainage area in Carroll County. The monitoring indicated that this site showed improvement between 2012 and 2013 for low flow concentrations, meeting the bacteria water quality standard in 2013 for low flow conditions on both an annual and seasonal basis. The

MDE data for this site indicated a seasonal dry weather geometric mean of 172 MPN/100ml for this site. The previous years of Baltimore County data resulted in a geometric mean of 113 MPN/100 ml for the dry weather seasonal data. When the 2015 data is incorporated, the mean slightly increases to 122 MPN/100ml. This would indicate that there has been an improvement at this site. The TMDL indicated a reduction of 28.6% reduction necessary for meeting bacteria water quality standards in the drainage area to this site.

LIB-3 (MDE0026): This monitoring site is located on Middle Run in Carroll County, with all of the drainage area in Carroll County. The monitoring data indicate that the geometric mean *E.coli* concentrations did not meet the bacteria water quality standards for any of the flow conditions for any year of monitoring. The MDE data indicated a seasonal dry weather concentration of 607 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 485 MPN/100ml indicating improvement. The TMDL indicated 80.4% reduction necessary for meeting bacteria water quality standards at this site.

LIB-4 (BEA0016): This site is located on Beaver Run in Carroll County, with all of the drainage area in Carroll County. The monitoring data indicate that the geometric mean *E.coli* concentrations may be improving on a year over year basis, with most of the improvement in low flow conditions. The MDE data indicated a seasonal dry weather concentration of 278 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 147 MPN/100ml indicating improvement. The TMDL indicated 58.3% reduction necessary for meeting bacteria water quality standards at this site.

LIB-5 (NPA0165): This site is located on the North Branch of the Patapsco River in Carroll County, with all of the drainage area in Carroll County. The monitoring data indicate that this site experiences high variability in conditions between years. In 2013, it met standards for geometric mean under annual low flow and aggregate annual conditions. In other years of monitoring, however, it did not meet standards under any condition. The MDE data indicated a seasonal dry weather concentration of 427 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 279 MPN/100ml, indicating improvement. The TMDL indicated 72.1% reduction necessary for meeting bacteria water quality standards at this site.

Lower North Branch of the Patapsco River

Table 9-29 shows the latitude/longitude locations of the current bacteria monitoring stations within the Lower North Branch of the Patapsco River. All of the monitoring locations are on the mainstem of the Lower North Branch of the Patapsco River, with drainage from Baltimore, Carroll, Howard, and Anne Arundel counties, and Baltimore City.

Table 9-29: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed	Latitude	Longitude
PAT0148	PAT-1	LNB Patapsco River	39.231	-76.665
PAT0176	PAT-2	LNB Patapsco River	39.218	-76.707
PAT0222	PAT-3	LNB Patapsco River	39.251	-76.764
PAT0285	PAT-4	LNB Patapsco River	39.310	-76.792
PAT0347	PAT-5	LNB Patapsco River	39.332	-76.870

Table 9-30 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. These data are presented graphically in Figure 9-38 through Figure 9-42, which include the MDE results for comparison. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means below the water quality standard (126 MPN) are highlighted in green.

Table 9-30: Lower North Branch of the Patapsco River E. coli Results on an Annual and Seasonal Basis

Annual Data – Geometric Mean (MPN/100 ml)											
Site	**Flow Type**	**2011**		**2012**		**2013**		**2014**		**2015**	
		N	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**
PAT-1	High	4	604	3	1531	3	1174	3	1174	7	489
	Low	9	114	8	49	8	102	8	102	10	242
	All	11	209	11	125	11	198	11	198	17	324
PAT-2	High	3	134	3	527	4	784	4	784	7	139
	Low	9	47	9	32	8	33	8	33	10	94
	All	11	62	12	65	12	94	12	94	17	111
PAT-3	High	4	353	3	891	3	676	3	676	7	135
	Low	8	57	8	59	8	27	8	27	10	140
	All	12	104	11	123	11	65	11	65	17	138
PAT-4	High	4	185	3	817	4	548	4	548	7	95
	Low	8	34	9	20	8	33	8	33	10	133
	All	12	59	12	50	12	84	12	84	17	116
PAT-5	High	4	163	3	165	4	321	4	321	7	106
	Low	8	28	9	24	7	34	7	34	10	78
	All	12	76	12	39	11	77	11	77	17	88
Seasonal Data (May 1st to September 30th) – Geometric Mean (MPN/100 ml)											
Site	**Flow Type**	**2011**		**2012**		**2013**		**2014**		**2015**	
		N	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**
PAT-1	High	2	644	3	1020	1	2420	1	921	3	1760
	Low	3	992	2	130	4	163	3	141	7	277
	All	5	834	5	447	5	279	4	226	10	482
PAT-2	High	2	334	2	160	1	649	2	709	3	898
	Low	3	80	3	92	4	107	3	45	7	88
	All	5	142	5	115	5	153	5	135	10	177
PAT-3	High	2	283	2	351	1	411	1	411	3	727
	Low	3	71	3	124	4	187	3	68	7	142
	All	5	123	5	188	5	257	4	107	10	232
PAT-4	High	2	178	2	80	1	435	2	422	3	337
	Low	3	62	3	71	4	60	3	67	7	154
	All	5	94	5	75	5	90	5	141	10	195
PAT-5	High	2	111	2	115	1	248	2	322	3	336
	Low	3	83	3	139	4	64	2	109	7	75
	All	5	93	5	129	5	84	4	187	10	118

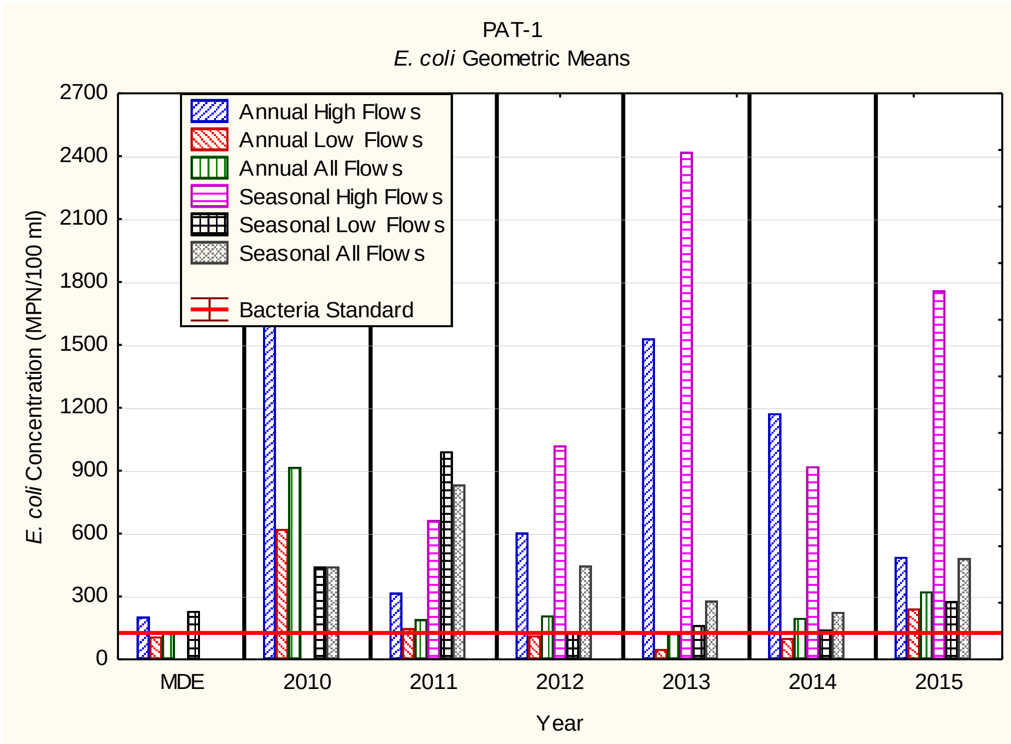


Figure 9-38: E. coli Geometric Mean Concentrations at Site PAT-1 for Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

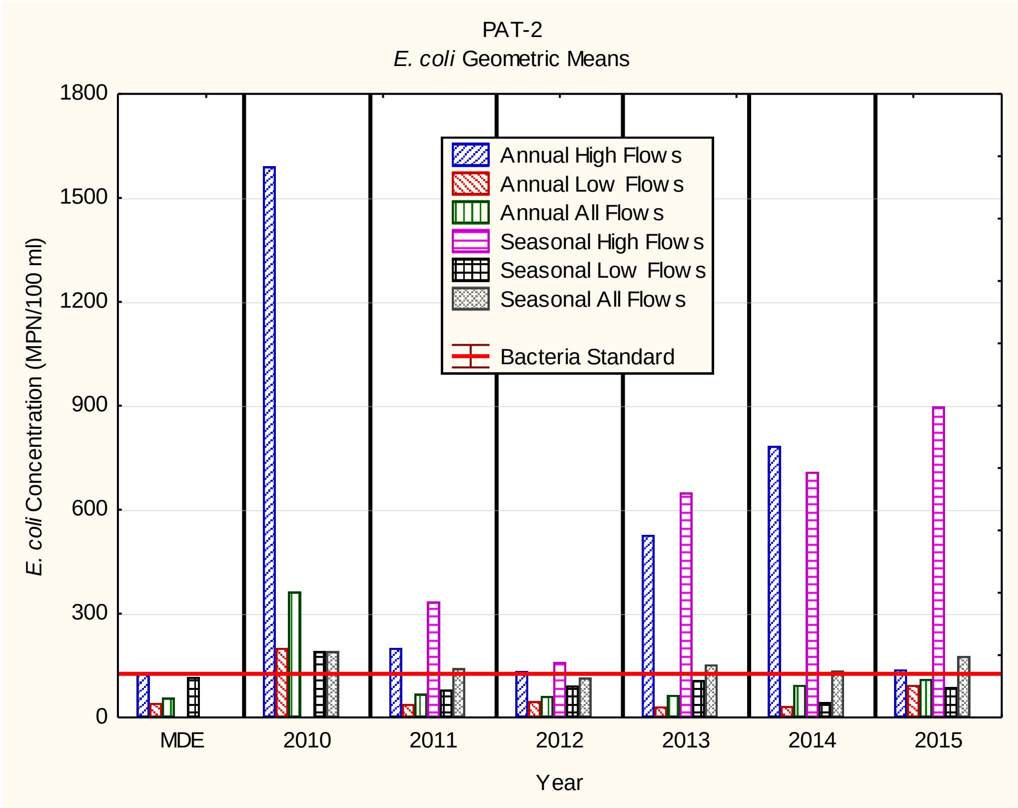


Figure 9-39: E. coli Geometric Mean Concentrations at Site PAT-2 for Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

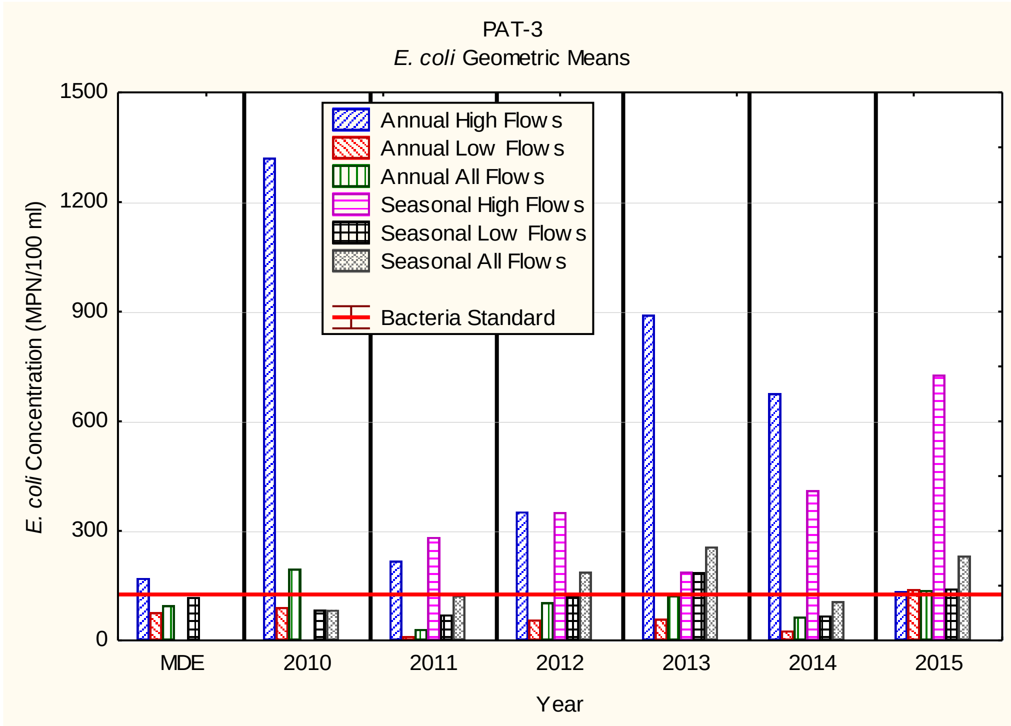


Figure 9-40: E. coli Geometric Mean Concentrations at Site PAT-3 for Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

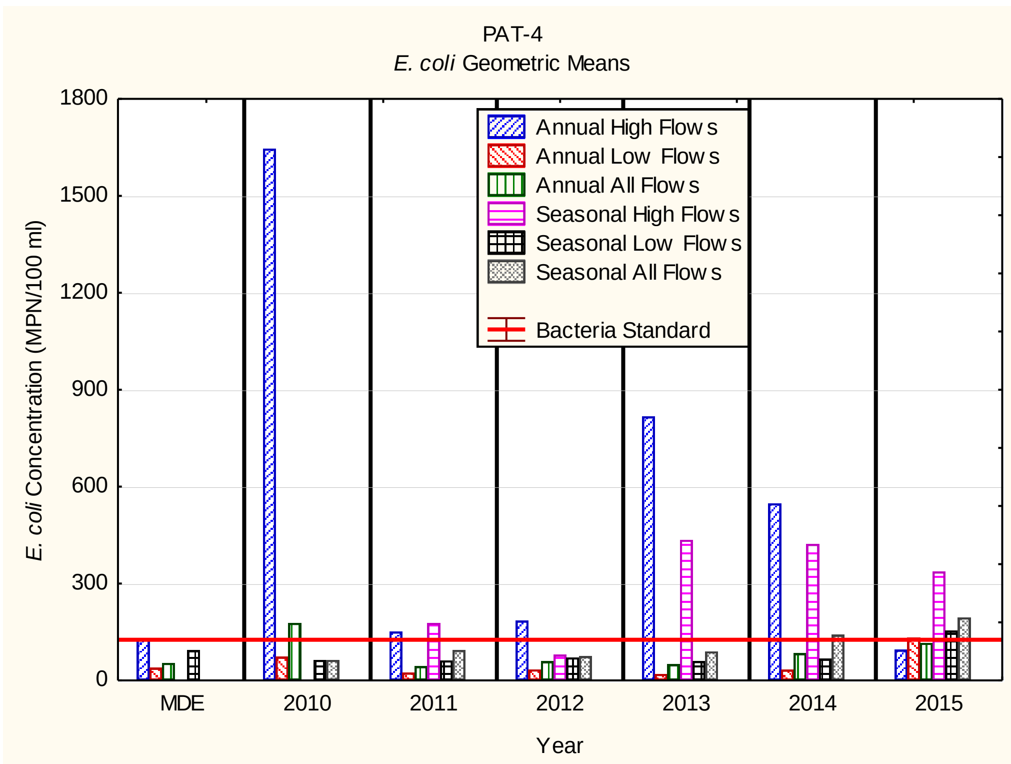


Figure 9-41: E. coli Geometric Mean Concentrations at Site PAT-4 for Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

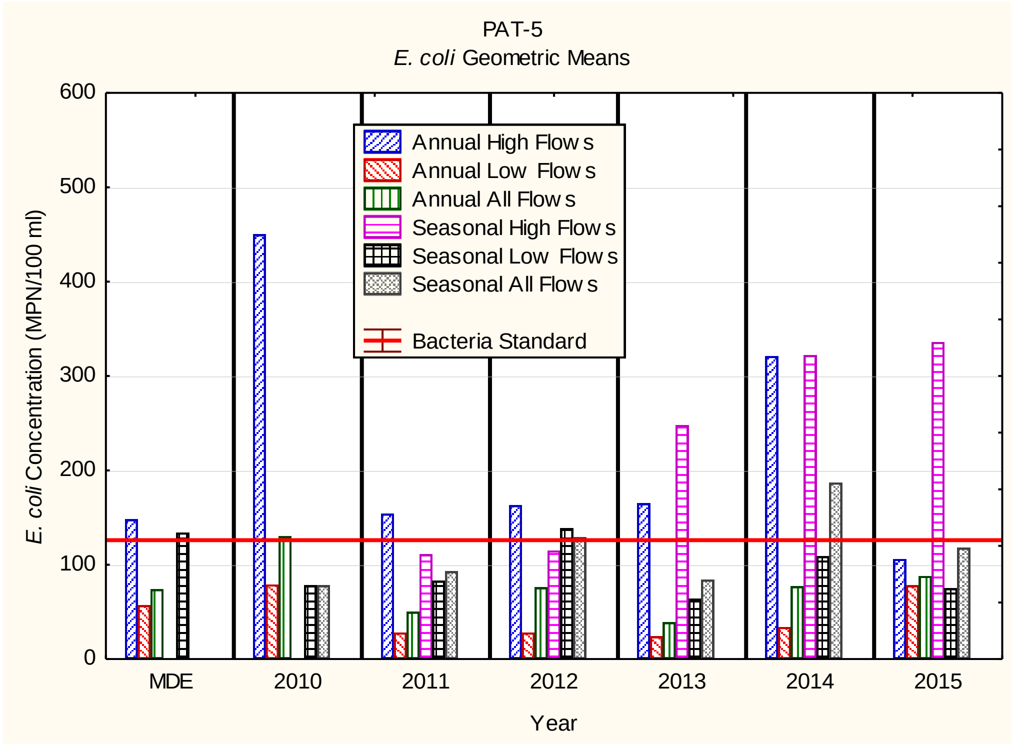


Figure 9-42: E. coli Geometric Mean Concentrations at Site PAT-5 for Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

PAT-1 (PAT148): This site is the located on the mainstem of the Lower North Branch of the Patapsco River and is the lowest monitoring point on the mainstem. It receives drainage from Carroll, Baltimore, Howard, and Anne Arundel counties. The data indicate that this site is degrading slightly, with fewer of the flow regimes meeting the water quality standard each year during the monitoring period. In 2015, none of the flow regimes met the standard. The Maryland Department of the Environment (MDE) data for this site indicted a geometric mean of 231 MPN/100ml for dry weather seasonal samples based on monitoring conducted between 10/2/2002 and 10/21/2003. A weighted mean for dry weather seasonal sampling for the six years of monitoring conducted by Baltimore County results in a value of 284 MPN/100ml. This would indicate worsening of conditions at this station between the two monitoring periods. The TMDL requires a 56.1% reduction of bacteria at this site.

PAT-2 (PAT0176): This monitoring site is located on the mainstem of the Lower North Branch of the Patapsco River above the confluence of the highly urbanized Herbert Run subwatershed in Baltimore County and Deep Run in Howard County. The Baltimore County monitoring indicated that this site has consistently met the water quality standard of 126 MPN/100ml for the last four years for both the annual and seasonal dry weather measurements. The MDE data for this site indicated a seasonal dry weather geometric mean of 117 MPN/100ml for this site. The five years of Baltimore County data resulted in a geometric mean of 99 MPN/100 ml for the dry weather seasonal data. This would indicate that there has been little change at this site or a slight improvement. The TMDL indicated no reductions necessary for meeting bacteria water quality standards in the drainage area to this site.

PAT-3 (PAT0222): This site is located on the mainstem of the Lower North Branch of the Patapsco River where it is crossed by Ilchester Road. The Baltimore County monitoring data indicates that this site meets the bacteria water quality standards during dry weather flow on an annual basis for five of six years of monitoring, and four of six years for seasonal samples. While 2015 data exceeded the standard no matter the flow regime, only the seasonal high flows exceeded the standard by more than fifteen percent. The MDE data indicated a seasonal dry weather concentration of 119 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 116 MPN/100ml indicating little change or a slight improvement. The TMDL indicated no reductions necessary for meeting bacteria water quality standards at this site.

PAT-4 (PAT0285): This site is located where Old Frederick Road crosses the mainstem of the Lower North Branch of the Patapsco River. It is downstream of the confluence of a number of urbanized subwatersheds (Miller Run, Cedar Branch). The Baltimore County monitoring data indicates that this site meets the bacteria water quality standards during dry weather flow on an annual basis and a seasonal basis for five of six years of monitoring. In 2015, only the annual and annual high flow regimes met the standard. The MDE data indicated a seasonal dry weather concentration of 93 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 83 MPN/100ml, indicating improvement at this site. The TMDL indicated no reductions necessary for meeting bacteria water quality standards at this site.

PAT-5 (PAT0387): This site is located where Old Court Road crosses the Patapsco River below the confluence of Falls Run and several unnamed tributaries with the Patapsco mainstem. The Baltimore County monitoring data indicates that this site meets the bacteria water quality standards during annual dry weather flow for all six years of monitoring, and five of six years for seasonal dry weather samples. The MDE data indicated a seasonal dry weather concentration of 134 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 83 MPN/100ml indicating improvement at this site. The TMDL indicated a 12.9% reduction of bacteria necessary for meeting bacteria water quality standards at this site. Based on the Baltimore County data this site may already be meeting the water quality standards. The majority of the drainage area to this site is outside of Baltimore County and lies mainly in Carroll and Howard counties.

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-31 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are high-lighted in green.

Table 9-31: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
PAT-1	2011	2	3	50%	67%	50%	67%	50%	67%	100%	67%
	2012	3	2	67%	0%	100%	0%	100%	0%	100%	0%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	50%
	2014	1	3	100%	0%	100%	0%	100%	0%	100%	33%
	2015	3	7	100%	29%	100%	29%	100%	29%	100%	29%
PAT-2	2011	2	3	0%	0%	25%	0%	25%	0%	100%	0%
	2012	2	3	0%	0%	0%	0%	0%	0%	25%	0%
	2013	1	4	100%	0%	100%	0%	100%	0%	100%	0%
	2014	2	3	50%	0%	50%	0%	100%	0%	100%	0%
	2015	3	7	67%	0%	100%	14%	100%	14%	100%	14%
PAT-3	2011	2	3	0%	0%	0%	0%	25%	0%	25%	0%
	2012	2	3	50%	0%	50%	0%	50%	0%	50%	0%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	25%
	2014	1	3	0%	0%	100%	0%	100%	0%	100%	0%
	2015	3	7	33%	0%	67%	29%	100%	29%	100%	29%
PAT-4	2011	2	3	0%	0%	0%	0%	50%	0%	50%	0%
	2012	2	3	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	0%	0%	100%	0%	100%	0%	100%	0%
	2014	2	3	0%	0%	50%	0%	100%	0%	100%	0%
	2015	3	7	33%	0%	33%	29%	33%	29%	67%	29%
PAT-5	2011	2	3	0%	0%	0%	0%	0%	0%	0%	0%
	2012	2	3	0%	0%	0%	0%	0%	25%	0%	25%
	2013	1	4	0%	0%	0%	0%	0%	0%	50%	0%
	2014	2	2	0%	0%	50%	0%	50%	0%	50%	0%
	2015	3	7	33%	14%	33%	14%	33%	14%	67%	14%

Monitoring sites PAT-3 and PAT-5 have excursions over the single sample standards and need to have potential sources identified. PAT-1 needs greater improvement and indeed has the highest bacteria reduction target at 56.1% in the TMDL. High flows are more variable in meeting the single sample standards.

Gwynns Falls

Table 9-32 shows the latitude/longitude locations of the current bacteria monitoring stations within the Gwynns Falls watershed. All of the monitoring locations are on the mainstem of the Gwynns Falls, with the upper two thirds of the watershed in Baltimore County and the lower third of the watershed in Baltimore City. Two of the monitoring sites are in the city and two are in the county.

Table 9-32: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed	Latitude	Longitude	Location
GWN0015	GWY-1	Gwynns Falls	39.271	-76.648	City
GWN0115	GWY-2	Gwynns Falls	39.346	-76.724	County
GWN0026	GWY-5	Gwynns Falls	39.277	-76.662	City
GWN0160	GWY-6	Gwynns Falls	39.392	-76.765	County
	DR-B-10	Gwynns Falls	39.304	-76.712	County
	GF-B-8	Gwynns Falls	39.322	-76.712	County

Table 9-33 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means below the water quality standard (126 MPN) are highlighted in green. These results are displayed graphically in Figure 9-43 through Figure 9-48. The new trend sites, DR-B-10 and GF-B-8, have been compared to GWY-5, the closest downstream MDE site.

Table 9-33: Gwynns Falls E. coli Results on an Annual and Seasonal Basis

Annual Data (MPN/100 ml)											
Site	**Flow Type**	**2011**		**2012**		**2013**		**2014**		**2015**	
		N	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**
GWY-1	High	3	1452	3	1726	2	2420	4	1742	3	1754
	Low	8	2143	9	1554	10	542	7	925	7	1534
City	All	11	1927	12	1595	12	696	11	1164	10	1597
	High	4	732	3	567	2	212	4	1451	3	1372
GWY-2	Low	8	159	9	163	10	87	8	269	8	132
	All	12	265	12	222	12	101	12	471	11	299
GWY-5	High	4	776	3	1083	2	1646	4	1844	3	970
	Low	8	447	9	421	10	91	7	237	6	514
City	All	12	537	12	533	12	148	11	499	9	635
	High	4	422	3	526	3	927	4	1330	6	737
GWY-6	Low	8	127	8	169	9	72	7	119	11	97
	All	12	190	11	231	12	137	11	285	17	199
	High									6	2027
DR-B-10	Low									11	465
	All									17	782
										6	1444
GF-B-8										11	300
										17	522
Seasonal Data (May 1st to September 30th) (MPN/100 ml)											
Site	**Flow Type**	**2011**		**2012**		**2013**		**2014**		**2015**	
		N	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**	**N**	**MPN**
GWY-1	High	2	3006	1	4352	1	2420	2	2420	1	2420
	Low	3	1124	4	2394	4	570	3	855	3	1081
City	All	5	2029	5	2698	5	761	5	1296	4	1322
	High	2	755	1	816	1	172	2	2420	1	1553
GWY-2	Low	3	452	3	395	4	181	3	314	3	189
	All	5	555	4	474	5	180	5	711	4	321
GWY-5	High	2	951	1	3784	1	1120	2	2420	1	2420
	Low	3	592	4	365	4	177	3	175	3	667
City	All	5	716	5	404	5	256	5	501	4	921
	High	2	411	1	579	1	921	2	1773	3	1685
GWY-6	Low	3	198	3	267	4	96	2	298	7	232
	All	5	265	4	324	5	151	4	727	10	420
	High									3	1971
DR-B-10	Low									7	634
	All									10	891
	High									3	1727
GF-B-8	Low									7	238
	All									10	432

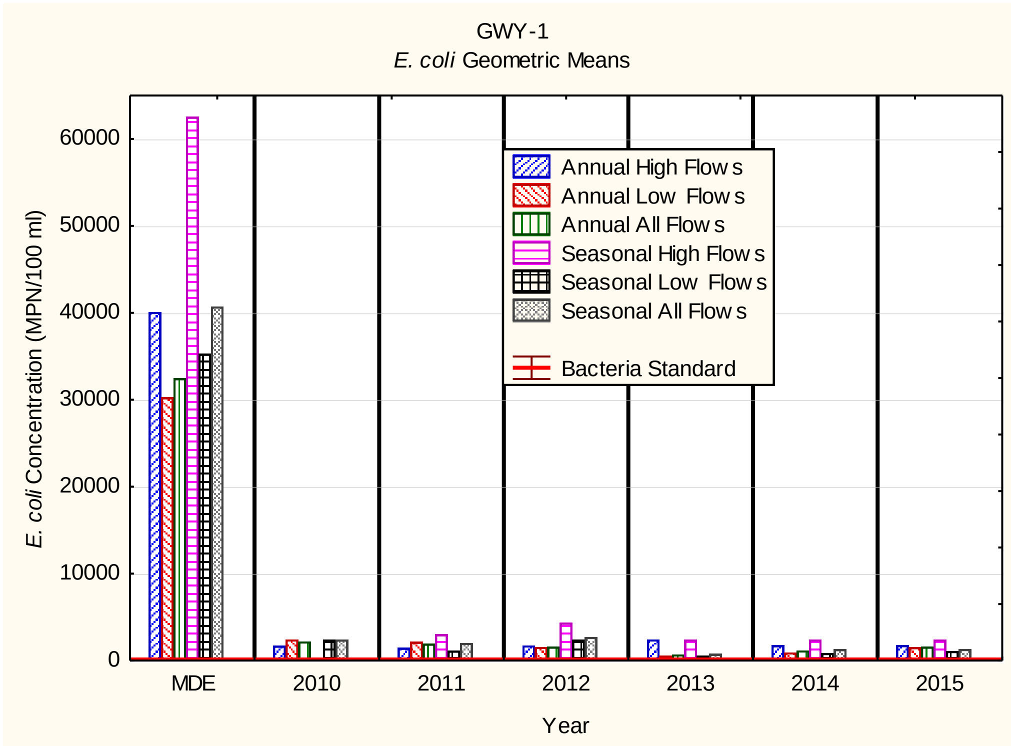


Figure 9-43: E. coli Geometric Mean Concentrations at Site GWY-1 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

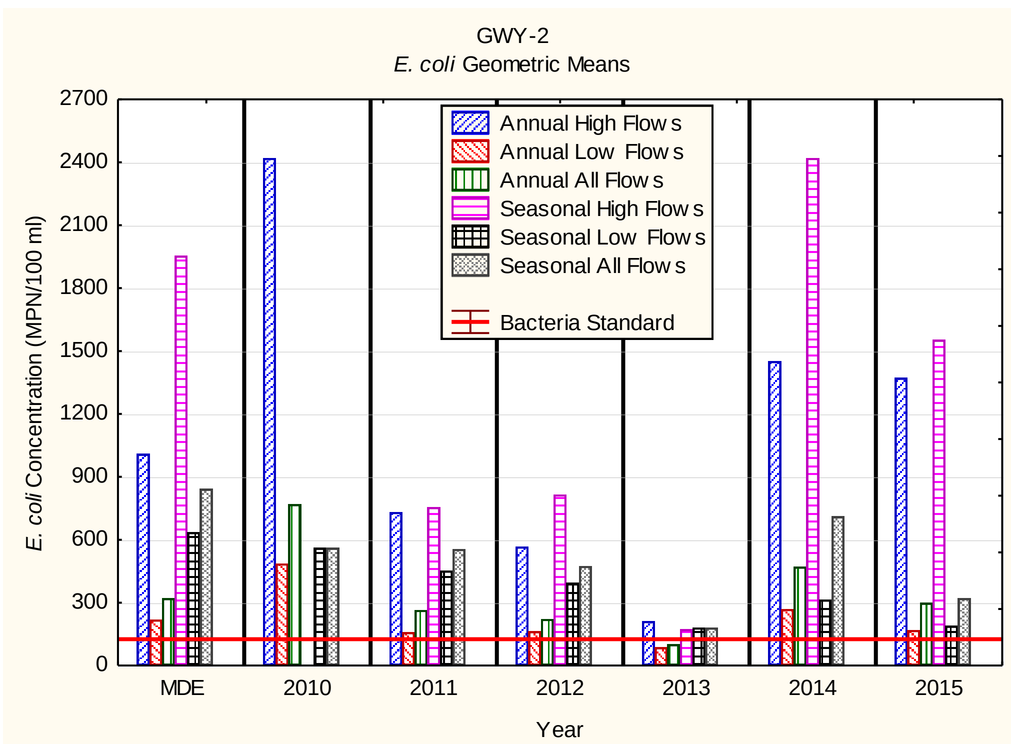


Figure 9-44: E. coli Geometric Mean Concentrations at Site GWY-2 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

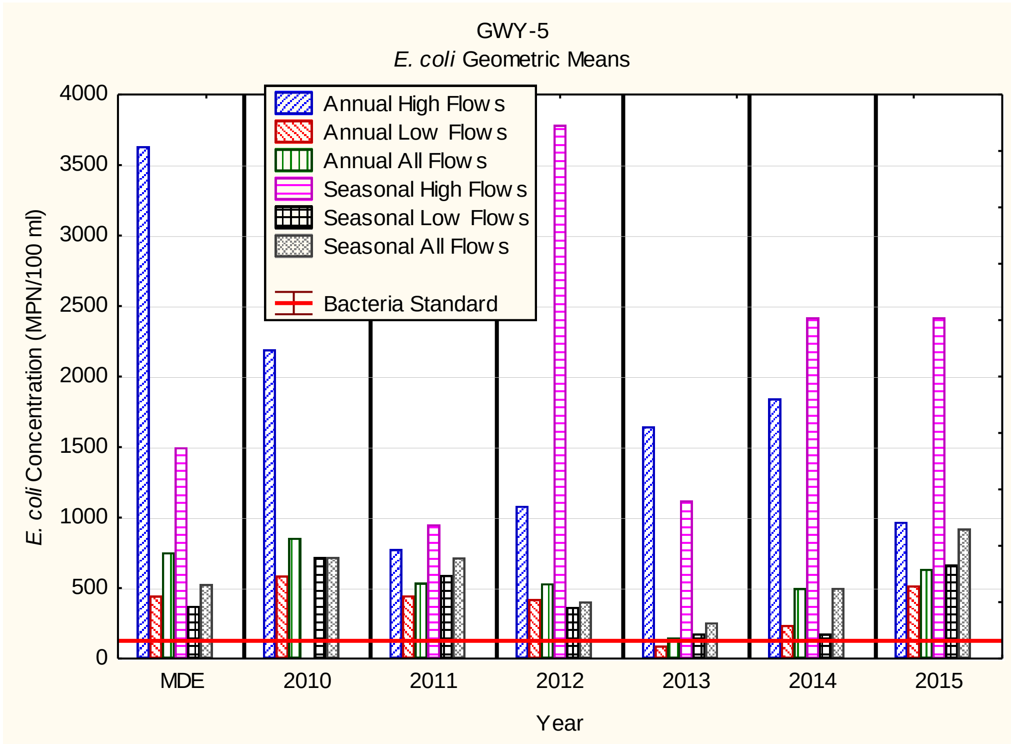


Figure 9-45: E. coli Geometric Mean Concentrations at Site GWY-5 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

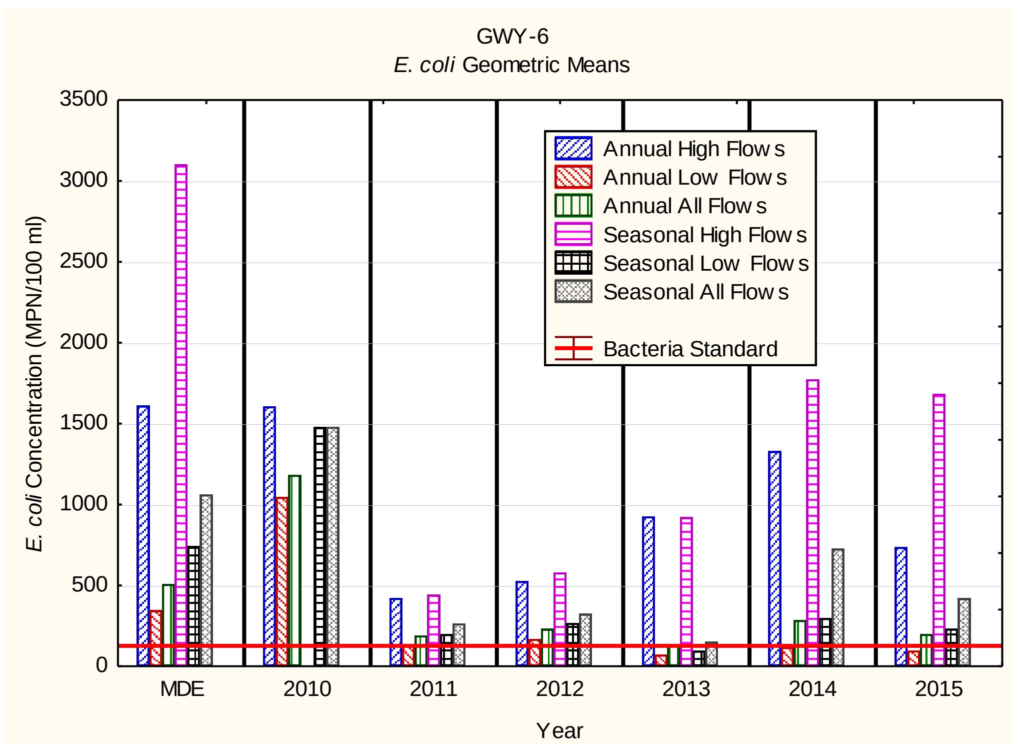


Figure 9-46: E. coli Geometric Mean Concentrations at Site GWY-6 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

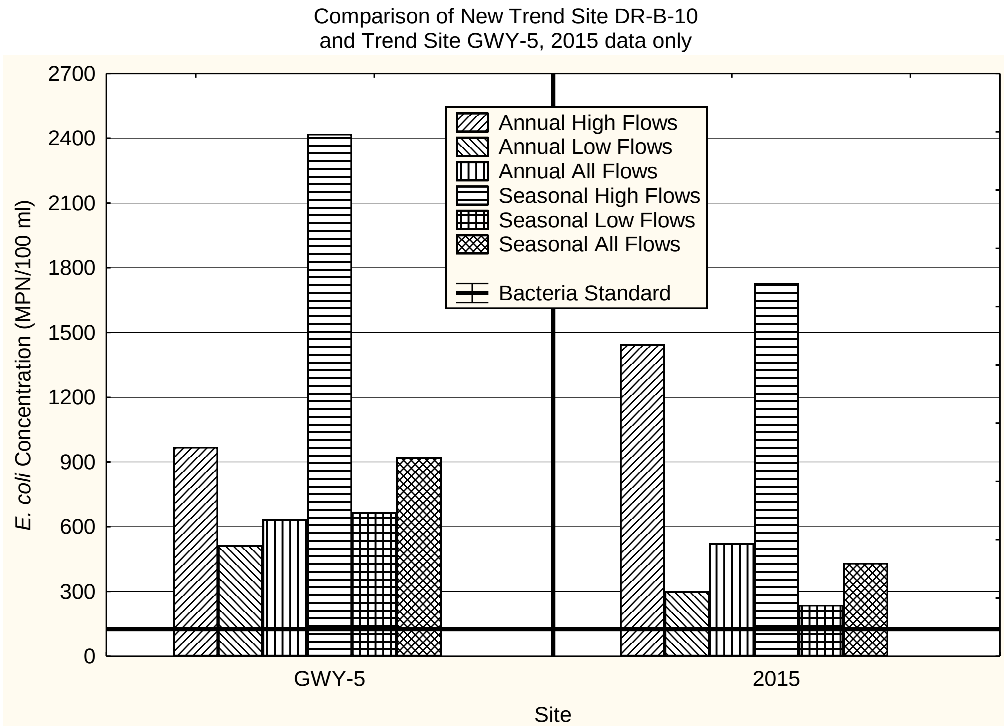


Figure 9-47: E. coli Geometric Mean Concentrations at Site DR-B-10 for both Annual and Seasonal Flow Periods Stratified by Flow Condition for first year of sampling, with GWY-5 for comparison

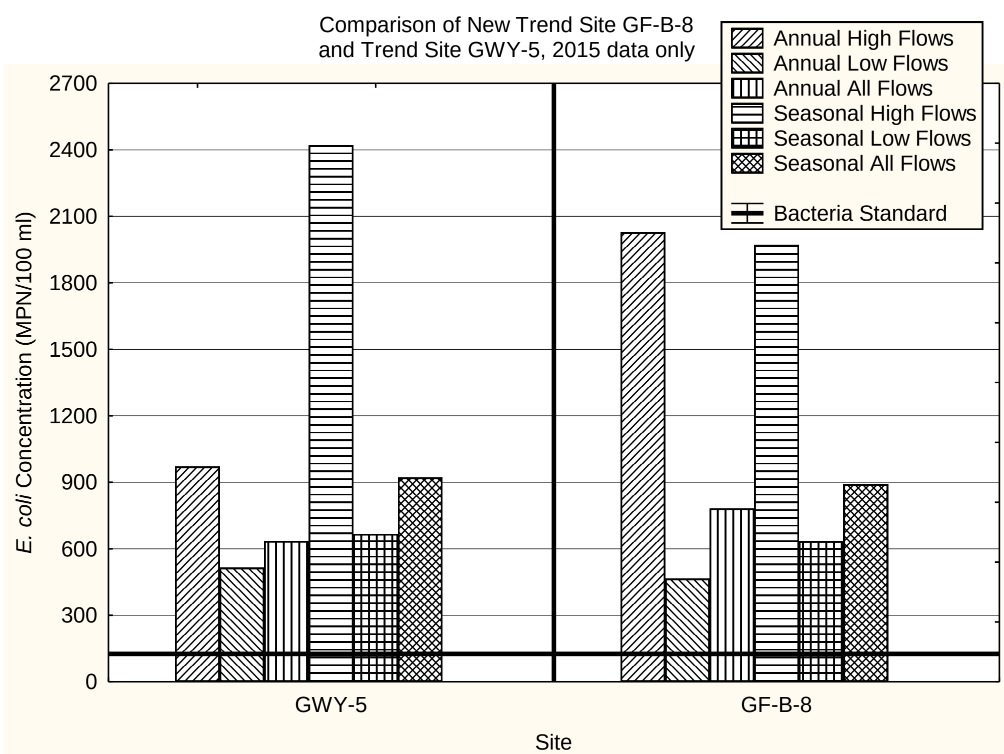


Figure 9-48: E. coli Geometric Mean Concentrations at Site GF-B-8 for both Annual and Seasonal Flow Periods Stratified by Flow Condition for first year of sampling, with GWY-5 for comparison

GWY-1 (GWN0015): This site is the located in Baltimore City on the mainstem of the Gwynns Falls and is the lowest monitoring point on the mainstem. It receives drainage from both Baltimore County and Baltimore City. While the data indicate a generally improving trend over the five years of monitoring on an annual and seasonal basis, monitoring in 2014 showed an increase for both seasonal and annual geometric mean under any flow regime. The geometric mean for all conditions is still significantly higher than the water quality standard of 126 MPN/100 ml for *E. coli*. The Maryland Department of the Environment (MDE) data for this site indicted a geometric mean of 35,290 MPN/100ml for dry weather seasonal samples based on monitoring conducted between 10/2002 and 10/2003. A weighted mean for dry weather seasonal sampling for the six years of monitoring conducted by Baltimore County resulted in a value of 1,453 MPN/100ml. This, along with the general downward trend in the dry weather seasonal geometric mean year over year, would indicate the conditions are improving at this station based on the difference between the two monitoring periods. The TMDL requires a 99.98% reduction of bacteria at this site.

GWY-2 (GWN0115): This monitoring site is located on the mainstem of Gwynns Falls in Baltimore County, above the confluence of both Dead Run and Powdermill Run. The entire drainage area is in Baltimore County. The Baltimore County monitoring indicates that this site has displayed general improvement for both low flow on an annual and a seasonal basis. It met water quality standards for the annual low flow data in 2013, but has exceeded those standards for every other year of monitoring. The MDE data for this site indicated a seasonal dry weather geometric mean of 373 MPN/100ml for this site. The five years of Baltimore County data resulted in a geometric mean of 353 MPN/100 ml for the dry weather seasonal data. This would indicate that there has been no change or slight improvement at this site. The TMDL indicated a reduction of 67.2% reduction necessary for meeting bacteria water quality standards in the drainage area to this site.

GWY-5 (GWN0026): This is located on the mainstem of Gwynns Falls in Baltimore City upstream of GWY-1 where Wilkens Ave. crosses the stream. The Baltimore County monitoring data indicates that this site met the bacteria water quality standards during dry weather flow on an annual basis in 2013, but, like GWY-2, has exceeded the water quality standard regardless of flow regime before and since. The MDE data indicated a seasonal dry weather concentration of 636 MPN/100ml for this site, while the Baltimore County data indicate a concentration of 349 MPN/100ml, indicating improvement. The TMDL indicated 96.5% reduction necessary for meeting bacteria water quality standards at this site.

GWY-6 (GWN0160): This site is located in Baltimore County on the mainstem of Gwynns Falls where McDonogh Road crosses the stream. It is upstream of the confluence of Scotts Level Branch. The Baltimore County monitoring data indicates improving trends for low flow on both an annual basis and a seasonal basis. The site has met the water quality standard for annual low flow every year since 2013. The data for high flows is more variable. The MDE data indicated a seasonal dry weather concentration of 743 MPN/100ml for this site, while the Baltimore County data for the six years of monitoring resulted in a geometric mean concentration of 280 MPN/100ml; indicating improvement at this site. The TMDL indicated a 93.2% reduction is necessary for meeting bacteria water quality standards at this site.

DR-B-10: This site is located in Baltimore County on Dead Run on the city/county line. This site and the next site, GF-B-8, were added to the trend program beginning in 2015 to obtain a clearer picture of the bacterial loads present in the two major branches of the Gwynns Falls which flow into Baltimore City from the County. Compared with GWY-5, this site has a lower geometric mean for every flow regime except annual high flows. The seasonal low flow geometric mean for 2015 was 238 MPN/100ml.

GF-B-8: This site is located in Baltimore County on the Gwynns Falls mainstem downstream of site GWY-2, and just before the city/county border. This site seems closer in behavior to GWY-5 than the Dead Run site described above, based on the 2015 monitoring data. This site had a seasonal low flow geometric mean of 891 MPN/100 ml.

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-34 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are high-lighted in green.

Table 9-34: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N Flow Type High	N Flow Type Low	576 High	576 Low	410 High	410 Low	298 High	298 Low	235 High	235 Low
GWY-1 City	2011	2	3	50%	100%	100%	100%	100%	100%	100%	100%
	2012	1	4	100%	100%	100%	100%	100%	100%	100%	100%
	2013	1	4	100%	50%	100%	75%	100%	75%	100%	75%
	2014	2	3	100%	100%	100%	100%	100%	100%	100%	100%
	2015	1	3	100%	100%	100%	100%	100%	100%	100%	100%
GWY-2	2011	2	3	100%	33%	100%	67%	100%	67%	100%	100%
	2012	1	3	100%	33%	100%	67%	100%	67%	100%	67%
	2013	1	4	0%	0%	0%	0%	0%	0%	0%	25%
	2014	2	3	100%	67%	100%	67%	100%	67%	100%	67%
	2015	1	3	100%	0%	100%	0%	100%	0%	100%	33%
GWY-5 City	2011	2	3	100%	67%	100%	67%	100%	67%	100%	100%
	2012	1	4	100%	0%	100%	0%	100%	50%	100%	50%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	25%
	2014	2	3	100%	0%	100%	0%	100%	33%	100%	33%
	2015	1	3	100%	67%	100%	67%	100%	67%	100%	67%
GWY-6	2011	2	3	0%	0%	50%	0%	100%	0%	100%	33%
	2012	1	3	100%	0%	100%	0%	100%	33%	100%	67%
	2013	1	4	100%	0%	100%	0%	100%	0%	100%	0%
	2014	2	2	100%	50%	100%	50%	100%	50%	100%	50%
	2015	3	7	100%	14%	100%	29%	100%	29%	100%	43%
DR-B-10	2015	3	7	100%	14%	100%	14%	100%	29%	100%	43%
GF-B-8	2015	3	7	100%	57%	100%	57%	100%	71%	100%	86%

Column groups: N = Flow Type; 576, 410, 298, 235 = Percent Single Sample Exceedance (MPN).

GWY-2 exceeded every standard during high flows in 2015, but this is based on a single high flow sample collected. The low flow samples at GWY-2 have generally improved over those observed in 2014. GWY-6 exceeded all standards during high flows and showed some improvement over 2014.

Jones Falls

Table 9-35 shows the latitude/longitude locations of the current bacteria monitoring stations within the Jones Falls watershed. There are five bacteria trend monitoring sites in the Jones Falls. Two of the monitoring sites are in the city and three are in the county.

Table 9-35: Baltimore County Bacteria Monitoring Station Locations

MDE Station Code	County Code	Watershed/ Subshed	Latitude	Longitude	Location
JON0039	JON-1	Jones Falls	39.327	-76.640	City
JON0082	JON-2	Jones Falls	39.378	-76.644	County
JON0184	JON-3	Jones Falls	39.391	-76.661	County
UQQ005	JON-4	Roland Run	39.399	-76.649	County
SRU0005	JON-5	Stoney Run	39.326	-76.626	City
	JF-B-12	Western Run – East	39.373	-76.668	City
	JF-B-13	Western Run – West	39.372	-76.708	County

Table 9-36 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year). Geometric means below the water quality standard (126 MPN) are highlighted in green. These results are displayed graphically in Figure 9-49 through Figure 9-55.

Table 9-36: Jones Falls E. coli Results on an Annual and Seasonal Basis

Annual (MPN/100 ml)													
Site	Flow Type	2010		2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
JON-1 City	High	2	2,420	4	632	3	98	2	2,420	3	1684	3	930
	Low	5	942	8	605	8	547	8	328	8	317	8	273
	All	7	1,233	12	614	11	342	10	489	11	500	11	341
JON-2	High	2	703	4	173	3	32	2	24	4	442	3	840
	Low	5	187	8	46	9	283	10	28	7	55	8	30
	All	7	273	12	71	12	55	12	27	11	117	11	80
JON-3	High	2	1,119	4	460	3	240	2	748	4	751	3	300
	Low	5	761	8	65	9	94	10	82	8	104	8	95
	All	7	849	12	124	12	119	12	118	12	201	11	145
JON-4	High	2	1,119	4	716	3	449	2	2,420	4	688	3	508
	Low	5	696	8	111	9	64	10	60	8	186	8	125
	All	7	797	12	207	12	105	12	110	12	288	11	191
JON-5 City	High	2	2,420	4	973	3	200	2	2,420	4	1151	3	721
	Low	5	373	8	360	9	182	9	200	8	230	8	167
	All	7	636	12	502	12	186	11	315	12	394	11	249
JF-B-12	High											4	528
	Low											13	284
	All											17	329
JF-B-13	High											4	697
	Low											12	237
	All											16	310
Seasonal (May 1st to September 30th) (MPN/100 ml)													
Site	Flow Type	2010		2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
JON-1 City	High	0		2	751	1	**	1	2,420	2	2420	1	1046
	Low	4	1,210	3	538	4	824	4	283	3	706	3	161
	All	4	1,210	5	615	5	215	5	434	5	1155	4	257
JON-2	High	0		2	228	1	75	1	63	2	1087	1	1553
	Low	4	147	3	186	4	35	4	17	2	113	3	30
	All	4	147	5	202	5	40	5	49	4	351	4	81
JON-3	High	0		2	551	1	387	1	770	2	1053	1	866
	Low	4	994	3	377	4	254	4	266	3	549	3	188
	All	4	994	5	439	5	277	5	329	5	712	4	276
JON-4	High	0		2	2,178	1	210	1	2,420	2	1365	1	2420
	Low	4	889	3	869	4	251	4	152	3	305	3	295
	All	4	889	5	1,255	5	242	5	684	5	555	4	500
JON-5 City	High	0		2	773	1	166	1	2,420	2	1773	1	1414
	Low	4	311	3	275	4	93	4	479	3	372	3	376
	All	4	311	5	416	5	105	5	662	5	695	4	524
JF-B-12	High											2	1000
	Low											8	337
	All											10	419
JF-B-13	High											2	687
	Low											8	295
	All											10	350

** Data suspect, results indicated 1 MPN/100 ml

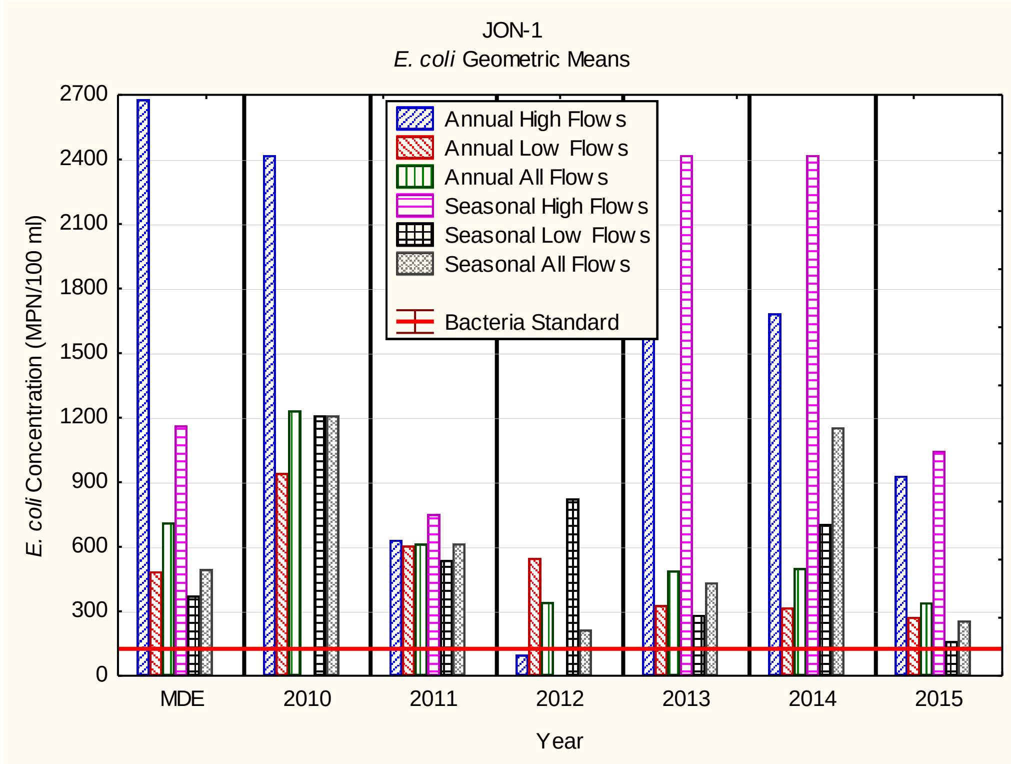


Figure 9-49: E. coli Geometric Mean Concentrations at Site JON-1 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

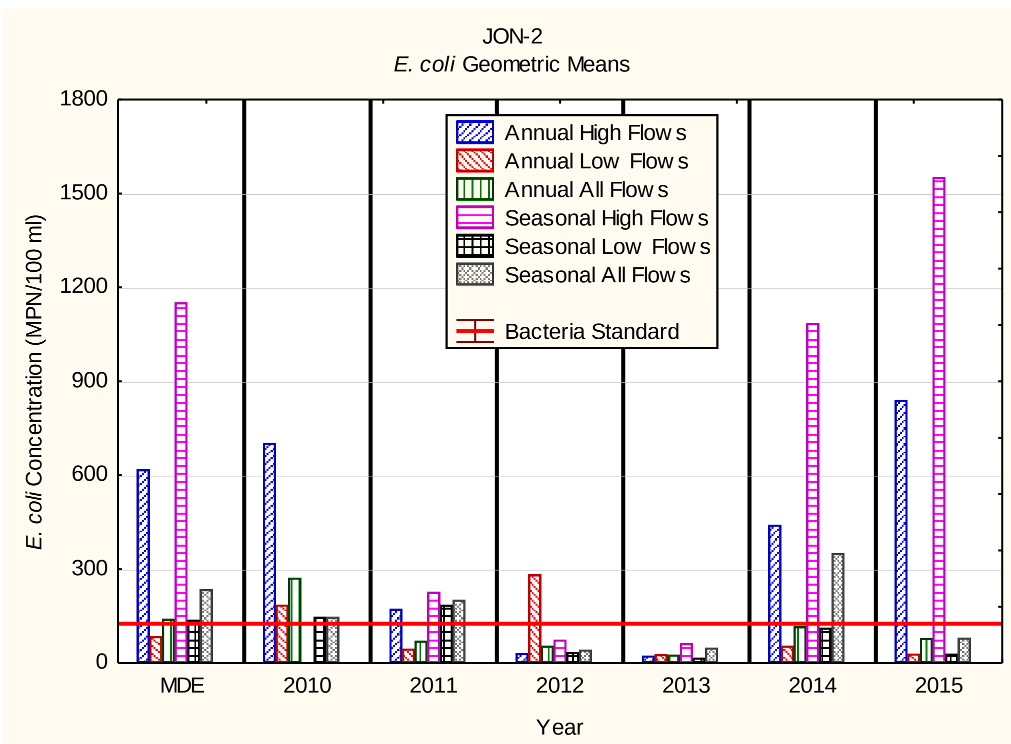


Figure 9-50: E. coli Geometric Mean Concentrations at Site JON-2 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

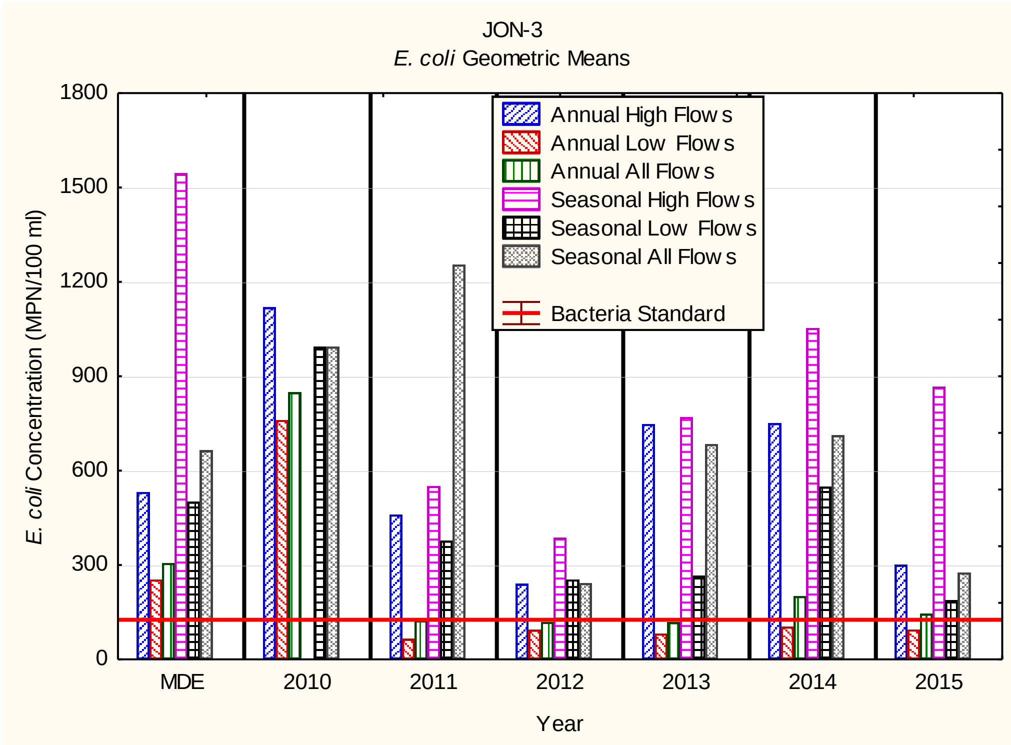


Figure 9-51: E. coli Geometric Mean Concentrations at Site JON-3 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

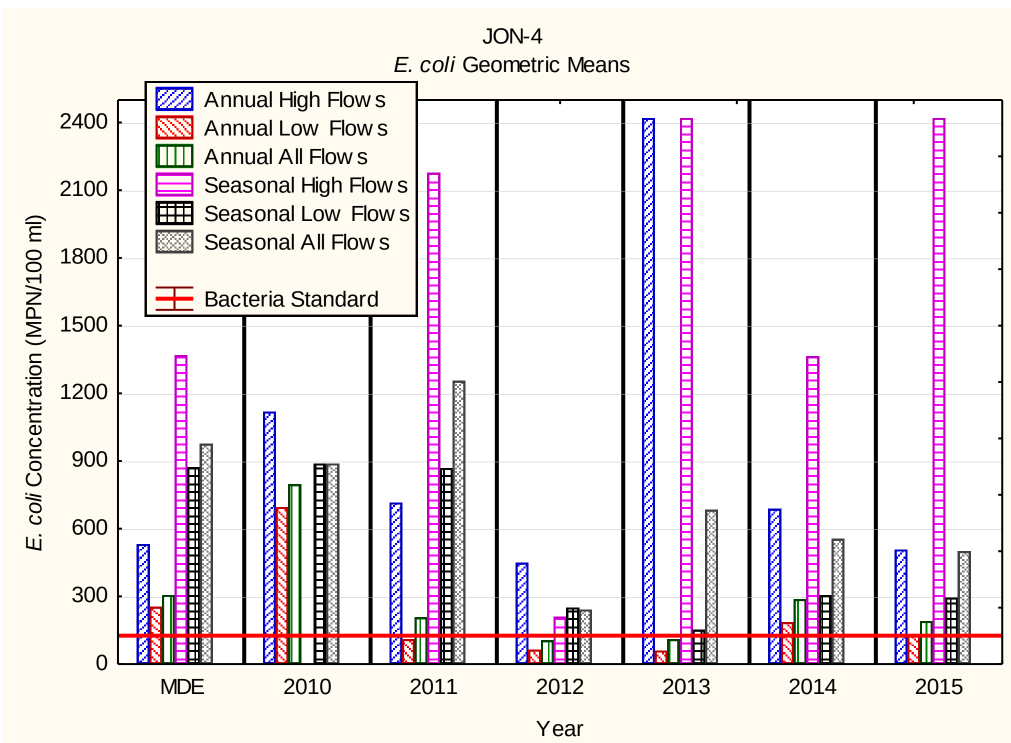


Figure 9-52: E. coli Geometric Mean Concentrations at Site JON-4 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

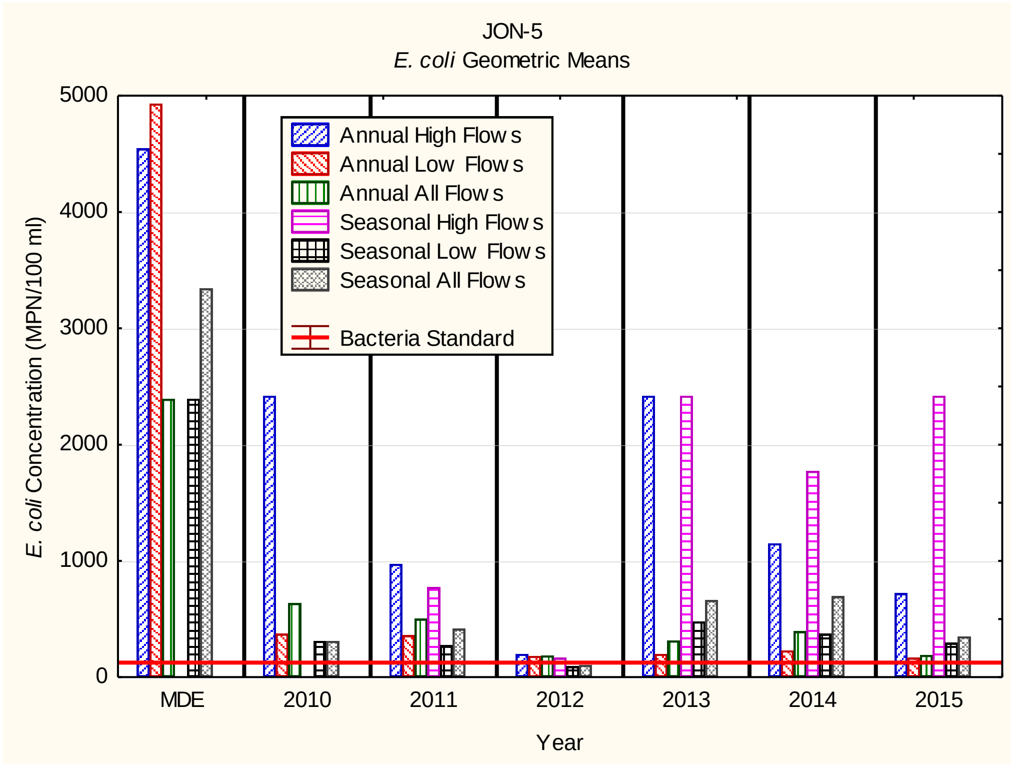


Figure 9-53: E. coli Geometric Mean Concentrations at Site JON-5 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

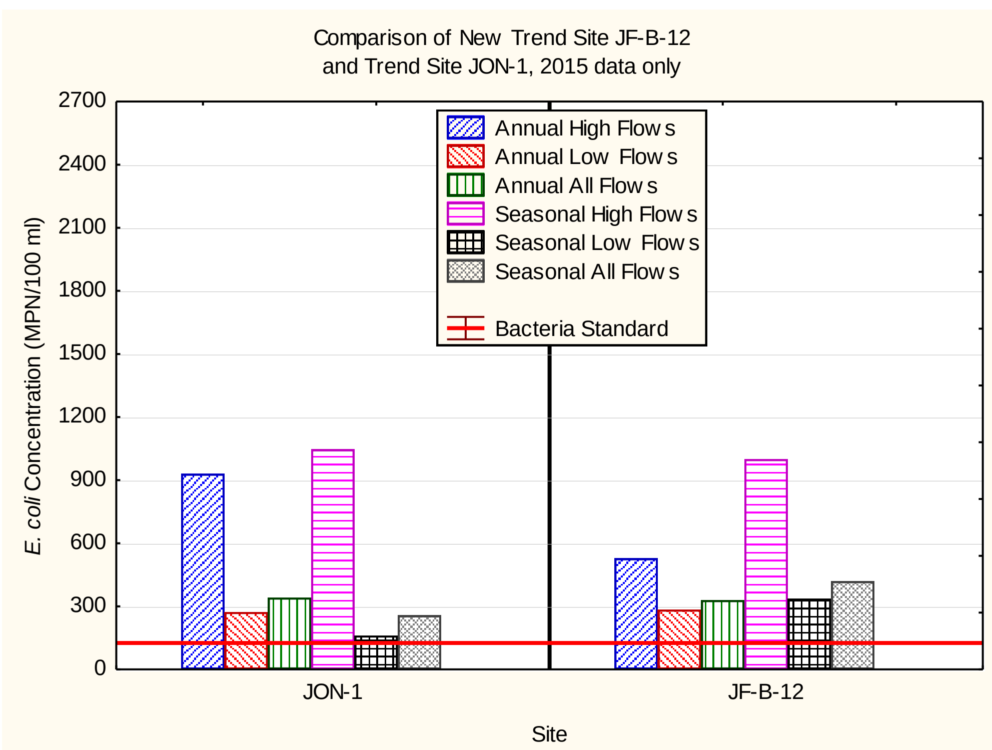


Figure 9-54: E. coli Geometric Mean Concentrations at Site JF-B-12 for both Annual and Seasonal Flow Periods Stratified by Flow Condition for first year of sampling, with JON-1 for comparison

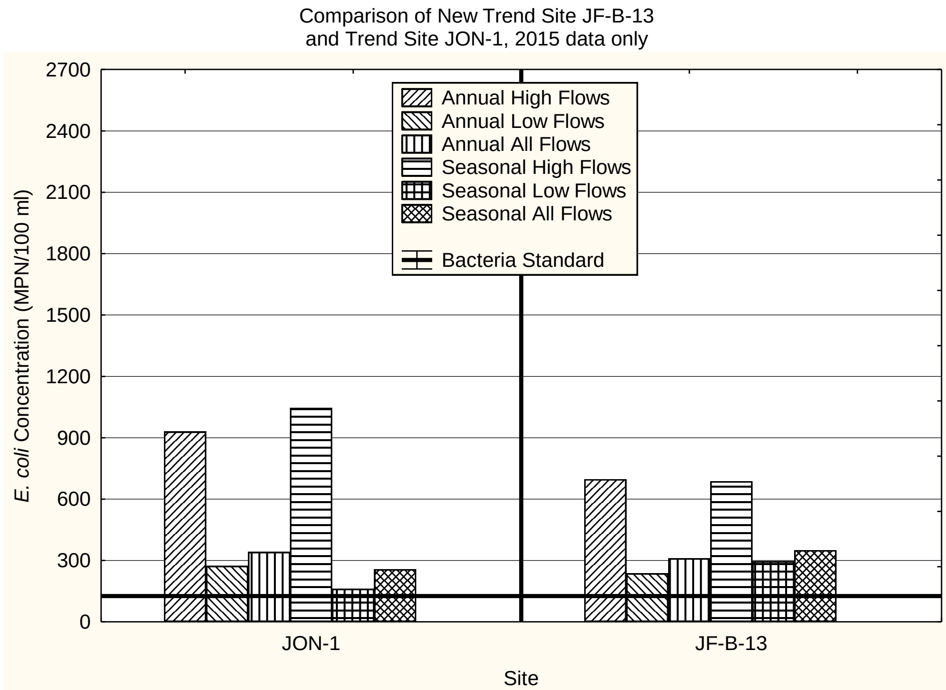


Figure 9-55: E. coli Geometric Mean Concentrations at Site JF-B-13 for both Annual and Seasonal Flow Periods Stratified by Flow Condition for first year of sampling, with JON-1 for comparison

JON-1 (JON0039): This site is the located in Baltimore City on the mainstem of the Jones Falls and is the lowest monitoring point on the mainstem. It receives drainage from both Baltimore County and Baltimore City. The monitoring site is located above the confluence with Stoney Run. While the data indicate an improving trend over six years of monitoring for annual low flow conditions, the geometric mean for all conditions is still higher than the water quality standard of 126 MPN/100 ml for *E. coli*. The Maryland Department of the Environment (MDE) data for this site had a geometric mean of 372 MPN/100ml for dry weather seasonal samples based on monitoring conducted between 10/2002 and 6/2003. A weighted mean for dry weather seasonal sampling for the six years of monitoring conducted by Baltimore County resulted in a value of 527 MPN/100ml. This would indicate the conditions are worsening at this station based on the difference between the two monitoring periods. The TMDL requires a 95.3% reduction of bacteria at this site.

JON-2 (JON0082): This monitoring site is located on the mainstem of Jones Falls in Baltimore County, below the Lake Roland dam. The entire drainage area is in Baltimore County. The Baltimore County monitoring indicated that this site has displayed continuing improvement for both low flow and high flow on an annual and a seasonal basis. However, beginning in 2014, the high flow regimes have shown a marked increase over previous years' averages, while the other flow regimes remained relatively stable. The MDE data for this site indicated a seasonal dry weather geometric mean of 139 MPN/100ml for this site. The six years of Baltimore County data resulted in a geometric mean of 74 MPN/100 ml for the dry weather seasonal data. This would indicate that there has been improvement at this site. The TMDL indicated a reduction of 95.3% reduction necessary for meeting bacteria water quality standards in the drainage area to this site. Based on the Baltimore County monitoring data, this site may have had enough bacteria reduction to meet the bacteria water quality standards. Monitoring will continue at this site to confirm that bacteria water quality standards are being met.

JON-3 (JON0184): This is located on the mainstem of Jones Falls in Baltimore County upstream of Lake Roland at the Sorrento Run USGS gage. The entire drainage area is in Baltimore County. The Baltimore County monitoring data indicates that the bacteria concentrations are improving, particularly for low flow conditions. Low flows taken annually have met bacteria standards every year since 2011. The other flow regimes have been more variable, but have generally returned to levels seen in 2012, after high years in 2013 and 2014. The MDE data indicated a seasonal dry weather concentration of 501 MPN/100ml for this site, while the Baltimore County data, geometric mean for six years shows a concentration of 376 MPN/100ml indicating improvement. The TMDL requires 92.4% reduction for meeting bacteria water quality standards at this site.

JON-4 (UQQ005): This site is located in Baltimore County on Roland Run upstream from Lake Roland. The entire drainage is in Baltimore County and represents an urban subwatershed. The Baltimore County monitoring data indicates improving trends for low flow on both an annual basis and a seasonal basis. The annual low flow geometric means met the bacteria water quality standards between 2011 and 2013, but has since exceeded the standard every year. However, the seasonal low flow, while improving, has yet to meet the bacteria water quality standards. The MDE data indicated a seasonal dry weather concentration of 872 MPN/100ml for this site, while the Baltimore County data for six years of monitoring resulted in a geometric mean concentration of 365 MPN/100ml; indicating improvement at this site. The TMDL indicated a 92.1% reduction is necessary for meeting bacteria water quality standards at this site.

JON-5 (SRU0005): This site is located on Stoney Run in Baltimore City. A very small portion of the drainage area is in Baltimore County just above the city line. Since 2013, many flow regimes have shown decreasing or relatively steady geometric means, but still higher than those observed in 2012. Continued monitoring will determine if there is a consistent improvement of bacteria concentrations at this site. The MDE data indicated a seasonal dry weather concentration of 2,394 MPN/100ml at this site based on monitoring in 2002-2003, while the Baltimore County data for the six years of monitoring results in a geometric mean of 278 MPN/100 ml for the seasonal dry weather samples. This would indicate a significant improvement between the two monitoring periods. The TMDL indicated a 97.8% reduction in bacteria loads as necessary to meet bacteria water quality standards.

JF-B-12: This site is located in Baltimore City on an eastern tributary of Western Run. Most of the drainage area is in Baltimore County and is within an urban watershed. This site and the next site, JF-B-13, were added to the trend program beginning in 2015 to obtain a clearer picture of the bacterial loads present in two branches of Western Run, which then flows into the Jones Falls mainstem. These sites have been graphically compared to the nearest downstream site for which there is historical data, JON-1. The seasonal low flow geometric mean for this site was 337 MPN/100ml.

JF-B-13: This site is located in Baltimore County on the westernmost end of Western Run. Most of its drainage area is located within Baltimore County and is within an urban watershed. While this site is considered urban, it has a larger variety of land uses present, including a cemetary and golf course (both classified as open urban land use). The seasonal low flow geometric mean for this site was 295 MPN/100ml.

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-37 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are highlighted in green.

Table 9-37: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
JON-1	2011	2	3	100%	67%	100%	67%	100%	67%	100%	67%
	2012	1	4	0%	75%	0%	100%	0%	100%	0%	100%
	2013	1	4	100%	25%	100%	25%	100%	50%	100%	75%
	2014	2	3	100%	100%	100%	100%	100%	100%	100%	100%
	2015	1	3	100%	0%	100%	0%	100%	0%	100%	0%
JON-2	2011	2	3	50%	0%	50%	33%	0%	33%	0%	67%
	2012	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2013	1	4	0%	0%	0%	0%	0%	0%	0%	0%
	2014	2	2	50%	0%	100%	0%	100%	0%	100%	0%
	2015	1	3	100%	0%	100%	0%	100%	0%	100%	0%
JON-3	2011	2	3	50%	0%	50%	33%	50%	100%	100%	100%
	2012	1	4	0%	50%	0%	75%	100%	75%	100%	75%
	2013	1	4	100%	50%	100%	50%	100%	50%	100%	50%
	2014	2	3	100%	67%	100%	67%	100%	67%	100%	100%
	2015	1	3	100%	0%	100%	0%	100%	67%	100%	67%
JON-4	2011	2	3	100%	100%	100%	100%	100%	100%	100%	100%
	2012	1	4	0%	25%	0%	75%	0%	75%	0%	75%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	25%
	2014	2	3	100%	0%	100%	33%	100%	67%	100%	67%
	2015	1	3	100%	0%	100%	33%	100%	33%	100%	67%
JON-5	2011	2	3	50%	33%	50%	33%	50%	33%	100%	33%
	2012	1	4	0%	0%	0%	0%	0%	25%	0%	25%
	2013	1	4	100%	25%	100%	25%	100%	25%	100%	75%
	2014	2	3	100%	0%	100%	33%	100%	67%	100%	100%
	2015	1	3	100%	67%	100%	67%	100%	100%	100%	100%
JF-B-12	2015	2	8	100%	25%	100%	25%	100%	63%	100%	63%
JF-B-13	2015	2	8	100%	13%	100%	13%	100%	38%	100%	63%

Site JON-2 exceeded every standard during high flows, but has not exceeded any standard during low flow conditions since 2011. The other four sites are more variable in results with no specific trends noted. The new trend sites had at least one exceedance during 2015. Further monitoring is needed at these sites in order to detect trends.

Herring Run

Table 9-38 shows the latitude/longitude locations of the current bacteria monitoring stations within Back River watershed. Four additional bacteria trend sites were added in 2015. Two sites are in the headwaters of Herring Run and are intended to look at the concentration of bacteria at the city/county line for the two headwater branches. The other two sites are located in Redhouse Run, which was included in the Herring Run Bacteria TMDL, but for which there was no bacteria monitoring data.

Table 9-38: Baltimore County Bacteria Monitoring Station Locations

Station Code	County Code	Stream	Watershed	Latitude	Longitude	County
HER0065	HER-1	Herring Run	Back River	39.3455	-76.581167	Balt. City
Pulaski	Pulaski	Herring Run	Back River	39.305453	-76.538939	Balt. City
Biddle/62	Biddle	Moore's Run	Back River	39.314985	-76.534365	Balt. City
	HR-B-12	Herring Run – East	Back River	39.368927	-76.573717	Balt. City
	HR-B-13	Herring Run – West	Back River	39.370618	-76.58334	Balt. City
	HR-B-14	UNT to Redhouse Run	Back River	39.31609	-76.518137	Balt. County
	HR-B-15	Redhouse Run	Back River	39.317338	-76.515859	Balt. County

Table 9-39 presents the number of samples and the geometric mean for high (wet) flow and low (dry) flow by year. It also presents the geometric mean of all samples by year regardless of condition. The table is stratified by annual data (includes all data collected for the year) and seasonal data (includes only those samples collected between May 1st and September 30th each year. Geometric means that meet the water quality standard (126 MPN) are highlighted in green. Sampling at the Biddle Street and Pulaski Highway sites did not commence until 2011. These data are displayed graphically in Figure 9-56 through Figure 9-62.

Table 9-39: Herring Run Annual Geometric Mean by Weather

Annual Data (number of samples and geometric mean MPN)													
Site	Flow Type	2010		2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
HER-1	High	2	2420	4	1267	2	448	2	1253	3	2023	2	2420
	Low	5	616	6	842	7	136	9	85	8	304	8	122
	All	7	910	10	991	9	177	11	139	11	510	10	165
Biddle	High			2	863	3	388	2	618	2	1591	2	1184
	Low			4	667	8	196	8	103	7	251	8	419
	All			6	727	11	236	10	147	9	378	10	506
Pulaski Hwy	High			2	1218	3	763	2	1849	3	1621	2	1289
	Low			4	512	8	123	4	402	8	461	8	350
	All			6	684	11	202	10	146	11	650	10	444
HR-B-12	High											5	5823
	Low											12	682
	All											17	1333
HR-B-13	High											5	3026
	Low											12	717
	All											17	1124
HR-B-14	High											5	1012
	Low											12	120
	All											17	226
HR-B-15	High											5	8227
	Low											12	2246
	All											17	3370

Seasonal Data (May 1st to September 30th)													
Site	Flow Type	2010		2011		2012		2013		2014		2015	
		N	MPN	N	MPN	N	MPN	N	MPN	N	MPN	N	MPN
HER-1	High	0		2	1455	0		1	649	1	2420	1	2420
	Low	4	921	3	989	4	74	3	106	3	426	3	41
	All	4	790	5	1154	4	74	4	166	4	658	4	113
Biddle	High	0		1	2420	1	167	1	158	1	2420	1	2420
	Low	0		3	1383	4	356	3	192	2	461	3	356
	All	0		4	1591	5	306	4	183	3	801	4	575
Pulaski Hwy	High	0		1	2420	1	333	1	2420	1	2420	1	2420
	Low	0		3	695	4	189	3	649	3	580	3	231
	All	0		4	950	5	211	4	170	4	829	4	415
HR-B-12	High											3	14430
	Low											7	870
	All											10	2020
HR-B-13	High											3	3512
	Low											7	1353
	All											10	1801
HR-B-14	High											3	2057
	Low											7	372
	All											10	658
HR-B-15	High											3	18601
	Low											7	2599
	All											10	4690

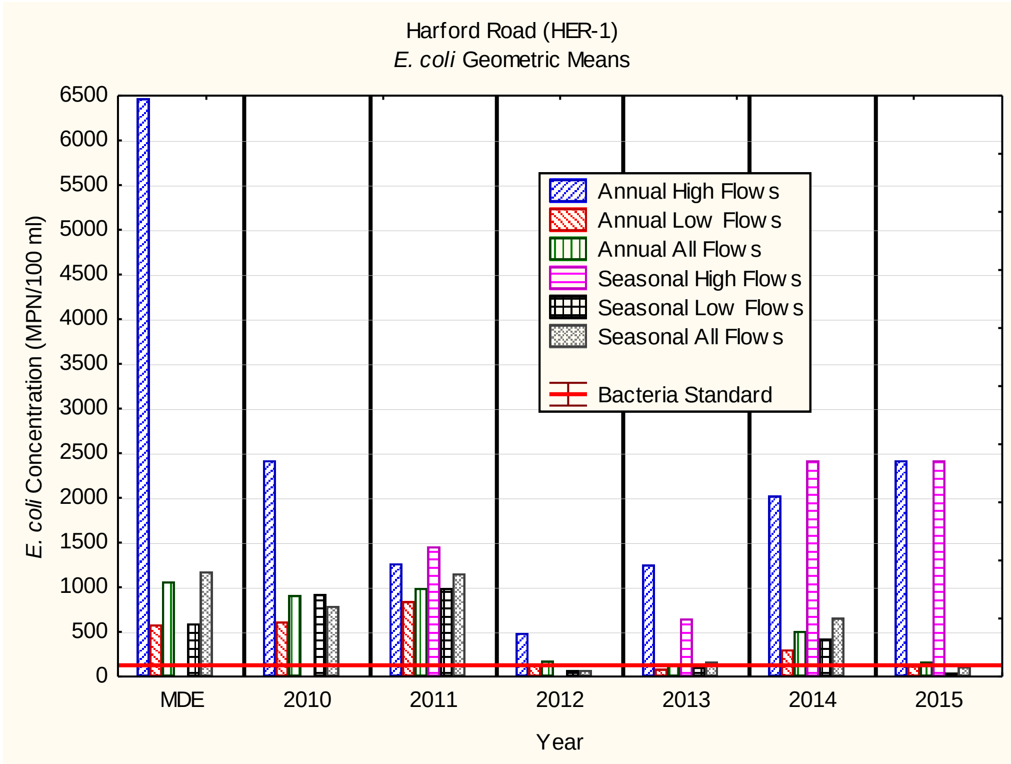


Figure 9-56: E. coli Geometric Mean Concentrations at the Harford Road Site (HER-1) for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison

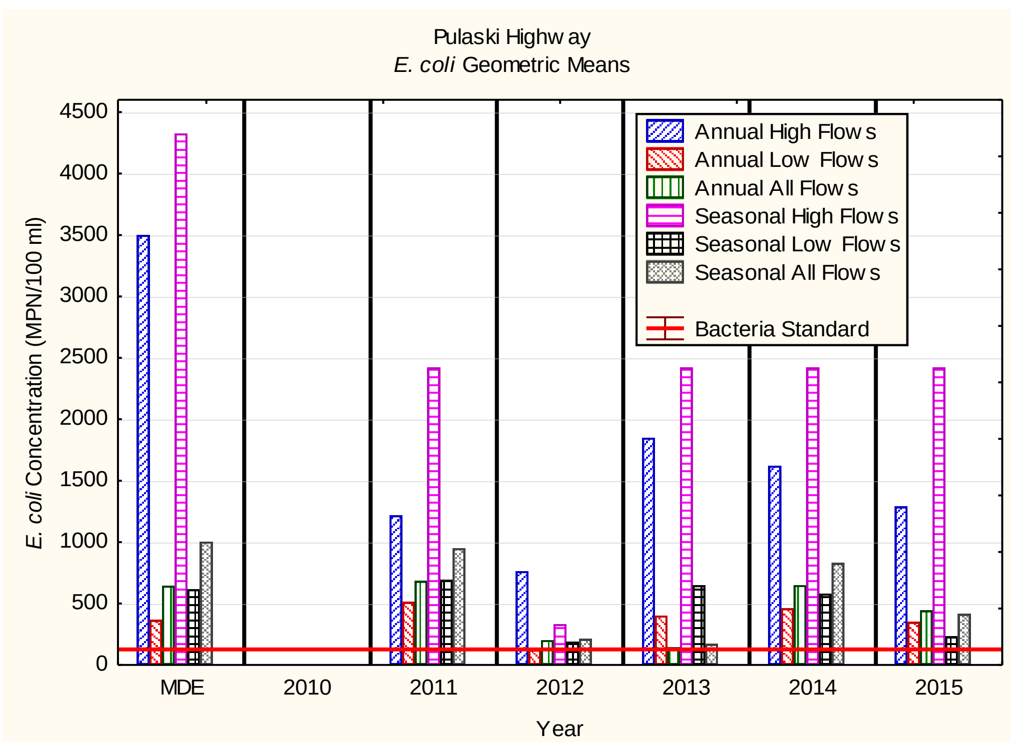


Figure 9-57: E. coli Geometric Mean Concentrations at the Pulaski Highway Site for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No Samples Collected in 2010

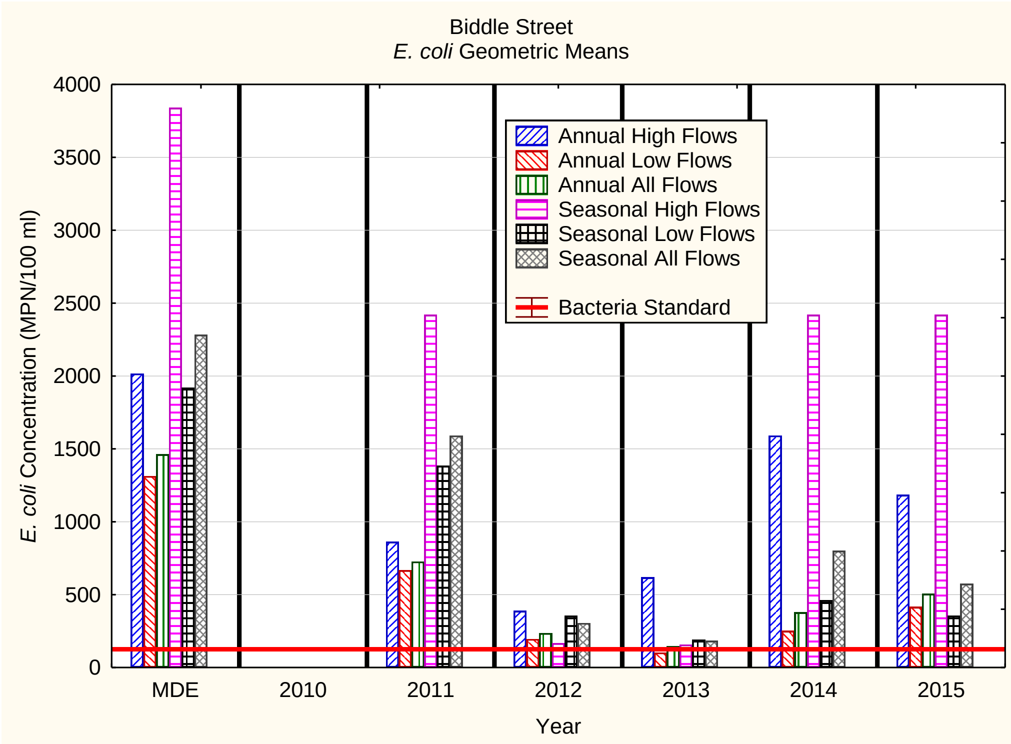


Figure 9-58: E. coli Geometric Mean Concentrations at the Biddle Street Site for both Annual and Seasonal Flow Periods Stratified by Flow Condition, MDE Results Added for Comparison. No Samples Collected in 2010

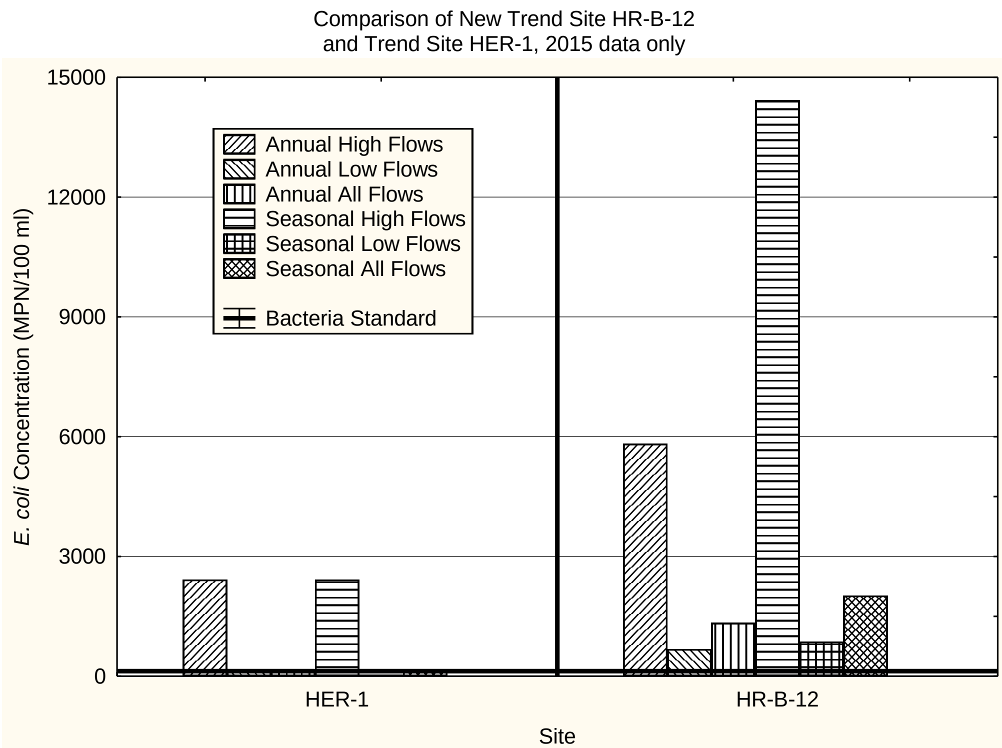


Figure 9-59: *E. coli* Geometric Mean Concentrations at Site HR-B-12 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, HER-1 Results Added for Comparison.

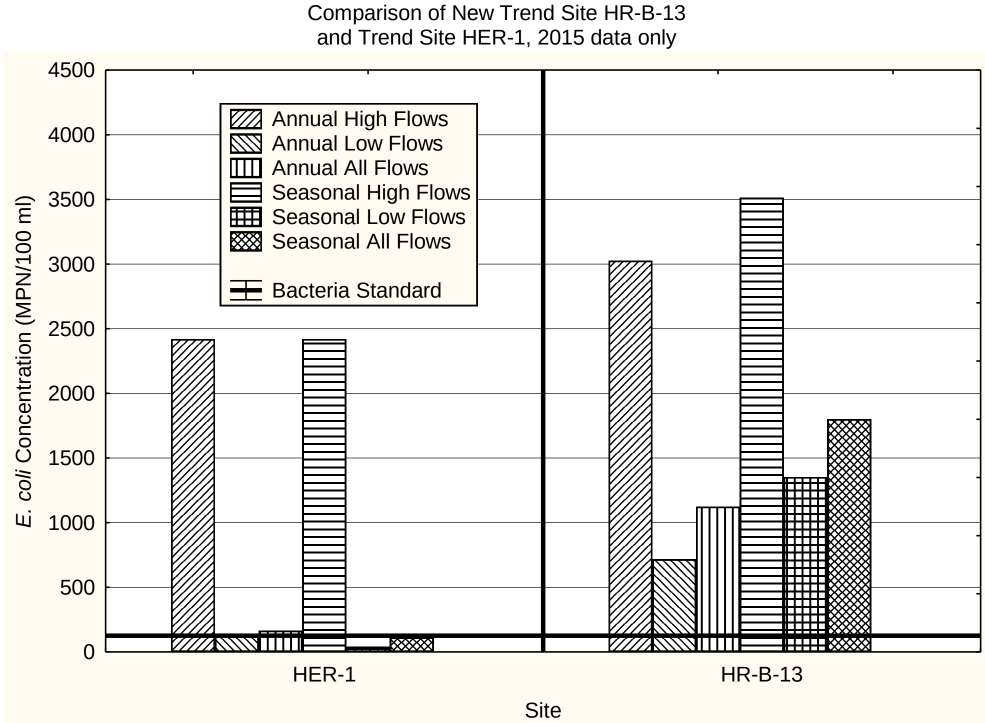


Figure 9-60: E. coli Geometric Mean Concentrations at Site HR-B-13 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, HER-1 Results Added for Comparison.

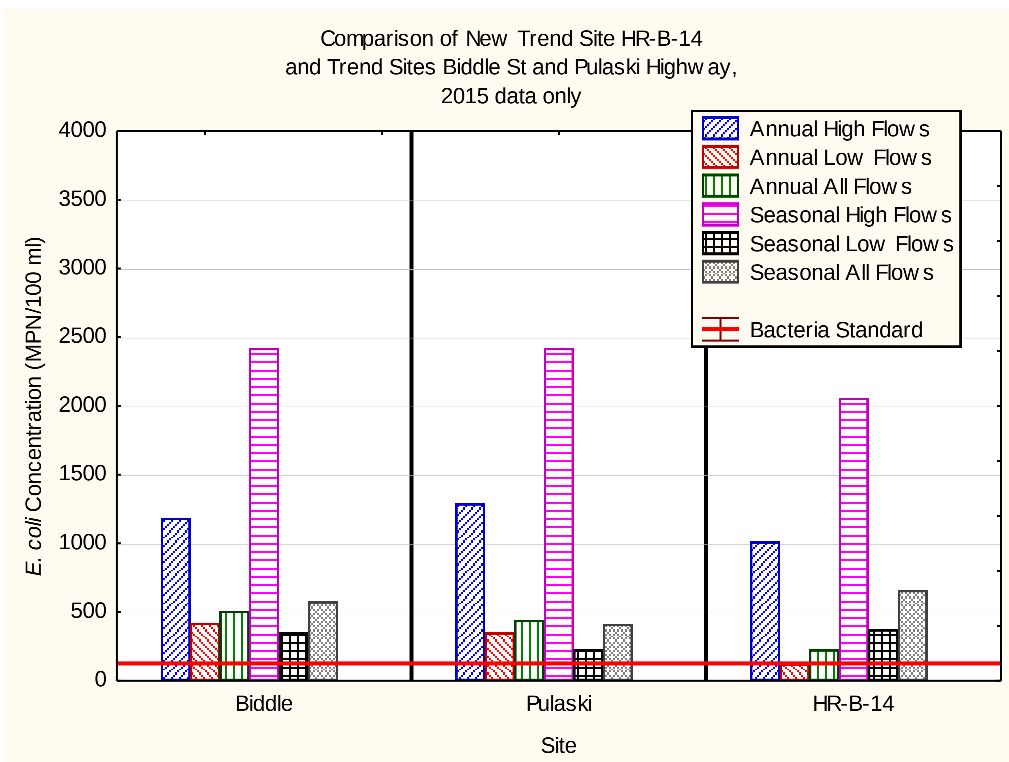


Figure 9-61: E. coli Geometric Mean Concentrations at Site HR-B-14 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, Biddle and Pulaski Results Added for Comparison.

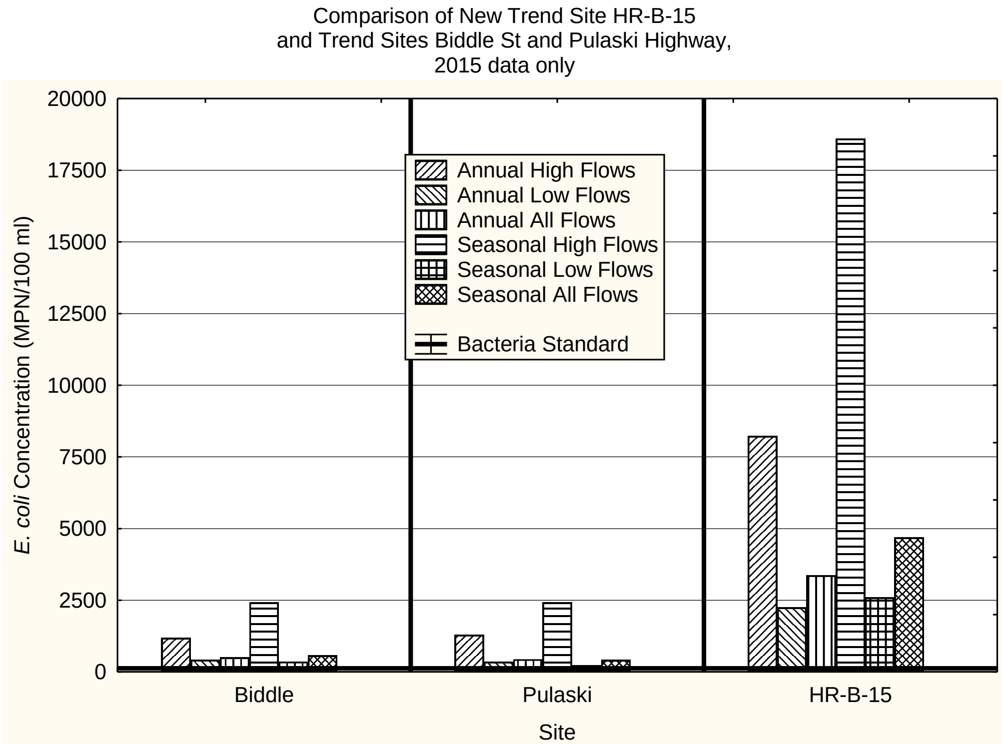


Figure 9-62: *E. coli* Geometric Mean Concentrations at Site HR-B-15 for both Annual and Seasonal Flow Periods Stratified by Flow Condition, Biddle and Pulaski Results Added for Comparison.

With the addition of the 2015 data, the trends appear to be more variable. HER-1 met the bacteria standard for seasonal and annual flows as a whole, as well as during seasonal low flows, high flows remain well above the standard for all sites. Among the new trend sites added in 2015, HR-B-14 met bacterial standards during annual low flows. The high flow geometric means imply that additional monitoring and bacterial source tracking may be needed in order to identify sources to be addressed by other programs.

In addition to analyzing the data for the geometric means, the data were analyzed based on the single sample exceedance for seasonal data (May 1st to September 30th). Single sample exceedance standards are based on frequency of full body contact, ranging from infrequent (576 MPN) to frequent (235). The objective in the control of bacteria is to not only meet the geometric mean water quality standards, but to also meet the single sample water quality standards. This is particularly important for the low flow (dry weather) component of the flow regime, as this is when human recreational use of water is most likely to occur. Table 9-40 presents the results of the analysis by station, by year and by flow regime. The zero percent exceedances are high-lighted in green.

Table 9-40: Frequency of Exceedance of Single Sample Water Quality Standards

Site	Year	N		Percent Single Sample Exceedance (MPN)							
		Flow Type		576		410		298		235	
		High	Low	High	Low	High	Low	High	Low	High	Low
HER-1	2011	2	3	100%	67%	100%	67%	100%	100%	100%	100%
	2012	0	4		0%		0%		0%		0%
	2013	1	3	100%	0%	100%	0%	100%	0%	100%	33%
	2014	1	3	100%	33%	100%	67%	100%	67%	100%	67%
	2015	1	3	100%	33%	100%	33%	100%	33%	100%	33%
Biddle	2011	1	3	100%	100%	100%	100%	100%	100%	100%	100%
	2012	1	4	0%	50%	0%	50%	0%	75%	75%	0%
	2013	1	3	0%	33%	0%	33%	0%	33%	0%	67%
	2014	1	2	100%	50%	100%	50%	100%	50%	100%	100%
	2015	1	3	100%	33%	100%	67%	100%	67%	100%	67%
Pulaski	2011	1	2	100%	75%	100%	75%	100%	100%	100%	100%
	2012	1	4	0%	0%	0%	25%	0%	50%	0%	50%
	2013	1	3	0%	0%	0%	0%	0%	0%	0%	25%
	2014	1	3	100%	33%	100%	67%	100%	100%	100%	100%
	2015	1	3	100%	33%	100%	33%	100%	67%	100%	67%
HR-B-12	2015	3	7	100%	57%	100%	86%	100%	86%	100%	86%
HR-B-13	2015	3	7	100%	86%	100%	86%	100%	86%	100%	100%
HR-B-14	2015	3	7	100%	43%	100%	43%	100%	43%	100%	57%
HR-B-15	2015	3	7	100%	100%	100%	100%	100%	100%	100%	100%

These data also indicate a generally improving trend over time in the bacteria concentrations, particularly during low flow (dry weather) conditions, but since 2014 has become more variable. Site HER-1 has generally decreased, but the other sites have been more variable. The high flows also indicate improving trends, but given the limited number of samples, it is not possible to ascertain the accuracy of this trend.

9.4.2.3 Subwatershed Prioritization Program

In order to more effectively target Baltimore County's efforts in reducing bacterial loads, a subwatershed prioritization program was instituted beginning in May 2015. This program is intended to assess the bacterial loads associated with streams and tributaries draining to each of the watersheds impaired by fecal bacteria. This program is intended to last two seasonal sampling periods, May-September 2015 and May-September 2016. Presented below are the results from the first seasonal sampling period. If the results show that a particular stream or tributary is consistently exceeding bacterial standards, it can be considered a focus for efforts to detect and eliminate the source of the bacterial load. By systematically examining streams in the watershed and focusing detection and elimination efforts in streams with consistently high bacteria counts, Baltimore County intends to effect bacterial load reductions in the associated watersheds.

Prettyboy Reservoir

Table 9-41 shows the latitude/longitude locations of the current bacteria monitoring stations within the Prettyboy Reservoir watershed. Figure 9-63 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-42 shows information from Figure 9-63 quantitatively, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data.

Table 9-41: Prettyboy Reservoir Subwatershed Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
PR-B-1	Prettyboy Branch	39.616	-76.734
PR-B-2	George's Run	39.616	-76.793
PR-B-3	Peggy's Run	39.616	-76.814
PR-B-4	Murphy Run	39.920	-76.814
PR-B-5	Compass Run	39.638	-76.781
PR-B-6	Indian Run	39.655	-76.809
PR-B-7	Poplar Run	39.662	-76.780
PR-B-8	Prettyboy Direct Drainage 1	39.676	-76.778
PR-B-9	Prettyboy Direct Drainage 2	39.681	-76.776
PR-B-10	Prettyboy Direct Drainage 3	39.658	-76.742
PR-B-11	Walker Run	39.689	-76.776
PR-B-12	Silver Run	39.691	-76.764
PR-B-13	Prettyboy Direct Drainage 4	39.682	-76.755
PR-B-14	Prettyboy Direct Drainage 5	39.675	-76.741
PR-B-15	Prettyboy Direct Drainage 6	39.663	-76.727
PR-B-16	Frog Hollow Run	39.645	-76.721

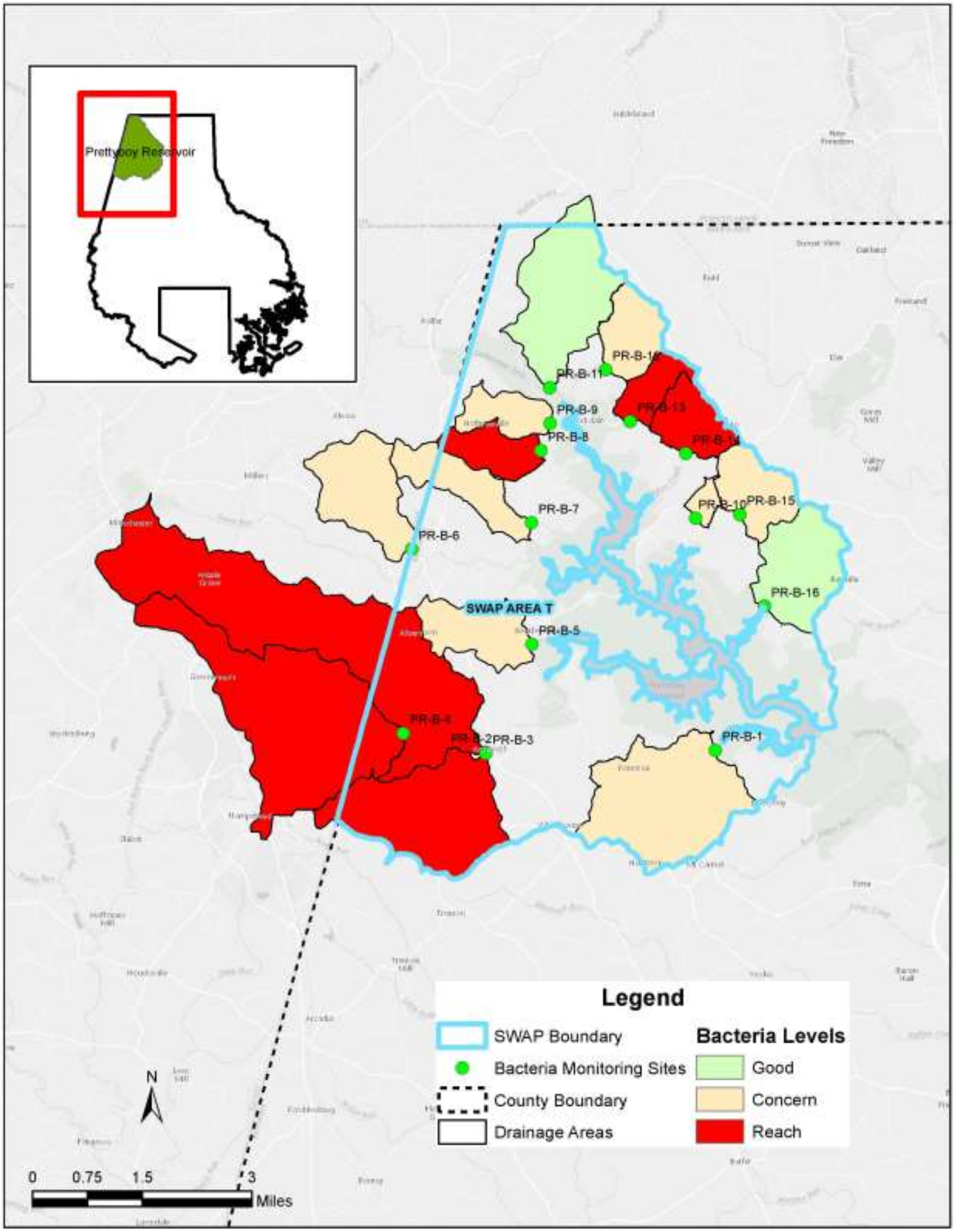


Figure 9-63: Prettyboy Reservoir Subwatershed Prioritization Site Results

Table 9-42: Prettyboy Reservoir Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area T

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
PR-B-1	5	417	0	N/A	5	417	1870	11.5	94	N/A	0	44.0	21.3	23.0
PR-B-2	5	522	0	N/A	5	522	6812	8.2	137	N/A	0	10.0	3.9	33.8
PR-B-3	5	292	0	N/A	5	292	1704	8.8	102	N/A	0	44.8	24.5	19.1
PR-B-4	5	385	0	N/A	5	385	2839	9.5	32	N/A	0	4.4	0.4	50.7
PR-B-5	5	307	0	N/A	5	307	687	9.8	93	N/A	0	23.1	28.5	38.6
PR-B-6	5	200	0	N/A	5	200	960	3.1	*	N/A	0	0	0	42.3
PR-B-7	5	128	0	N/A	5	128	638	8.6	54	N/A	0	13.3	6.4	55.4
PR-B-8	5	437	0	N/A	5	437	449	5.7	34	N/A	0	33.1	11.3	42.6
PR-B-9	5	142	0	N/A	5	142	408	7.2	20	N/A	0	34.7	12.5	45.7
PR-B-10	5	164	0	N/A	5	164	120	16.5	19	N/A	0	13.3	17.8	52.4
PR-B-11	5	87	0	N/A	5	87	1455	7.5	135	N/A	0	23.3	15.4	49.2
PR-B-12	5	174	0	N/A	5	174	538	7.2	21	N/A	0	26.8	26.4	39.7
PR-B-13	5	372	0	N/A	5	372	344	6.6	15	N/A	0	23.1	25.8	44.6
PR-B-14	5	294	0	N/A	5	294	524	10.4	24	N/A	0	28.8	25.7	35.1
PR-B-15	5	202	0	N/A	5	202	611	13.2	69	N/A	0	20.4	21.8	44.5
PR-B-16	5	123	0	N/A	5	123	975	23.5	183	N/A	0	13.9	8.5	53.6

*-Data unavailable for septic systems due to the majority of the drainage area being located in Carroll County.

Of the sixteen subwatersheds sampled in 2015, only two have been consistently below the 126 MPN/100ml limit – Frog Hollow Run (PR-B-16) and Walker Run (PR-B-11). Pending results from 2016, these sites may be considered not a significant source of bacteria and subject to less monitoring in the future.

Six of the subwatersheds have been recommended for additional reach monitoring. These sites are: PR-B-2, PR-B-3, PR-B-4, PR-B-8, PR-B-13, and PR-B-14. The first three sites are tributaries of George's Run, upstream of Bacteria Trend site PRE-1. These sites are quite similar in Land Use, with less than 10% urban land use, and most of the Land Use as either Agricultural or Forest. These Land Uses imply that the fecal source is most likely wildlife or agricultural. The potential agricultural sources will be shared with an Agricultural TMDL workgroup so that our efforts can be coordinated with the agricultural community. PR-B-2 and PR-B-3 also have over 100 septic systems within their drainage areas, so these may also be a source of bacteria.

More generally, the land uses around Prettyboy Reservoir are generally split between Agricultural and Forest, with very little Urban Land Use. The subwatershed with the highest proportion of urban land use, PR-B-16, is a candidate for elimination pending additional data. This data implies that our efforts should be focused on working with the agricultural community, as Forest Land Use, and the implied wildlife sources of bacteria have 0% maximum practicable reduction.

Loch Raven Reservoir

Table 9-43 shows the latitude/longitude locations of the current bacteria monitoring stations within the Loch Raven Reservoir watershed. Figure 9-64 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-44 through Table 9-48 shows information from Figure 9-64 quantitatively, broken out by SWAP Area, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data.

Table 9-43: Loch Raven Subwatershed Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
LR-B-1	Loch Raven Reservoir Direct Drainage 1	39.427	-76.581
LR-B-2	Hampton Branch	39.425	-76.594
LR-B-3	Long Quarter Branch	39.426	-76.596
LR-B-4	Loch Raven Reservoir Direct Drainage 2	39.461	-76.544
LR-B-5	Kelly's Branch	39.446	-76.595
LR-B-6	Merryman's Branch	39.461	-76.589
LR-B-7	Rushbrook	39.440	-76.559
LR-B-8	Lower Loch Raven	39.428	-76.545
LR-B-9	Dulaney Valley Branch	39.467	-76.545
LR-B-10	Jenkins Run	39.467	-76.558
LR-B-11	Fitzhugh Run	39.466	-76.572
LR-B-12	Goodwin Run	39.474	-76.657
LR-B-13	Upper Beaverdam Run	39.457	-76.692
LR-B-14	East Beaverdam Run	39.473	-76.640
LR-B-15	Baisman Run	39.479	-76.678
LR-B-16	Oregon Run	39.485	-76.656
LR-B-17	Slade Run	39.494	-76.778
LR-B-18	McGill Run	39.513	-76.769
LR-B-19	Piney Run	39.521	-76.767

LR-B-20	Little Piney Run	39.567	-76.735
LR-B-21	Blackrock Run	39.544	-76.733
LR-B-22	Indian Run	39.541	-76.735
LR-B-23	Quail Creek	39.515	-76.637
LR-B-24	Overshot Run	39.496	-76.569
LR-B-25	Greene Branch	39.506	-76.614
LR-B-26	Carroll Branch/My Lady's Manor Branch	39.534	-76.616
LR-B-27	Unnamed Western Run Tributary	39.514	-76.660
LR-B-28	Waterspout Run	39.492	-76.753
LR-B-29	Piney Creek	39.538	-76.648
LR-B-30	Buffalo Creek	39.556	-76.669
LR-B-31	Bush Cabin Run	39.610	-76.684
LR-B-32	Charles Run	39.576	-76.611
LR-B-33	Upper Little Falls – West Branch	39.692	-76.720
LR-B-34	Panther Branch	39.600	-76.650
LR-B-35	Mingo Branch	39.612	-76.675
LR-B-36	First Mine Branch	39.617	-76.621
LR-B-37	Second Mine Branch	39.623	-76.630
LR-B-38	Third Mine Branch	39.632	-76.640
LR-B-39	Fourth Mine Branch	39.642	-76.658
LR-B-40	Owl Branch	39.646	-76.663
LR-B-41	Upper Little Falls – East Branch	39.696	-76.710
LR-B-42	Little Falls	39.668	-76.678
LR-B-43	Beetree Run	39.672	-76.674
LR-B-44	Delaware Run/Councilman's Run	39.494	-76.777
LR-B-45	Deadman's Run	39.505	-76.743

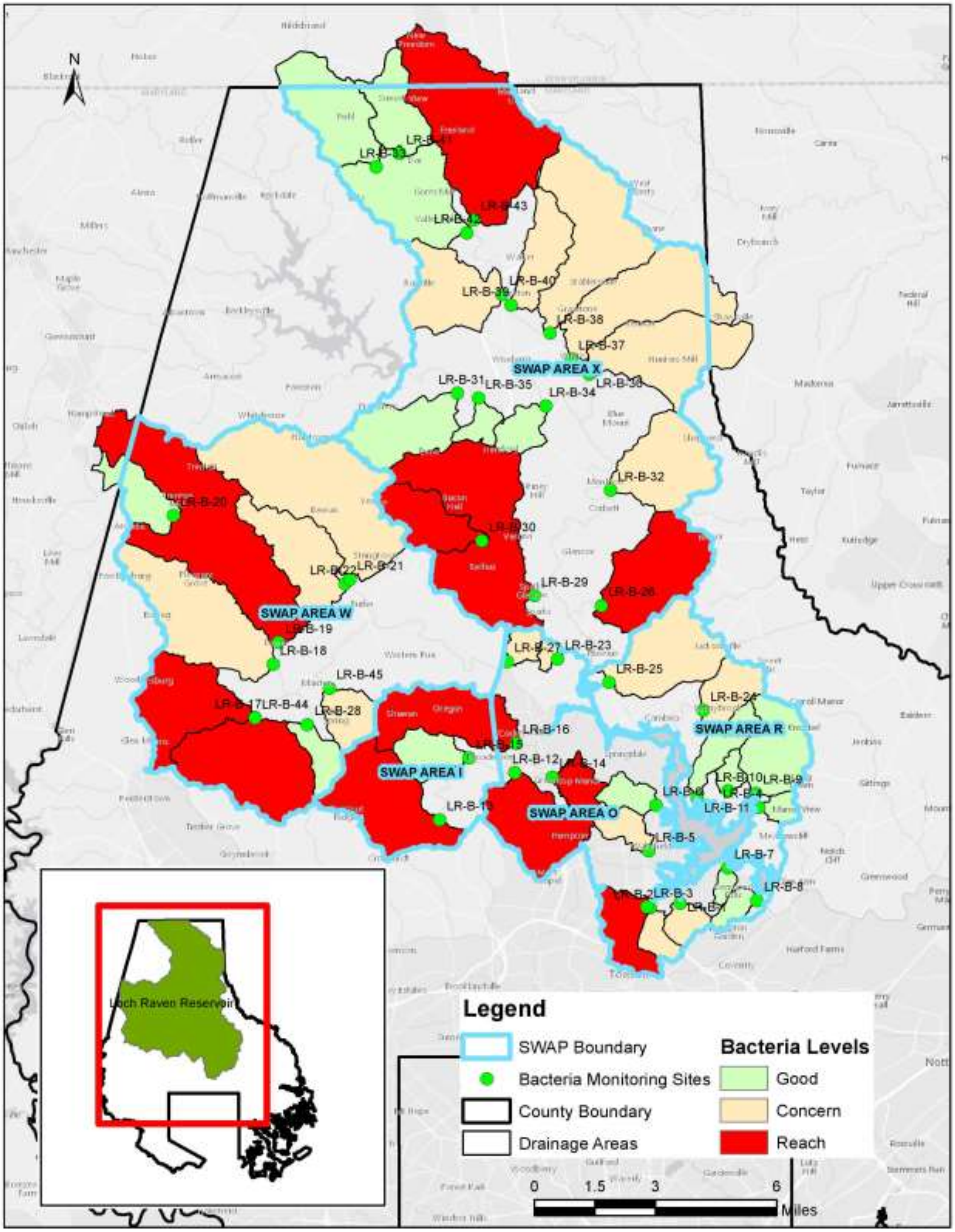


Figure 9-64: Loch Raven Reservoir Subwatershed Prioritization Site Results

Table 9-44: Loch Raven Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area I

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LR-B-13	5	260	0	N/A	5	260	3360	58.8	1272	0	0	1.4	0.0	39.8
LR-B-15	5	47	0	N/A	5	47	950	27.2	171	0	0	0	0.9	71.9

Of the two sites sampled in SWAP Area I, only one was above the limit for bacteria. This site, located on the upper portion of Beaverdam Run, is largely urban land use, but with septic systems instead of sanitary sewer. Investigation into possible leaking septic systems may prove fruitful in determining the cause of the bacterial load.

Table 9-45: Loch Raven Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area O

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LR-B-1	4	227	2	1304	6	407	536	55.5	326	0.33	0	0	0	44.5
LR-B-2	4	202	2	2420	6	462	523	73.2	25	4.82	0	0	0	26.8
LR-B-3	4	445	2	2420	6	783	1330	84.5	54	26.73	2*	0	0	15.6
LR-B-5	4	205	2	631	6	298	682	84.1	10	9.79	0	0	0	16.0
LR-B-6	4	124	2	1706	6	296	609	76.1	36	3.40	0	0	0	23.1
LR-B-7	4	63	2	301	6	106	229	21.7	109	0	0	0	0	78.3
LR-B-8	4	24	2	278	6	54	406	28.8	217	0	0	0	0	71.2
LR-B-12	5	409	0	N/A	5	409	2550	81.0	104	34.55	0	0	0.1	18.9
LR-B-14	5	1838	0	N/A	5	1838	741	91.2	51	9.63	0	0	0	8.9
LR-B-16	5	409	0	N/A	5	409	2696	30.5	185	3.36	0	10.6	25.1	33.7
LR-B-23	5	171	0	N/A	5	171	199	91.2	2	3.65	0	0	0	8.8
LR-B-27	5	195	0	N/A	5	195	426	44.7	32	3.22	0	4.0	5.6	45.7

***- Overflows occurred on 2/6/15 and 8/28/15, and were 100 and 200 gallons, respectively.**

SWAP Area O, containing 12 monitoring sites, had 2 below the limit and therefore recommended for no further action. The East Beaverdam Run site, LR-B-14, had one of the highest geometric means of any site monitored within Loch Raven in 2015. There was a sewage overflow, starting in June of 2015, less than 150 feet upstream of the site. Samples were taken at the site close to the day of the overflow. While not directly in the drainage area for this site, it would be close enough that this overflow may have contributed to the high bacteria results observed at this site.

Table 9-46: Loch Raven Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area R

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LR-B-4	4	50	2	417	6	101	351	29.4	99	0	0	2.1	3.1	65.4
LR-B-9	4	120	2	583	6	203	2047	37.8	620	0	0	4.4	16.0	41.8
LR-B-10	3	117	2	70	5	95	331	55.2	24	0	0	8.2	6.7	29.8
LR-B-11	4	39	2	710	6	102	1019	26.5	107	0	0	10.3	24.1	39.0
LR-B-24	2	40	3	768	5	236	1129	46.5	241	0	0	1.1	12.3	40.1
LR-B-25	5	127	0	N/A	5	127	2848	32.3	669	0	0	5.0	15.8	46.8

SWAP Area R, containing five sites, had only one site above the geometric limit. This site, Greene Branch, was just above the limit at 127 MPN/100ml. Further monitoring will be used to evaluate whether or not this site will undergo increased inspection.

Table 9-47: Loch Raven Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area W

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LR-B-17	4	246	1	2420	5	388	2848	8.3	126	0	0	15.7	29.6	46.4
LR-B-18	4	190	1	2420	5	317	4070	5.7	238	0	0	29.2	22.2	42.9
LR-B-19	3	312	2	2420	5	708	8165	9.0	307	0	0	21.1	27.7	33.3
LR-B-20	4	105	1	1300	5	173	1235	21.8	63	0	0	16.6	17.5	30.7
LR-B-21	4	153	1	291	5	174	6212	10.7	427	0	0	27.5	17.9	43.8
LR-B-22	4	143	1	1120	5	215	2417	7.0	87	0	0	22.9	27.7	42.3
LR-B-28	4	88	1	1553	5	157	764	21.3	91	0	0	2.4	22.8	53.6
LR-B-44	4	109	1	1733	5	546	3963	16.6	560	0.20	0	17.4	21.1	44.9
LR-B-45	4	240	1	2420	5	380	990	11.6	39	0	0	13.3	24.5	50.6

SWAP Area W, with nine sites, had three below the geometric limit. The sites remaining had no single majority land use. These sites typically had a large percentage of forest and agricultural land use, but very little urban land use. These sites also tended to have over a hundred septic systems in their drainage area. Two sites, LR-B-19 and LR-B-20, had drainage areas which extend into Carroll County.

Table 9-48: Loch Raven Reservoir Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area X

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LR-B-26	5	1761	0	N/A	5	1761	3258	6.2	168	0	0	28.2	29.7	35.9
LR-B-29	5	345	0	N/A	5	345	7526	18.7	678	0	0	23.6	23.3	34.4
LR-B-30	5	362	0	N/A	5	362	1700	5.6	72	0	0	26.4	29.3	38.7
LR-B-31	5	50	0	N/A	5	50	2263	10.0	238	0	0	24.3	18.4	47.2
LR-B-32	5	290	0	N/A	5	290	2791	9.1	237	0	0	15.1	21.8	53.9
LR-B-33	5	163	0	N/A	5	163	2774	6.9	103	0	0	31.0	15.4	21.8
LR-B-34	5	47	0	N/A	5	47	740	23.3	116	0	0	4.5	10.6	61.6
LR-B-35	5	72	0	N/A	5	72	488	14.6	10	0	0	0.2	16.6	68.7
LR-B-36	5	265	0	N/A	5	265	3558	15.2	77	0	0	16.5	16.6	51.7
LR-B-37	5	306	0	N/A	5	306	3714	9.5	195	0	0	27.4	19.6	35.8
LR-B-38	5	233	0	N/A	5	233	4415	6.8	208	0	0	28.7	19.5	44.9
LR-B-39	5	285	0	N/A	5	285	1631	14.8	79	0	0	24.9	12.8	47.6
LR-B-40	5	128	0	N/A	5	128	2383	32.0	15	0	0	9.8	5.4	52.8
LR-B-41	5	168	0	N/A	5	168	1620	8.8	111	0	0	31.7	15.4	28.0
LR-B-42	5	110	0	N/A	5	110	7638	8.8	489	0	0	27.0	17.2	38.3
LR-B-43	4	325	1	1414	5	437	6518	16.2	493	0	0	17.6	9.5	38.3

SWAP Area X had the largest number of sites of any SWAP in the Loch Raven Watershed. Four of the eighteen sites did not exceed the geometric limit. Four sites have been recommended for reach monitoring. These sites are relatively similar—a large percentage (but not majority) forest, then a roughly even split between cropland and pasture, then a relatively small percentage of urban land use. This proportion of land use implies that sources of bacteria within these reaches may be similarly distributed.

Jones Falls

Table 9-49 shows the latitude/longitude locations of the current bacteria monitoring stations within the Jones Falls watershed. Figure 9-65 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-50 through Table 9-52 shows information from Figure 9-65 quantitatively, broken out by SWAP Area, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data.

Table 9-49: Jones Falls Subwatershed Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
JF-B-1	Towson Run	39.389	-76.641
JF-B-2	Ruxton Run	39.393	-76.642
JF-B-3	Roland Run – West Branch	39.415	-76.646
JF-B-4	Roland Run – East Branch	39.415	-76.645
JF-B-5	Deep Run – Jones Falls	39.417	-76.671
JF-B-6	Jones Falls – Unnamed Trib. 1	39.416	-76.674
JF-B-7	Dipping Pond Run	39.425	-76.689
JF-B-8	North Branch Jones Falls	39.422	-76.710
JF-B-8	Jones Falls – Headwaters	39.410	-76.719
JF-B-10	Slaughterhouse Branch	39.399	-76.668
JF-B-11	Moores Branch	39.394	-76.670
JF-B-14	Dipping Pond Run – East Branch	39.419	-76.670

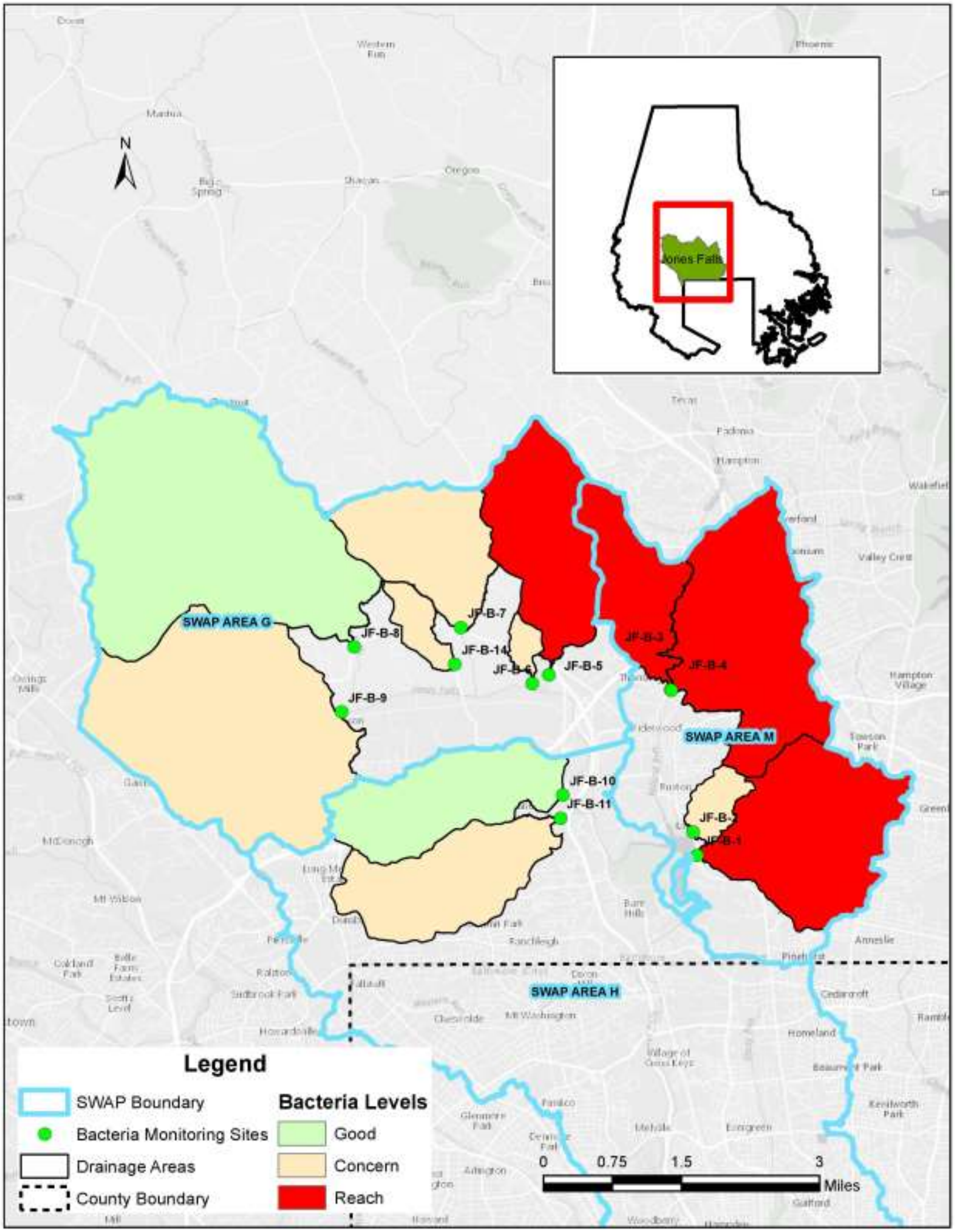


Figure 9-65: Jones Falls Subwatershed Prioritization Site Results

Table 9-50: Jones Falls Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area M

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
JF-B-1	5	511	1	2420	6	663	1834	82.6	164	36.0	0	0	0	17.4
JF-B-2	5	188	1	1986	6	278	234	49.4	64	2.9	0	0	0	50.6
JF-B-3	5	937	1	2420	6	1097	898	74.5	39	11.9	0	1.6	1.9	21.8
JF-B-4	5	617	1	166	6	496	2206	88.3	56	44.4	0	0.3	0.4	11.0

The four sites in SWAP Area M are very similar, with the exception of JF-B-2. JF-B-2 is located on Ruxton Run, and the land it drains is just over half forest. Combined with the relatively low number of septic systems and sanitary sewer miles, the land use implies that the fecal source may be wildlife-based. The other sites, however, are heavily urbanized and contain more miles of sanitary sewers. These sites have all been recommended for reach source tracking.

Table 9-51: Jones Falls Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area G

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
JF-B-5	5	463	1	1203	6	543	1369	39.3	373	1.63	0	3.2	3.3	54.1
JF-B-6	5	405	1	1203	6	486	107	29.3	13	0	0	17.9	43.5	9.4
JF-B-7	5	206	1	1300	6	280	1141	40.9	277	0	0	1.3	5.6	52.2
JF-B-8	5	126	1	2420	6	206	4144	28.1	1079	0	0	10.6	3.4	57.9
JF-B-9	5	207	1	2420	6	312	3377	41.3	660	7.7	0	6.2	5.8	46.7
JF-B-14	5	308	1	2420	6	435	232	26.8	34	0	0	9.2	13.3	50.7

Six sites are located within SWAP Area G. One site, located on the north branch of the Jones Falls mainstem, is below the geometric mean and no further action is recommended, pending an additional year of monitoring data. JF-B-6, a small tributary located on the western side of Meadowood Park, has a small drainage area mainly made up of pasture. This implies that the fecal source may be due to livestock, but it is also likely that the fecal source is wildlife-based, given the size of the stream and its surroundings being mostly forest.

JF-B-5, located on Deep Run within Meadowood Park, is recommended for reach monitoring. This site drains an area which is mostly forest, but the site itself is located within a popular park. While the land use would imply a wildlife-based fecal source, it is also possible that the source may be domesticated animals. The other sites within the SWAP have predominantly forest within their drainage areas. The high amount of septic systems within the drainage area of site JF-B-9 could be a source of bacteria.

Table 9-52: Jones Falls Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area H

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
JF-B-10	5	120	1	2420	6	199	1295	57.7	143	13.8	0	5.7	0.8	35.8
JF-B-11	5	439	1	2420	6	439	1290	67.4	53	20.4	0	0.4	2.4	28.8

SWAP Area H has two subwatershed sites. One of the sites, located on Slaughterhouse Branch, is below the limit and no further action will be taken, assuming data from 2016 does not indicate otherwise. The other site, located on Moores Branch, drains an area which is predominantly urban. A sewer line runs along Moores Branch for most of its length upstream of the site, which may be a good place to start investigating the source of bacteria.

Gwynns Falls

Table 9-53 shows the latitude/longitude locations of the current bacteria monitoring stations within the Gwynns Falls watershed. Figure 9-66 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-54 and Table 9-55 shows information from Figure 9-66 quantitatively, broken out by SWAP Area, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data

Table 9-53: Gwynns Falls Subwatershed Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
GF-B-1	Gwynns Falls UN Trib 2	39.324	-76.725
GF-B-2	Gwynns Falls UN Trib 1	39.347	-76.737
GF-B-3	Gwynns Falls UN Trib 3	39.378	-76.757
GF-B-4	Gwynns Falls UN Trib 4	39.370	-76.737
GF-B-5	Gwynns Falls UN Trib 5	39.376	-76.423
GF-B-6	Gwynns Falls UN Trib 6	39.433	-76.781
RR-B-1	Red Run	39.405	-76.778
GF-B-7	Upper Gwynns Falls	39.405	-76.777
HH-B-1	Horsehead Branch	39.389	-76.780

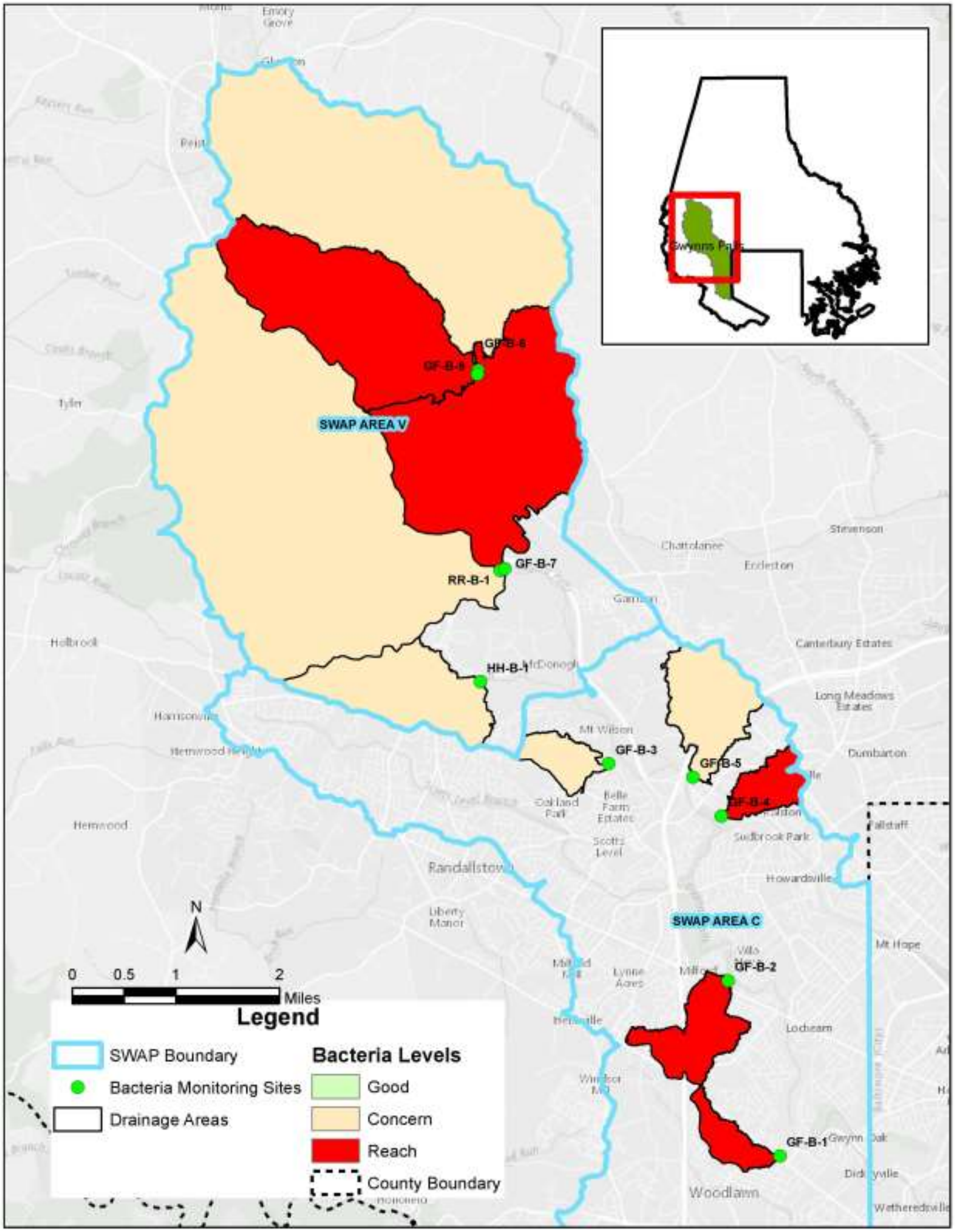


Figure 9-66: Gwynns Falls Subwatershed Prioritization Site Results

Table 9-54: Gwynns Falls Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area C

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
GF-B-1	4	389	1	2420	5	527	163	94.2	4	3.4	0	0	0	5.8
GF-B-2	4	262	1	2420	5	380	365	99.0	1	11.4	0	0	0	1.0
GF-B-3	4	158	1	1046	5	216	185	69.2	1	4.3	0	0.1	0	30.8
GF-B-4	4	569	1	2420	5	724	206	94.6	4	4.4	0	0	0	5.4
GF-B-5	4	215	1	980	5	277	503	94.4	21	6.8	0	0.3	0	5.3

The sites within the Gwynns Falls are split in half between SWAP Areas C and V. Within SWAP Area C, site GF-B-3 is the only site with less than 94% urban land use within its drainage area. This site is located on a small tributary to Gwynns Falls north of Scotts Level Branch, with forest surrounding most of its length upstream of the site. This may imply a higher influence of wildlife sources over anthropogenic sources. The other four sites within SWAP Area C have almost completely urban drainage areas and sources which are concomitant with urban land uses.

Table 9-55: Gwynns Falls Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area V

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
GF-B-6	3	141	1	2420	4	249	3185	76.2	221	67.8	1	3.2	0.1	20.5
GF-B-7	4	470	1	2420	5	617	6637	77.6	464	117.9	2	2.2	0.5	19.7
GF-B-9	4	772	1	2420	5	934	1542	85.8	187	28.4	1	0	0	14.2
RR-B-1	4	170	1	2420	5	265	4753	51.5	576	41.4	0	6.3	2.0	40.0
HH-B-1	4	216	1	2420	5	323	695	61.4	12	14.2	0	7.0	2.2	29.4

The Sites within SWAP Area V, while draining areas which are still a majority urban land use, have more forest and some crops and pasture, but are never more than ten percent of total land within the drainage area. Sites GF-B-7, GF-B-6 and GF-B-9 may be taken as a set of sites to provide information on the behavior of the Upper Gwynns Falls. GF-B-7 includes both GF-B-6 and GF-B-9 within its drainage area. GF-B-6 and GF-B-9 are taken at each branch of a major confluence of the Gwynns Falls near Owings Mills Boulevard. Based on the 2015 data, GF-B-7 and GF-B-9 have been recommended for reach monitoring.

Patapsco

Table 9-56 shows the latitude/longitude locations of the current bacteria monitoring stations within the Gwynns Falls watershed. Figure 9-67 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-57 shows information from Figure 9-67 quantitatively, broken out by SWAP Area, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data

Table 9-56: Lower North Branch Patapsco Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
PA-B-1	West Branch Herbert Run	39.235	-76.693
PA-B-2	East Branch Herbert Run	39.235	-76.692
PA-B-3	Herbert Run	39.228	-76.690
PA-B-4	Patapsco River – UN Trib. 1	39.222	-76.707
PA-B-5	Patapsco River – UN Trib. 2	39.226	-76.717
PA-B-6	Patapsco River – UN Trib. 3	39.230	-76.724
PA-B-7	Bull Branch	39.231	-76.728
PA-B-8	Patapsco River – UN Trib. 4	39.243	-76.738
PA-B-9	Patapsco River – UN Trib. 5	39.251	-76.754
PA-B-10	Thistle Branch	39.254	-76.767
PA-B-11	Patapsco River – UN Trib. 6	39.261	-76.784
PA-B-12	Cooper Branch	39.266	-76.791
PA-B-13	Miller Branch	39.294	-76.777
PA-B-14	Cedar Branch – West	39.306	-76.779
PA-B-15	Cedar Branch – East	39.301	-76.774

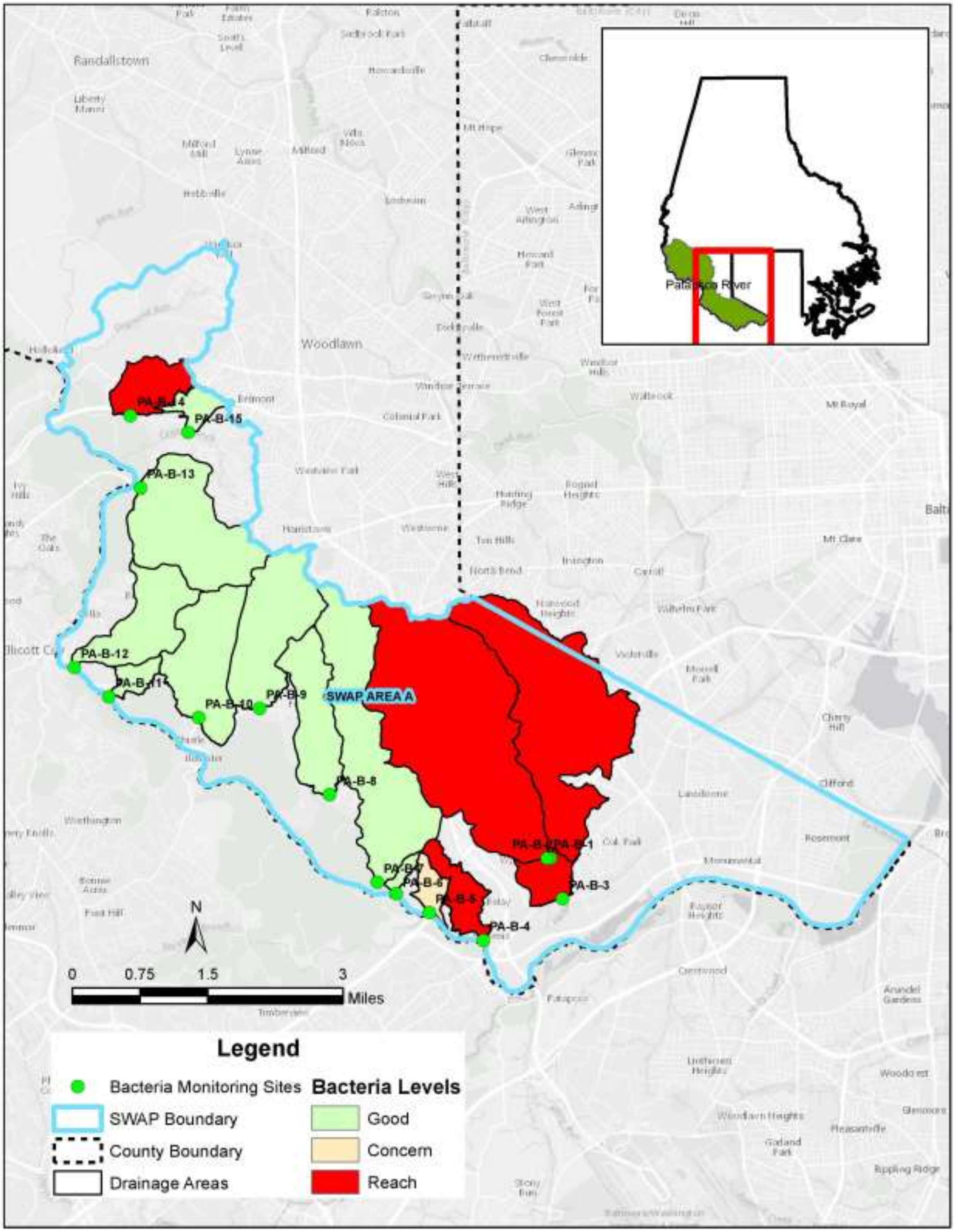


Figure 9-67: Patapsco Subwatershed Prioritization Site Results

Table 9-57: Patapsco Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area A

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
PA-B-1	5	1989	0	N/A	5	1989	2222	85.4	32	33.8	1	0	0	14.6
PA-B-2	5	386	0	N/A	5	386	1637	93.3	24	29.1	1	0	0	6.7
PA-B-3	5	757	0	N/A	5	757	4030	89.0	61	66.8	2	0	0	11.0
PA-B-4	5	1077	0	N/A	5	1077	216	49.0	14	1.9	0	0	0	51.0
PA-B-5	5	160	0	N/A	5	160	104	42.8	16	0	0	0	0	57.2
PA-B-6	5	40	0	N/A	5	40	42	15.4	7	0	0	0	0	84.6
PA-B-7	5	67	0	N/A	5	67	1182	60.0	30	17.2	0	0	0	40.0
PA-B-8	5	95	0	N/A	5	95	493	66.9	2	10.8	0	0	0	33.1
PA-B-9	5	59	0	N/A	5	59	731	71.9	32	13.7	0	0	0	28.1
PA-B-10	5	67	0	N/A	5	67	654	60.5	13	11.3	0	0	4.8	34.7
PA-B-11	5	65	0	N/A	5	65	95	39.6	1	1.0	0	0	22.2	38.2
PA-B-12	5	24	0	N/A	5	24	505	58.9	8	8.3	0	0	0.7	40.4
PA-B-13	5	53	0	N/A	5	53	909	74.7	19	16.8	0	0	0	25.3
PA-B-14	5	332	0	N/A	5	332	271	88.6	0	6.0	0	0.2	0.1	11.1
PA-B-15	5	79	0	N/A	5	79	116	93.9	1	1.9	2	0	0	6.1

All of the subwatershed sites sampled are within SWAP Area A. The first three sites are characterizing the behavior of Herbert Run, a highly urbanized stream in the southeastern portion of the watershed. PA-B-3 is the downstream site which contains both PA-B-1, on the West Branch of Herbert Run, and PA-B-2, on the East Branch. Both the West and East Branch had an overflow in 2015. The overflow in the West Branch occurred in June, but at the very top of the drainage area. The overflow in the east branch did not occur within the sampling period. All three sites have been recommended for reach monitoring.

Of the remaining sites, only two have been recommended for reach monitoring. The first, PA-B-4, is an Unnamed Tributary located in the Avalon area of Patapsco Valley State Park. This site drains forest and urban in nearly equal proportion. This nearly equal proportion of forest and urban land uses, with few septic systems and less than two miles of sanitary sewer, implies a wildlife or domesticated source.

The other site, PA-B-14, is located on the Western portion of Cedar Branch. This site drains a predominantly urban area, but with no septic systems and a low amount of sanitary sewer. This implies that the source at this site may be due to wildlife or other domesticated sources, similar to site PA-B-4.

Liberty Reservoir

Table 9-58 shows the latitude/longitude locations of the current bacteria monitoring stations within the Patapsco watershed. Figure 9-68 shows a map of the monitored subwatersheds. The subwatersheds' drainage areas are highlighted according to low flow geometric mean and if it is recommended for source tracking, of concern, or below the 126 MPN/100ml geometric mean. Table 9-59 shows information from Figure 9-68 quantitatively, as well as features of the drainage area for each subwatershed sampled. Samples highlighted in green indicate no further action, pending 2016 bacteria data

Table 9-58: Liberty Reservoir Prioritization Site Locations and Descriptions

Station Code	Subwatershed	Latitude	Longitude
LI-01	Aspen Run	39.562	-76.840
LI-02	Broad Run	39.543	-76.847
LI-03	Cliffs Branch – North Branch	39.524	-76.850
LI-04	Cliffs Branch – South Branch	39.511	-76.863
LI-05	Glen Falls Run	39.494	-76.868
LI-06	Keysers Run	39.467	-76.868
LI-07	Norris Run	39.462	-76.872
LI-08	Timber Run/Cooks Branch	39.478	-76.871
LI-09	Liberty Reservoir Unnamed Trib. 1	39.418	-76.866
LI-10	Chimney Branch/Locust Run	39.405	-76.861
LI-10a	Chimney Branch	39.407	-76.858
LI-10b	Locust Run	39.405	-76.861
LI-11	Liberty Reservoir – Unnamed Trib 2	39.398	-76.875
LI-12	Liberty Reservoir – Unnamed Trib 3	39.389	-76.872

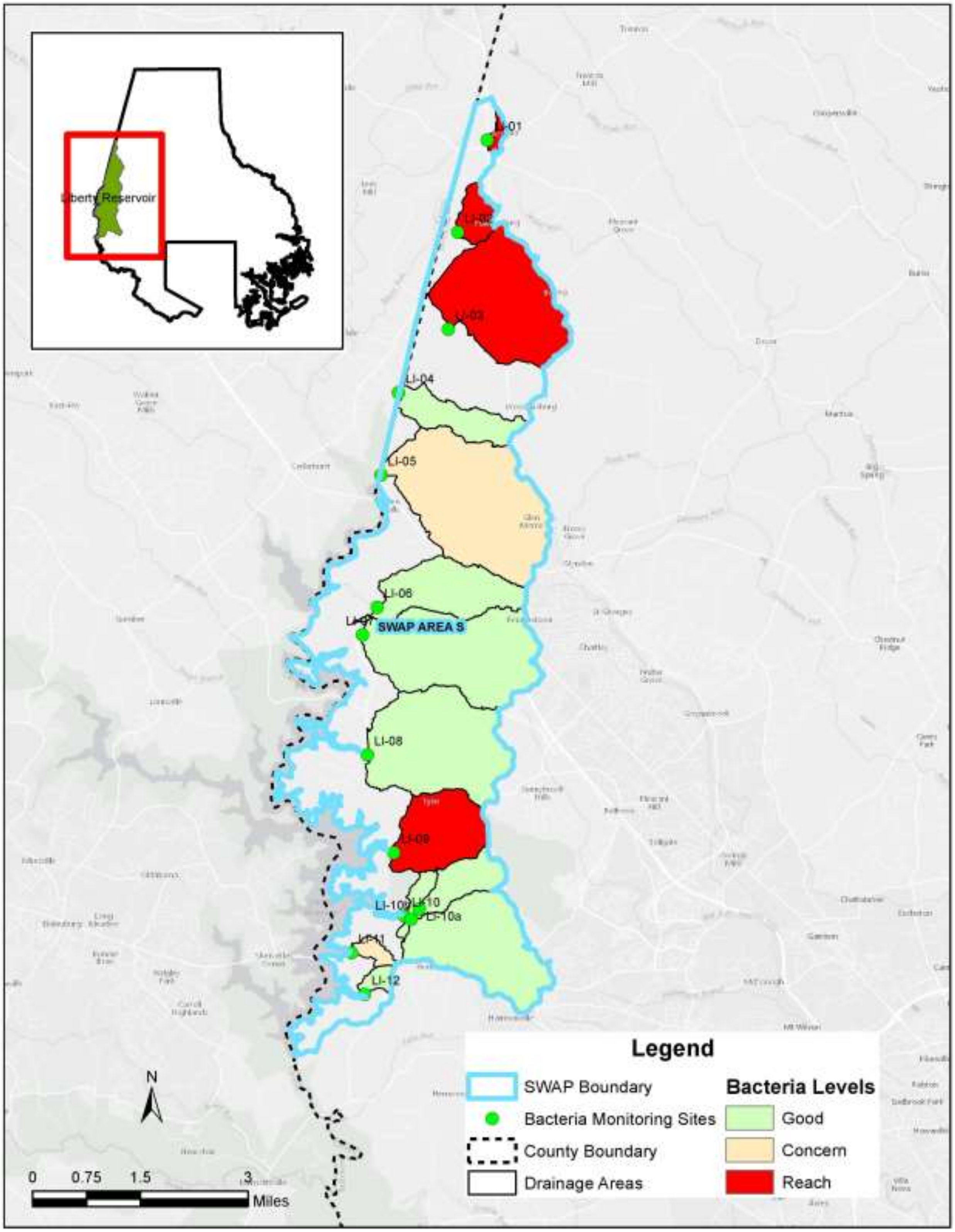


Figure 9-68: Liberty Subwatershed Prioritization Site Results

Table 9-59: Liberty Reservoir Subwatershed Prioritization Site Results and Drainage Area Properties, SWAP Area S

Site	Low Flow		High Flow		All Samples		Acres of Drainage Area	Urban Land Use (%)	# Septic Systems	Miles of Sanitary Sewer	# of Overflows	% Land Use (Crops)	% Land Use (pasture)	% Forest
	#	Geo Mean	#	Geo Mean	#	Geo Mean								
LI-01	4	1128	1	2420	5	1314	56	41.3	28	0	0	42.3	7.2	9.2
LI-02	4	449	1	2420	5	629	204	15.9	25	0	0	44.0	12.4	27.7
LI-03	3	322	2	1773	5	638	1495	12.1	167	0	0	32.2	31.1	24.6
LI-04	4	124	1	517	5	165	451	13.7	40	0	0	35.7	20.4	30.3
LI-05	3	128	2	1939	5	380	2054	19.1	270	0.2	0	12.2	10.0	58.4
LI-06	5	122	0	N/A	5	122	794	26.3	119	1.6	0	12.9	22.1	38.7
LI-07	3	105	2	2192	5	355	1643	26.5	257	2.0	0	10.3	10.2	53.0
LI-08	5	82	0	N/A	5	82	1579	9.9	233	0.1	0	9.2	5.8	75.1
LI-09	4	805	1	345	5	679	751	10.6	52	0	0	13.9	15.5	60.0
LI-10	4	60	1	248	5	80	1721	14.5	193	0.4	0	5.1	6.5	73.8
LI-10A	2	99	0	N/A	2	99	349	12.2	18	0	0	4.9	0.4	82.5
LI-10B	4	113	1	387	5	144	1251	15.1	164	0.4	0	5.0	8.3	71.7
LI-11	4	145	1	96	5	133	91	40.5	21	0	0	5.1	20.7	33.7
LI-12	4	31	1	32	5	31	86	6.9	3	0	0	20.0	28.3	44.8

The first site, LI-01, is located at the headwaters of Aspen Run. This site has a very small drainage area, but the highest geometric mean amongst the sites in the Liberty watershed. It drains an area which is roughly split between cropland and urban land use. The implication of the land use is that fecal sources may arise due to a leaking septic system or possible runoff from cropland.

Similarly, the drainage area of sites LI-02 and LI-03, are mostly agricultural. LI-03 also has a large number of septic systems which may also be a source of bacteria observed at that site.

Site LI-09 is located on a direct tributary to Liberty Reservoir. After observing over range values for the first two samples taken during 2015, the site was recommended for reach monitoring. The reach monitoring, performed in late June 2015, revealed that fencing had recently been installed along the stream upstream of the site to prevent livestock access. The next sample taken at the site, in late July 2015, had a much lower bacterial result than the previous two samples. While the bacteria level remained above the limit, this result shows that coordination with agricultural sources may be helpful in reducing fecal sources.

9.4.3 Biological Monitoring

In addition to the biological monitoring required at Scotts Level Branch under Baltimore County’s NPDES permit, the County has five additional biological monitoring programs. These programs use the biological community to assess the ecological health of the streams within the County both freshwater and tidal (Probabilistic Monitoring Program), assess the effectiveness of stream restoration projects (CIP Monitoring Program), provide data on the best streams in Baltimore County to serve as bench marks for other stream assessments (Reference Site Monitoring Program), represent environmental variation over a range of watershed land uses (Sentinel Site Monitoring Program), and assess Submerged Aquatic Vegetation (Submerged Aquatic Vegetation (SAV) Monitoring Program). The first four 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.

9.4.3.1 Probabilistic Monitoring

Since 2003, Baltimore County has followed Maryland Biological Stream Survey (MBSS) probabilistic monitoring methods. Probabilistic monitoring (random selection of monitoring stations) allows statistically valid conclusions to be drawn regarding stream condition. This approach provides greater resolution of County stream condition because there are more stations in County streams and the data are directly comparable to data generated by MBSS.

The County contracts 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.

Fifty sites are randomly selected and macroinvertebrates are sampled during the spring index period, March 1 to April 30, 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.

Baltimore County has two physiographical provinces, the Piedmont and Coastal Plain, both of which have separate BIBI metrics. These metrics according to province, what they measure and the expected response to stressors are displayed in Table 9-60 and Table 9-61.

Table 9-60: BIBI Piedmont 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

Table 9-61: BIBI Coastal Plain 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 Ephemeroptera	Taxonomic Composition	Decrease
Number of Scrapers	Habit	Decrease
Percent Climber	Habit	Decrease

The raw BIBI scores for each site from the 2015 probabilistic monitoring are displayed in Appendix 9-1 at the end of this section. The sites are grouped by subwatershed and 12-digit watershed, along with their respective BIBI condition rating. The BIBI condition ratings are "Very Poor" (1.00 – 1.99), "Poor" (2.00 – 2.99), "Fair" (3.00 – 3.99), and "Good" (4.00 – 5.00).

Table 9-62 shows the results by watershed, as the percentage of sites within each BIBI range, for the entire nine-year probabilistic data set. In 2015, 38% of sites were considered to have Good biological water quality. The highest percentage of sites were rated Good and Fair, while the rest of the sites were evenly distributed between Poor and Very Poor. Since 2003, half of sites have BIBIs of Fair (32%) or Good (21%).

Table 9-62: 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 Res.	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 Res.	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 Res.	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**
Patapsco/Back River Basin – Sampled in 2009					
Liberty Reservoir	15	0	7	60	33
Patapsco River	23	22	30	43	4
Gwynns Falls	26	35	42	23	0
Jones Falls	20	35	50	15	0
Back River	16	69	31	0	0
Total	**100**	**32**	**34**	**28**	**6**
Gunpowder River Basin/Deer Creek – Sampled in 2010					
Deer Creek	3	0	0	100	0
Prettyboy Res.	11	0	27	64	9
Loch Raven Res.	59	7	15	68	10
Lower Gunpowder	13	8	38	54	0
Little Gunpowder	7	0	29	71	0
Bird River	7	57	43	0	0
Total	**100**	**9**	**22**	**62**	**7**

Patapsco/Back River Basin – Sampled in 2011					
Liberty Reservoir	**10**	0	10	70	20
Patapsco River	**31**	26	48	26	0
Gwynns Falls	**23**	35	30	30	4
Jones Falls	**21**	19	29	29	24
Back River	**15**	47	53	0	0
Total	**100**	**27**	**37**	**28**	**8**
Gunpowder River Basin/Deer Creek – Sampled in 2012					
Deer Creek	**4**	0	0	0	100
Prettyboy Res.	**6**	33	17	0	50
Loch Raven Res.	**58**	3	3	40	54
Lower Gunpowder	**16**	31	13	25	31
Little Gunpowder	**9**	0	11	0	89
Bird River	**7**	57	43	0	0
Total	**100**	**13**	**9**	**27**	**51**
Patapsco/Back River Basin – Sampled in 2013					
Liberty Reservoir	**7**	0	0	43	57
Patapsco River	**18**	17	22	44	17
Gwynns Falls	**10**	10	60	30	0
Jones Falls	**9**	67	0	22	11
Back River	**6**	83	17	0	0
Total	**50**	**15**	**11**	**16**	**8**
Gunpowder River Basin/Deer Creek – Sampled in 2014					
Deer Creek	**2**	0	0	50	50
Prettyboy Res.	**5**	0	0	40	60
Loch Raven Res.	**29**	4	10	38	48
Lower Gunpowder	**6**	17	50	33	0
Little Gunpowder	**4**	0	0	75	25
Bird River	**4**	100	0	0	0
Total	**50**	**6**	**6**	**19**	**19**

Patapsco/Back River Basin – Sampled in 2015					
Liberty Reservoir	**5**	1	1	3	0
Patapsco River	**18**	4	4	8	3
Gwynns Falls	**13**	6	6	3	0
Jones Falls	**9**	5	5	3	0
Back River	**5**	4	4	0	0
Total	**50**	**20**	**12**	**17**	**3**
County Total	**1,150**	**251**	**269**	**352**	**228**

Figure 9-69 and Figure 9-70 show the means and one standard deviation of the mean BIBI scores for each watershed between 2003 and 2015. Among Patapsco/Back River watersheds, Liberty Reservoir consistently has the highest biological integrity, while Back River has the lowest. Among Gunpowder River watersheds, the Lower Gunpowder and Bird River watersheds have the lowest biological integrity. In both the Patapsco and Gunpowder basins, the watersheds with the poorest biological condition coincide with the most populated and urbanized areas within Baltimore County.

The procedure 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 eleven sampling years. The procedure 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 from reference conditions. Watersheds are listed as “Attaining,” “Impaired,” or “Inconclusive.” The results of the biological listing method are presented in Table 9-63. Figure 9-71 display site and watershed condition for sites sampled in 2014 and 2015. The sites, with color-coded condition, are overlain on their respective sub-watersheds.

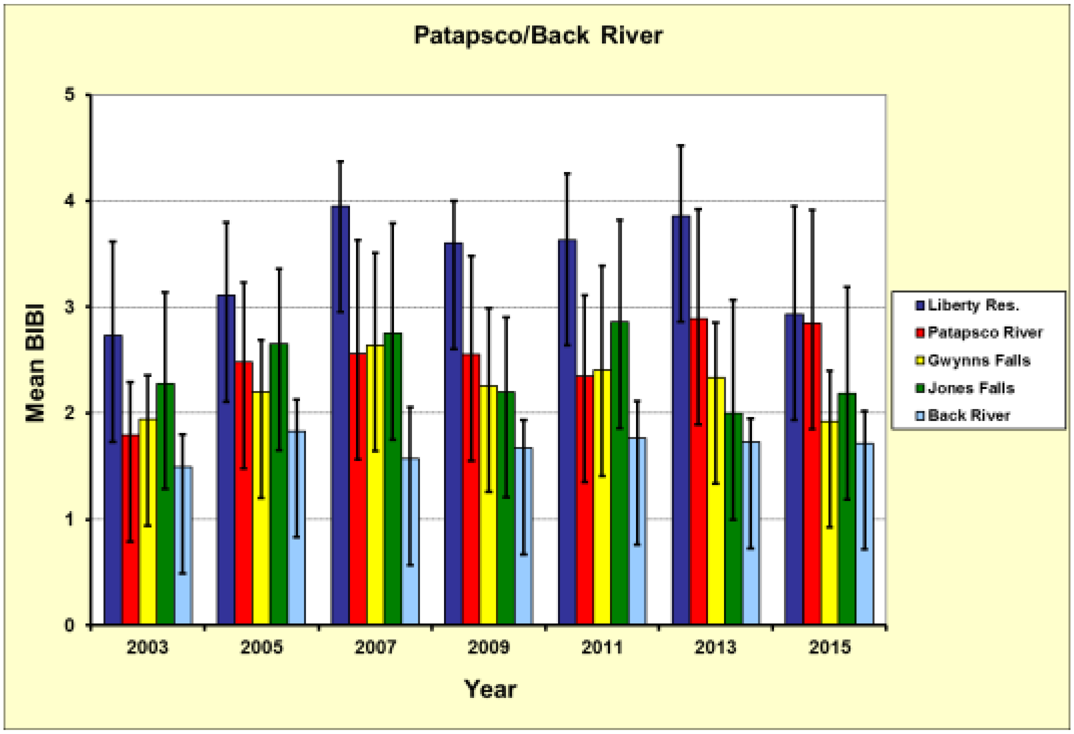


Figure 9-69: Means and one standard deviation of BIBI scores for Patapsco/Back River watersheds between 2003 and 2013.

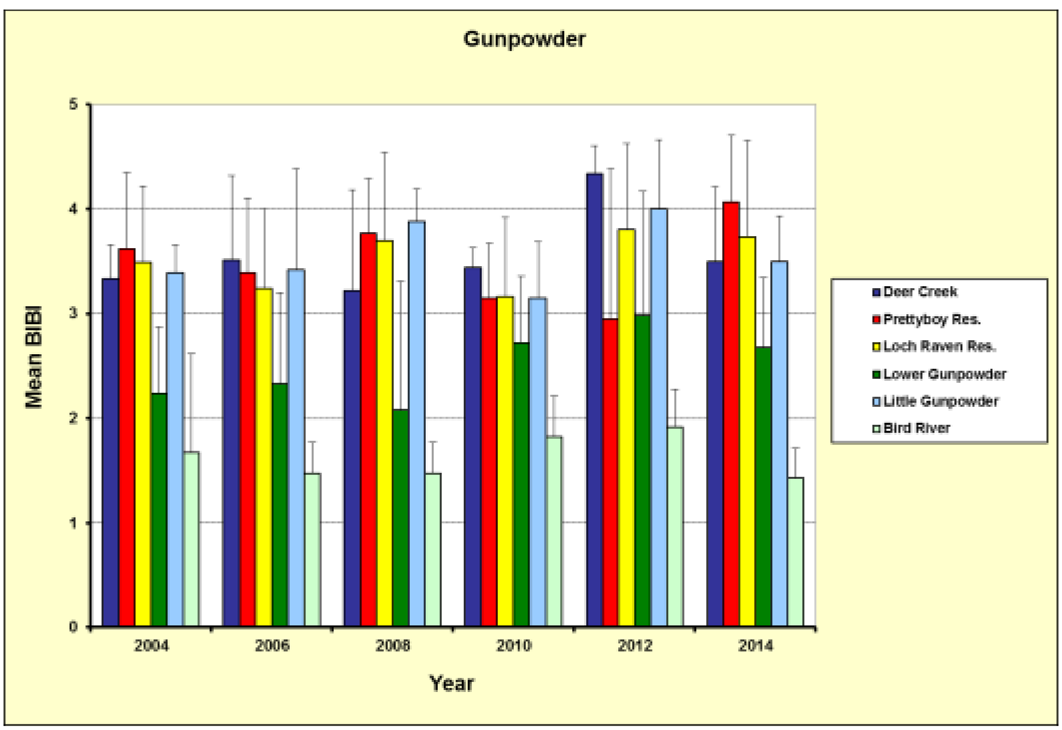


Figure 9-70: Means and one standard deviation of BIBI scores of Gunpowder Falls/Deer Creek watersheds between 2004 and 2015.

Table 9-63: Watershed Biological Condition Using Percent Stream Mile Method

Watershed	Sites Degraded	N	% Stream Miles With Possible Degradation	Category
2003 Sampling Year				
Liberty	6	10	60	Impaired
Patapsco River	13	13	100	Impaired
Gwynns Falls	29	30	97	Impaired
Jones Falls	22	32	69	Impaired
Back River	15	15	100	Impaired
2004 Sampling Year				
Deer Creek	1	3	33	Inconclusive
Prettyboy	1	7	14	Attaining
Loch Raven	10	67	15	Attaining
Lower Gunpowder	5	7	71	Impaired
Little Gunpowder	0	6	0	Attaining
Bird River	2	2	100	Impaired
2005 Sampling Year				
Liberty	8	22	36	Impaired
Patapsco River	15	21	71	Impaired
Gwynns Falls	19	22	86	Impaired
Jones Falls	11	23	48	Impaired
Back River	12	12	100	Impaired
2006 Sampling Year				
Deer Creek	2	13	15	Attaining
Prettyboy	5	17	29	Impaired
Loch Raven	10	44	23	Impaired
Lower Gunpowder	11	17	65	Impaired
Little Gunpowder	1	4	25	Inconclusive
Bird River	5	5	100	Impaired
2007 Sampling Year				
Liberty	0	20	0	Attaining
Patapsco River	16	24	67	Impaired
Gwynns Falls	17	26	65	Impaired
Jones Falls	15	28	54	Impaired
Back River	18	19	95	Impaired

2008 Sampling Year				
Deer Creek	4	12	33	Impaired
Prettyboy	1	13	8	Attaining
Loch Raven	6	47	13	Attaining
Lower Gunpowder	9	12	75	Impaired
Little Gunpowder	0	11	0	Attaining
Bird River	5	5	100	Impaired
2009 Sampling Year				
Liberty	0	15	0	Attaining
Patapsco River	9	23	39	Impaired
Gwynns Falls	18	26	69	Impaired
Jones Falls	13	20	65	Impaired
Back River	16	16	100	Impaired
2010 Sampling Year				
Deer Creek	0	3	0	Attaining
Prettyboy	3	11	27	Impaired
Loch Raven	13	59	22	Impaired
Lower Gunpowder	6	13	46	Impaired
Little Gunpowder	2	7	29	Attaining
Bird River	7	7	100	Impaired
2011 Sampling Year				
Liberty	1	10	10	Attaining
Patapsco River	23	31	74	Impaired
Gwynns Falls	15	23	65	Impaired
Jones Falls	10	21	48	Impaired
Back River	15	15	100	Impaired
2012 Sampling Year				
Deer Creek	0	4	0	Attaining
Prettyboy	3	6	50	Impaired
Loch Raven	4	58	7	Attaining
Lower Gunpowder	7	16	44	Impaired
Little Gunpowder	1	9	11	Attaining
Bird River	7	7	100	Impaired

2013 Sampling Year				
Liberty	0	7	0	Attaining
Patapsco River	7	18	39	Impaired
Gwynns Falls	7	10	70	Impaired
Jones Falls	6	9	67	Impaired
Back River	6	6	100	Impaired
2014 Sampling Year				
Deer Creek	0	2	0	Attaining
Prettyboy	0	5	0	Attaining
Loch Raven	4	29	13	Attaining
Lower Gunpowder	4	6	67	Impaired
Little Gunpowder	0	4	0	Attaining
Bird River	4	4	100	Impaired
2015 Sampling Year				
Liberty	2	5	40	Attaining
Patapsco River	7	18	39	Impaired
Gwynns Falls	12	13	92	Impaired
Jones Falls	6	9	67	Impaired
Back River	5	5	100	Impaired

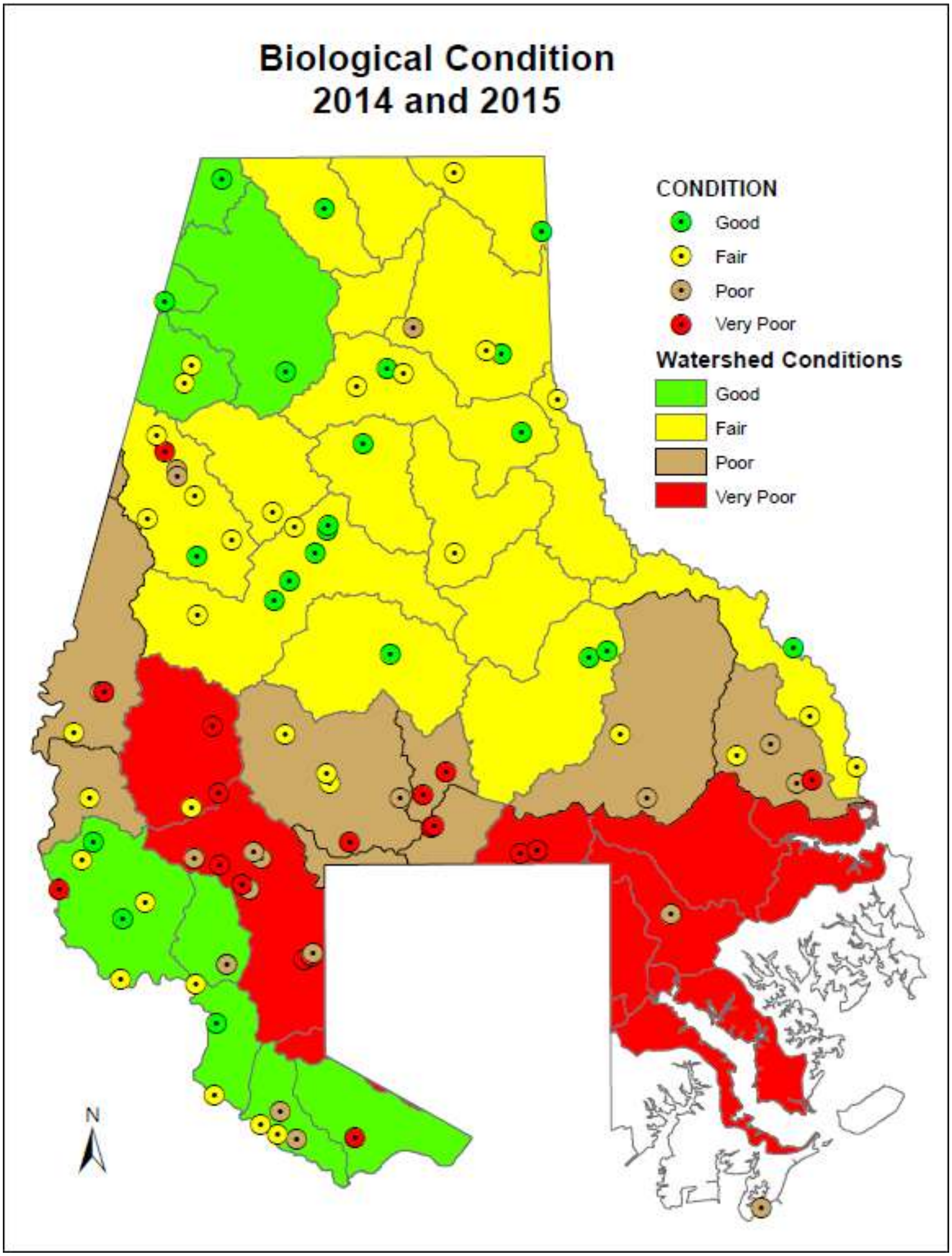


Figure 9-71: Probabilistic Biological Monitoring results for 2014 and 2015. Sample points are superimposed on named Baltimore County subwatersheds.

Based on the percent stream mile criteria, Prettyboy, Loch Raven, Deer Creek, and Little Gunpowder met biological criteria. Lower Gunpowder and Bird River were impaired. Figure

9-71 indicates sites and sub-watersheds that are close to the population centers of Baltimore County are the most impaired. Two year rolling averages were calculated using the probabilistic data for the entire period of record. This simple, smoothing technique clarifies underlying patterns in data. The results are shown in Figure 9-72 and Figure 9-73. Patapsco River, Gwynns Falls, and Jones Falls averages were almost identical to the Patapsco-Back River overall averages, which showed a slight increase followed by a slight decrease. 2003 may have displayed lower results due to a 2 year drought followed by the third highest record rainfall the following year in 2003. Liberty Reservoir rolling averages were the highest in Patapsco-Back River, and Back River rolling averages were the lowest. Both were clearly separated from the other sub-watersheds. Sub-watersheds in the Gunpowder Falls showed slight changes. Little Gunpowder, Prettyboy, Loch Raven, and Deer Creek grouped together, slightly above the overall Gunpowder Falls average. For the 2013/2015 averages, Gunpowder, Little Gunpowder, Prettyboy, Loch Raven, and Lower Gunpowder increased, while Deer Creek and Bird River decreased. The Lower Gunpowder and Bird River separated from the other sub-watershed rolling averages. The Lower Gunpowder displayed significant improvement by shifting from the Poor category to the Fair category. For all watersheds, the rolling averages suggest stability in biological condition over this short period of record.

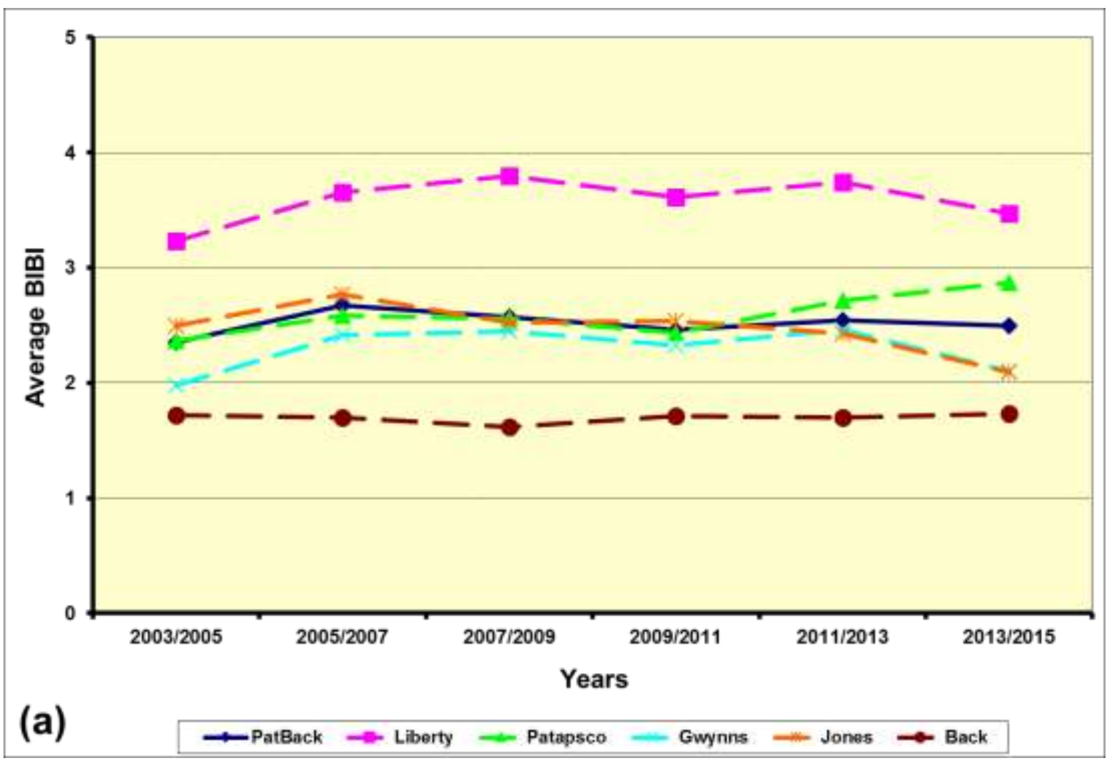


Figure 9-72: BIBI rolling averages for Patapsco/Back River probabilistic monitoring sites between 2003 and 2015.

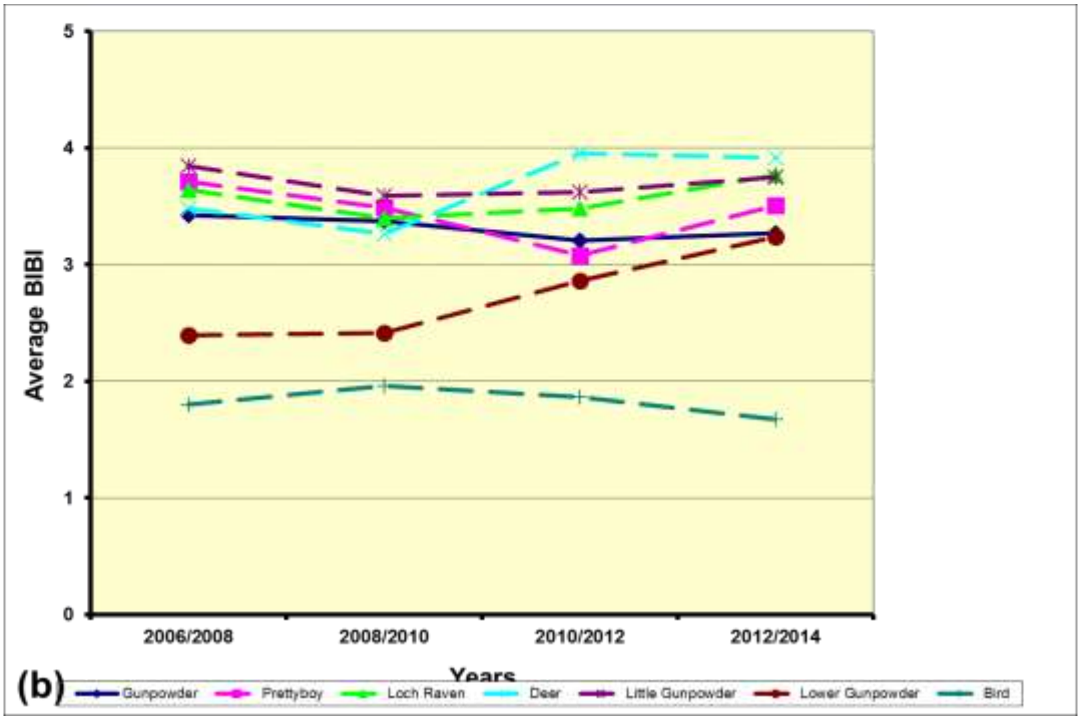


Figure 9-73: BIBI rolling averages for Gunpowder/Deer Creek probabilistic monitoring sites between 2006 and 2014.

There are 14 sentinel sites in the Patapsco/Back River drainage and 8 sentinel sites in the Gunpowder River/Deer Creek drainage. The sentinel sites represent environmental variation over a range of watershed land use. Sentinel sites were sampled in 2003 and 2004, and 2006-2015. Figure 9-74 and Figure 9-75 show the mean BIBI scores for sentinel sites, by watershed, between 2003 and 2015. The biological condition of sentinel sites in the Patapsco/Back River drainage tended toward Poor and Very Poor ratings over the period of record. Liberty Reservoir sentinel sites were in the Fair category. The BIBI for Gunpowder River/Deer Creek sites were Fair to Good. Loch Raven BIBI varied from Poor to Fair. Lower Gunpowder BIBI varied between Very Poor and Poor.

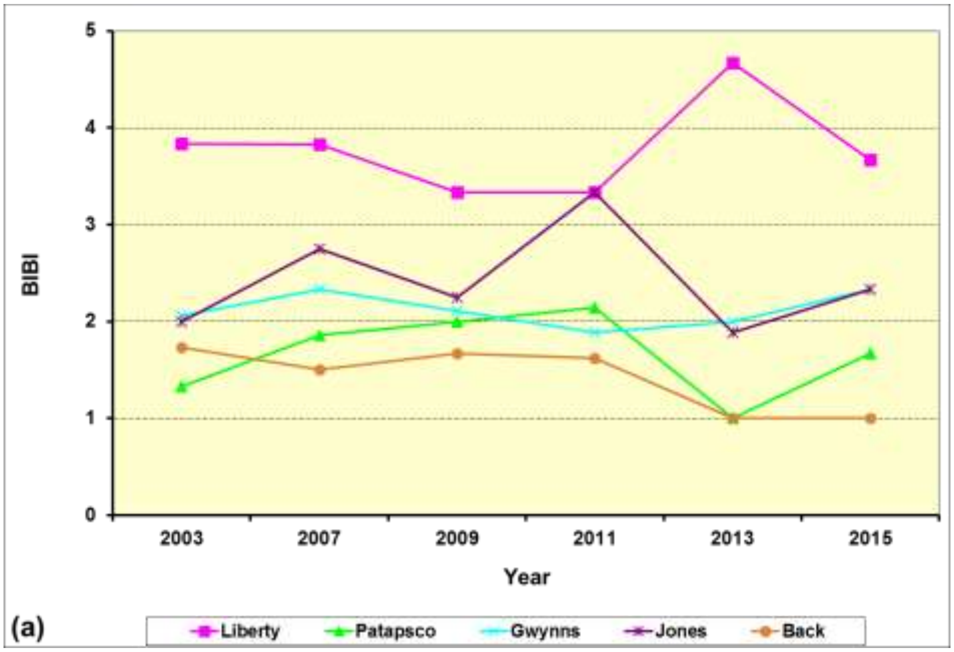


Figure 9-74: Mean BIBI scores for Patapsco/Back River Sentinel Sites between 2003 and 2015.

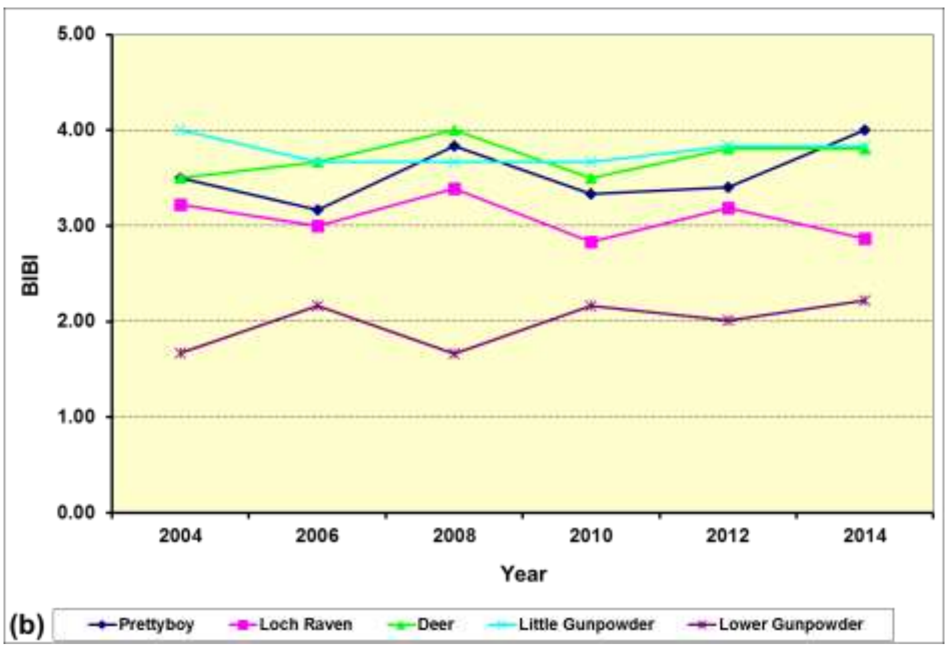


Figure 9-75: Mean BIBI scores for Gunpowder/Deer Creek Sentinel Sites between 2004 and 2014.

9.4.3.2 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

Probabilistic 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, Redhouse Run, and Spring Branch projects are currently monitored under the Capital Improvement Projects Monitoring Program. All monitoring site locations are displayed in Table 9-64.

Table 9-64: Stream Restoration Biological Monitoring Site Locations

Station	Stream and Location		
Minebank Run II Stream Restoration		**Lat**	**Long**
MNBK-1	Minebank Run upstream of Gunpowder River	-76.538880	39.421513
MNBK-4	Minebank Run upstream of bridge @ park	-76.554317	39.411404
JB-1	Jennifer Branch upstream of Gunpowder River	-76.500100	39.420145
JB-2	Jennifer Branch near archery range	-76.501365	39.414997
Redhouse Run Stream Restoration			
RH-1	Redhouse Run upstream of Twilight Court	-76.516626	39.344482
RH-3	Redhouse Run downstream of Raspe Avenue	-76.522042	39.348331

Benthic, fish, and physical habitat index values are shown in Table 9-65. Refer to this table in the following discussions of each project.

Table 9-65: BIB, FIBI, and PHI values for 2015 at Capital Programs Stream Restoration Projects

Project	Station	BIBI	FIBI	PHI
Minebank Run	MNBK-1	2.33	4.00	57
	MNBK-4	1.00	2.00	49
	JB-1	1.00		
	JB-2	1.33		
Redhouse Run	RH-1	2.33	3.00	60
	RH-3	2.33	3.00	44

The Minebank Run stream restoration project has been monitored annually since April 2004, at eleven sampling stations (Figure 9-76). 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. MNBK-1 restoration was completed in 2014 (Phase III). Stations JB-1, and JB-2 are controls. Only one site from Phase II was sampled in 2015 (MNBK-4). MNBK-1 (Phase III) was sampled. Fish were sampled at a sub-set of the stations: MNBK-1 and MNBK-4.

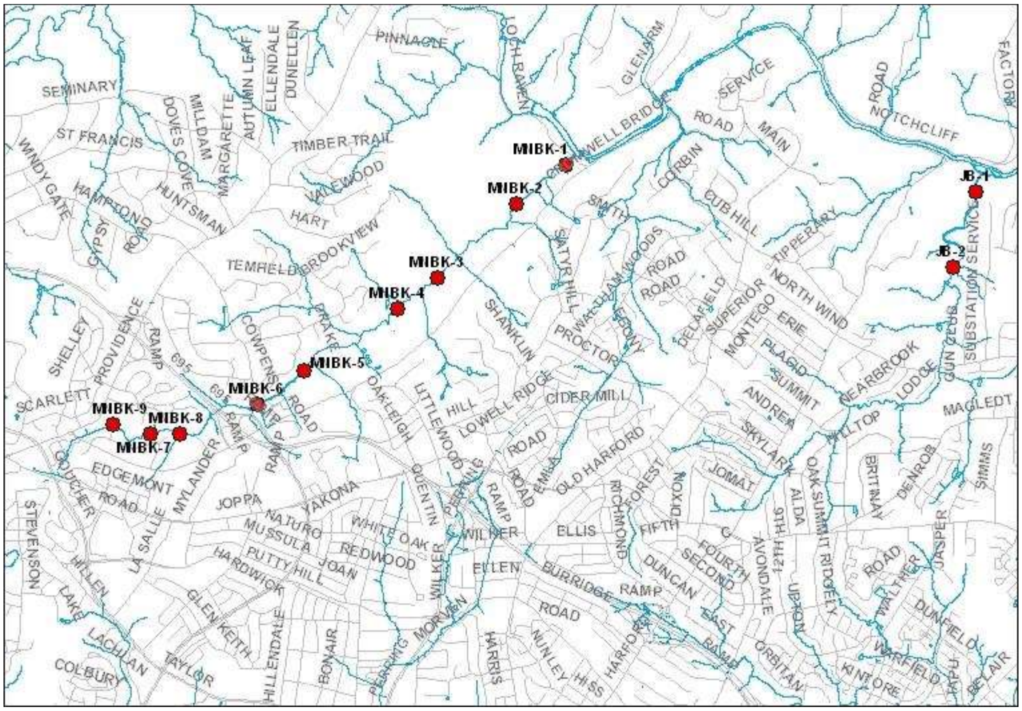
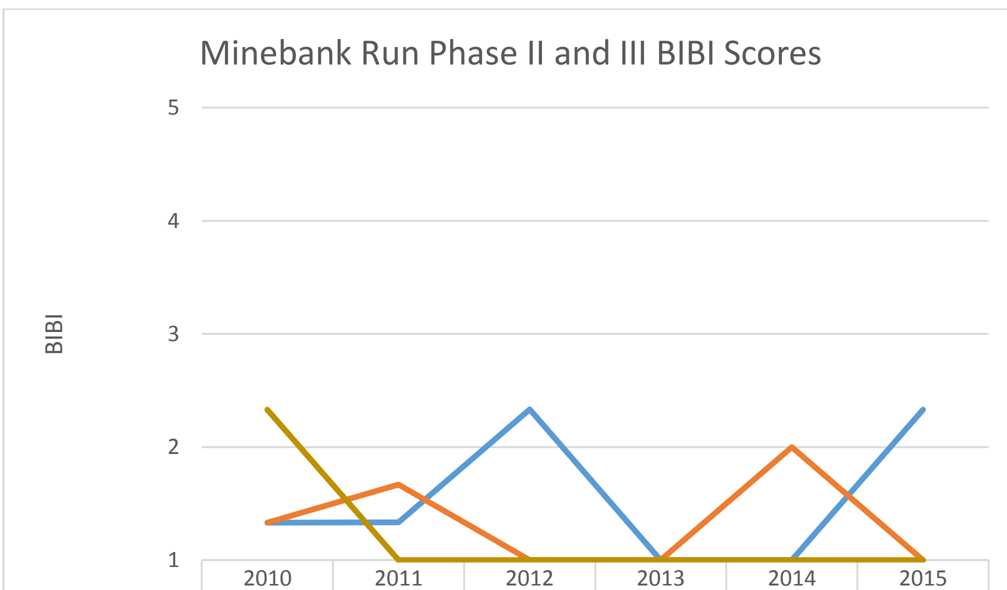


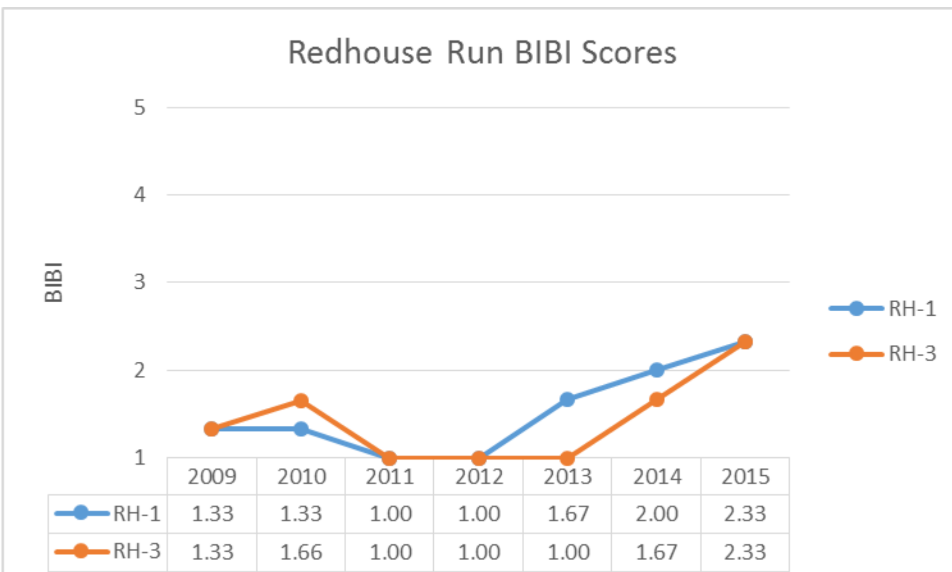
Figure 9-76: Minebank Run Biological Monitoring Stations



	2010	2011	2012	2013	2014	2015
MNBK-1	1.33	1.33	2.33	1.00	1.00	2.33
MNBK-4	1.33	1.67	1.00	1.00	2.00	1.00
JB-1	2.33	1.00	1.00	1.00	1.00	1.00

The BIBI score of 2.33 at MNBK-1 was most likely due to the disturbance to the stream channel during restoration construction and channel alteration from two years ago. The entire left bank and portions of the right bank were armored with large boulders. Wood debris and rootwads were placed in the stream in order to provide enhanced habitat for benthos and fish. Although the BIBI score is within the Poor Category, MNBK-1 has shown an improvement. MNBK-4 fell back into the Very Poor Category this year with a BIBI score of 1.00. The restoration structures that were placed at MNBK-4 during Phase II construction have become to dislodge from the stream banks. Also, more gravel and sand is being deposited in the reach reducing the habitat for benthos and fish. Jennifer Branch, the control for this project, continues to fall into the Very Poor Category with a BIBI score of 1.00.

Redhouse Run, a tributary of the Back River, was restored in early 2011. Pre-restoration monitoring of benthos and fish at three stations was completed in 2009 and 2010 (Figure 9-77). three years after restoration, Redhouse Run exhibits the biological and physical characteristics of an urbanized stream. Benthic and fish populations are depressed (all BIBI are rated Very Poor). The tropical storms of summer 2011 severely affected the biota of Redhouse Run at a time when the communities were attempting to stabilize shortly after restoration. RH-2 was dropped as a sampling station during 2012 because a long reach of the restoration was damaged during stormflows. The damage will not be repaired, which makes this a poor reach with which to evaluate the effects of restoration. Benthos were sampled in 2015, and both sites' BIBI scores continue to improve. However, RH-1 and RH-3 are still within the Poor Category with BIBI scores of 2.33.



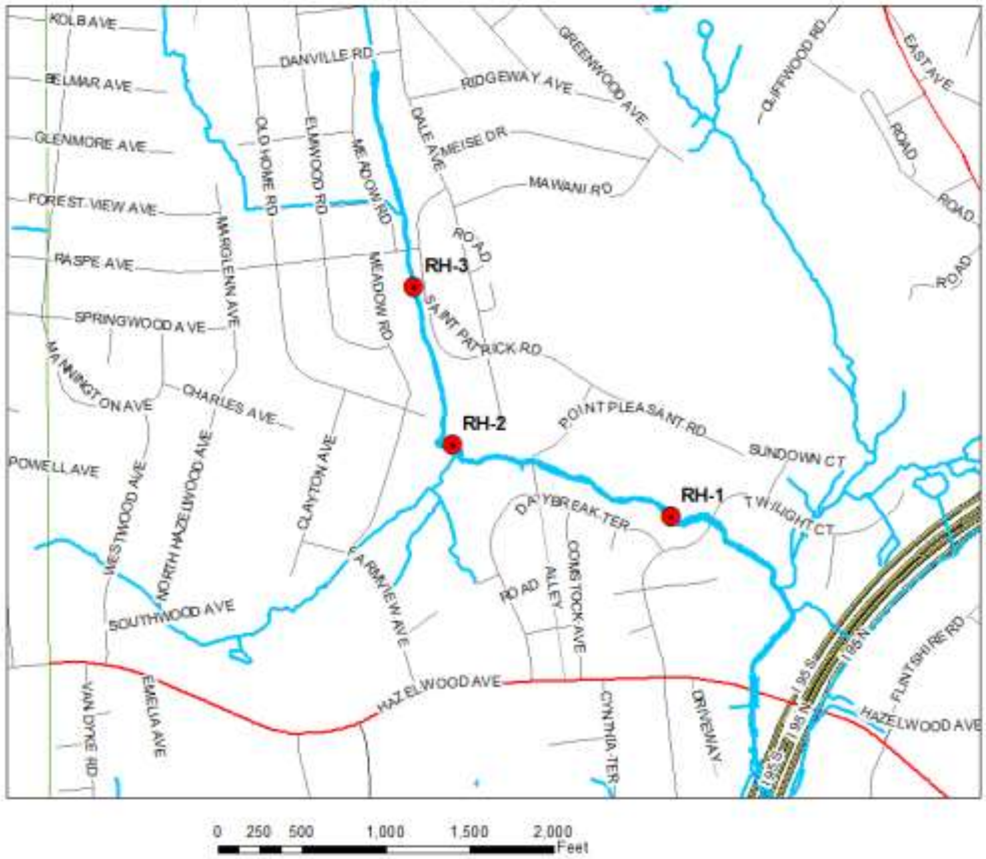


Figure 9-77: Redhouse Run Biological Monitoring Station Locations

9.4.3.3 <u>Reference Site Monitoring</u>

Baltimore County has been monitoring six (6) 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 latitude and longitude site locations, along with the stream name are displayed in Table 9-66.

Table 9-66: Reference Site Locations

Station	Stream Name and Location	Lat	Long
REF-004	Poplar Run upstream of Gunpowder Road	-76.781047	39.661848
REF-009B	Springhouse Run downstream of Gunpowder Rd	-76.771473	39.676285
REF-012	Panther Branch upstream of Gunpowder Falls	-76.642492	39.606599
REF-013	Mingo Branch upstream of Gunpowder Falls	-76.673612	39.605859
REF-017	Sunnyking Run near Sunnyking Drive	-76.824300	39.416937
REF-019	Fourth Mine Branch upstream of Stablers Church Road	-76.642243	39.655567

The six 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, and the Maryland BIBI is calculated. Fish sampling is done only periodically to reduce stress to the naturally reproducing trout populations inhabiting these streams. All reference sites had BIBI values in the Fair to Good range in 2015 (Figure 9-78), although BIBI values have varied in relation to climactic factors over the period of record. The cycles in benthic populations are largely the result of climactic cycles (precipitation and temperature). However, the streams differed in their response to environmental conditions due to the unique characteristics of each stream (geology and land use). Extreme precipitation years were 2001-2002 (drought), 2003 (very wet), 2007 (drought), and 2009 (very wet). The expectation is that aquatic organisms will be negatively impacted most during these extremes of weather. Drought reduces habitat availability due to decreased water levels and increases water temperature. Water temperature is critical in cold-water streams, where many of the organisms are adapted for cooler temperatures. The reference streams clearly responded to the droughts of 2007. Biological condition in 2003 at all but Poplar (REF-004) and Charles (REF-015) Runs rated Fair or worse. In 2008, the condition of most streams decreased, and was largely Fair or worse. The wet year (2009) initiated a return to Good biological condition at all but Panther Branch (REF-012). Land use also influences the response of the reference streams. Baisman Run (REF-001), Panther Branch (REF-012), and Mingo Branch (REF-013) are the most urban of the reference streams. Baisman Run is located west of Hunt Valley, MD, in a suburban setting. Panther Branch originates at Interstate 83, York Road, and Monkton Road. Mingo Branch's headwaters drain Interstate 83 and Mount Carmel Road. These streams are subject to high storm flows and stormwater pollutants, which cause physical damage to stream banks and riparian zones, and degrade instream habitat. This may, in part, explain the wider annual fluctuations biological condition in these streams. Fourth Mine Branch (REF-019) is the most agricultural of the reference streams, and is subject to high sediment and nutrient loads during storms. In 2015, the PHI score dropped in the degraded category due to an increase in silt and sand moving into the sample reach. It also had widely fluctuating annual BIBI values. Sunnyking Run (REF-017) is unique among the reference streams and most other Baltimore County streams in that it is underlain by serpentine rock. Serpentine is naturally high in metals and low in nutrients. This could make it difficult for benthic populations to recover after extreme climactic events. However, Sunnyking Run rebounded from the 2007 wet year by improving the BIBI value from Poor to Good. Stream physical habitat index (PHI) values have not varied as widely as BIBI values (Figure 9-79). Most PHI values have remained in the minimally or partially degraded categories. Differences in physical habitat appear related to the differences in stream features discussed above. Streams with more human influence have more degraded physical habitat. The reference station suite illustrates the benefits of forested land and functional stream buffers.

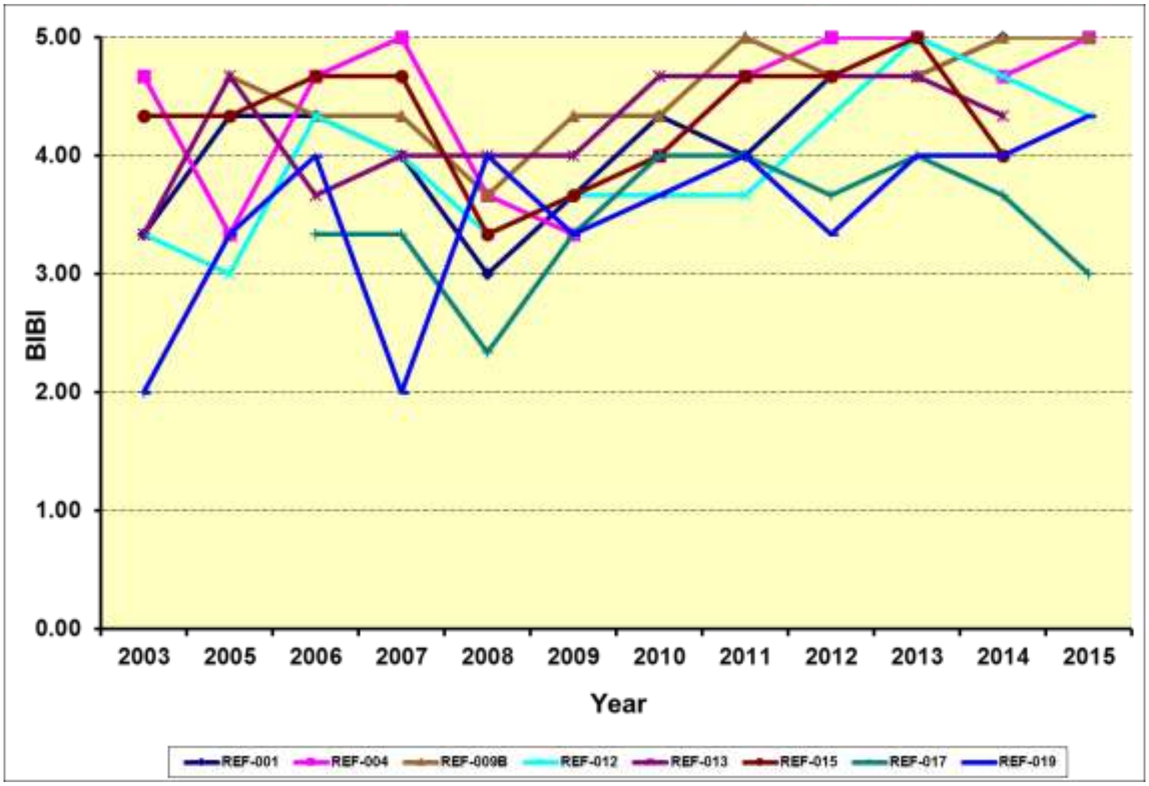


Figure 9-78: Benthic IBI values for Reference Sites, 2003-2015

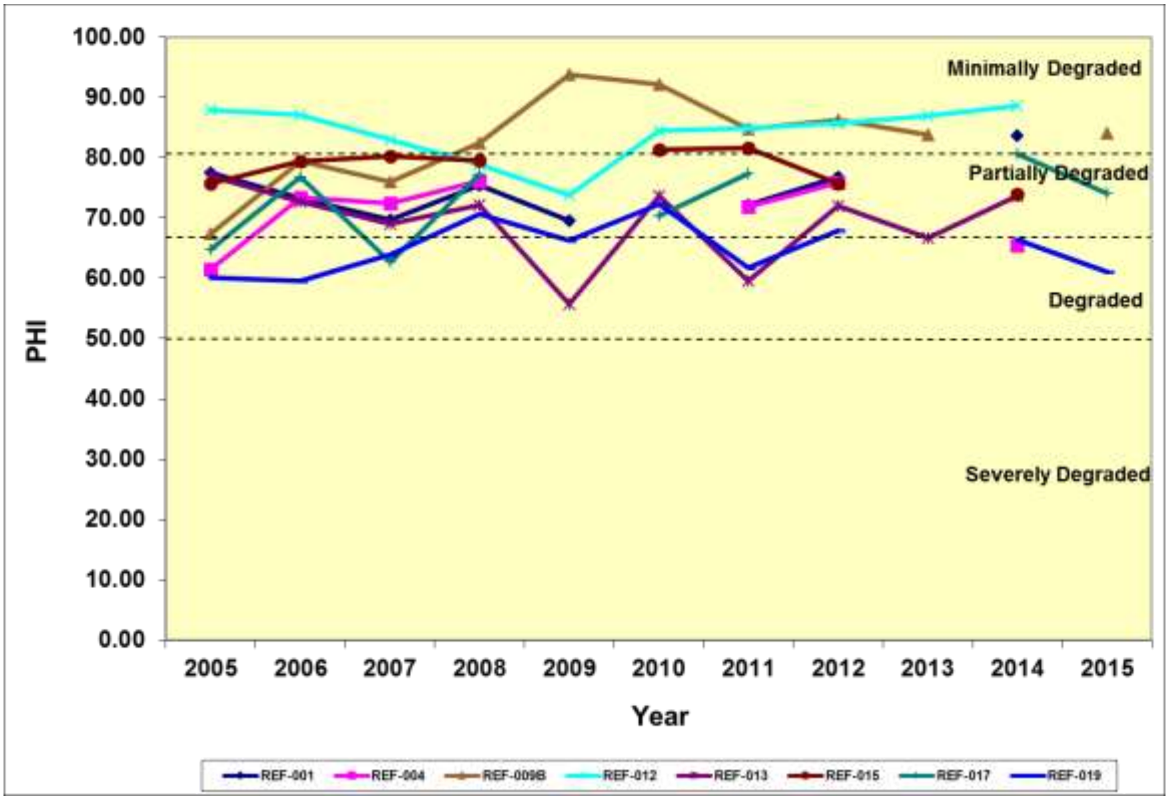


Figure 9-79: Physical Habitat Index values for Reference Sites, 2005-2015

9.4.3.4 Tidal Benthic Monitoring

In 2013, Baltimore County added Tidal Random Sampling to its County wide monitoring program. The tidal sampling occurs biennially, in the same year as the stream sites within the Patapsco/Back River and Gunpowder River Basins. The 25 tidal benthic samples were sampled from July 15 to September 30, 2015 and followed the methods established by the Maryland Department of Natural Resources (DNR) for its Chesapeake Bay Long-Term Monitoring and Assessment Program. The four tidal subestuary systems sampled in the Patapsco/Back River Basin for 2015, were Bear Creek, Old Road Bay, Shallow Creek, and Back River. All samples were taken from unvegetated soft substrates (sand or mud) using a Young Grab with a sampling area of 0.044 m^2 to a depth of 10 cm.

Along with the macroinvertebrate data, the bottom water quality and sediment characteristics were sampled. Baltimore County required the consultant to calculate the percent silt/clay, percent total organic carbon (TOC), and percent nitrogen in conjunction with the 25 tidal benthic samples. All the specimens were identified to the lowest practical taxonomic category as required by the MD DNR Long Term Benthic Program.

The Chesapeake Bay Benthic Index of Biological Integrity (BIBI) is calculated by scoring each of several attributes of benthic community structure and function (abundance, biomass, Shannon diversity, etc.) and then the scores are averaged across attributes to form the index (Table 9-67). Samples with index values of 3.0 or more are considered to have good benthic condition, indicative of good habitat quality. The BIBI was designed to account for varying salinities and substrates which effect benthic community structure. There are five salinity classes, however only three are applicable for Baltimore County tidal waters, which are the Tidal Freshwater (0-0.5 ppt), Oligohaline (≥0.5-5.0 ppt), and Low Mesohaline (≥ 5.0–12.0 ppt) ranges.

Table 9-67: Metrics used for Tidal IBI Calculations

Metrics Used in BIBI Calculations	Tidal Freshwater	Oligohaline	Low Mesohaline
Percent abundance of deep-deposit feeders	X		
Tolerance Score	X	X	
Percent Abundance of Pollution-Sensitve Taxa		X	
Percent Abundance of Carnivores & Omnivores		X	
Tanydodini to Chironomidae per abundance ratio		X	
Total Species Biomass			X
Shannon-Weiner Diversity Index			X
Percent biomass of tollution-sensitive taxa			X
Total Specied Abundance	X	X	X
Percent Abundance of Pollution Indicative Taxa	X	X	X
Total Metrics in Score	4	6	5

The results from the 2014 and 2015 tidal benthic samples can be seen in Table 9-68 and Table 9-69. In 2014 60% of the samples met the restoration goal with a BIBI score above a 3.0, however 32% of the samples were below a 2.1 BIBI score indicating a degraded condition. In 2015 48% of the samples met the restoration goal, with 32% of the samples in a degraded condition and 20% of the samples in a severely degraded condition. All of the sites sampled had at least one sample that met the restoration goal of 3.0 except for Bear Creek (Figure 9-80). Overall, the average BIBI scores for 2014 met the restoration goal of 3.0 BIBI scores in both Browns Cove and Middle River (Figure 9-81). However, in 2015 the average BIBI scores fell below the impairment threshold of 3.0 (Figure 9-82). Next years report will include a four year comparison of the four tidal segments.

Table 9-68: 2014 Tidal BIBI Results

Station	Salinity (ppt)	% siltclay	% TOC	% N	Salinity Class	Substrate Class	Tidal BIBI Score	Condition
BC-14-02	3.50	71.08	2.13	0.25	OH	MUD	3.67	Meets Restoration Goal
BC-14-03	3.42	52.48	2.02	0.22	OH	MUD	3.67	Meets Restoration Goal
BR-14-01	0.18	43.59	3.39	0.35	TF	MUD	3.00	Meets Restoration Goal
BR-14-02	0.16	88.21	3.85	0.38	TF	MUD	2.00	Severely Degraded
BR-14-03	0.12	91.62	4.53	0.39	TF	MUD	3.50	Meets Restoration Goal
BR-14-04	0.11	93.15	4.44	0.43	TF	MUD	2.00	Severely Degraded
BR-14-05	0.13	35.18	2.35	0.35	TF	SAND	2.50	Degraded
GR-14-01	3.11	71.80	2.58	0.33	OH	MUD	3.00	Meets Restoration Goal
GR-14-02	2.44	87.04	3.03	0.36	OH	MUD	2.00	Severely degraded
GR-14-03	2.68	89.98	5.28	0.52	OH	MUD	3.00	Meets Restoration Goal
GR-14-04	1.63	85.32	4.80	0.46	OH	MUD	2.33	Degraded
GR-14-05	1.89	81.67	5.35	0.48	OH	MUD	3.67	Meets Restoration Goal
GR-14-06	1.90	82.87	4.35	0.41	OH	MUD	3.00	Meets Restoration Goal
GR-14-07	3.53	93.13	5.37	0.52	OH	MUD	2.67	Marginal
MR-14-01	3.03	81.06	5.01	0.42	OH	MUD	3.00	Meets Restoration Goal
MR-14-02	2.62	41.67	3.35	0.34	OH	MUD	3.67	Meets Restoration Goal
MR-14-03	2.32	35.92	2.04	0.24	OH	SAND	4.00	Meets Restoration Goal
MR-14-04	2.16	91.19	2.58	0.40	OH	MUD	4.00	Meets Restoration Goal
MR-14-05	2.09	86.56	2.35	0.28	OH	MUD	3.67	Meets Restoration Goal
MR-14-06	1.88	88.87	3.30	0.32	OH	MUD	2.67	Marginal
MR-14-07	1.93	54.57	3.67	0.38	OH	MUD	3.00	Meets Restoration Goal
MR-14-08	1.83	19.20	1.81	0.21	OH	SAND	2.33	Degraded
MR-14-09	2.34	93.19	5.18	0.46	OH	MUD	3.50	Meets Restoration Goal
MR-14-10	1.56	26.55	1.83	0.16	OH	SAND	2.00	Severely Degraded
MR-14-11	1.61	76.58	1.83	0.24	OH	MUD	2.20	Degraded

Table 9-69: 2015 Tidal BIBI Results

Station	Salinity (ppt)	% siltclay	% TOC	% N	Salinity Class	Substrate Class	Tidal BIBI Score	Condition
OR-15-01	7.21	77.12	3.65	0.27	LM	MUD	3.40	Meets Restoration Goal
OR-15-02	6.10	71.69	3.44	0.25	LM	MUD	1.40	Severely Degraded
OR-15-03	7.79	88.10	4.23	0.35	LM	MUD	1.00	Severely Degraded
BC-15-26	6.59	44.16	2.14	0.19	LM	MUD	1.80	Severely Degraded
BC-15-27	5.84	82.04	4.04	0.28	LM	MUD	1.00	Severely Degraded
BC-15-28	7.21	79.40	3.89	0.27	LM	MUD	2.20	Degraded
BC-15-29	7.03	66.88	2.58	0.22	LM	MUD	2.60	Degraded
BR-15-06	2.26	89.89	4.25	0.35	OH	MUD	2.33	Degraded
BR-15-07	0.53	90.19	4.29	0.39	OH	MUD	3.00	Meets Restoration Goal
BR-15-08	2.88	86.45	4.15	0.34	OH	MUD	3.00	Meets Restoration Goal
BR-15-09	1.47	90.14	4.28	0.37	OH	MUD	3.00	Meets Restoration Goal
BR-15-10	1.42	90.45	4.30	0.38	OH	MUD	3.00	Meets Restoration Goal
BR-15-11	2.21	44.51	2.35	0.21	OH	MUD	3.33	Meets Restoration Goal
BR-15-12	1.95	93.77	5.37	0.51	OH	MUD	3.33	Meets Restoration Goal
BR-15-13	0.64	93.25	5.29	0.48	OH	MUD	2.20	Degraded
BR-15-14	0.94	84.45	4.17	0.34	OH	MUD	2.00	Severely Degraded
BR-15-15	0.61	93.24	5.18	0.46	OH	MUD	3.33	Meets Restoration Goal
BR-15-16	0.77	90.98	4.43	0.41	OH	MUD	2.33	Degraded
BR-15-17	0.98	91.99	5.01	0.46	OH	MUD	3.00	Meets Restoration Goal
BR-15-18	1.72	91.82	4.79	0.43	OH	MUD	3.33	Meets Restoration Goal
BR-15-19	0.98	90.54	4.29	0.39	OH	MUD	2.33	Degraded
BR-15-20	3.33	83.79	4.12	0.32	OH	MUD	3.40	Meets Restoration Goal
BR-15-21	0.86	91.17	4.53	0.42	OH	MUD	2.33	Degraded
SC-15-32	4.12	93.30	5.36	0.52	OH	MUD	3.33	Meets Restoration Goal
SC-15-33	4.08	90.61	4.35	0.40	OH	MUD	2.20	Degraded

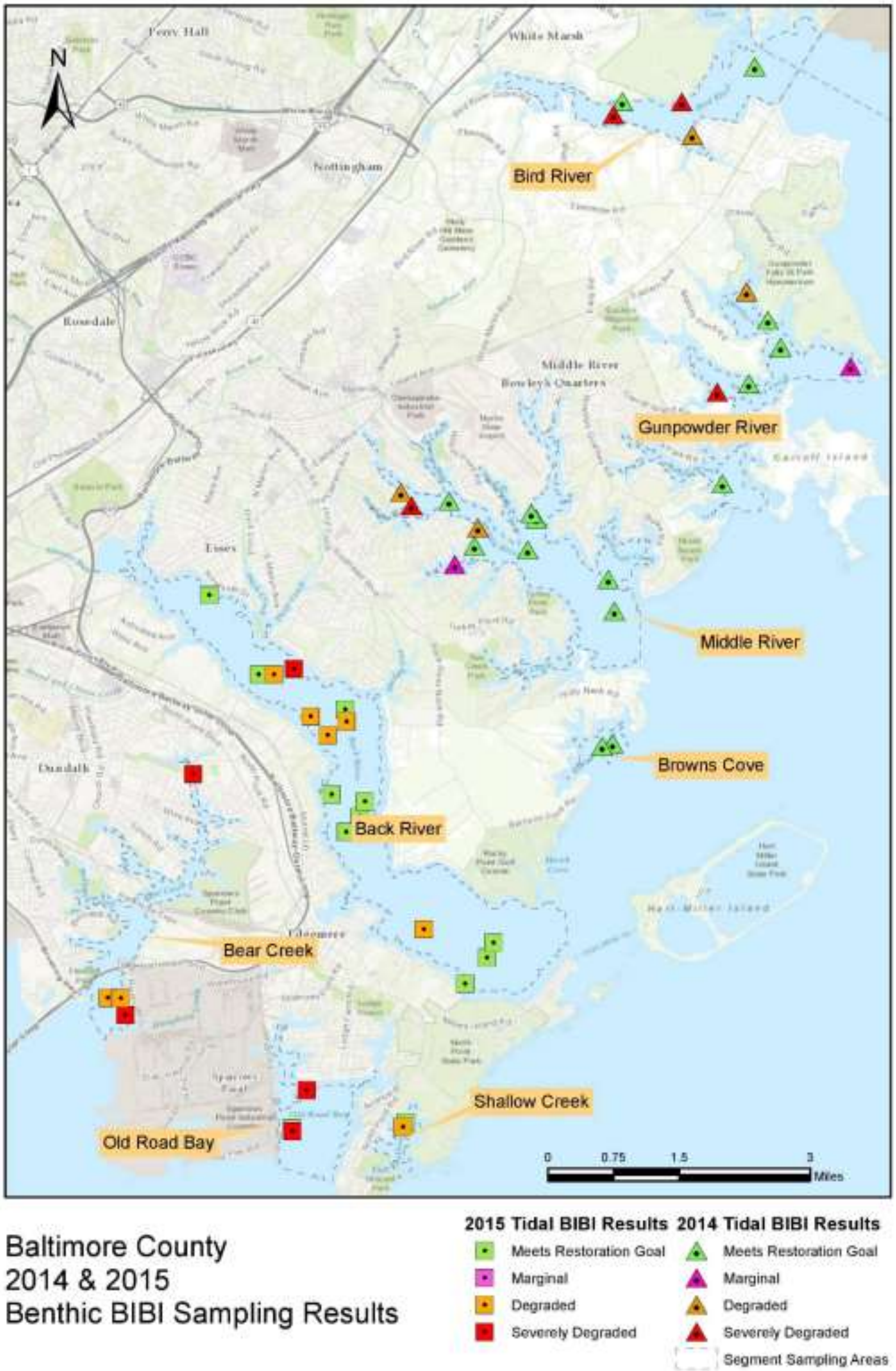


Figure 9-80: Map of 2014 and 2015 tidal benthic sample results

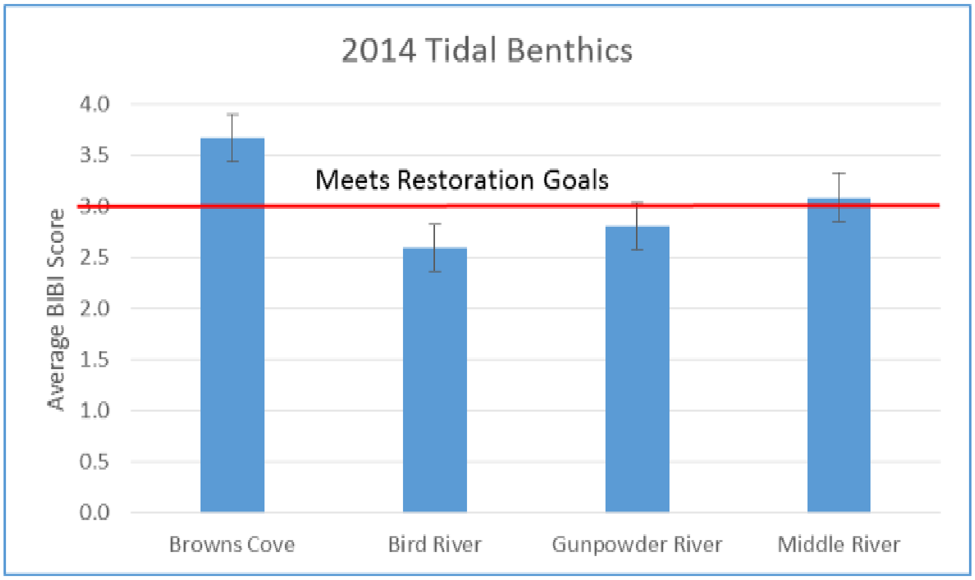


Figure 9-81: 2014 Average Tidal BIBI Scores for Each Tidal System

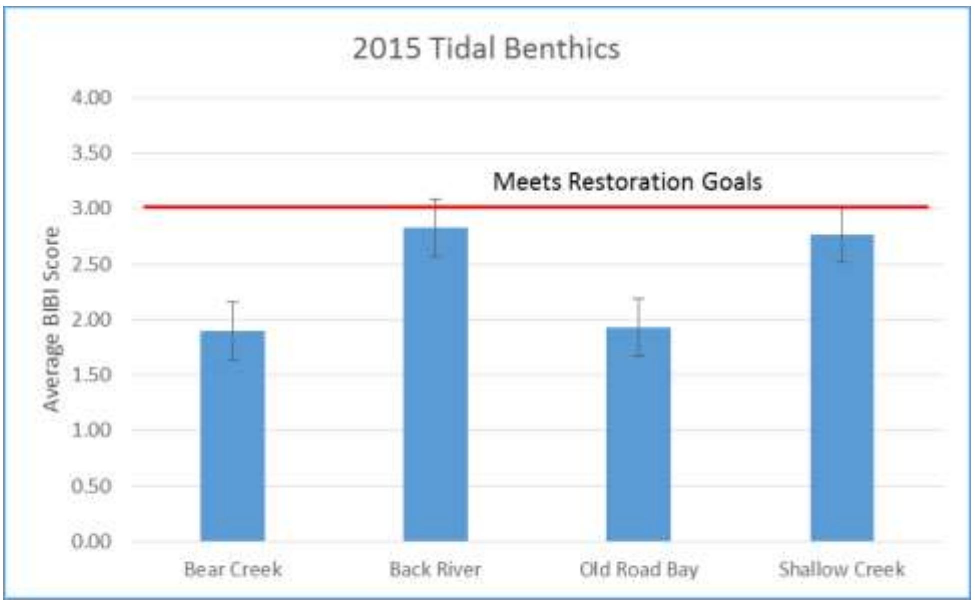


Figure 9-82: 2015 Average Tidal BIBI Scores for Each Tidal System

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. 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 9-70). Water clarity data is currently not collected in Baltimore County, so only the SAV acreage will be used.

The 2009 Triennial Review of Water Quality Standards proposed 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:

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

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 entirely surveyed for SAV coverage and so, like the other five segments this analysis will only provide a conservative estimate of SAV criteria attainment. Table 9-70 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 green highlighted cells are the highest percent attainment for each water quality segment based on the last three years of data.

Table 9-70: SAV Standards and Baltimore County SAV Monitoring Results (2013-2015)

Water Quality Segment	SAV Goal (Acres)	Water Clarity Depth (m)	2013		2014		2015	
			Acres	% of Goal	Acres	% of Goal	Acres	% of Goal
MIDOH	**879**	**2.0**	**435.8**	49.6	**645.1**	73.3	**868.3**	98.8
GUNOH1	**1,860**	**0.5**	**	**	**	**	**	**
GUNOH2	**572**	**2.0**	**204.5**	37.8	**422.5**	73.9	**551.0**	96.3
BACOH	**340**	**0.5**	**0.0**	0.0	**3.2**	0.9	**19.7**	5.8
PATMH	**389**	**1.0**	**3.4**	0.9	**32.0**	8.2	**40.6**	10.4
CB2OH	**705**	**0.5**	**138.0**	19.6	**138.9**	19.7	**176.9**	25.1
CB3MH	**1,370**	**0.5**	**76.0**	5.5	**122.6**	8.9	**143.8**	10.5
Total SAV Acres	**6,115**		**857.7**		**1,364.3**		**1,800.3**	

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

Overall the 2015 SAV monitoring year shows a continuing trend of increased coverage of SAV over the last three years. The Middle River segment (MIDOH) continues to have one of the highest amount of SAV coverage, and shows a continued increase in the acres of coverage; from 435.8 acres in 2013 to 868.3 acres in 2015. Overall, all segments showed an increase in SAV coverage. All of the segments had the highest three year coverage recorded in 2015, with two segments reaching over 95% of the SAV goal (MIDOH and GUNOH2).

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 9-83 displays the trends in SAV coverage over 25 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 37.0% in 2009. The 2010 SAV coverage was reduced to 35.2% and further reduced in 2011 to 30.4%, in 2012 to 24.5% and in 2013 to 11.2%. However, 2014 showed an increase in coverage with 23%, with a continuing trend in 2015 showing a coverage of 28%. 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.

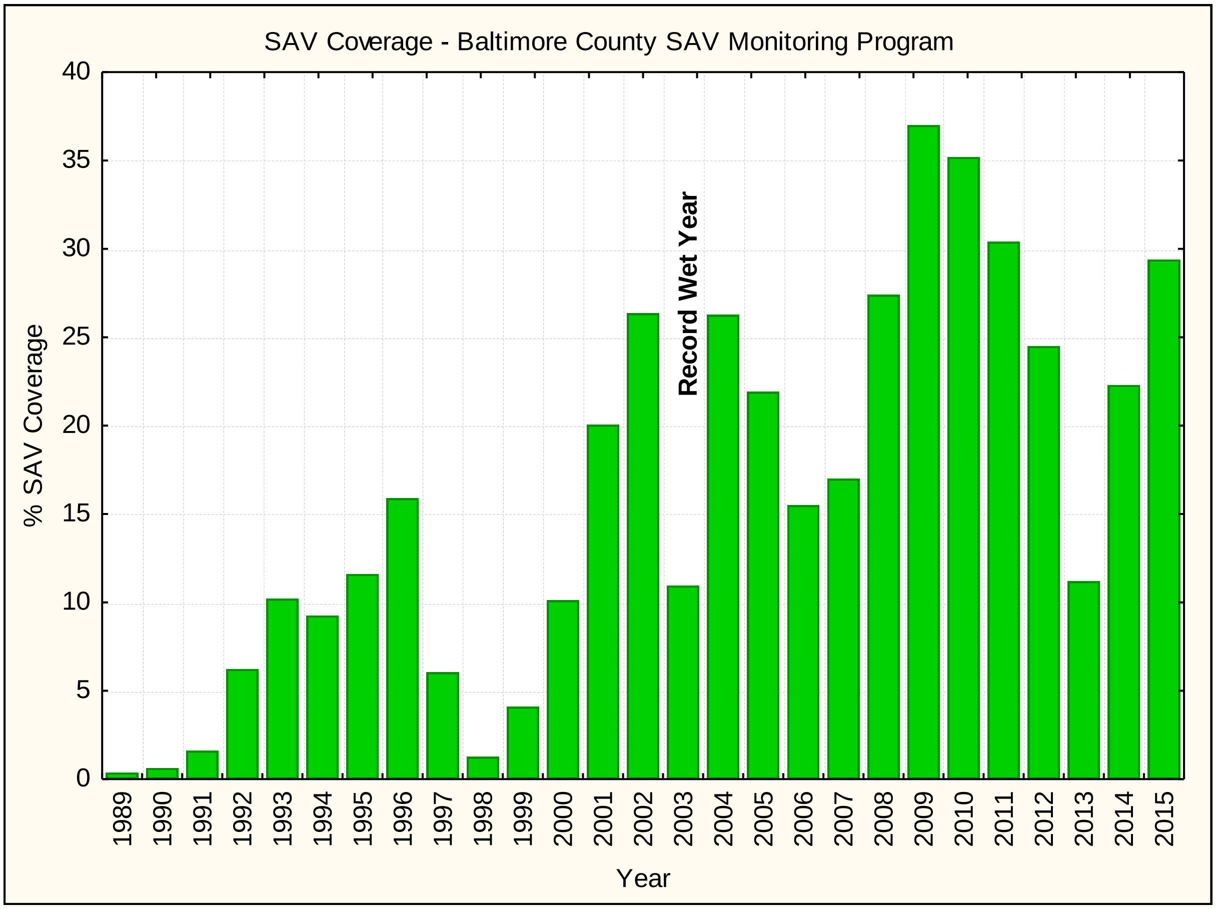


Figure 9-83: Baltimore County SAV Monitoring Program – Trends in % Coverage

Appendix 9-1: Results of 2015 Probabilistic Monitoring

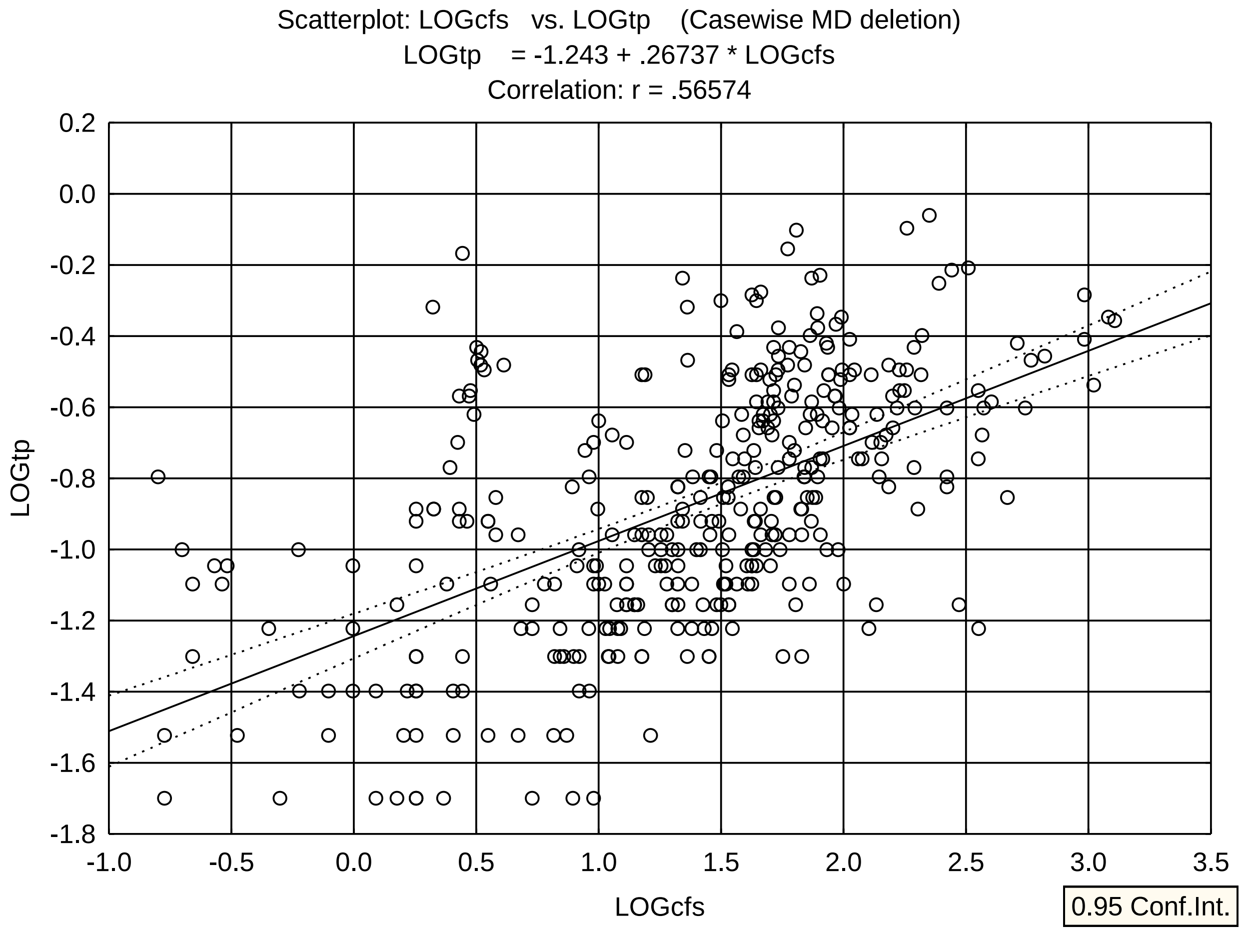
StationID	Subwatershed	DNR 12digit Subsheds	Benthic Index of Biotic Integrity Score	Rating	Y	X
Prettyboy Reservoir						
0214001	Walker Run	021308060316	5.00	Good	39.710347	-76.774884
0214002	Georges Run	021308060314	3.33	Fair	39.6189	-76.794933
0214003	UNT Peggy's Run	021308060314	3.67	Fair	39.609892	-76.799503
0214004	UNT Prettyboy Branch	021308060313	4.33	Good	39.615601	-76.734757
0214005	Grave Run	021308060315	4.00	Good	39.650112	-76.811857
Loch Raven Reservoir						
0314001	Piney Run	021308050308	3.00	Fair	39.554473	-76.792789
0314002	UNT Gunpowder Falls	021308050306	4.67	Good	39.616407	-76.670298
0314003	UNT Dulaney Branch	021308050300	4.67	Good	39.473753	-76.542233
0314004	Slade Run	021308050303	3.67	Fair	39.495798	-76.791593
0314006	Piney Run	021308050308	2.00	Poor	39.56719	-76.804429
0314007	Western Run	021308050303	4.00	Good	39.526129	-76.716482
0314008	Beaverdam Run	021308050302	4.67	Good	39.476079	-76.668906
0314009	UNT Western Run	021308050303	4.67	Good	39.53718	-76.708679
0314010	Piney Run	021308050308	1.67	Very Poor	39.576388	-76.812122
0314011	Bush Cabin Run	021308050306	3.67	Fair	39.608426	-76.68975
0314012	Gunpowder Falls	021308050306	3.33	Fair	39.614327	-76.659856
0314013	Indian Run	021308050307	3.00	Fair	39.546542	-76.743163
0314014	Little Falls	021308050309	2.33	Poor	39.636784	-76.65342
0314015	McGill Run	021308050308	3.33	Fair	39.543083	-76.823101
0314016	Piney Run	021308050308	3.33	Fair	39.532142	-76.769323
0314017	UNT Charles Run	021308050306	4.67	Good	39.584842	-76.584473
0314018	UNT McGill Run	021308050308	4.33	Good	39.524722	-76.791803
0314019	Blackrock Run	021308050303	3.33	Fair	39.538478	-76.729401
0314020	UNT Piney Creek	021308050305	4.00	Good	39.579832	-76.685773
0314021	UNT Western Run	021308050303	4.33	Good	39.539302	-76.708054
0314022	UNT Western Run	021308050303	5.00	Good	39.51203	-76.732858
0314023	Deadman Run	021308050303	4.33	Good	39.502303	-76.742488
0314024	Gunpowder Falls	021308050304	3.67	Fair	39.52588	-76.627646
0314025	UNT Dulaney Branch	021308050300	5.00	Good	39.477212	-76.530828

StationID	Subwatershed	DNR 12digit Subsheds	Benthic Index of Biotic Integrity Score	Rating	Y	X
0314026	UNT First Mine Branch	021308050309	5.00	Good	39.624119	-76.597216
0314027	UNT Little Falls	021308050312	4.00	Good	39.696191	-76.709923
0314028	First Mine Branch	021308050309	3.00	Fair	39.625316	-76.6072
0314029	Piney Run	021308050308	3.00	Fair	39.58426	-76.817246
0314044	Little Piney Run	021308050308	2.67	Poor	39.563697	-76.803842
Little Gunpowder Falls						
0914001	UNT Little Gunpowder Falls	021308040298	3.00	Fair	39.444442	-76.402317
0914002	Little Gunpowder Falls	021308040298	3.67	Fair	39.418989	-76.372484
0914003	Little Gunpowder Falls	021308040298	4.00	Good	39.478274	-76.412467
0914004	Little Gunpowder Falls	021308040299	3.33	Fair	39.601333	-76.561661
Lower Gunpowder						
1014001	UNT Cowen Run	021308020297	3.67	Fair	39.435881	-76.522803
1014002	Jennifer Branch	021308020297	2.33	Poor	39.404108	-76.506159
1014003	UNT Gunpowder Falls	021308020296	3.00	Fair	39.425265	-76.448922
1014005	UNT Gunpowder Falls	021308020296	2.67	Poor	39.410937	-76.411004
1014006	UNT Gunpowder Falls	021308020296	1.67	Very Poor	39.412577	-76.40096
1014004	UNT Gunpowder	021308020296	2.71	Poor	39.430649	-76.427048
Deer Creek						
0414001	UNT Little Deer Creek	021202020332	3.00	Fair	39.713323	-76.627023
0414002	UNT Deer Creek	021202020332	4.00	Good	39.684091	-76.571002
Bird River						
1114001	White Marsh Run	021308030295	1.57	Very Poor	39.379124	-76.468451
1114002	White Marsh Run	021308030295	1.57	Very Poor	39.366683	-76.432452
1114003	UNT White Marsh Run	021308030295	1.00	Very Poor	39.36517	-76.454354
1114004	Honeygo Run	021308030295	1.57	Very Poor	39.382083	-76.431287

Appendix 9-2: Trend Monitoring Sites by Watershed

Site ID	Subwatershed	Site ID	Subwatershed
Liberty Reservoir – 3 Sites			
LI-01	Cliffs Branch	LI-04	Norris Run
LI-02	Glen Falls Run		
Patapsco River – 5 Sites			
PA-04	Ben's Run	PA-15	Patapsco River Direct Drainage
PA-14	Herbert Run- East Branch		
Gwynns Falls – 5 Sites			
GW-01	Gwynns Falls – Glyndon	GW-11	USGS gage at Gwynnbrook Road
GW-04	Red Run	GW-12	Gwynns Falls Direct Drainage
GW-10	Dead Run – Mainstem		
Jones Falls – 3 Sites			
JF-07	Roland Run	JF-12	Lake Roland Reservoir
JF-11	Jones Falls		
Back River – 3 Sites			
HR-05	Herring Run	BR-05A	Stemmers Run
BR-01	Bread and Cheese Creek		
Middle River – 1 Site			
MR-03	Frog Mortar Creek		
Prettyboy Reservoir – 3 Sites			
PR02	Gunpowder Falls above Prettyboy	PR04	George's Run
PR03	Grave Run		
Loch Raven Reservoir – 13 Sites			
LR-11	Spring Branch	LR-24	Little Falls
LR-13	Beaver Dam Run – York Road	LR-27	Third Mine Branch
LR-14	Baisman Run	LR-30	Beetree Run
LR-17	Western Run	LR-35	Piney Run
LR-19	Overshot Run	LR-39	Slade Run
LR-22	Gunpowder Falls - Glencoe	LR-40	Gunpowder Falls
LR-23	Charles Run		
Lower Gunpowder Falls – 3 Sites			
GU-03	Haystack Branch	GU-08	Minebank Run
GU-05	Long Green Creek – Hartley Mill		
Little Gunpowder Falls – 1 Site			
LG-05	Little Gunpowder Falls		
Bird River – 3 Sites			
BI-01	Windlass Run	BI-03	Whitemarsh Run - Headwaters
BI-02	Honeygo Run		
Baltimore Harbor – 1 Site			
BH-07	Bear Creek		

Appendix 9-3: Example Regression Analysis Graph



SL-01 Total Phosphorus Data and Regressions for 2005-2015.

db