FREDERICK COUNTY
ASSESSMENT OF CONTROLS:
PETER PAN RUN MONITORING
JULY 2023 - JUNE 2024

Prepared for

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November 2024

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TABLE OF CONTENTS

Page

APPENDICES

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

1.0 INTRODUCTION

1.1 REGULATORY REQUIREMENT

The performance of long-term monitoring in Peter Pan Run fulfills requirements specified in Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit No. 11-DP-3321, MD0068357 and Permit No. 22-DP-3321, MD0068357. Permit No. 11-DP-3321 is a third-generation Phase I NPDES MS4 permit, which took effect December 30, 2014 and covers stormwater discharges from the municipal separate storm sewer system in Frederick County, was enforced by Maryland Department of the Environment (MDE) through December 29, 2019. Frederick County ended its existing permit on December 29, 2019 in compliance. MDE administratively extended the County's third generation MS4 Permit until December 30, 2022 when Permit No. 22-DP-3321, the fourth-generation permit, was executed by MDE. This monitoring report documents the monitoring activities at Peter Pan Run to meet requirements under Permit No. 22-DP-3321 during the reporting period of July 1, 2023 – June 30, 2024, the first complete monitoring year under the new permit.

For Permit No. 22-DP-3321, the Peter Pan Run monitoring meets Frederick County's NPDES MS4 permit obligations under Part IV, Standard Permit Conditions, Subpart G, Assessment of Controls. Specifically, the monitoring meets IV.G.1 – BMP Effectiveness Monitoring, as the watershed has been monitored before and after the retrofit of several stormwater management ponds in the study drainage area to detect changes over time in water quality and channel stability. The monitoring program in Peter Pan Run was designed to build a long-term database (currently 1999 to 2024) of water quality and biological conditions and to assess the cumulative effects of both stormwater runoff stemming from development and the implementation of restoration projects in the watershed.

1.2 DESCRIPTION OF STUDY AREA

With approval from the Maryland Department of the Environment (MDE), the County selected Peter Pan Run as the study stream to assess the effect of the construction of The Villages of Urbana planned unit development (PUD) within the headwaters on the stream's chemical, physical, and biological functions. Peter Pan Run is located within the Bush Creek watershed, which flows westward into the Monocacy River near Frederick Junction.

The Villages of Urbana is a mixed-use development consisting of 3,500 residential units, along with substantial commercial and office space. Initial construction activities within the PUD began in early 1999, with major construction activities beginning in August of that year. Estimates in the County's regional plan (FCDPZ 2004) indicated that between 200 and 300 new residential lots would be recorded each year in the Urbana PUD, accounting for most of the expected growth within the Urbana Planning Region through 2010. During fiscal year (FY) 2020, construction of the PUD was completed with all sections occupied by residents. Washington Square at Villages of Urbana, located along Urbana Pike, was the last residential section that was completed in 2019. No new commercial development occurred in the PUD since fiscal year 2020. Figures 1-1 and 1-2 provide a series of aerial photographs illustrating changes in land use that have occurred within the study portion of the watershed of Peter Pan Run over the course of the PUD's development.

1.3 LONG-TERM MONITORING PLAN

In May 1999, the County initiated a long-term monitoring program for the Peter Pan Run study area to establish baseline and pre-construction conditions in the watershed, and subsequently monitor conditions as development progressed (Figure 1-1) within watershed to assess potential long-term impacts associated with changes in land use. The program involves monitoring flow volumes and water quality from both instream and SWM pond outfall stations, as well as collecting physical and biological data from four permanent stream monitoring stations on the mainstem and its tributaries (Figure 1-2). Monitoring is focused on the long-term stream and watershed degradation commonly associated with residential development, and their potential to occur within Peter Pan Run. These potential problems include sedimentation and erosion resulting from increased runoff from impervious surfaces, pollutant runoff from roads and parking lots, elevated nutrient loading caused by the application of lawn fertilizers, and the illegal disposal of oil and other household chemicals via storm drains.

Frederick County has compiled data to characterize the watershed upstream of the Peter Pan Run instream monitoring station (PPAN-01) and the Pond-R (BMP NPDES # 199FR) outfall station. Data on watershed area, land uses, and station location are provided in the geodatabase that comprises the County's MS4 Annual Report submittal. Land use was derived from 2010 Maryland Department of Planning GIS data, which is the most recent data available. At present, the County's SWM database indicates that 89 structural SWM facilities (22 extended detention dry ponds, 27 extended detention wet ponds, 15 bioretention practices, nine sand filters, five underground filters, four permeable pavements, two grass swales, two shallow marshes, one infiltration trench, one wet pond, and one bio-swale) have been constructed within the Peter Pan Run watershed area. These data will be updated in future years as needed.

In 2018, Frederick County began retrofitting 15 extended detention dry ponds to extended detention wet ponds or surface sand filters in the Peter Pan Run watershed. Retrofits of all stormwater facilities were completed by the end of 2019 and are summarized in Table 1-1 below. A more detailed breakdown of the pond retrofit construction schedule, including the different phases of monitoring used for data analysis (i.e, pre-construction, during construction, post-construction/pre-vegetation, and post-construction) is included in Figure 1-3. Due to high infiltration rates at some retrofit sites, some of the intended designs from extended detention dry ponds to extended detention wet ponds have been modified to sand filters to achieve water quality benefits and are noted below in the table as such. As these retrofits become functional, this study will look to assess the impact of their performance in the watershed. To date, the County has collected 17 years of pre-construction condition (2001-2017) data, 2 years of retrofit conditions (2018-2019) data, and 5 years of post-construction conditions (2020-2024) data. Data include chemical monitoring at the instream station and the Pond-R monitoring station, and physical (geomorphic) and biological monitoring at four instream locations.

Monitoring activities within the study area were initially described in the County's *Long-Term Monitoring Plan for the Peter Pan Run Watershed, Frederick County, Maryland* (Southerland et al. 1999), which laid out methods for biological, physical, and water chemistry monitoring of the stream. To keep pace with the changing program needs and evolving science, Frederick County continues to make periodic revisions and improvements to its monitoring efforts, as documented in the County's MS4 Annual Reports.

Two quality assurance/quality control documents have been developed for the County's monitoring efforts: *Quality Assurance Project Plan for Water Chemistry Monitoring in Peter Pan Run* (Drescher 2024), and *Quality Assurance Project Plan for Biological and Physical Monitoring in Peter Pan Run* (Drescher 2020). A Quality Assurance Project Plan (QAPP) is developed for monitoring projects and describes in detail the quality assurance (QA) and quality control (QC) procedures that will be implemented to standardize data collection and minimize error. The QAPP ensures the gathering of high quality, accurate data that will meet a study or project's objectives and goals. It also serves as a reference to guide field crews or when questions arise about field or laboratory procedures. The two 2020 and 2024 QAPPs are updated versions of the QAPPs originally developed by Versar (Jones & Roth, 2005; Morgan & Roth, 2005). The QAPP for Water Chemistry Monitoring was updated in FY2024 to reflect the new permit requirements of Permit No. 22-DP-3321.

Table 1-1. Pond retrofits completed within the Peter Pan Run watershed area

Peter Pan Run Pond Retrofit Project Name	REST BMP ID	REST BMP Type	BMP Class	# of BMPs	Impervious Acres Treated	Built Date
Villages of Urbana, Sec. M - 5, Pond 'C' - Retrofit	FR17RST000077	PWED	S	1	14.53	1/9/2019
Villages of Urbana, Section M-10, SWM Pond 'R' - Retrofit	FR17RST000199	PWED	S	1	15.31	1/9/2019
Villages of Urbana, Village I, Pond B - Retrofit	FR17RST000060	PWED	S	1	9.05	1/9/2019
Villages of Urbana, Sec. M-8, Pond M1 - Retrofit	FR17RST000186	PWED	S	1	10.98	4/30/2019
Villages of Urbana, Section K4, Pond 'FF' - Retrofit	FR17RST000197	PWED	S	1	2.64	4/30/2019
Villages of Urbana, Village 1, Pond F - Retrofit	FR17RST000046	PWED	S	1	4.60	5/20/2019
Villages of Urbana, Sec. K - 2, Pond 'J' - Retrofit	FR17RST000078	PWED	S	1	11.28	6/1/2019
Villages of Urbana, Village V, Sec. K3, Pond "L" - Retrofit	FR17RST000039	PWED	S	1	7.10	6/1/2019
Urbana Highlands, Sec. P3 - SWM Pond 'PA' - Retrofit	FR17RST000928	PWED	S	1	15.98	8/22/2019
Urbana Highlands, Sec. P3 - SWM Pond 'PB' - Retrofit	FR17RST000922	PWED	S	1	20.56	8/22/2019
Urbana Highlands, Sec. P4 - SWM Pond 'PC' - Retrofit	FR17RST000924	FSND	S	1	4.68	8/22/2019
Villages of Urbana, Pond 'N' - Retrofit	FR17RST000663	PWED	S	1	6.04	10/25/2019
Villages of Urbana, SWM Pond A1 - Retrofit	FR17RST000662	PWED	S	1	4.44	10/25/2019
Villages of Urbana, SWM Pond 'S' - Retrofit	FR17RST000200	FSND	S	1	1.95	10/25/2019
Villages of Urbana, Village I, Pond G - Retrofit	FR17RST000047	PWED	S	1	4.94	10/25/2019

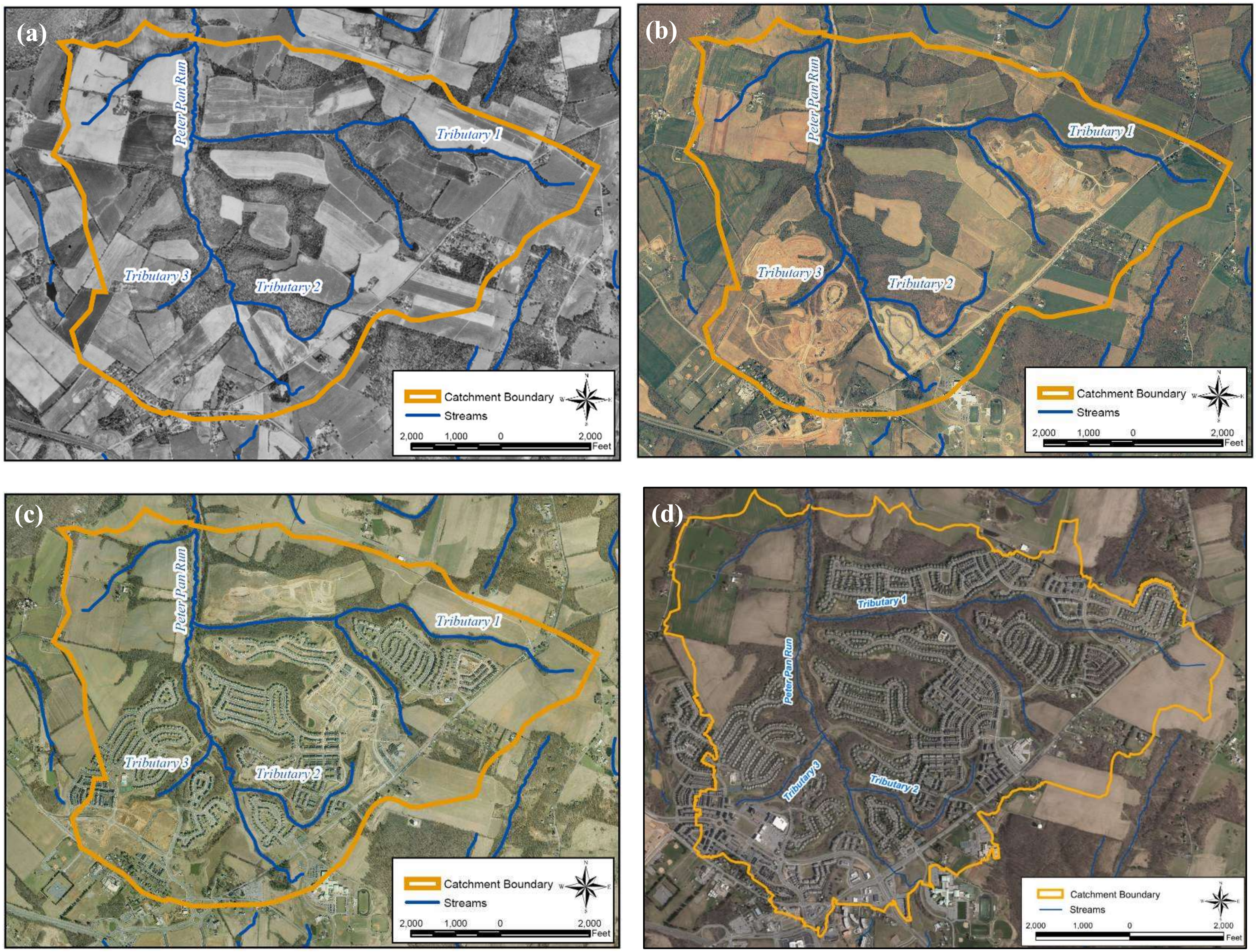

Figure 1-1. Aerial photographs of the Urbana Planned Unit Development (PUD) showing changes in the area over time. (a) predevelopment conditions in April 1988 (Source: USGS), (b) initial stages of development in March 2000 (Source: Frederick County), (c) conditions in March-April 2005 (Source: Frederick County), and (d) conditions in 2017. (Source: Frederick County)

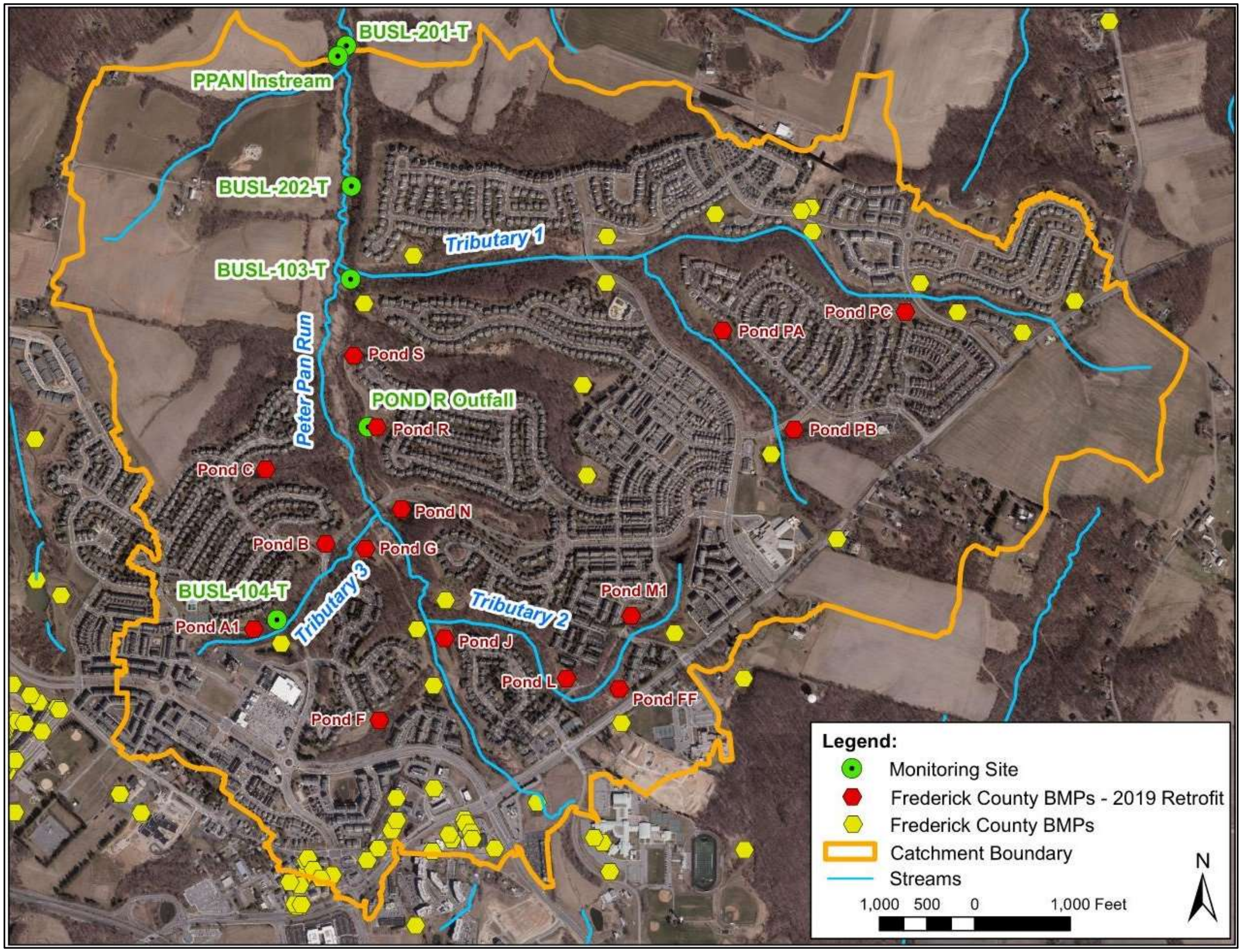

Figure 1-2. Annotated aerial photograph of Peter Pan Run in Lower Bush Creek watershed, Frederick County, Maryland showing the Peter Pan Run monitoring sites, BMPs, and retrofit BMPs in 2019. (Image source: Maryland iMAP Image Service, 2020)

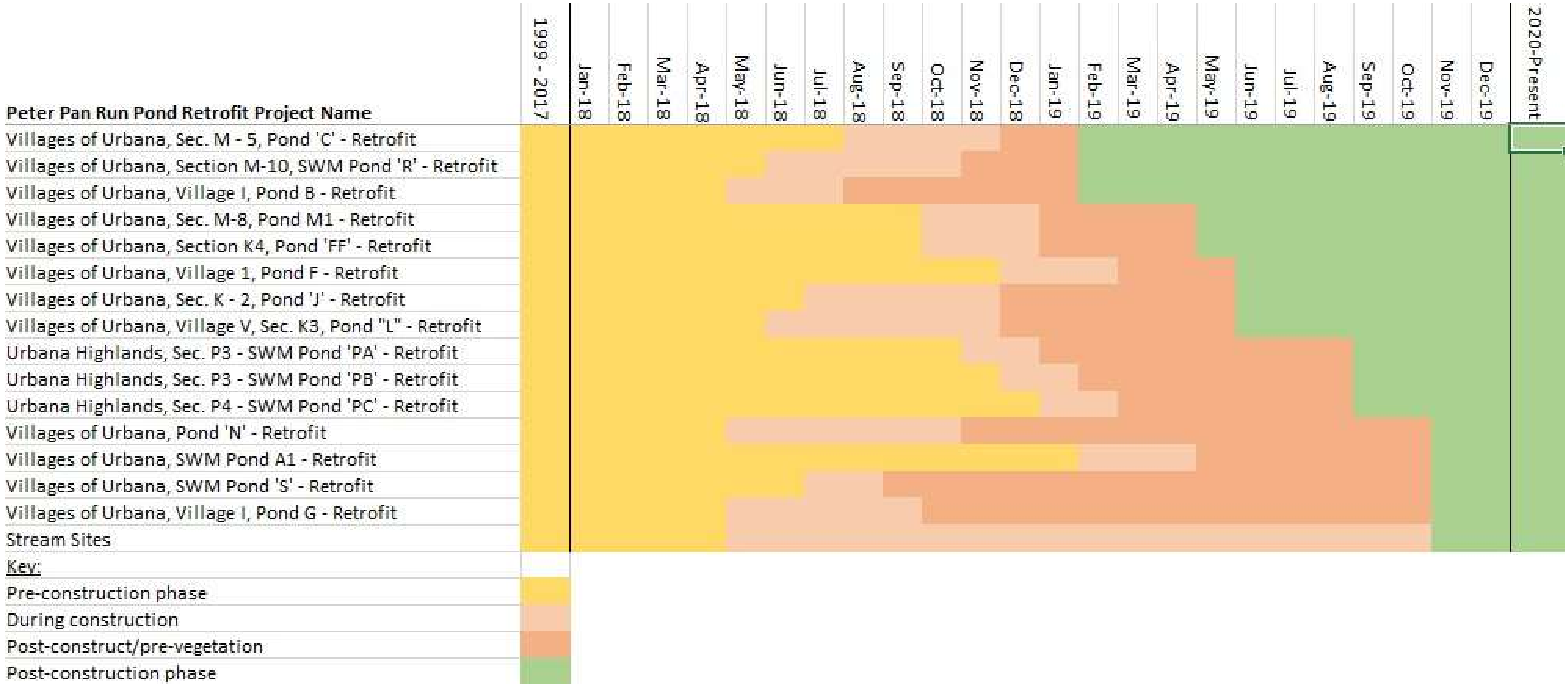

Figure 1-3. Peter Pan Run pond retrofit construction schedule and phases of monitoring used for data analysis. Note: Condensed schedule from 1999 – 2017 and 2020 – Present.

1.4 MONITORING METHODS

Currently, the methodologies used to assess streams in Frederick County are comparable to that used by other counties in Maryland, as approved by MDE, which facilitates integration of Frederick County's monitoring efforts with those of State and other county programs. Methods for biological and physical stream assessments were developed by the Maryland Department of Natural Resources (DNR) for its Maryland Biological Stream Survey (MBSS), a statewide biological and physical habitat assessment program. MBSS methods (Harbold et al. 2024) are a regional adaptation of EPA's Rapid Bioassessment Protocols (RBP, Plafkin et al. 1989, Barbour et al. 1999). Quantitative physical habitat assessment methods developed by Montgomery County Department of Environmental Protection were also employed from 1999 through 2006. Beginning in 2007, it was determined that this additional dataset was not significantly adding to the understanding of stream conditions, and so use of the Montgomery County protocols was discontinued. In keeping with the sampling schedule established by these model programs, physical, biological, and water chemistry monitoring activities follow the annual schedules presented in Table 1-2 and Table 1-3.

Table 1-2. Annual physical and biological sampling schedule for watershed monitoring stations

Spring (March through April)	**Summer** (June through September)
Physical habitat: • MBSS Spring Habitat assessment • Quantitative Geomorphologic assessment	Physical habitat: • MBSS Summer Habitat assessment
Ambient water quality: • dissolved oxygen, specific conductivity, pH, turbidity, and water temperature	Ambient water quality: • dissolved oxygen, specific conductivity, pH, turbidity, and water temperature
Biological monitoring: • benthic macroinvertebrate community	Biological monitoring: • fish community

Table 1-3. Annual stream water chemistry sampling schedule for the instream and outfall stations

Baseflow (Monthly)	**Wet Weather** (up to 2 storms per quarter)
Chemical water quality: • dissolved oxygen, specific conductivity, pH, and water temperature • baseflow samples for laboratory analysis	Chemical water quality: • dissolved oxygen, specific conductivity, pH, and water temperature • storm samples for laboratory analysis

In 2017, the County made contractual changes in the responsible engineering firm from Versar to KCI Technologies (KCI) such that KCI assumed responsibility of the chemical, physical, and biological monitoring of the instream and SWM pond outfall stations. Frederick County invested heavily in upgrading the water quality monitoring equipment to ensure the permit monitoring requirements would be met. These efforts included retiring old equipment and purchasing two ISCO automated samplers, one rain gauge, two flow modules, two solar panels, and two multi-parameter water quality sondes.

2.0 MONITORING RESULTS AND DISCUSSION

2.1 CHEMICAL MONITORING

As specified in the County's MS4 permit, the County has established, and maintains, two long-term chemical stormwater monitoring stations within the Urbana PUD to characterize stormwater discharges from both a stormwater management pond outfall draining a specific land use (Pond-R; Figure 2-2) and an associated instream station (PPAN-01; Figure 2-1).

In the beginning of FY2018, a change in contracted engineering firm occurred from Versar to KCI Technologies (KCI). In July 2017, Versar removed all equipment from the two stations and the County purchased new Teledyne ISCO equipment that was installed by KCI in October of 2017. KCI installed an ISCO 6712 automated sampler with an ISCO 730 Bubbler Flow Module at each station. A new tipping bucket rain gauge was installed at the POND-R station. Two new ISCO AQ 700 multi-parameter sondes were also purchased for deployment during sampled storm events at each station. Data collection with new equipment began on October 20, 2017.

<u>Peter Pan Run Instream Station</u>

Long-term chemical monitoring has continued at the instream monitoring station (located at PPAN-01) since May 1999. A photograph of the monitoring equipment as set up by KCI is presented in Figure 2-1. The instream station includes sample intake tubing located near a stilling well at the center of the stream, a staff gauge and water level sensor against the left bank, and a "storm box" housing located in a clearing near the bank. In November 2018, KCI installed a PVC stilling well in a pool feature of Peter Pan Run to monitor water levels within the channel. The stilling well is frequently observed for sedimentation and is reset if sediment is impacting water level readings. Historically, water level data was collected in a riffle approximately 15 feet downstream of the stilling well.

Figure 2-1. Ambient instream monitoring station at Peter Pan Run in the Lower Bush Creek watershed, Frederick County, MD. Photograph taken August 23, 2024.

Land use immediately surrounding the instream station remains primarily agricultural; however, the completed Urbana PUD construction has occurred within approximately 500 yards of the station. The instream station is located on the west bank (left bank) of Peter Pan Run. The station is bordered by agricultural fields to the immediate west and east with patches of densely forested and shrub areas along the stream and tributaries. A sanitary sewer pipeline (completed winter 1999/2000) runs parallel to the east side of the stream (right bank), extending the full length of Peter Pan Run, south to the Urbana PUD area. A branch sanitary sewer line extends eastward, along the north side of Tributary 1.

Outfall Station

Pond-R is located within the Urbana PUD and treats an area of 30.4 acres. Land use upstream of Pond-R consists of medium-density residential housing comprising 38.8% of the total 78.4 acres of the Village VII section of the Urbana PUD. Pond-R was monitored as a land use-specific extended detention dry pond from December 2002 thru July 2018. Installation of water chemistry monitoring and automated sampling equipment was completed on December 24, 2002, removed in July 2017 by Versar, and new monitoring equipment purchased by Frederick County was reinstalled by KCI on October 16, 2017. A photograph of the monitoring equipment as set up by KCI is presented in Figure 2-3. Initial monitoring characterized water quality at the outfall of the basin during residential construction with the facility functioning as a sediment trap. Conversion of the Pond-R sediment trap to a functional dry extended detention pond began in approximately late March 2004 and concluded during the first week of July 2004. Active construction of the Pond-R retrofit conversion from a dry extended detention pond to a wet extended detention pond occurred from July 2017 to October 24, 2018. Storm monitoring efforts were deferred while the pond was undergoing construction and resumed in November 2018.

Figure 2-2. Villages of Urbana Pond-R outfall water chemistry monitoring station and rain gauge. Photograph taken August 23, 2024.

Figure 2-3. Bubbler flow module located at the midpoint of the Pond-R outfall pipe sampling stage data for the Pond-R station.

2.1.1 Chemistry Monitoring Procedures

As part of the monitoring program, Frederick County conducted monthly baseflow monitoring at both the ambient instream (PPAN-01) and the Pond-R outfall (POND-R) stations beginning in FY2016 to develop a dry weather flow database. Baseflow monitoring included manual grab sampling with parameter-specific sampling bottles containing the appropriate lab-specified preservative. Calibrated field instruments were used to measure basic physiochemical water quality parameters (e.g., water temperature, dissolved oxygen, specific conductivity, and pH). Field notes and data were recorded on preprinted, project-specific field data sheets. Both sites are visited weekly to inspect the equipment and perform any needed maintenance to assure minimal breaks in the data record. During maintenance inspections, field teams also downloaded recorded data and maintained equipment logs. Baseflow monitoring at the outfall station occurred only when flow was present since its conversion to an extended detention dry pond in July 2004. Baseflow was infrequent in 2016, was observed more frequently in FY2017, and was not observed at the Pond-R outfall from FY2018 to the present fiscal year.

Storm event monitoring at PPAN-01 and POND-R began in May 1999 and February 2003, respectively. New monitoring schedules were implemented in 2015 to meet the minimum number of annual storm events per the County's MS4 Permit. This new schedule expanded monitoring efforts to capture up to two events per quarter, accounting for eight storm events per year. Bi-quarterly storm sampling of Peter Pan Run and Pond-R was performed using ISCO automated samplers and flow meters located at each water chemistry monitoring station (changed to water level stage sensors in FY2018). For each storm, the equipment at each station was used to collect and prepare volume-weighted, composite samples that represent the rising, peak, and falling limbs of each storm hydrograph. Initially, manual grab samples were collected for "first flush" parameters (e.g. oil and grease, total petroleum hydrocarbons (TPH), phenols, and fecal coliform) using dedicated bottles containing preservative. Starting in FY2018, TPH and *E. coli* were tested throughout the storm. In FY2019, TPH and *E. coli* were collected by the ISCO machines and not performed with manual grab samples. An electronic rain gauge located at the outfall station recorded rainfall data for calculation of rainfall totals and storm intensity and to determine storm event validity (i.e., rainfall quantity greater than 0.10”). At each station, the flow meter measured stage height and converted the value to a discharge rate. The replacement equipment installed in FY2018 measured stage height and discharge rates were calculated utilizing a rating table derived from field measured data at the instream station and Manning’s equation at the outfall station. Field discharge measurements at the instream station were collected using the USGS’ stream velocity profile measurement technique (USGS 1982), and updated, as needed. These continuous water level, flow, and rainfall measurements were downloaded at least twice monthly.

Following NPDES permit requirements, all baseflow and stormflow samples were analyzed for the parameters listed in Table 2-1. Samples were stored on ice until they could be transported under chain of custody to the laboratory. Sample analysis was performed by Martel Laboratories, Inc., of Towson, MD. Field and laboratory results from the monitored storms are discussed in the sections below.

Table 2-1. Parameters and detection limits for Frederick County's Water Chemistry Monitoring Program

Parameter	Detection Limit	Method
Biochemical Oxygen Demand	2.0 mg/L	SM 5210 B
Total Nitrogen	--	SM Calc
Nitrate and Nitrite	0.05 mg/L	SM 4500NO3-H
Total Ammonia	0.2 mg/L	SM 4500-NH3C2011
Total Phosphorus	0.01 mg/L	SM 4500P-E
Orthophosphate	0.01 mg/L	SM 4500-P E-99
Total Suspended Solids	1.0 mg/L	SM 2540D
Chloride	1.0 mg/L	SM 4500-CL E-97
E.Coli	1/100 ml	SM 9223B

2.1.2 Storm Information

KCI field staff successfully monitored nine storm events at the instream station and Pond-R outfall station during the sampling period July 1, 2023, through June 30, 2024. All FY2024 samples collected at the Pond-R outfall station reflect the post-retrofit condition. Baseflow monitoring was carried out monthly between July 2023 and June 2024 at the instream station accounting for twelve samples.

Short periods of data were occasionally lost due to environmental and mechanical issues despite adherence to the maintenance and calibration procedures in the monitoring plan. Identified issues were corrected during maintenance visits to each site and calibration or replacement of field equipment. These gaps were filled with intact recorded data representative of the conditions onsite at the time of data loss as part of the QAQC process. No discharge was observed at Pond-R during the September 9th, 2023, October 14th, 2023, and May 5th, 2024 storm events. The discharge flow at Pond-R was too low during the June 5th, 2024 event and the equipment did not collect samples for the rising limb. The pump tubing in the Pond-R sampler experienced a failure during the storm on September 25th, 2023 storm that halted sampling after the rising limb was collected, staff took a falling grab sample upon the composite field visit but there was no peak sample collected for this storm event.

As presented in Table 2-2, rainfall measured on site from sampled storms ranged in quantity from 0.51 to 2.19 inches during qualifying events, and in duration from 8.25 hours to 36.17 hours. Average rainfall intensities from sampled storms ranged from 0.02 to 0.14 inches per hour.

Table 2-2. Summary of storm events monitored in FY2024 at Peter Pan Run

Date	Start Time	Rainfall Duration (hrs)	Rainfall** (in)	Avg. Intensity (in/hr)	Storm as % of Total Rainfall for Month
9/9/2023	2:10	32.58	0.51	0.02	13%
9/23/2023	0:25	36.17	2.19	0.06	57%
10/14/2023	7:40	12.67	0.57	0.05	40%
11/21/2023	8:55	14.67	2.06	0.14	85%
12/10/2023	8:25	26.17	1.65	0.06	31%
2/12/2024	16:35	20.00	1.56	0.08	67%
3/23/2024	21:55	12.33	1.18	0.10	28%
5/6/2024	7:15	27.17	0.77	0.03	17%
6/5/2024	14:00	8.25	0.67	0.08	20%

FY denotes "Fiscal Year," defined as July to June.
**For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station (KMDFREDE3) data.

Variation in pollutant loads and changes in channel geometry can result from variable weather and stream discharge patterns. An analysis is conducted to check the project rainfall measurements against other local datasets, and to determine the departure from normal or average conditions. Table 2-3 compares monthly rainfall totals recorded at the Peter Pan Run station to monthly data collected at a local National Oceanic and Atmospheric Administration (NOAA) weather monitoring station (NOAA, 2024). The NOAA weather stations at Emmitsburg, MD and Clarksburg, MD are approximately 25 miles north and 6 miles south-southeast, respectively, of Urbana, MD. Rainfall amounts recorded during monitored storms are presented in Figure 2-4. Note that the project rain gauge was located at instream station until early 2003 when the rain gauge was relocated to the Pond-R outfall station.

For the twelve-month monitoring period in FY2024, total annual rainfall near the site, as recorded at NOAA's Clarksburg gauge (50.18 inches) was higher than the long-term annual average of 40.40 inches recorded in Frederick County (Figure 2-5) although monthly rainfall was variable (Figure 2-6). Total annual rainfall data was used from the NOAA Emmitsburg rainfall gauge from 1991 to 2007 and the NOAA Clarksburg rainfall gauge from October 2007 (Water Year 2007; NOAA follows Water Year convention, October 1 through September 30) through June 2024 (FY2024). Note that the Emmitsburg rainfall gauge was offline between July 2005 and July 2006, the June 2007 rainfall data were missing from the Emmitsburg station, and the September 2018 rainfall data were missing from the Clarksburg station. During FY2024, the in-situ rain gauge located at Pond-R recorded 41.8 inches between July 2023 and June 2024, 3% above the normal average rainfall in Frederick County for the same time period. Total discharge volume at the instream monitoring station between July 2023 and June 2024 was 42% higher than in the prior fiscal year (July 2022 – June 2023) (Figure 2-7 and Figure 2-8).

Table 2-3. FY2024 Rainfall data (totals by month; inches)					
Month	**In-situ ISCO[(a)]**	**Clarksburg[(b)]**	**Emmitsburg[(b)]**	**Normal[(c)]**	**In-situ Departure from Normal**
July-23	2.28	4.64	3.72	3.70	-1.42
August-23	2.54	3.09	4.71	3.50	-0.96
September-23	3.85	8.25	3.85	3.60	0.25
October-23	1.42	1.59	1.67	3.10	-1.68
November-23	2.43	2.5	2.88	3.30	-0.87
December-23	5.30	6.43	5.41	2.90	2.40
January-24	5.12	6.38	5.86	2.80	2.32
February-24	2.34	2.32	2.08	2.70	-0.36
March-24	4.27	4.33	3.67	3.30	0.97
April-24	4.34	3.19	4.31	3.30	1.04
May-24	4.49	4.62	4.42	4.30	0.19
June-24	3.42	2.84	1.99	3.90	-0.48

(a) For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station (KMDFREDE3) data.

(b) Clarksburg and Emmitsburg monthly rainfall data from National Oceanic and Atmospheric Administration.

(c) Based on Frederick County regional long-term rainfall data from National Oceanic and Atmospheric Administration.

ND = No Data

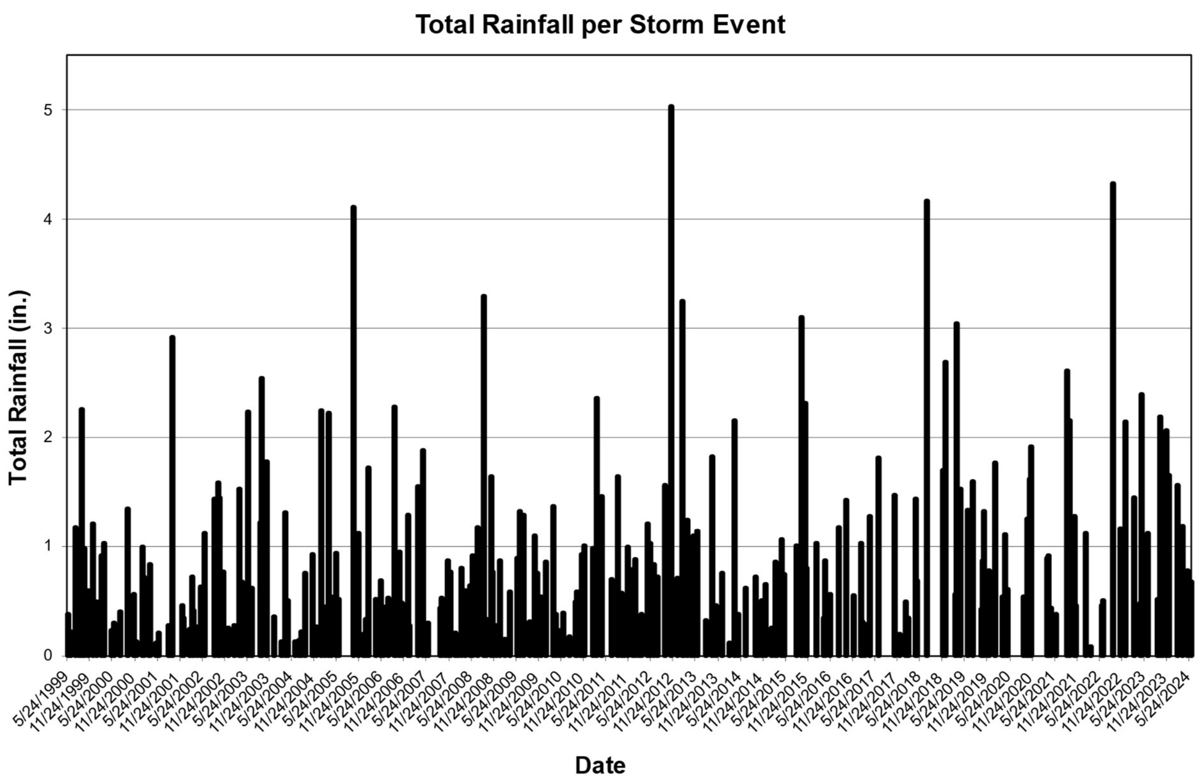

Figure 2-4. Rainfall totals for sampled storm events (May 1999 through June 2024).

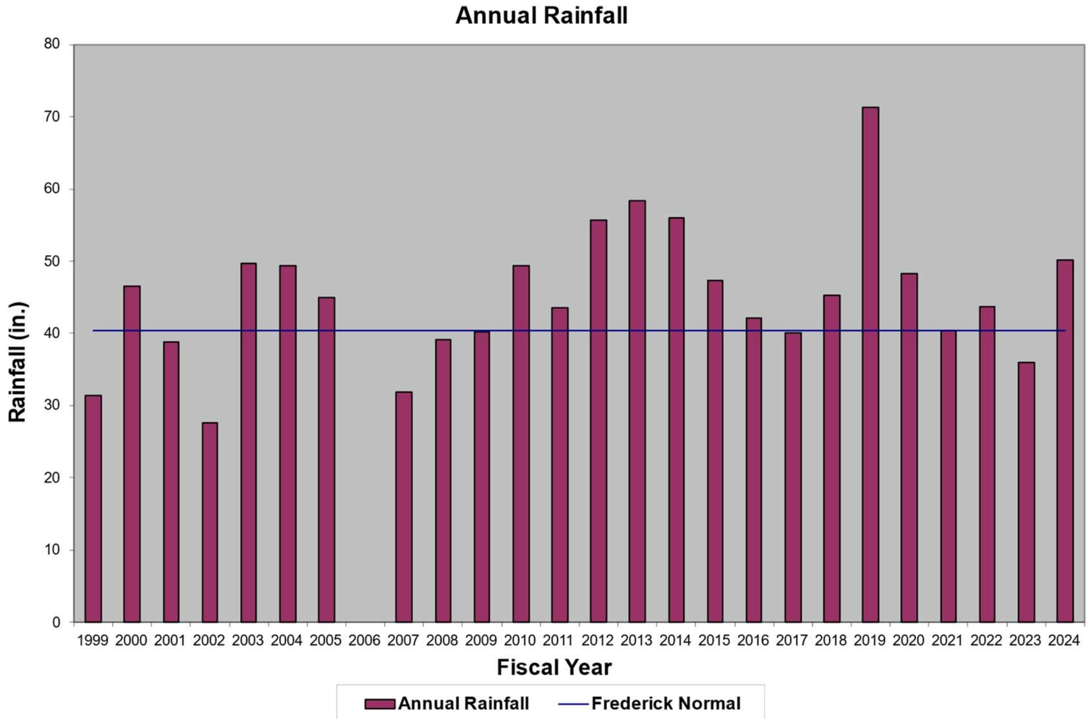

Figure 2-5. Annual rainfall recorded at NOAA's Emmitsburg, MD station, FY1999-2008 (no data for FY2006) and at NOAA's Clarksburg, MD station, FY2009-2024. Note: Emmitsburg data for FY2007 do not include July 2006 and June 2007.

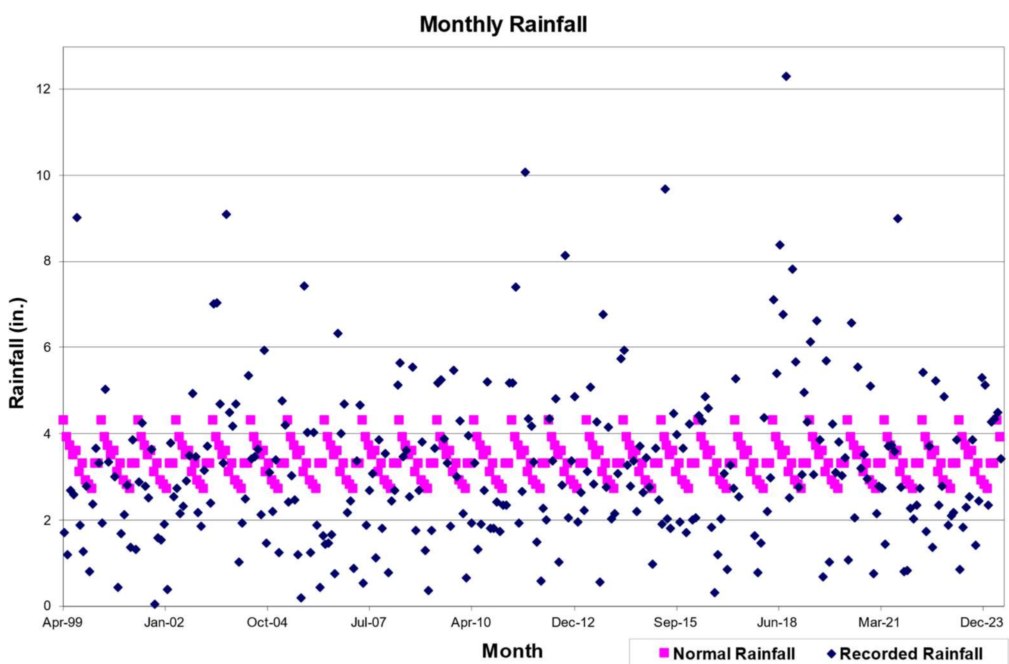

Figure 2-6. Monthly rainfall recorded at the Peter Pan site (at instream station prior to early 2003; at Pond-R after early 2003) and NOAA's long-term Frederick County regional average monthly (i.e., normal) rainfall, April 1999 – July 2024.

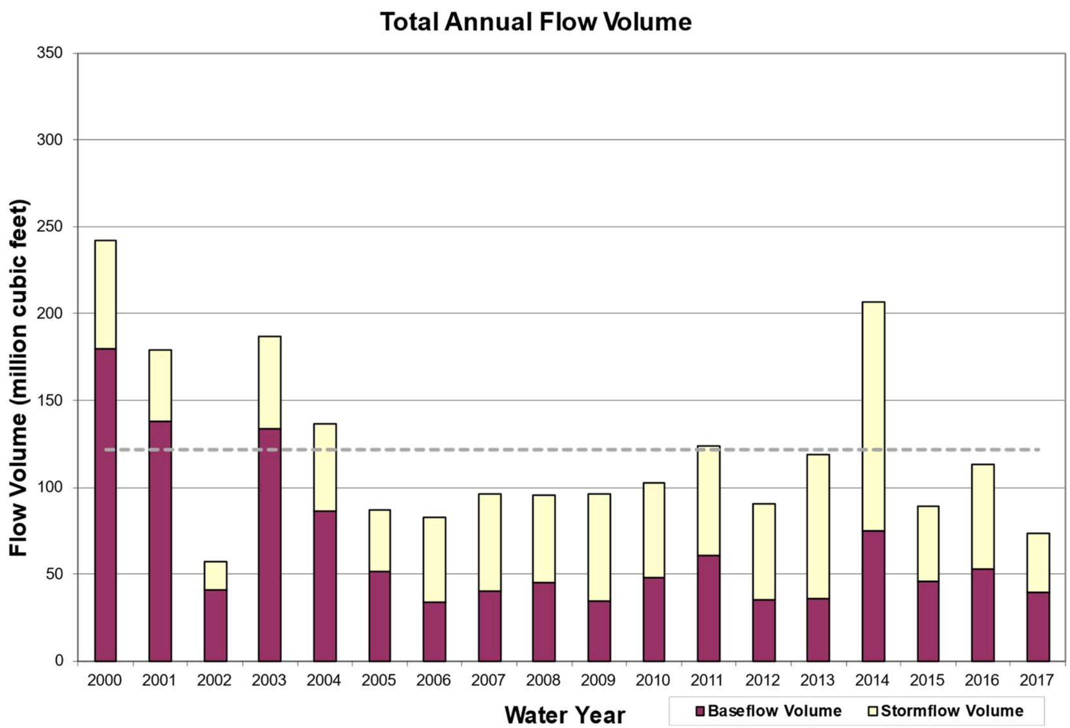

Figure 2-7. Annual discharge volume measured at the Peter Pan Run instream monitoring station, WY2000 – WY2017. Marker line indicates the overall average total annual flow volume.

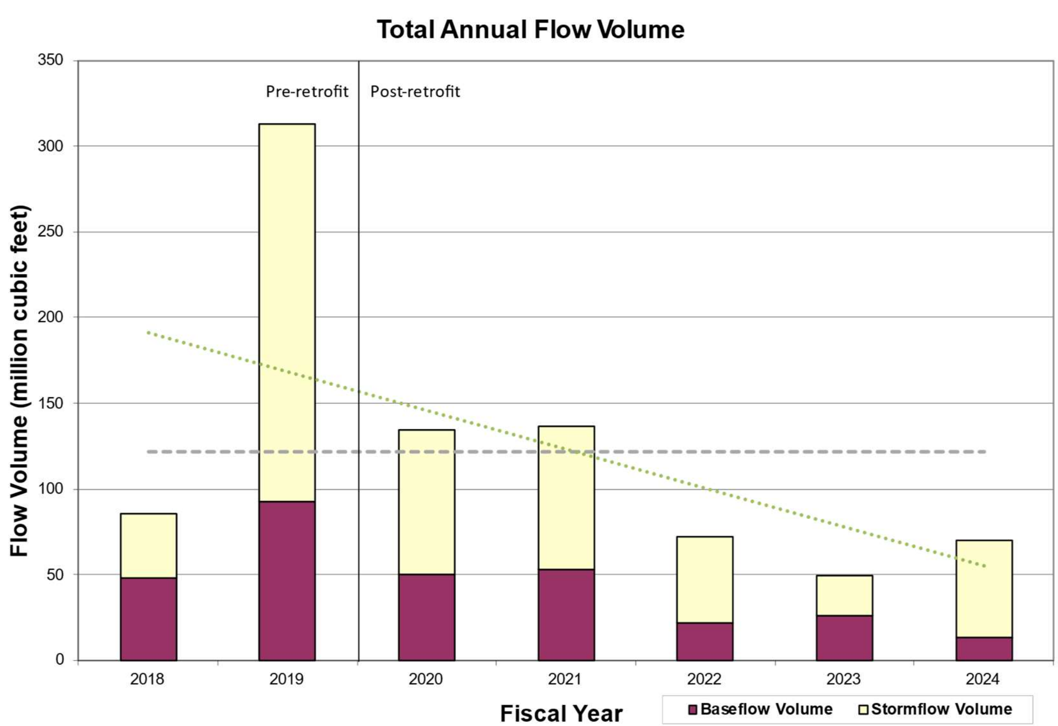

Figure 2-8. Annual discharge volume measured at the Peter Pan Run instream monitoring station, FY2018 – FY2024. Marker line indicates the overall average total annual flow volume.

2.1.3 Water Chemistry Analysis

Laboratory and Field Results

A summary of analytical results for baseflow and storm event water chemistry monitoring at the instream station and Pond-R outfall station from July 2023 through June 2024 are shown in Table 2-4, Table 2-5, and Table 2-6. Baseflow monitoring analytical results from the Peter Pan Run instream station includes twelve samples during the period of July 2023 to June 2024.

Table 2-4. FY2024 water chemistry results for instream storm event monitoring at Peter Pan Run (PPAN-01)

Date	Storm Limb	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	TSS	Chloride	Orthophos-phate Phosphorus	Ammonia Nitrogen	Total Nitrogen	*E. coli*
9/9/2023	Rising	5	0.7	1.40	0.14	170	ND	ND	ND	ND	1410
	Peak	< 2	0.3	1.30	0.12	110	ND	ND	ND	ND	1730
	Falling	< 2	0.5	0.94	0.08	30	ND	ND	ND	ND	1990
9/23/2023	Rising	3	0.2	1.80	0.09	32	88	< 0.01	< 0.2	2	6090
	Peak	3	0.8	1.40	0.26	100	41	0.02	< 0.2	2.2	7490
	Falling	4	0.3	1.40	0.04	2	64	< 0.01	< 0.2	1.7	1990
10/14/2023	Rising	6	< 0.5	1.00	0.03	3	92	< 0.01	< 0.2	1	1300
	Peak	< 2	< 0.5	1.10	0.08	12	80	< 0.01	< 0.2	1.1	3360
	Falling	< 2	< 0.5	1.10	0.06	3	77	< 0.01	< 0.2	1.1	1200
11/21/2023	Rising	9	ND	1.30	0.07	8	80	< 0.01	< 0.2	1.3	548
	Peak	10	ND	0.72	0.62	580	43	0.03	< 0.2	1.8	15500
	Falling	3	ND	0.63	0.08	16	62	< 0.01	< 0.2	0.63	1200
12/10/2023	Rising	8	ND	1.80	0.08	17	89	< 0.01	< 0.2	2.2	2420
	Peak	4	ND	1.00	0.23	100	49	0.02	< 0.2	1.8	4020
	Falling	< 2	ND	1.30	0.07	8	54	< 0.01	< 0.2	1.3	649
2/13/2024	Rising	7	ND	2.30	0.04	19	99	< 0.01	< 0.2	2.3	461
	Peak	11	ND	0.95	0.25	95	76	0.04	< 0.2	0.95	1990
	Falling	4	ND	1.40	0.06	7	110	< 0.01	< 0.2	1.4	261
3/23/2024	Rising	3	< 0.4	2.10	0.04	8	93	< 0.01	< 0.2	2.1	1730
	Peak	5	0.7	1.10	0.28	74	70	0.08	< 0.2	1.8	8130
	Falling	2	< 0.4	1.60	0.04	3	89	< 0.01	< 0.2	1.6	184
5/5/2024	Rising	5	< 0.5	2.20	0.02	4	91	< 0.01	< 0.2	2.2	2650
	Peak	2	< 0.5	1.60	0.05	10	85	< 0.01	< 0.2	1.6	2560
	Falling	2	< 0.5	2.00	0.02	5	82	< 0.01	< 0.2	2	1200
6/5/2024	Rising	4	0.6	2.20	0.21	61	87	0.01	< 0.2	2.8	5460
	Peak	5	1.1	1.10	0.49	140	50	0.13	< 0.2	2.2	16100
	Falling	3	< 0.5	1.60	0.14	18	60	0.02	< 0.2	1.6	3050

Results are in mg/L except *E. coli* results are in MPN/100 mL.

Table 2-5. FY2024 water chemistry results for baseflow monitoring at instream Peter Pan Run (PPAN-01)

Date	**BOD**	**TKN**	**Nitrate+Nitrite**	**Total Phosphorus**	**TSS**	**Chloride**	**Orthophos-phate Phosphorus**	**Ammonia Nitrogen**	**Total Nitrogen**	***E. coli***
7/13/2023	< 2	< 0.2	1.80	0.04	4	ND	ND	ND	ND	1200
8/29/2023	< 2	< 0.2	1.40	0.03	1	ND	ND	ND	ND	2420
9/22/2023	< 2	ND	1.80	0.05	2	98	ND	< 0.2	1.8	687
10/6/2023	< 2	< 0.2	1.40	0.03	5	100	ND	< 0.2	1.4	365
11/2/2023	6	ND	1.30	0.05	< 1	110	< 0.01	< 0.2	1.7	435
12/7/2023	< 2	ND	1.90	0.04	< 1	97	< 0.01	< 0.2	1.9	139
1/5/2024	< 2	ND	2.40	0.02	< 1	90	< 0.01	< 0.2	2.4	78
2/6/2024	11	ND	3.00	0.04	3	110	< 0.01	< 0.2	3	56
3/22/2024	< 2	< 0.4	2.80	0.02	< 1	98	< 0.01	< 0.2	2.8	291
4/10/2024	< 2	0.4	2.80	< 0.01	< 1	95	< 0.01	< 0.2	3.2	102
5/22/2024	< 2	< 0.5	2.20	0.04	< 1	81	< 0.01	< 0.2	2.2	489
6/5/2024	< 2	< 0.5	2.20	0.05	4	81	< 0.01	< 0.2	2.2	580

Results are in mg/L except *E. coli* results are in MPN/100 ml.

Table 2-6. FY2024 water chemistry results for outfall storm event monitoring at Pond-R

Date	Storm Limb	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	TSS	Chloride	Orthophos-phate Phosphorus	Ammonia Nitrogen	Total Nitrogen	*E. coli*
9/9/2023	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/23/2023	Rising	17	0.5	0.1	0.11	12	< 1	< 0.01	< 0.2	0.6	6770
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	2	0.2	0.10	0.16	5	< 1	0.0	< 0.2	0.3	291
10/14/2023	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/21/2023	Rising	10	ND	< 0.05	0.17	7	4.9	0.0	< 0.2	0.6	6
	Peak	17	ND	0.05	0.19	11	3.9	0.1	< 0.2	0.8	579
	Falling	7	ND	< 0.05	0.31	10	2.5	0.1	< 0.2	< 0.5	1300
12/10/2023	Rising	18	ND	0.11	0.27	3	3.1	0.2	< 0.2	0.6	19
	Peak	6	ND	0.10	0.25	2	3.0	0.1	< 0.2	0.5	33
	Falling	8	ND	0.08	0.16	4	2.9	0.1	< 0.2	0.08	192
2/13/2024	Rising	9	ND	0.06	0.10	10	37.0	0.0	< 0.2	0.60	206
	Peak	7	ND	0.13	0.11	11	25.0	0.0	< 0.2	0.13	1410
	Falling	5	ND	0.09	0.08	8	19.0	0.0	< 0.2	0.09	1550
3/23/2024	Rising	7	< 0.4	0.09	0.13	7	6.5	< 0.01	< 0.2	0.09	291
	Peak	6	0.4	0.16	0.11	6	6.4	< 0.01	< 0.2	0.50	1990
	Falling	4	< 0.4	0.09	0.09	4	6.4	0.0	< 0.2	0.40	520
5/5/2024	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Falling	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/5/2024	Rising	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Peak	18	2.1	0.06	0.49	26	4.2	0.0	< 0.2	2.20	727
	Falling	14	1.6	< 0.05	0.35	20	2.2	< 0.01	< 0.2	1.60	2590

Results are in mg/L except *E. coli* results are in MPN/100 mL.

Calculation of Event Mean Concentration

Storm event mean concentrations (EMC) of the various pollutants at each station were calculated from laboratory results and flow rate data from the monitored storms. To arrive at the EMC of a particular pollutant, a volume-weighted average was calculated for the rising, peak, and falling limbs of each storm hydrograph. Stage data were collected at five-minute intervals at the instream and the Pond-R outfall monitoring stations. Rating curves were developed using in-situ flow and stage measurements at the instream station and Manning's equation applied to the Pond-R outfall pipe. Flow rate data were estimated by applying the rating curves to the measured stage data at both stations.

Table 2-7 presents the calculated annual average EMCs compared to Maryland freshwater acute and chronic water quality criteria, average EMC values reported by the MDE for NPDES Part 2 sampling from jurisdictions across the State (Bahr 1997), and values reported in two national datasets. The National Urban Runoff Program (NURP) average EMC values were taken from median urban site concentration results. The National Stormwater Quality Database (Maestre and Pitt 2005) average values are from a more recent national compilation of data from stormwater runoff in a variety of conveyances in residential land use.

Comparisons with Maryland water quality criteria are presented only as a general aid to interpreting the data and are not intended as a regulatory review to assess compliance with standards. Maryland Drinking Water Criteria are listed because Peter Pan Run is designated as a "Use Class I-P" stream (potential public water supply), as are most waterways in Frederick County, and as such are subject to State drinking water criteria. Flow-weighted EMC data for each pollutant for each storm event have been submitted electronically as part of the County's Annual Report geodatabase submission.[1] Note that for this report, EMCs and baseflow mean concentrations (MCs) were calculated with non-detectible results set to zero.

[1]In the electronic geodatabase containing storm EMCs and baseflow mean concentrations, the following apply: (1) storm duration signifies the time period between the beginning of the rising limb and the ending of the falling limb of a particular storm; (2) data fields with entries "ND" denote samples not collected, tests not performed or field not applicable; (3) flow-weighted mean temperatures and pH were determined by averaging the individual temperature and pH measurements as taken by an *in-situ* recording device over the course of the monitoring of the storm event from the beginning of the rising limb to the end of the falling limb and obtaining the flow-weighted means of those overall averages.

Table 2-7. Comparison of annual average Peter Pan Run event mean concentrations (EMCs) from storms sampled between July 1, 2023 and June 30, 2024, with Maryland state average EMCs for all land uses, with values from two national datasets, and with Maryland water quality standards

Parameter	Average Annual Peter Pan Run EMC[a] (mg/l)	Average Annual Pond-R Outfall EMC[a] (mg/l)	Average MD EMC[b] (mg/l)	NSQD Residential Median[c] (mg/l)	NURP Runoff Water Quality EMC[d] (mg/l)	Part 2 Outfall EMC (mg/l)[e]	MD Freshwater Acute Criteria (mg/l)	MD Freshwater Chronic Criteria (mg/l)	MD Drinking Water Criteria (mg/l)
BOD	6.13 - 6.22	9.10	14.44	9	9	4.34	N/A	N/A	N/A
TKN	0.22 - 0.54	0.42 - 0.48	1.94	1.5	1.5	1.03	N/A	N/A	N/A
Nitrate + Nitrite	1.14	0.085 - 0.089	0.85	0.6	0.68	N/A	N/A	N/A	N/A
Total Phosphorus	0.23	0.18	0.33	0.31	0.33	0.13	N/A	N/A	N/A
TSS	132	8	66.57	49	100	15.21	N/A	N/A	N/A
Chloride	69.22 - 69.23	6.99 - 7.14	N/A	N/A	N/A	N/A			
Orthophosphate Phosphorus	0.025 - 0.029	0.052 - 0.054	N/A	N/A	N/A	N/A			
Ammonia Nitrogen	0.00 - 0.20	0.00 - 0.19	N/A	0.31	N/A	N/A			
Total Nitrogen	1.51 - 1.65	0.47 - 0.54	N/A	N/A	N/A	N/A			

(a) Where concentrations reported at the detection limit, loadings are presented as range of possible values, setting concentrations below the detection limit to zero or to the actual detection limit value.
(b) Maryland State average values from Bahr 1997.
(c) National Stormwater Quality Database values from Maestre and Pitt 2005.
(d) National Urban Runoff Program values from U.S. EPA 1983.
(e) Frederick County Part 2 Outfall Sampling Results from Third Annual Report 1999.
N/A = No value or criteria established
EMC = volume-weighted event mean concentration

Instream Event Mean Concentrations

This section describes the annual EMCs for each pollutant at the instream station. Refer to Figures 2-9, and 2-10 for graphs of the annual EMCs over time from 1999-2024.

During FY2024, average annual storm EMCs for BOD and nitrate and nitrite increased from FY2023 levels, while TKN, phosphorus, and TSS decreased. During baseflow conditions, BOD and TSS increased from FY2023 levels, nitrate-nitrite and phosphorus minimally decreased, and TKN decreased. BOD continued being detected in baseflow samples in FY24. The new parameters added in FY24 to satisfy new permit requirements (chloride, orthophosphate phosphorus, ammonia nitrogen, and total nitrogen) will be analyzed starting in FY25 after two monitoring years of data have been collected.

Average baseflow concentrations of combined nitrate and nitrite steadily increased between FY2009 and FY2015, reduced in FY2017, began to increase in FY2018 and FY2019, and began a decreasing trend in FY2020 with a further decrease of 10% in FY2023 since FY2020. The average annual storm EMC for combined nitrate and nitrite remained at a consistent level since FY2009 until a decreasing trend from FY2020 through FY2023, leveling out in FY2024 at a decrease of 1% from FY2023. Average baseflow concentrations of nitrate and nitrite are consistently higher than average storm flow concentrations for the entire monitoring period. This is likely caused by active and legacy agricultural land use within the watershed and nitrate and nitrite in groundwater reaching the stream during baseflow conditions. TKN average baseflow concentrations remained consistently low since FY2012, decreasing from FY2023 to FY2024 by 46%. Average storm EMCs of TKN have been measured on an increasing trend since FY1999 until the beginning of a decreasing trend in FY2017. Levels of TKN in stormwater runoff have been low and consistent since FY2018, with a large annual increase of 253% in FY2022, followed by another annual increase of 15% in FY2023 (Figure 2-9). In FY2024, TKN decreased to near FY2021 values, dropping 76%.

Excluding a spike in concentration in FY2009, average baseflow phosphorus concentrations have shown an overall declining trend since FY2004 with consistently low concentrations measured since FY2013. The FY2024 baseflow mean phosphorus minimally changed from FY2023, decreasing by 2%. The average storm event concentration of phosphorus in FY2024 was 16% lower than the average in FY2023. Phosphorus storm EMCs peaked between FY2008 and FY2011, but have been decreasing annually, with slight fluctuations on occasion, since FY2011 (Figure 2-10).

FY2024 storm runoff TSS concentrations decreased by 29% and baseflow TSS concentrations increased by 22% in comparison to FY2023, though the change between baseflow values was <1mg/L. TSS average baseflow concentrations have been negligible compared to average storm event concentrations for the entire monitoring period. TSS EMCs have fluctuated over the monitoring period, with a decreasing trend ending in FY2010, followed by an increasing trend peaking in FY2016 (Figure 2-10). Annual EMCs increased for FY2019 during the pond retrofit construction period and began decreasing again in FY2020. After annual fluctuations, a decreasing trend was measured in FY2024.

E. coli was detected in all baseflow and storm event samples at the Peter Pan Run instream station in FY2023. Average FY2024 *E. coli* baseflow concentrations decreased by 8% and stormflow concentrations increased by 34% when compared with FY2023 results. *E. coli* concentrations were typically higher during peak storm samples. The lowest concentrations of *E. coli* are generally found during the colder months during baseflow, with lower seasonality in stormflow concentrations. Typical sources of *E. coli* in surface waters in a watershed include wildlife, pet waste, and malfunctioning septic or sewage treatment systems (Vann et al. 2002). Starting in FY2023, cattle on the adjacent agricultural property were relocated away from the stream, reducing their impact on *E. coli* concentrations.

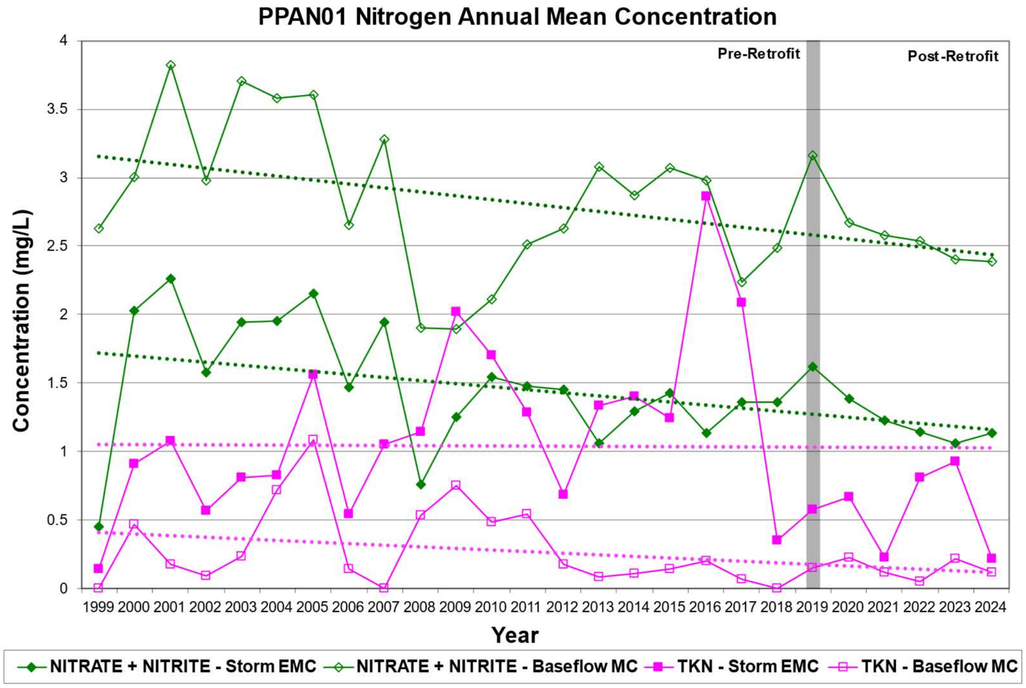

Figure 2-9. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Peter Pan Run instream site (FY1999 – FY2024).

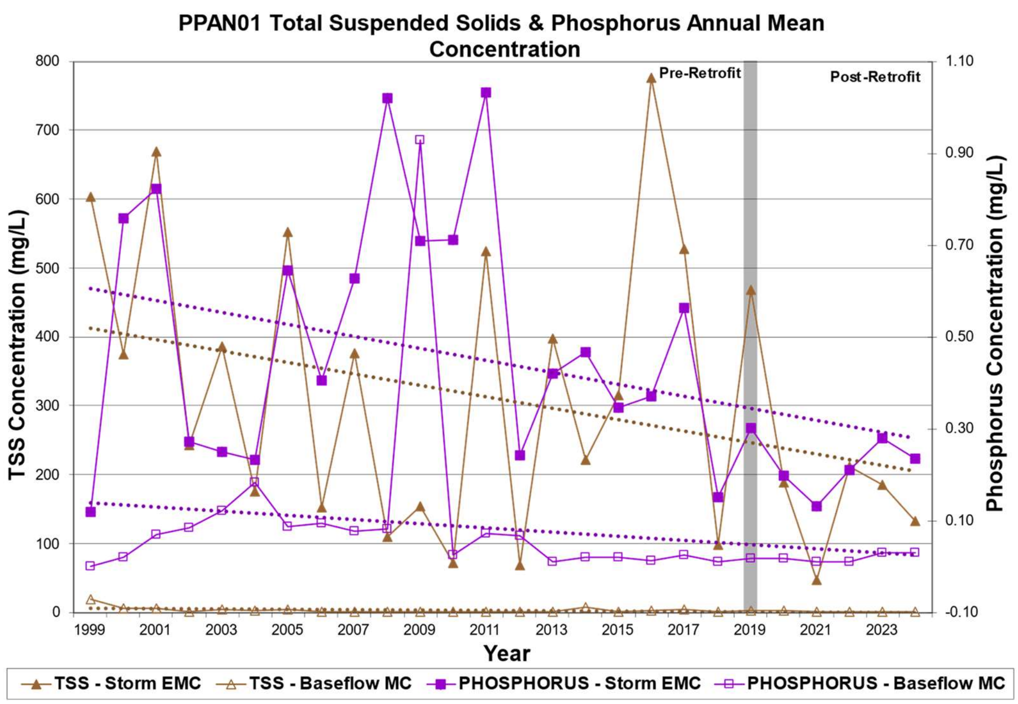

Figure 2-10. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at the Peter Pan Run instream station (FY1999 – FY2024).

Outfall Event Mean Concentrations

Monitored results at the pond's outfall, POND-R, prior to FY2019 represent a dry extended detention stormwater BMP; results after FY2019 represent a wet extended detention stormwater BMP design, which is more effective at removing pollutants from stormwater runoff. Baseflow was not observed during FY2009, FY2012, FY2013, and each successive year after FY2017. Average annual storm EMCs at the outfall in FY2024 decreased for all parameters except BOD compared to FY2023. The average annual storm EMC for BOD increased by 331% in FY2024 compared to FY2023. *E. coli* was detected in all FY2024 storm samples, and the average annual storm EMC for *E. coli* was 34% lower than in FY2023. Annual EMCs for nitrate and nitrite and TSS have been generally lower at the Pond-R outfall in comparison to EMCs measured at the instream station for the entire monitoring period. The new parameters added in FY24 to satisfy new permit requirements (chloride, orthophosphate phosphorus, ammonia nitrogen, and total nitrogen) will be analyzed starting in FY25 after two monitoring years of data have been collected.

Average concentrations of combined nitrate and nitrite carried by stormflow at the Pond-R outfall in FY2024 decreased by 61% since FY2023, returning to an overall decreasing trend since FY2018. The annual storm EMC for TKN decreased by 60% from FY2023 to FY2024. (Figure 2-11).

The average annual storm EMC for phosphorus at the Pond-R site decreased by 12% in FY2024, following a level trend after a significant spike in EMC in FY2008. The average annual storm EMC for TSS decreased by 13% in FY2024. TSS EMCs were measured at high levels at the beginning of the monitoring period in FY2003. After the conversion of Pond-R from a sediment basin to an extended dry detention pond in July 2004, TSS EMCs dropped significantly in comparison to historical levels, but have been variable after the pond retrofit (Figure 2-12).

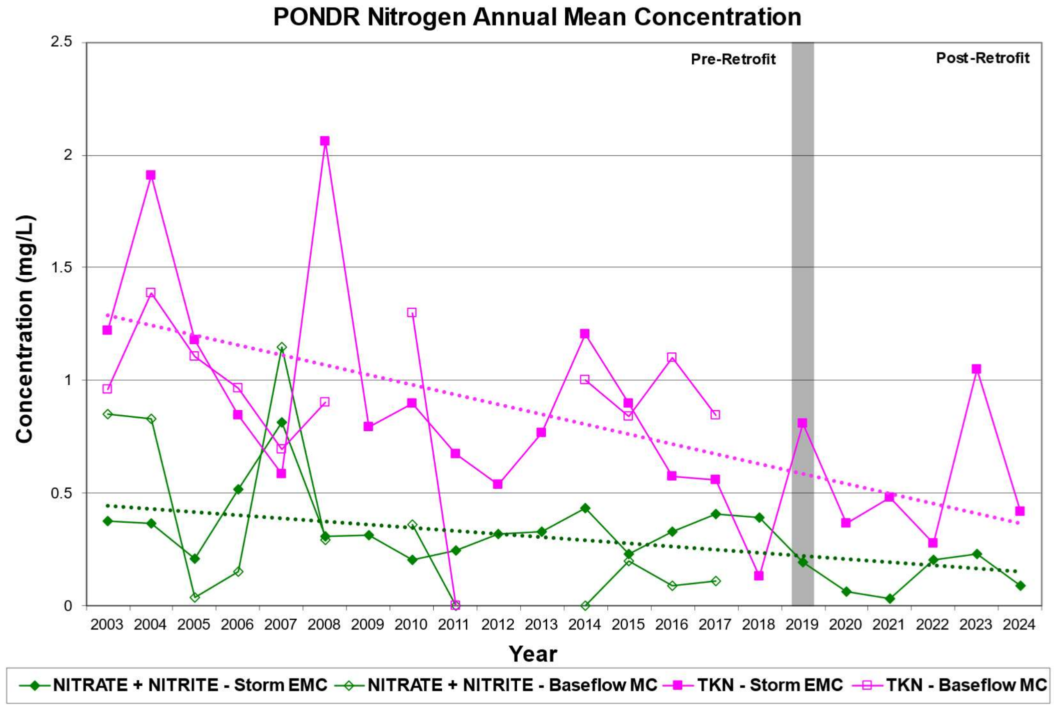

Figure 2-11. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Pond-R outfall site (FY2003 – FY2024).

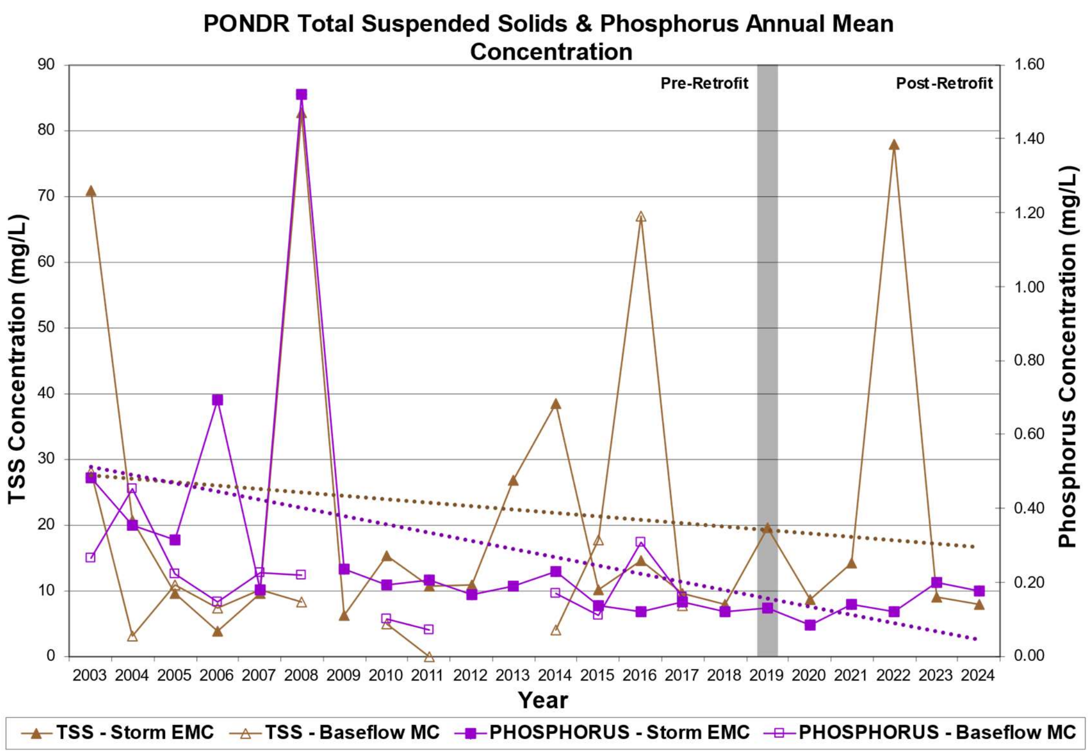

Figure 2-12. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at POND-R (FY2003 – FY2024).

2.1.4 Pollutant Loading Estimates for Peter Pan Run and the Pond-R Outfall

Pollutant loading estimates, as required by the conditions of Frederick County's MS4 permit, were calculated for each storm event for both the instream and outfall stations (Table 2-8 and Table 2-9). Total storm event loadings were calculated by multiplying the storm EMC for each parameter, the corresponding total volume for that storm event calculated from stage data collected by the ISCO meter, and the appropriate conversion factor to obtain pounds. Methods for determining calculation factors are outlined in Appendix B.

Annual and seasonal loading estimates were calculated using estimated flow and analyzed concentration data from both the instream station and the Pond-R outfall station over a twelve-month period (July 1, 2023 through June 30, 2024). Table 2-8 and Table 2-9 show comparative estimated results of stormflow pollutant loadings at the instream and Pond-R stations for the storms sampled. An analogous calculation was used to determine seasonal and annual loading estimates. Seasonal and annual loading estimates for the instream and pond outfall stations are presented in Table 2-10 and Table 2-11. Note that loading estimates are based on calculations from continuous flow rate data as well as a sampled subset of storms that represent less than the actual number of storms that occurred in the watershed. Storm characteristics (i.e., size, duration, intensity, time of year, antecedent dry time) of the storms selected for monitoring may have an effect on loading calculations in a given year.

Table 2-8. Storm event flow volume and pollutant loads per storm event at the instream station of Peter Pan Run.

Date	Total Storm Volume (cf)	Total Storm Volume (acre-ft)	BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	E. coli	Chloride	Orthophosphate Phosphorus	Ammonia Nitrogen	Total Nitrogen
9/9/2023	63,520	1.46	0.9 - 8.5	1.5	4.7	0.43	341	3.2E+10	ND	ND	ND	ND
9/23/2023	348,403	8.00	73.8	10.6	32.1	3.05	1,046	5.0E+11	1,288	0.18 - 0.31	0.00 - 4.35	43
10/14/2023	69,550	1.60	4.5 - 11.7	0.0 - 2.2	4.7	0.29	37	5.0E+10	354	0.00 - 0.04	0.00 - 0.87	5 - 7
11/21/2023	1,723,288	39.56	874.3	ND	78.5	48.29	43,188	5.3E+12	5,380	2.21 - 2.55	0.00 - 21.52	158 - 165
12/10/2023	1,365,616	31.35	324.5 - 353.5	ND	97.9	15.73	6,330	1.3E+12	4,665	1.21 - 1.46	0.00 - 17.05	150 - 153
2/13/2024	2,621,127	60.17	1,385.2	ND	187.3	29.17	10,209	1.0E+12	14,467	4.09 - 4.71	0.00 - 32.73	187 - 220
3/23/2024	1,229,802	28.23	271.6	26.8 - 42.2	105.2	12.27	2,968	1.5E+12	6,117	3.07 - 3.45	0.00 - 15.35	132 - 147
5/5/2024	177,773	4.08	30.4	0.0 - 5.5	21.8	0.29	64	9.2E+10	941	0.00 - 0.11	0.00 - 2.22	22 - 27
6/5/2024	432,796	9.94	107.4	14.5 - 21.1	37.9	8.23	2,064	1.1E+12	1,495	1.88	0.00 - 5.26	51 - 58

Flow volume in cubic feet and acre-feet and pollutant loads in pounds (*E. coli* in MPN)

NC = sample not collected.

Where concentrations reported below detection limit, loads are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 2-9. Storm event flow volume and pollutant loads per storm event at the Pond-R Outfall												
Date	**Total Storm Volume (cf)**	**Total Storm Volume (acre-ft)**	**BOD**	**TKN**	**Nitrate + Nitrite**	**Total Phosphorus**	**TSS**	**E. coli**	**Chloride**	**Orthophosphate Phosphorus**	**Ammonia Nitrogen**	**Total Nitrogen**
9/9/2023	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/23/2023	22,388	0.51	13.4	0.5	0.14	0.19	12	2.3E+10	0.0 - 1.4	0.01 - 0.02	0.00 - 0.28	0.63
10/14/2023	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/21/2023	34,521	0.79	31.3	ND	0.08 - 0.11	0.47	23	7.1E+09	7.8	0.16	0.00 - 0.43	1.32 - 1.44
12/10/2023	36,302	0.83	17.3	ND	0.22	0.54	6	5.9E+08	6.8	0.29	0.00 - 0.45	1.00 - 1.08
2/13/2024	29,882	0.69	12.5	ND	0.23	0.20	20	1.2E+10	45.0	0.02	0.00 - 0.37	0.23 - 0.61
3/23/2024	15,118	0.35	5.2	0.3 - 0.4	0.13	0.10	5	6.5E+09	6.0	0.01 - 0.02	0.00 - 0.19	0.43 - 0.51
5/5/2024	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/5/2024	7,728	0.18	7.7	0.9	0.01 - 0.03	0.20	11	3.7E+09	1.5	0.00 - 0.00	0.00 - 0.10	0.91 - 0.93

Flow volume in cubic feet and acre-feet and pollutant loads in pounds (*E. coli* in MPN)

NC = sample not collected.

Where concentrations reported below detection limit, loads are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 2-10. Seasonal and FY2024 baseflow and stormflow concentrations and loads at PPAN-01.

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Chloride	Orthophos-phate Phosphorus	Ammonia Nitrogen	Total Nitrogen	*E. coli*
Summer (Jul. – Sep. 2023)	Average Storm EMC (mg/L)	2.91 - 3.20	0.47	1.43	0.14	54	59.21	0.008 - 0.014	0.00 - 0.20	1.96	4,547
	Estimated Total Storm Load (lbs)	223 - 246	36	110	10	4,141	4,545	0.6 - 1.1	0.0 - 15.4	150.7	1.58E+12
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.00 - 0.20	1.73	0.04	2.54	98.00	ND	0.00 - 0.20	1.80 - 2.00	1,182
	Estimated Total Baseflow Load (lbs)	0 - 123	0 - 12	107	3	157	6,050	ND	0 - 12	111 - 123	3.31E+11
	Total Estimated Seasonal Load (lbs)	223 - 369	36 - 48	217	13	4,298	10,595	ND	0 - 28	262 - 274	1.91E+12
Fall (Oct. – Dec. 2023)	Average Storm EMC (mg/L)	6.10 - 6.29	0.00 - 0.50	0.92	0.33	251	52.74	0.017 - 0.021	0.00 - 0.20	1.59 - 1.65	7,435
	Estimated Total Storm Load (lbs)	3,915 - 4,033	0 - 321	589	209	161,213	33,831	11 - 13	0 - 128	1,018 - 1,057	2.16E+13
	Average Baseflow MC (mg/L)	2.27 - 3.51	0.00 - 0.20	1.51	0.04	1.63 - 2.31	102.90	0.00 - 0.01	0.00 - 0.20	1.66 - 1.79	325
	Estimated Total Baseflow Load (lbs)	402 - 621	0 - 35	267	7	289 - 408	18,193	0 - 2	0 - 35	294 - 316	2.61E+11
	Total Estimated Seasonal Load (lbs)	4,317 - 4,654	0 - 356	856	216	161,502 - 161,621	52,024	11 - 15	0 - 164	1,312 - 1,373	2.19E+13
Winter (Jan. – Mar. 2024)	Average Storm EMC (mg/L)	6.89	0.35 - 0.55	1.22	0.17	55	85.62	0.030 - 0.034	0.00 - 0.20	1.33 - 1.53	2,263
	Estimated Total Storm Load (lbs)	12,013	609 - 958	2,121	300	95,541	149,249	52 - 59	0 - 349	2,315 - 2,664	1.79E+13
	Average Baseflow MC (mg/L)	4.25 - 5.48	0.00 - 0.40	2.79	0.03	1.16 - 1.77	100.86	0.00 - 0.01	0.00 - 0.20	2.79 - 3.07	153
	Estimated Total Baseflow Load (lbs)	1,167 - 1,503	0 - 110	765	8	318 - 486	27,671	0 - 3	0 - 55	765 - 841	1.90E+11
	Total Estimated Seasonal Load (lbs)	13,180 - 13,517	609 - 1,068	2,886	308	95,860 - 96,028	176,920	52 - 62	0 - 403	3,080 - 3,506	1.81E+13

E. coli is in MPN/100mL for the EMC/MC and MPN for the loads.
Where concentrations are reported at the detection limit, loads are presented as a range of possible values setting concentrations to either zero or the detection limit.

Table 2-10. (Continued)

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Chloride	Orthophosphate Phosphorus	Ammonia Nitrogen	Total Nitrogen	*E. coli*
Spring (Apr. – Jun. 2024)	Average Storm EMC (mg/L)	3.61	0.38 - 0.70	1.57	0.22	56	63.92	0.049 - 0.052	0.00 - 0.20	1.92 - 2.23	7,038
	Estimated Total Storm Load (lbs)	3,919	414 - 758	1,701	242	60,559	69,326	53 - 57	0 - 213	2,082 - 2,417	3.46E+13
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.17 - 0.46	2.46	0.03 - 0.03	0.96 - 1.72	87.07	0.00 - 0.01	0.00 - 0.20	2.63 - 2.92	343
	Estimated Total Baseflow Load (lbs)	0 - 634	55 - 145	779	8 - 9	303 - 544	27,582	0 - 3	0 - 63	834 - 924	4.9E+11
	Total Estimated Seasonal Load (lbs)	3,919 - 4,553	469 - 903	2,480	250 - 252	60,862 - 61,103	96,908	53 - 60	0 - 276	2,916 - 3,341	3.5E+13
FY2024 (Jul. 2023 – Jun. 2024)	Average Storm EMC (mg/L)	6.13 - 6.22	0.22 - 0.54	1.14	0.23	132	69.69	0.025 - 0.029	0.00 - 0.20	1.51 - 1.65	4,777
	Estimated Total Storm Load (lbs)	21,730 - 22,039	783 - 1,906	4,032	833	468,483	247,105	90 - 103	0 - 708	5,346 - 5,854	7.68E+13
	Average Baseflow MC (mg/L)	1.76 - 3.39	0.12 - 0.41	2.39	0.03 - 0.03	1.22 - 1.87	94.55	0.00 - 0.01	0.00 - 0.20	2.51 - 2.77	326
	Estimated Total Baseflow Load (lbs)	1,456 - 2,809	99 - 344	1,979	24 - 26	1,010 - 1,553	78,442	0 - 8	0 - 166	2,086 - 2,298	1.2E+12
	Total Estimated FY2024 Load (lbs)	23,186 - 24,847	881 - 2,250	6,012	857 - 859	469,493 - 470,035	325,548	90 - 111	0 - 874	7,433 - 8,152	7.8E+13

Where concentrations are reported at the detection limit, loads are presented as a range of possible values setting concentrations to either zero or the detection limit.

Table 2-11. Seasonal and FY2024 stormflow concentrations and loads at the Pond-R Outfall station.

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Chloride	Orthophos-phate Phosphorus	Ammonia Nitrogen	Total Nitrogen	*E. coli*
Summer (Jul. – Sep. 2023)	Average Storm EMC (mg/L)	9.58	0.35	0.10	0.13	9	0.00 - 1.00	0.010 - 0.015	0.00 - 0.20	0.45	3.57E+03
	Total Estimated Seasonal Load (lbs)	24	1	0	0	22	0 - 3	0.03 - 0.04	0 - 1	1.15	4.13E+10
Fall (Oct. – Dec. 2023)	Average Storm EMC (mg/L)	10.98	ND	0.07 - 0.07	0.23	6	3.30	0.10	0.00 - 0.20	0.53 - 0.57	3.83E+02
	Total Estimated Seasonal Load (lbs)	227	ND	1 - 2	5	133	68	2	0 - 4	10.87 - 11.79	3.59E+10
Winter (Jan. – Mar. 2024)	Average Storm EMC (mg/L)	6.30	0.28 - 0.40	0.13	0.11	9	18.15	0.011 - 0.014	0.00 - 0.20	0.24 - 0.40	1.46E+03
	Total Estimated Seasonal Load (lbs)	96	4 - 6	2	2	135	276	0.17 - 0.21	0 - 3	3.59 - 6.04	1.01E+11
Spring (Apr. – Jun. 2024)	Average Storm EMC (mg/L)	15.96	1.84	0.03 - 0.05	0.42	23	3.18	0.005 - 0.010	0.00 - 0.20	1.89 - 1.92	1.68E+03
	Total Estimated Seasonal Load (lbs)	206	24	0 - 1	5	296	41	0.06 - 0.13	0 - 3	24.48 - 24.81	2.17E+04
FY2024 (Jul. 2023 – Jun. 2024)	Average Storm EMC (mg/L)	9.10	0.42 - 0.48	0.085 - 0.089	0.18	8	6.99 - 7.14	0.052 - 0.054	0.00 - 0.19	0.47 - 0.54	1.21E+03
	Total Estimated FY2024 Load (lbs)	468	21 - 25	4 - 5	9	409	360 - 367	2.68 - 2.77	0 - 10	24.27 - 27.81	2.82E+11

E. coli is in MPN/100mL for the EMC and MPN for the load.
Where concentrations are reported at the detection limit, loadings are presented as a range of possible values setting concentrations to either zero or the detection limit.

Annual estimated pollutant loadings at the instream station increased for all parameters during FY2024 compared to FY2023 except for TKN, though an increased detection limit during the latter half of the year may contribute to this exception. This increase in pollutant loadings is likely due to the stormflow and baseflow volumes in the stream increasing between the two sampling years by 42%. Despite a 32% increase in discharge from FY2023 to FY2024, only half of the annual estimated pollutant loadings at the pond outfall station increased this monitoring year: BOD, total phosphorus, and TSS increased while TKN, nitrate-nitrite, and E. coli decreased. The pond retrofit from a dry extended detention pond to a wet extended detention pond may have increased the pollutant removal efficiency of the facility. Future monitoring will further determine if the retrofit improved pollutant loadings to the stream. The annual loading values for all parameters were within their respective historical ranges for both stations. The new parameters added in FY24 to satisfy new permit requirements (chloride, orthophosphate phosphorus, ammonia nitrogen, and total nitrogen) will be analyzed starting in FY25 after two monitoring years of data have been collected. For parameters that were detected in outfall samples during FY2023, the estimated contribution of the pond's outfall, Pond-R, to the total loading of the watershed ranged from 0.07% (nitrate-nitrite) to a high of 2.99% (orthophosphate phosphorus). The percent contribution of the Pond-R load to the Peter Pan Run load was calculated by taking the load at the pond site and dividing it by the load from the instream site.

2.2 BIOLOGICAL MONITORING RESULTS FOR PETER PAN RUN

Frederick County annually monitors biological conditions within Peter Pan Run's approximately 3-square mile watershed. Annual monitoring of Peter Pan Run began in June 1999 and continues to the present. The following is a summary of the biological data collected at the four stream monitoring stations in 2024 (Figure 1-2), with sites named PPAN-01 to 04 (also known as BUSL-201-T, 202-T, 103-T and 104-T, respectively). Data from this year's survey, along with data from past years, have been compiled in Appendix A.

Benthic macroinvertebrate sampling and qualitative habitat assessments were conducted within the Maryland Biological Stream Survey (MBSS) Spring Index Period on March 21, 2024. Quantitative geomorphic assessments surveys, including cross-sectional measurements, longitudinal profiles, and pebble counts, were conducted on March 4 and March 21, 2024. Summer sampling was conducted within the MBSS Summer Index Period on July 30 and September 9, 2024, and included fish community sampling, *in situ* physiochemical water quality measurements, further qualitative and quantitative physical habitat assessment, and electrofishing surveys.

The Quality Assurance Project Plan (QAPP) for Frederick County's biological and physical stream monitoring program in Peter Pan Run (Drescher 2020) was adhered to for all sampling. Following EPA guidelines, the QAPP documents a set of quality assurance and quality control procedures used for field and laboratory practices. The biological and physical monitoring QAPP will be updated in FY2025.

Benthic macroinvertebrate and fish data were collected and used to calculate Maryland's Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) scores for each of the four stations in the Peter Pan Run watershed. Fish and benthic IBI ratings for all sites were calculated in accordance with the Maryland Biological Stream Survey (MBSS) revised scoring methods (Southerland et al. 2005; Appendix A, Tables A-4 and A-5). The Peter Pan Run sites are located in the MBSS highlands strata, thus the BIBI combined highland metrics and FIBI warmwater highlands metrics were calculated for each site. The IBI scores are divided into four classes as shown in Table 2-12.

Table 2-12. Narrative rating and score range for the Indices of Biotic Integrity used by the MBSS indices.

Rating	Range
Good	4.00 - 5.00
Fair	3.00 - 3.99
Poor	2.00 - 2.99
Very Poor	1.00 - 1.99

Physical habitat was visually assessed at each sampling location to reflect current conditions of physical complexity of the stream channel, the capacity of the stream to support healthy benthic macroinvertebrate and fish communities, and the potential of the channel to maintain normal rates of erosion and other hydrogeomorphic functions. Physical habitat of the stream channel can be affected by farming operations, increased housing density, and other urban-suburban developments; all of which may cause sedimentation, degradation of riparian vegetation, and bank instability, leading to reduced overall habitat quality (Richards et al. 1996).

The MBSS Physical Habitat assessment protocol was used to visually assess the physical habitat quality at each site. Each biological monitoring site was characterized based on visual observation of physical characteristics and various habitat parameters (Harbold et al. 2024). KCI staff performing the assessment hold current MBSS certification in habitat assessment techniques which rely on qualitative scoring of selected habitat parameters.

The MBSS Physical Habitat Index (PHI; Paul et al., 2003) incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont, and Highlands regions. While all habitat parameters are rated during the field assessment, the Highlands parameters were used to develop the PHI score for Peter Pan Run sites. In developing the PHI, MBSS identified five parameters that have the most discriminatory power for the Highlands streams (Table 2-13).

Table 2-13. Highlands PHI Parameters.

Remoteness
Shading
Epifaunal substrate
Riparian Width
Bank stability

Source: Paul et al. 2003

Using the raw habitat values recorded in the field, a scaled PHI score (ranging from 0-100) for each parameter is calculated following the methods described in Paul et al. (2003). Calculated metric scores are then averaged to obtain the overall PHI index score, and a corresponding narrative rating of the physical habitat condition is applied (Table 2-14).

Table 2-14. Narrative rating and score range for the Maryland Physical Habitat Index used by MBSS.	
Rating	**Range**
Minimally Degraded	81.0-100
Partially Degraded	66.0-80.9
Degraded	51.0-65.9
Severely Degraded	0-50.9
Source: Paul et al. 2003	

Peter Pan Run is listed as Use Class I-P in *Code of Maryland Regulations (COMAR) 26.08.02.08 – Stream Segment Designations.* Water quality data were compared to acceptable standards for the appropriate designated use listed in the *Code of Maryland Regulations (COMAR) 26.08.02.03-.03 - Water Quality* (Table 2-15). Specific designated uses for Use I-P streams include public water supply, water contact sports, fishing, the growth and propagation of fish (non-trout), and agricultural and industrial water supply. Use Class I-P streams receive regulatory protection from activities that may impact drinking water quality and general aquatic resources. Currently, there are no standards available for specific conductivity. However, Morgan et al. (2007) identified a critical threshold of impairment of BIBI scores for Maryland streams at 247 µS/cm.

Table 2-15. Maryland COMAR Standards	
Parameter	**Standard**
pH (SU)	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No State standard
Turbidity (NTU)	Maximum of 150 Nephelometric Turbidity Units (NTU's) and maximum monthly average of 50 NTU
Temperature (°C)	Use I - Maximum of 32°C (90°F) or ambient temperature of the surface water, whichever is greater; Use III - Maximum of 20°C (68°F) or ambient temperature of the surface water, whichever is greater; Use IV - Maximum of 23.9°C (75°F) or ambient temperature of the surface water, whichever is greater
Source: Code of Maryland Regulations (*COMAR*) 26.08.02.03-3 – Water Quality	

IBI scores for data collected in 2024 are summarized in Table 2-16 and displayed in Figure 2-11. The biological communities in Peter Pan Run have experienced land use-related impacts due to previous conversion to agriculture and more recent residential development. It is likely that these benthic communities now have less inherent stability and will therefore continue to fluctuate from year to year due to minor impacts or localized changes to the stream that otherwise would not lead to noticeable change (i.e., annual changes to BIBI narrative categories) in a minimally impacted watershed. Table 2-17 shows a summary of the water quality conditions at the time of sampling in 2024.

Table 2-16. Summary of 2024 Biological Results from Peter Pan Run

Station	Benthic IBI Score	Benthic IBI Rating	Fish IBI Score	Fish IBI Rating	MPHI Score	MPHI Rating
BUSL-201-T	2.25	Poor	4.33	Good	80.9	Partially Degraded
BUSL-202-T	2.50	Poor	4.33	Good	63.5	Degraded
BUSL-103-T	2.25	Poor	3.33	Fair	61.2	Degraded
BUSL-104-T	2.00	Poor	2.00	Poor	55.8	Degraded

Table 2-17. Summary of 2024 in-situ water quality results from Peter Pan Run

Station	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductivity (µS/cm)	Turbidity (NTU)
BUSL-201-T	9/9/2024	13.4	9.72	7.78	419.5	8.48
BUSL-202-T	9/9/2024	15.6	9.49	7.78	440.4	5.81
BUSL-103-T	7/30/2024	21.4	7.96	7.99	316.4	4.91
BUSL-104-T	7/30/2024	19.5	7.79	7.87	728.0	5.24

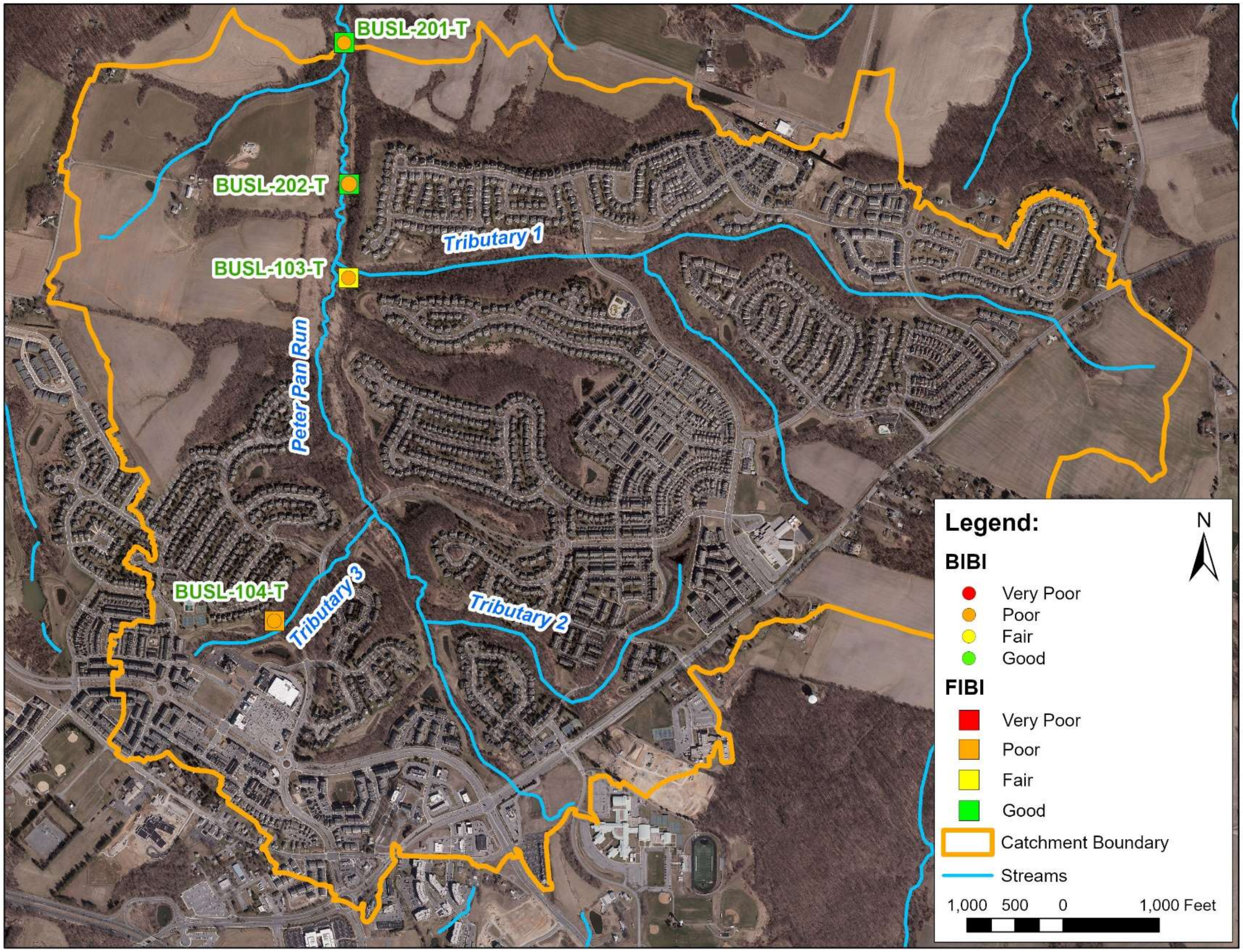

Figure 2-12. BIBI and FIBI results from 2024 at Peter Pan Run sites.

BUSL-201-T

This site is the most downstream site along Peter Pan Run with a drainage area of 1,585 acres. In 2024, the BIBI rating was 'Poor' (score of 2.25), which was a decrease from a score of 3.00 and a rating of "Fair" in 2023. The decrease in BIBI score between 2023 and 2024 can be attributed to a decrease in number of EPT taxa, number of Ephemeroptera taxa, and percent Scrapers (15.08% in 2023 to 9.29% in 2024) metrics. The FIBI score was rated as 'Good' (score of 4.33), which was an increase from the 2023 score of 3.67. A greater number of individuals were observed in 2022 than in 2023 and previous years; however, it is noted that the number of fish observed each year is quite variable and has ranged from just under 400 to over 1,100 with no distinct pattern over time. Twenty-seven species were encountered in 2024, the most of all sampling years. Of the 27 species observed there were a few of note: such as Silverjaw Minnow (last captured in 2020), Golden Redhorse and Rainbow Darter (last captured in 2022), and for the first time, a wild Brown Trout. Also, Mimic Shiner were first encountered during 2024, this is a non-native minnow that appears to be spreading throughout the Potomac River drainage (Jay Kilian, personal communication September 2024) The decrease in percent tolerant species and percent abundance of dominant taxa metrics contributed to the increase in score. The MPHI score indicates this site is in a 'Partially Degraded' habitat condition. All water quality parameters in the summer were within standards. Specific conductivity levels were above the 247 µS/cm threshold as described by Morgan et al. (2007) indicating chronic stress throughout the year for the benthic macroinvertebrate and fish communities. Full site data are presented in Appendix A and discussed in more detail later in this report in section 2.4 Integrated Analysis of Field Results, 2.4.2 Biological Indicators.

BUSL-202-T

BUSL-202-T is located on Peter Pan Run upstream of BUSL-201-T and has a drainage area of 1,377 acres. In 2024, the BIBI score increased slightly from 2023 with a score of 2.50 but maintained a narrative rating of 'Poor'. The FIBI score in 2024 increased to 4.33, or 'Good' from 3.67 or 'Fair' in 2023. This difference was primarily due to a decrease in the percent tolerant species and the percent abundance of dominant taxa metrics. The 2024 MPHI score remained similar to previous years (since 2021), with a rating of 'Degraded.' All water quality parameters in the summer were within standards. Turbidity value was higher here than at all other sites but still within standards. Conductivity levels were greater than 247 µS/cm as described by Morgan et al. (2007) indicating chronic stress for the biotic community and are likely impacting the BIBI scores at this site. Full site data are presented in Appendix A and discussed in more detail later in this report in section 2.4 Integrated Analysis of Field Results, 2.4.2 Biological Indicators.

BUSL-103-T

This site is upstream of BUSL-202-T on an unnamed tributary to Peter Pan Run. The drainage area of this site is 557 acres. The BIBI score has shown a slight, but steady increase between 2022 (score of 1.75, "Very Poor") and 2024 (score of 2.25, "Poor") with 2023 at 2.00 and "Poor". In 2023 BUSL-103-T had the first increase in BIBI rating since 2019, while FIBI scores decreased for the first time since 2019. There were less fish individuals present in 2024 (463) than in 2023 (485), but the number of fish observed varies annually and it appears that the 2024 results are in line with the variability of past observations of between 400-600 individuals. Despite the decrease in number of individuals the FIBI score remained the same between 2023 and 2024. The MPHI rating decreased in 2024 from the 2023 MPHI rating of "Partially Degraded" to a rating of 'Degraded'. All water quality parameters in both spring and summer were within the standards. Similar to the mainstem Peter Pan Run sites, the summer specific conductivity values were greater than the threshold described by Morgan et al. (2007) likely indicating year-round stress for the biological communities. Full site data are presented in Appendix A and discussed in more detail later in this report in section 2.4 Integrated Analysis of Field Results, 2.4.2 Biological Indicators.

BUSL-104-T

This site is on a small headwater unnamed tributary to Peter Pan Run, which receives drainage from two stormwater ponds. The drainage area of BUSL-104-T is 65 acres, the smallest of the four sites monitored. The BIBI score slightly decreased between 2023 and 2024 from score of 2.25 to 2.00 but stayed in the same rating category of 'Poor'. No fish were captured in 2023, which is likely due to the very dry months of May and June creating lower flow conditions and forcing fish to travel downstream and find deeper water refuge. In 2024 fish were captured and the FIBI resulted in a score of 2.00 and a 'Poor' rating. MPHI values indicate similar results to 2023 with a rating of 'Degraded' for 2024. Although the biological and habitat scores were low, the water quality parameters were all within the standards while specific conductivity values were elevated during both the spring and summer sampling visits, greater than the threshold identified in Morgan et al. (2007). Full site data are presented in Appendix A and discussed in more detail later in this report in section 2.4 Integrated Analysis of Field Results, 2.4.2 Biological Indicators.

2.3 PHYSICAL STREAM ASSESSMENTS

Physical stream assessments in Peter Pan Run began in 1999 with the measurement of cross-sections, stream slope, and substrate particle size at each of the four biological monitoring sites. Longitudinal profiles were added to the physical assessment at each of the sites in 2015. Field surveys are typically performed when conditions approximate baseflow, at least 24 hours after a major storm event.

Physical stream conditions within Peter Pan Run in 2024 were generally similar to those in years past, although certain physical stream parameters are beginning to show a pattern of incremental change over time. A summary of historical and current physical stream data is provided in Appendix A. Representative site photographs can be found in Appendix A.

2.3.1 Longitudinal Profile Analysis

In December 2015, longitudinal profiles were established at each of the four Peter Pan Run biological monitoring sites. Benchmark pins were installed at the starting point (i.e., station 0+00) and to mark the end of the survey profile. Each profile is approximately 300 feet in length and encompasses the previously established cross-sections. Both left and right bank cross-section pins were surveyed into the longitudinal profile to obtain relevant elevations for tying in the cross-sections to the profile. Profiles were established along the center of the channel and included a survey of breakpoints in and between bed features, as well as delineation of riffles, runs, pools, and glides. A survey of the bankfull elevation (where discernible), top of bank, and water surface was also performed. Longitudinal profile overlays for all four sites can be found in Appendix A.

As monitoring of the sites' longitudinal profiles only began in 2015, few major changes have occurred to date. Although bed features at each of the four sites may have shifted upstream or downstream by a few feet in some cases, the channel remained stable between 2015 and 2024.

At BUSL-103-T the pool at the beginning of the longitudinal profile has increased in depth between 2023 and 2024. The pool at Station 0+60 has increased in depth slightly in 2024 and depth increased slightly toward Station 1+40 The pool nearest station 1+59 has remained mostly the same between 2022 and 2024. The greatest change in the profile is above the bedrock step at station 1+60 where bed erosion had occurred all the way up to a downed tree near station 2+30 during previous years. This tree was first noted in 2017 and the scour pool had increased in size every year through 2020. In 2021, the downed tree was no longer in the stream channel and deposition has filled in the scour pool by approximately 1 foot. This area has remained the same through 2024. In April 2000, slope at BUSL-103-T decreased significantly as a result of channel elevation changes associated with a sewer line crossing between the station and its confluence with Peter Pan Run. Slope then increased in 2005 and 2006. From 2007 through 2017, slope increased or decreased slightly from year to year; however, in the past seven years, slope has remained consistent between 0.9% and 1.1%.

The BUSL-104-T profile depicts that the pool depth near station 0+50 has remained consistent. The pool near 1+75 has decreased in depth in 2022 due to sediment accumulation but has since increased in 2023 to be consistent with previous years due to the debris jam. The pool at station 2+85 also has just slightly increased in depth from the 2021 and 2022 survey to be more consistent with previous years. In 2024, the survey shows that these two pools near 1+75 and 2+85 remain consistent with the measurements recorded during the 2023 survey. The bed elevation through the riffles and runs has remained very consistent through the years with the major differences visible in the increase and decrease of pool depth depending on the severity of storms throughout the preceding year. The slope at BUSL-104-T has remained stable at approximately 1.3% to 1.5% for the past 16 years.

The longitudinal profile of BUSL-201-T demonstrates that some of the pools in this reach are continuing to accumulate sediment while some are now beginning to scour and deepen. Increased deposition on point bars was noted in 2020 to 2022 and has remained the same in 2023, which caused an increase in sinuosity, which in turn caused features to move slightly up and downstream. The pool from station 0+11 to 0+90 had filled in considerably towards the downstream portion in

2022 but has since increased in depth in 2023, being more consistent with surveys prior to 2022. This pool has continued to deepen in 2024 and measures the deepest it has been since 2019, but still not as deep as the initial 2015 survey. The pool around station 1+70 accumulated sediment in 2018 but then increased in depth and length in 2019. In 2020, there was a slight decrease in depth due to deposition of mostly sand. In 2021, the depth had increased by almost a foot from 2020. The pool in 2022 decreased back to 2019-2020 levels until 2023 where the pool depth increased back to 2021 levels. In 2024 the pool remains consistent with the 2023 survey. The pool located near station 2+75 has experienced a major increase in deposition between 2018 and 2019 with a one-foot decrease in depth and 10-foot decrease in length. In 2020 this pool had begun to deepen and migrate upstream. A continued scouring of approximately 1 foot of depth occurred between 2020 and 2021 along with a continued lengthening. In 2022, this pool depth deepened and increased the length towards the downstream portion. In 2023, this pool depth increased by approximately a foot compared to 2022 while the length decreased slightly. The depth remained the same and the length increased slightly in 2024 when compared to 2023. A rootwad/tree falling in at this location is the probable cause for the increase in depth. Stream gradient has been mostly stable at BUSL-201-T during the past eleven years, with a slight increase in 2022 from 0.51% to 0.70% and this remained steady in 2023 at 0.69%. In 2024 the stream gradient returned to pre-2022 percentages at 0.54%.

At BUSL-202-T the greatest change between 2018 and 2019 was the deepening of the pool at station 0+20. The pool had lengthened some, but the most significant change is the increase in depth of over one foot between the two years. In 2020 the same pool has filled in with 1.2 ft of sediment when compared to 2019. In 2021, the pool depth has remained consistent, but pool length has shrunk by approximately 9 feet. The length of the pool has remained consistent since 2022. Aside from the changes in the previously discussed pool, few changes along the thalweg occurred between 2021 and 2022. Slight bed scour occurred in 2022 between stations 0+60 and 0+90. The pool at station 1+05 in 2015/2016 became a riffle in 2017 and has changed from a riffle in 2020 to a shallow pool in 2021 and remained a shallow pool through 2024. The pool at station 1+60 has remained the same depth between 2022 and 2023 but has begun to lengthen. In 2024 the pool has deepened, but has not increased in length. The pool near station 2+40 has remained the same depth and length as in 2022, but a large rootwad falling into the stream at this location has caused the pool to shift downstream by about seven feet. The observed shift downstream continued in 2024 with a decrease in pool depth. Since 2010, the channel slope at BUSL-202-T has remained stable between 0.4% and 0.52% with a slight increase in 2023 to 0.54%. In 2024 the slope decreased to 0.49%, returning to the range that has been measured since 2010. While these vertical changes along the longitudinal profile document the amount of sediment moving through the stream, the cross-section comparisons discussed in the following section show the long-term lateral changes in the system.

2.3.2 Cross-Section Analysis

Cross-sectional surveys were conducted from 1999 through 2024 at monumented locations at each station; the cross-section data from all years, overlays of all years of data for each cross-section, and photos of the cross-sections can be found in Appendix A. The only exception is at BUSL-201-T, where data from 1999-2004 was excluded from the analysis. Monumented locations at all cross-sections were not established until 2004, and top of banks were not clearly defined at BUSL-201-T, making the overlay not accurate from 1999 to 2004.

Only minor changes to the channel cross-section occurred at BUSL-103-T between 2023 and 2024. While left and right bank erosion is observed from 1999 to 2016, only minor changes were observed between 2016 and 2024. The channel thalweg decreased in depth approximately six inches between 2020 and 2021. This decrease in depth caused a slight decrease in cross-sectional area and estimated discharge in 2021. In 2022, the bed scoured back to 2020 depths and slightly widened towards the right bank. A slight break in bank slope occurs on the right bank, which is a bankfull indicator. From 2015 to 2016, the right side of the channel downcut 0.75 feet, removing the depositional material which accumulated in 2014 and 2015. In 2017, the left side of the channel scoured slightly, and the right bank experienced some accumulating sediment just above the water surface, narrowing the channel by 0.5 feet. Data from 2023 showed additional sediment accumulation along the right bank and this deposition continued in 2024. The left and right banks outside of the active channel have both remained stable between years.

Cross-sectional surveys of BUSL-104-T suggest no visible alterations within its channel. Previous data had indicated that BUSL-104-T was downcutting slightly on the left bank, as evidenced by increased values for stream slope and average depth. Conditions at the site were stable from 2008 to 2016, however, in 2017 and 2018 the thalweg moved towards the left bank. Similarly to 2023, in 2024, the thalweg is along the right of the channel as sediment continues to slowly build up on the left bank. The left bank is becoming more vertical up to the bankfull elevation, where the bank slope then becomes less steep continuing to the top of bank. The right bank remains raw and vertical and has continued to erode slightly with an undercut forming approximately ¾ of the way up the bank.

The cross-sectional survey at BUSL-201-T illustrates channel widening, as it widened by 3.0 feet to the left between 1999 and 2005, and by an additional 1.9 feet between 2005 and 2009. The left bank at BUSL-201-T continues to erode each year, having scoured an additional foot between 2013 and 2019. In 2020 the left bank continued to scour while the top of bank continued to slump. A large gravel bar has filled in the center and the right half of the channel. Between 2015 and 2017, material continued to deposit, increasing bar height by 0.1 feet. In 2017, the bar shifted to the left as the right side of the channel underwent significant scour of about 1.05 feet, creating a new thalweg on the right side of the channel. These conditions were also observed in the 2018 survey, where the thalweg was more so along the right bank. In 2019 however, major deposition of one foot occurred. Erosion has begun behind a downed tree on the right bank slope causing an increase in bank erosion on the right bank. Both right and left banks were almost vertical. An increase in deposition beyond the right top of bank in the flood plain was observed in 2019 with the right bank monument being buried 5 inches under sediment in 2020. In 2021, the left bank remained mostly stable while deposition was observed on the right side of the bed along with 6 inches of bank erosion on the right bank. In 2022, the left and right banks remained stable while about half a foot of bed scour around station 0+25ft occurred. In 2023, the half foot of bed scour at station 0+25ft had filled in and was back to 2021/2020 elevation. Similar to 2021 conditions, the right bank monument was buried under 5 to 6 inches of sediment in 2023. In 2024, the cross section remained mostly stable with only a slight amount of aggradation occurring at the bottom of the right bank when compared to 2023.

At BUSL-202-T, bed material was removed from the cross-section by downward scouring between 2003 and 2008. From 2009-2011, a fallen tree was jammed at the cross-section location. Approximately two feet of bed material was scoured out below the log jam. After the log was dislodged and moved down-stream of the cross-section in 2012, depositional material filled in the scoured area at the cross-section. Between 2013 and 2015, streambed erosion and deposition appeared to have stabilized, however, from 2015 to 2016 slight aggradation was noticed along the left bank and the right side of the stream channel scoured down 0.95 feet. In 2017, the left side of the channel scoured slightly (0.4 feet), and the right side continued to scour down by an additional 0.25 feet from 2016. Between 2017 and 2018 almost 0.5 feet of deposition occurred in an area along the left back of about 2.5 feet. In 2019, the 0.5 feet of deposition along the left bank from 2018 has been scoured while the pool on the right side of the channel has experienced deposition of 0.5 feet of material. Very little change occurred between 2019 and 2020 as the thalweg was still located along the right bank, with vertical banks until the bankfull elevation with bank slopes becoming less steep up to the top of bank. In 2021, bank erosion was evident on the left bank as well as the thalweg migrating back to the center of the channel as aggradation occurred along the bottom of the right bank. In 2023, the survey looked very similar to that of 2020 and 2022 with more bank erosion occurring along the right bank. The 2024 survey indicated 0.5 feet of bed erosion along the right side when compared to 2023. Both right and left banks above the active channel have remained stable between the two years. The right monument was not located in 2023 as it had become buried under deposited sediment. The inability to find this monument likely contributed to the variation in cross-section from year to year.

2.3.3 Particle Distribution Analysis

Representative Wolman pebble counts were conducted at each cross-section location from 1999 to 2024 (see Table 2-18 for stream particle categories). Particle size distribution overlays from 1999 to 2024 are available in Appendix A and Table 2-19 compares the D_{16}, D_{50}, and D_{84} of all pebble count data.

Table 2-18. Stream Particle Grain-Size Classification			
		Median (mm)	**Range (mm)**
SILT/CLAY	Silt/Clay	0.01	< 0.062
SAND	Very Fine	0.02	0.062 - 0.13
	Fine	0.19	0.13 - 0.25
	Medium	0.38	0.25 - 0.50
	Coarse	0.75	0.50 - 1.0
	Very Coarse	1.5	1.0 - 2
GRAVEL	Very Fine	3	2 - 4
	Fine	5	4 - 6
	Fine	7	6 - 8
	Medium	10	8 - 11
	Medium	14	11 - 16
	Coarse	20	16 - 22
	Coarse	28	22 - 32
	Very Coarse	40	32 - 45
	Very Coarse	56	45 - 64
COBBLE	Small	80	64 - 90
	Small	109	90 - 128
	Large	154	128 - 180
	Large	218	180 - 256
BOULDER	Small	309	256 - 362
	Small	438	362 - 512
	Medium	768	512 - 1024
	Large	1500	1024 - 2048
	Very Large	3072	2048 - 4096
BEDROCK	Bedrock		> 4096

At BUSL-103-T the median particle size (D_{50}) has ranged from 16mm to 40mm between 2015 and 2024, which ranges between medium and very coarse gravel. A slight increase in larger material was observed in 2023, which is evident in the particle distribution overlay (Appendix A). The D_{84} in 2024 was 79mm, which is smaller than the previous year. Overall although minor shifts in the distribution have occurred, the particle size has remained relatively stable over time.

At BUSL-104-T the D_{50} remained in the coarse gravel category from 2002 to 2017, but in 2018 the D_{50} dropped to 1.9mm, which is in the very coarse sand category. In 2019, the D_{50} increased to 14mm which is similar to what it has been prior to 2018. The D_{50} in 2020 increased from 2019 to 20mm and decreased to 10mm in 2021 and 11mm in 2022 and in the medium gravel category. Particle size remained in the medium gravel category for 2023 and 2024 with a median particle size of to 13mm, similar to what was seen in 2019. The D_{84} also decreased slightly from 60mm in 2022 to 51mm in 2023 and fell within the very coarse gravel range. In 2024, the D_{84} did not change from 2023 and is still in the very coarse gravel range.

At BUSL-201-T the D_{50} in 2023 was 23mm, in the coarse gravel category. This is a slight decrease from 2022, but is similar to previous years, where the D_{50} primarily falls in the medium or coarse gravel category. The median particle size follows this pattern in 2024 with a D_{50} of 24mm. The particle overlay is located in Appendix A and shows that the particle distribution has been stable from 1999 to 2024.

At BUSL-202-T the D_{50} in 2024 was 8.8mm, which falls in the medium gravel category. This is an increase from 2023 though still a decrease from previous years when particle size was in the course gravel range (2018 to 2023) but is similar to the 2016 D_{50} at 8.8mm. While the range in D_{50} over the monitoring years is slightly greater here than at the other cross-sections, the D_{50} remains in the gravel category.

Table 2-19. Cross-Section Particle Distribution Comparison

METRIC	BUSL-103-T											BUSL-104-T										
	‘99	**‘15**	**‘16**	**‘17**	**‘18**	**‘19**	**‘20**	**‘21**	**‘22**	**‘23**	**‘24**	**‘99**	**‘15**	**‘16**	**‘17**	**‘18**	**‘19**	**‘20**	**‘21**	**‘22**	**‘23**	**‘24**
D_{16}	0.08	10	4	1.4	1.3	6.8	1.7	1.1	1.7	0.6	1.4	0.4	5	1.2	1.3	0.2	0.4	1.7	0.6	1.1	1.3	1.3
D_{50}	8.6	40	20	16	35	25	29	20	18	35	27	10	17	13	12	1.9	14	20	10	11	13	13
D_{84}	50	86	48	43	99	63	86	94	56	91	79	50	83	35	36	73	64	79	76	60	51	51
METRIC	**BUSL-201-T**											**BUSL-202-T**										
	‘99	**‘15**	**‘16**	**‘17**	**‘18**	**‘19**	**‘20**	**‘21**	**‘22**	**‘23**	**‘24**	**‘99**	**‘15**	**‘16**	**‘17**	**‘18**	**‘19**	**‘20**	**‘21**	**‘22**	**‘23**	**‘24**
D_{16}	1.4	1.2	16	2.6	8	2.7	14	2.8	4	1	0.68	0.1	2	0.7	0.1	6	3.5	14	1.5	4.5	0.25	0.27
D_{50}	9.9	19	29	13	28	12	25	14	29	23	24	8.2	34	8.8	2.8	27	27	26	20	24	19	8.8
D_{84}	34	45	50	48	74	45	43	47	62	45	72	27	71	16	12	72	44	43	52	42	49	36

2.4 INTEGRATED ANALYSIS OF FIELD RESULTS

Frederick County has collected and analyzed a considerable amount of data to assess physical, chemical, and biological conditions in the Peter Pan Run watershed since monitoring began in May 1999. During that time, land clearing and related development activities have occurred in phases, with construction starting in new sections as others are completed. Additionally, natural variation in precipitation patterns has occurred over the study years, with four very dry (FYs 1999, 2002, 2007, and 2023) and twelve very wet years (FYs 2000, 2003, 2004, 2010, 2012, 2013, 2014, 2015, 2018, 2019, 2020, and 2024).

These development and weather factors present a complex set of variables affecting conditions within the study area. While these factors should be considered in drawing conclusions about the stressors affecting stream conditions, data generally indicate that there are some adverse effects associated with construction and development within the watershed. It should also be noted that the development of the watershed is not the only factor influencing conditions within the study area; based on pre-construction, baseline-monitoring data, the effects of historical and pre-development land use activities within the watershed are also evident.

2.4.1 Hydrology and Water Chemistry

Pollutant loading estimates provide an illustration of the total quantity of pollutants transported out of a watershed but can vary widely on an annual basis due to variability in weather conditions and stream discharge. For this reason, the determination of trends in pollutant loading is challenging. To determine whether pollutant levels in Peter Pan Run have been changing significantly since the beginning of PUD construction and required water chemistry monitoring, statistical analysis was performed on the individual storm EMC data from FY1999 to present. A maximum likelihood distribution fitting was performed to determine which variables were normally distributed. Dixon and Grubbs outlier tests were performed, and outliers were removed from normally distributed variable data. Kendall Tau-b correlation tests were performed on the original data and the data with outliers removed and then compared. Since *E. coli* sampling was performed differently prior to July 2017, statistical analyses for *E. coli* were only performed on *E. coli* EMCs from July 2017 through the present fiscal year.

The Kendall Tau-b correlation for trends (Kendall 1948) on the individual storm EMC data with outliers removed showed statistically significant ($\alpha = 0.05$) decreasing trends over time for combined nitrate and nitrite ($\tau = -0.291$, $p = <0.0001$; Figure 2-13). Prior analysis indicated statistically significant decreasing trends for copper and lead at the instream station, although current data do not support the continued decreasing trend and these parameters are no longer measured.

Individual storm EMCs at the instream station for combined nitrate and nitrite have gradually, but significantly, declined since 1999 as shown by the Kendall's Tau-b statistical analysis. The nitrate and nitrite reduction may be the result of gradually increasing impervious cover in the watershed, which reduces groundwater, the primary contributor of nitrate and nitrite input to streams (EPA, 2015). Concentrations of nitrogen measured as combined nitrate and nitrite at the instream station have nearly always been greater than 1 mg/l, (Figure 2-14). This concentration level indicates nitrogen contributions from anthropogenic sources (Roth et al. 1999). TSS, BOD, TKN, phosphorus, and *E. coli* EMCs at the instream station have been variable with no statistically significant trends over time (Figure 2-15).

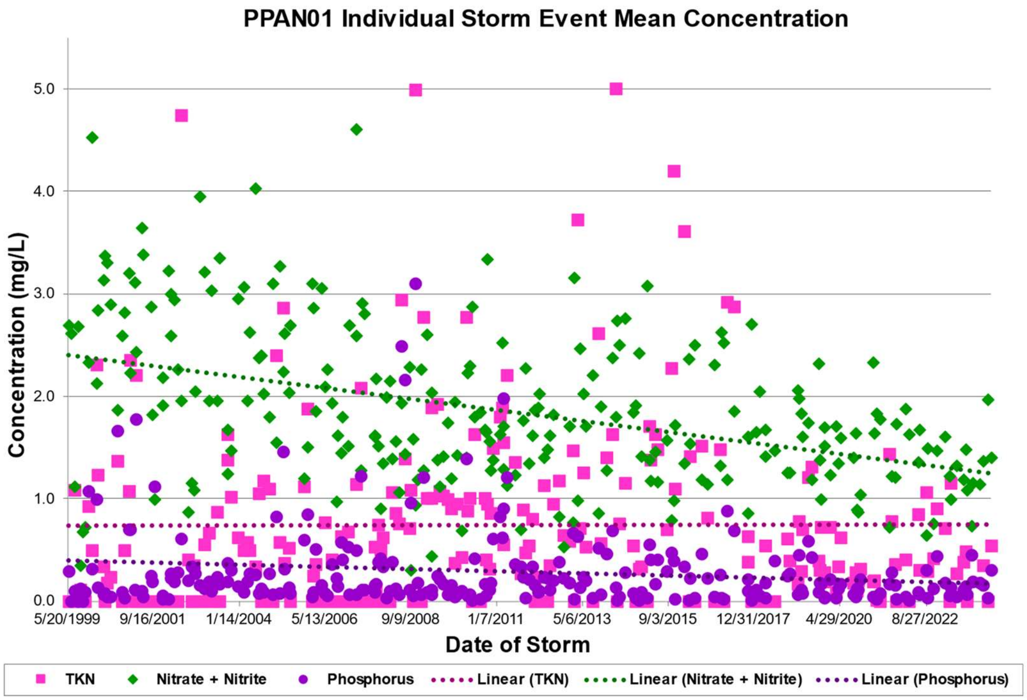

Figure 2-16. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2024) at the instream station. Note: Values below detection limit are set to zero.

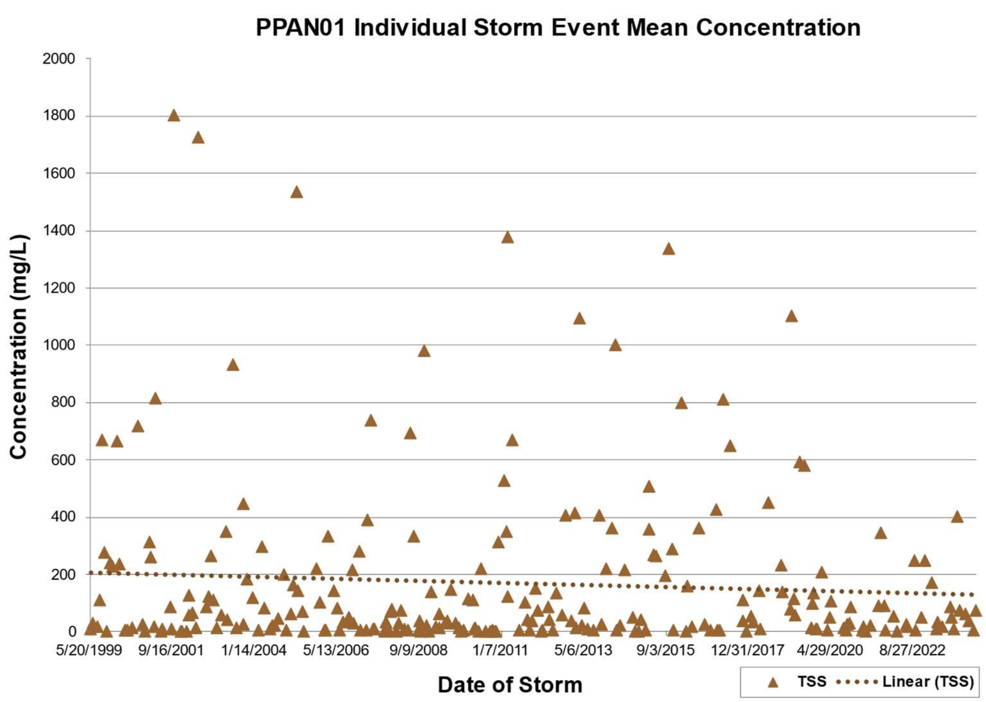

Figure 2-17. Storm event mean concentrations for TSS (May 1999 to July 2024) at the instream station.

Individual storm EMC data at the outfall station showed statistically significant decreasing trends over time for BOD (τ = -0.101, p = 0.049), TKN (τ = -0.102, p = 0.044), nitrate and nitrite (τ = -0.240, p = <0.0001), and phosphorus (τ = -0.182, p = <0.001), as shown in Figure 2-16 and Figure 2-17. Prior analysis indicated statistically significant decreasing trends for lead and zinc, although these parameters are no longer measured. TSS measured at the outfall station strongly correlated with BOD (τ = 0.166, p = 0.002), TKN (τ = 0.252, p = <0.0001), and phosphorus (τ = 0.150, p = 0.003), further suggesting that a portion of nutrients in storm water may be bound to suspended soil particles.

Trends in BOD, TKN, and phosphorus are decreasing at the outfall station in comparison to no statistically significant trends at the instream station. The Pond-R data shows that the facility is reducing nutrients, sediments, and previously heavy metals, reaching the Peter Pan Run mainstem from the Pond-R watershed over time.

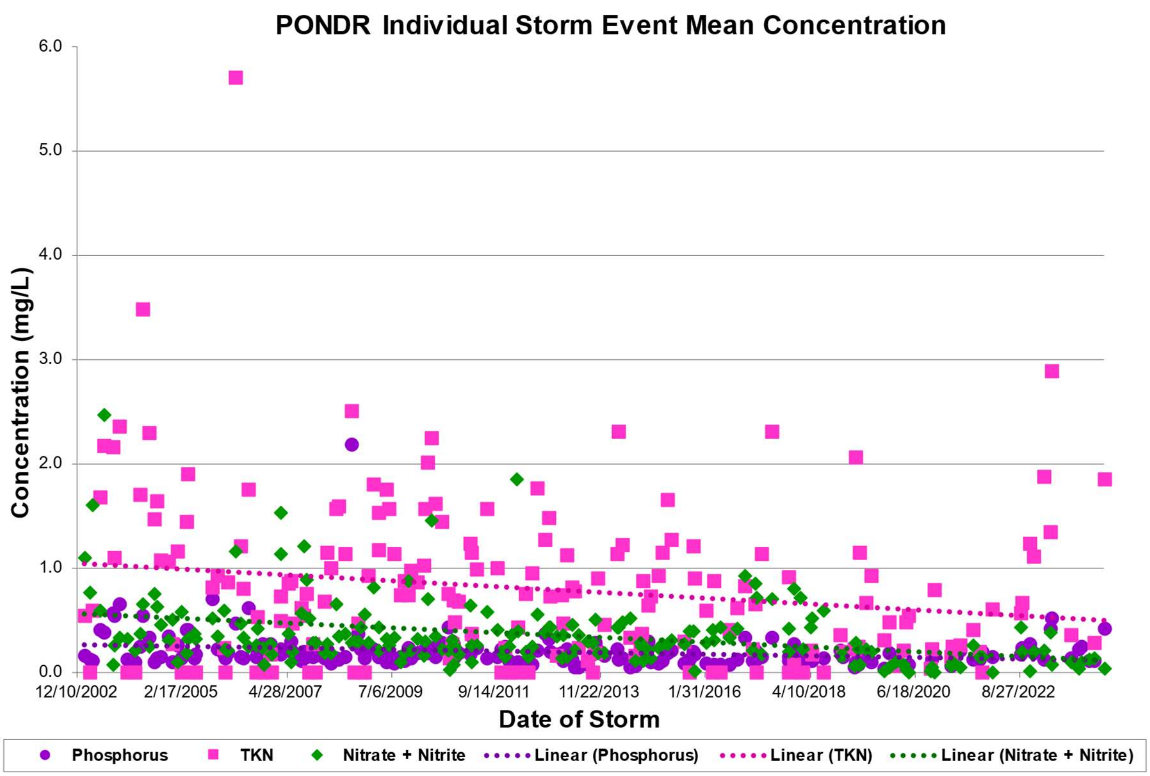

Figure 2-16. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2024) at the outfall station. Note: Values below detection limit are set to zero.

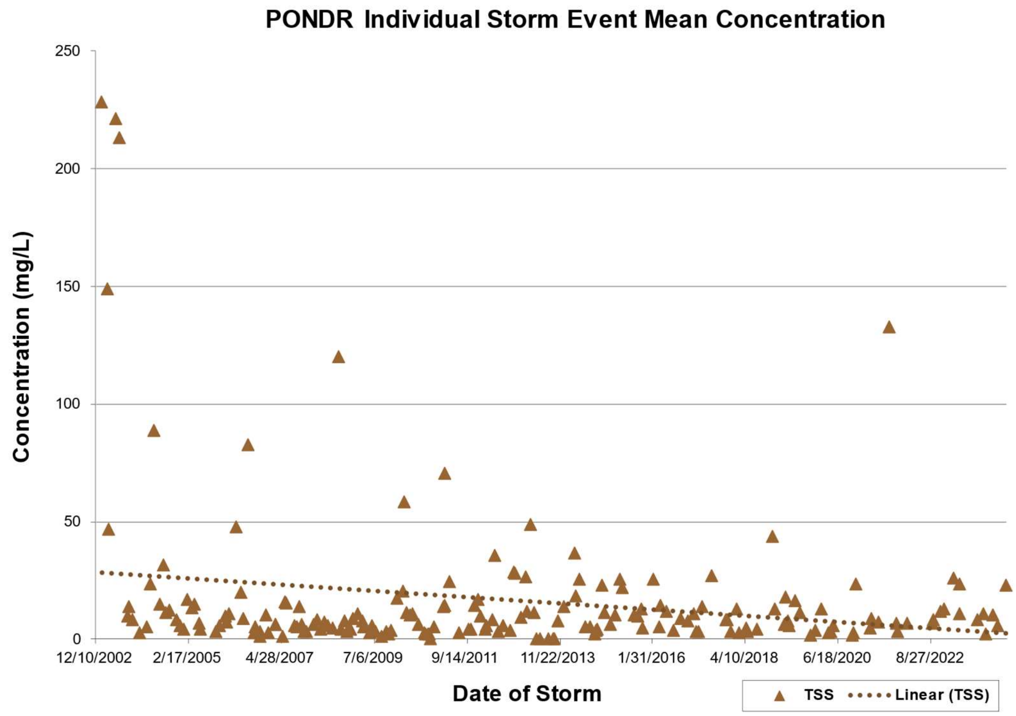

Figure 2-17. Storm event mean concentrations for TSS (May 1999 to July 2024) at the outfall station.

2.4.2 Biological Indicators

Benthic scores increased slightly at two of the stations and decreased slightly at two of the stations in 2024 when compared to 2023 scores. In 2024, all four stations received ‘Poor’ ratings. Results for BUSL-201-T and BUSL-103-T fall just below the long-term average BIBI scores, which have varied over the period of record between the ‘Fair’ and ‘Very Poor’ categories. Results for BUSL-202-T and BUSL-104 fall just above the long-term average BIBI scores, which have varied between Fair’ and ‘Very Poor’ for BUSL-202-T and ‘Poor’ and ‘Very Poor’ categories at BUSL-104-T (Figure 2-18). During a period of time that coincides with very active construction in 2003 and 2004, BIBI scores dropped to Poor or Very Poor at all four sites. These four sites all show a high year-to-year variability in the BIBI scores, with sites frequently changing up to 1.5 IBI units over a one-to-two-year period (Figure 2-18). The continued year-to-year fluctuations of the BIBI scores (between the ‘Fair’ and ‘Very Poor’ rating categories) reflect the noted changes in physical habitat, in particular the highly mobile substrate and changing bed features. The stream is capable of providing adequate habitat for the benthic community; however, this habitat is vulnerable to periodic disruption due to flashy flows and excessive sediment loads moving through the system and periodically covering benthic habitats. Changes in the watershed landscape, such as the conversion of forest to residential land use and impervious surface, leave a stream less able to withstand stressful climatic conditions, such as drought or frequent high flow conditions. Direct infiltration is reduced and lower baseflows leave stream biota vulnerable to increased temperature, decreased dissolved oxygen levels and flow-related fluctuations in available habitat. The elevated conductivity levels measured at all sites during both the spring and summer sampling visits suggest that the organisms living at these sites are subjected to osmotic difficulties due to high concentrations of dissolved solids as evidenced by the high conductivity routinely measured at each site.

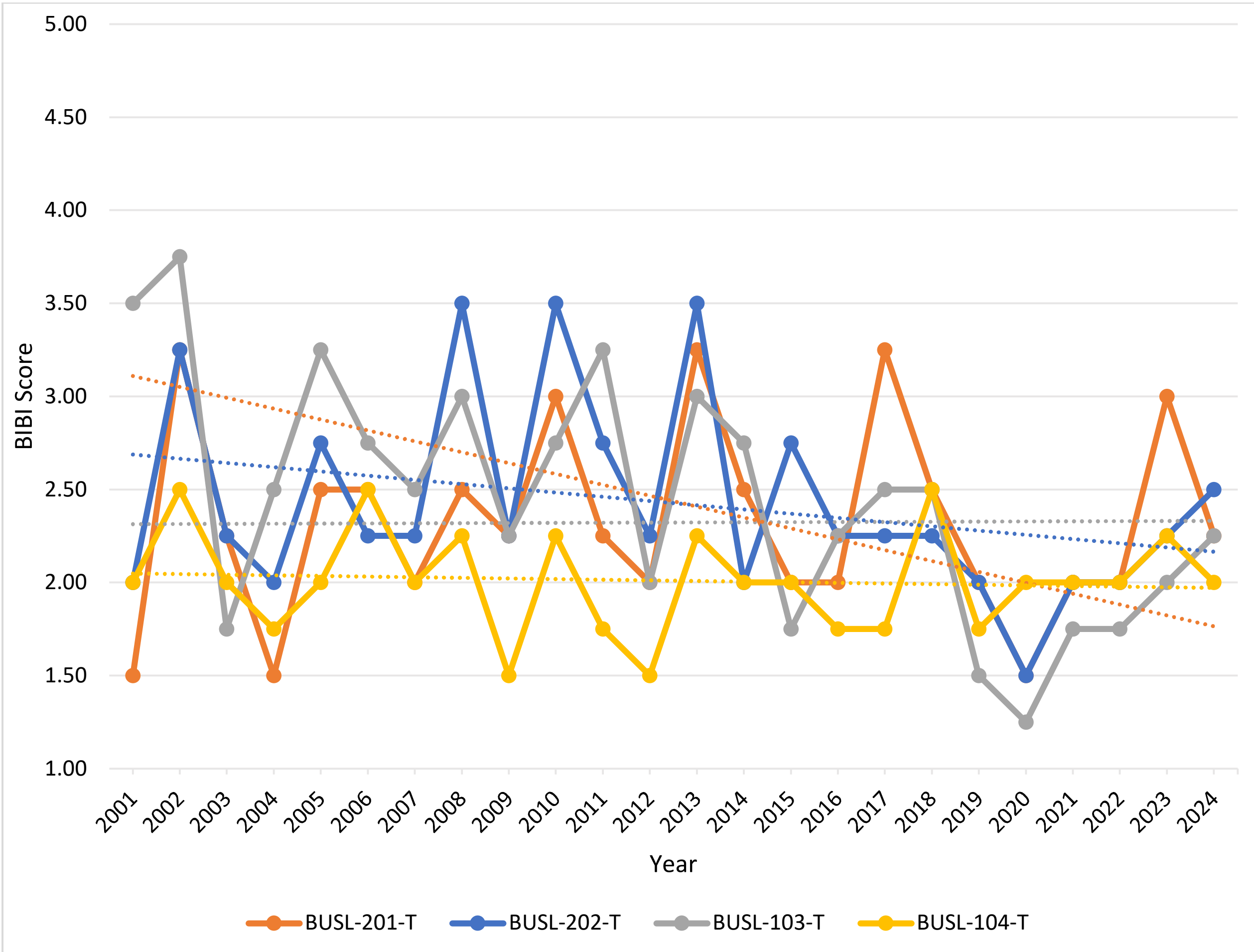

Figure 2-18. BIBI Scores from 2001-2024.

This year's FIBI score ratings were 'Good' for BUSL-201-T, BUSL-202-T, "Fair' for BUSL-103-T, and BUSL-104-T received a 'Poor' rating (Figure 2-19). When compared to 2023 results, three sites had a higher score in 2024 (BUSL-201-T, BUSL-202-T, and BUSL-104-T) and the fourth site showed no change (BUSL-103-T). Over the 22 years of sampling, FIBI scores have remained relatively constant, when compared to the variability observed in the BIBI scores, with minor fluctuations between years. BUSL-201-T, BUSL-202-T and BUSL-103-T have fluctuated between a rating of 'Good' and 'Fair' while BUSL-104-T has remained in the 'Poor' to 'Very Poor' category. Variability in FIBI scores over the period of record for these sites is much lower than variability observed for the BIBI scores. FIBI scores have usually varied by less than 1 IBI unit from year to year. In 2024, all sites saw an increase in the number of individuals captured, with the exception of BUSL-103-T, which caused an increase in narrative rating from the previous year for those sites. BUSL-103-T remained the same in 2024 as the difference in number of individuals were only 22. BUSL-104-T saw an increase from 0 to 58 individuals. This watershed wide increase can most likely be attributed to the very dry weather during May and June of 2023 compared to 2024. On average, the watershed receives 4.3" in May and 3.9" in June. In 2023, 0.85" were recorded in May and 1.83" in June while 2024 had 4.49" in May and 3.42" in June. The decrease in rainfall in 2023 likely caused lower water levels within the stream where fish traveled downstream to search for deeper water. Continued monitoring will help determine if decrease in rainfall and flow contributes to lower FIBI scores.

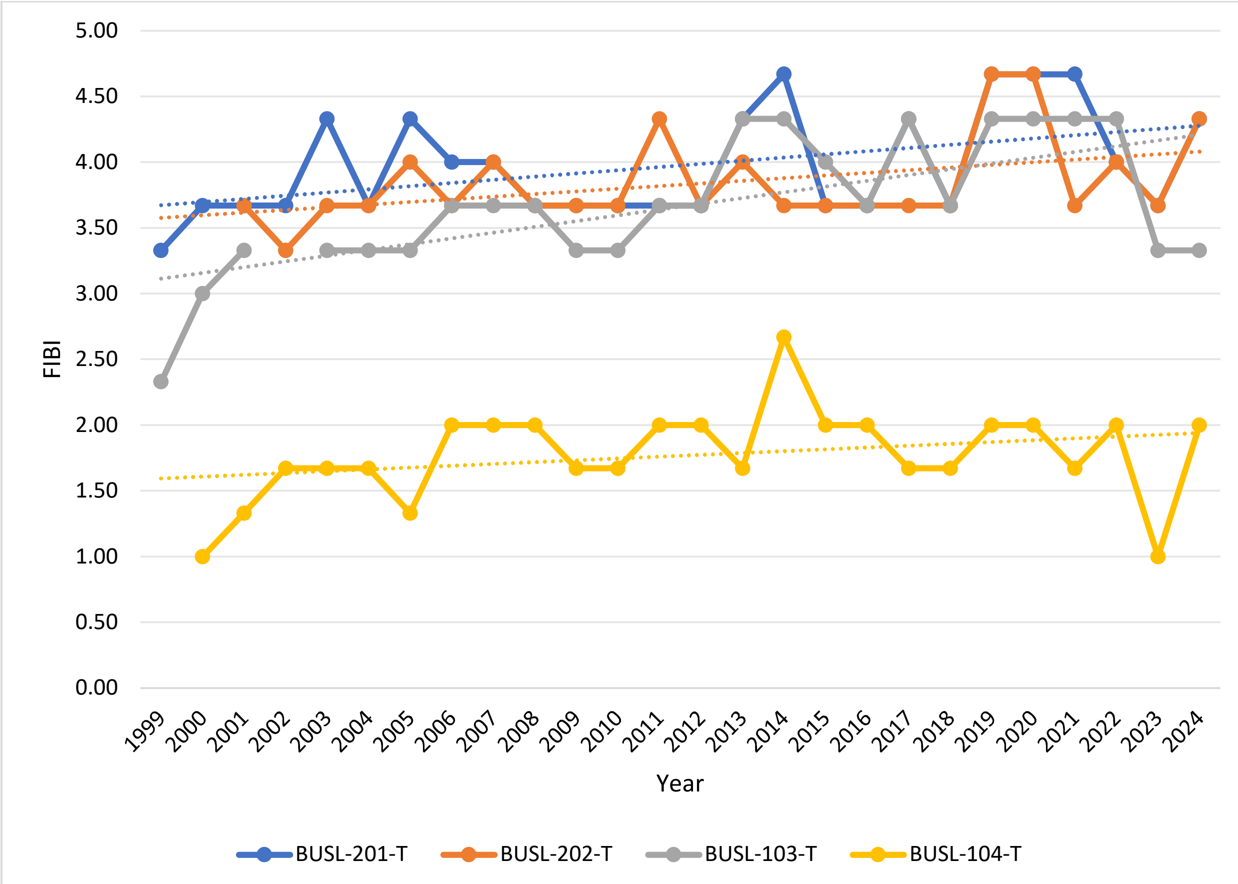

Figure 2-19. FIBI Scores from 1999-2024.

2.4.3 Physical Habitat

Physical habitat, especially increased bank erosion and sediment deposition, is the most obvious sign that the Peter Pan Run stream and watershed has suffered negative impacts as a result of disturbance due to upstream land use conversion to agriculture and more recently suburban development. While the planned construction and development in the watershed has been completed, no significant signs of recovery were noted in the habitat data. Physical habitat scores have largely remained similar at all sites over the monitoring years, with the fluctuations observed likely the result of depth-dependent habitat metrics varying with changes in stream flow conditions reflecting climactic variability (wet years and dry years). Legacy effects of historical and pre-development land use activities within the watershed also continue to impact current stream conditions (Figure 2-18).

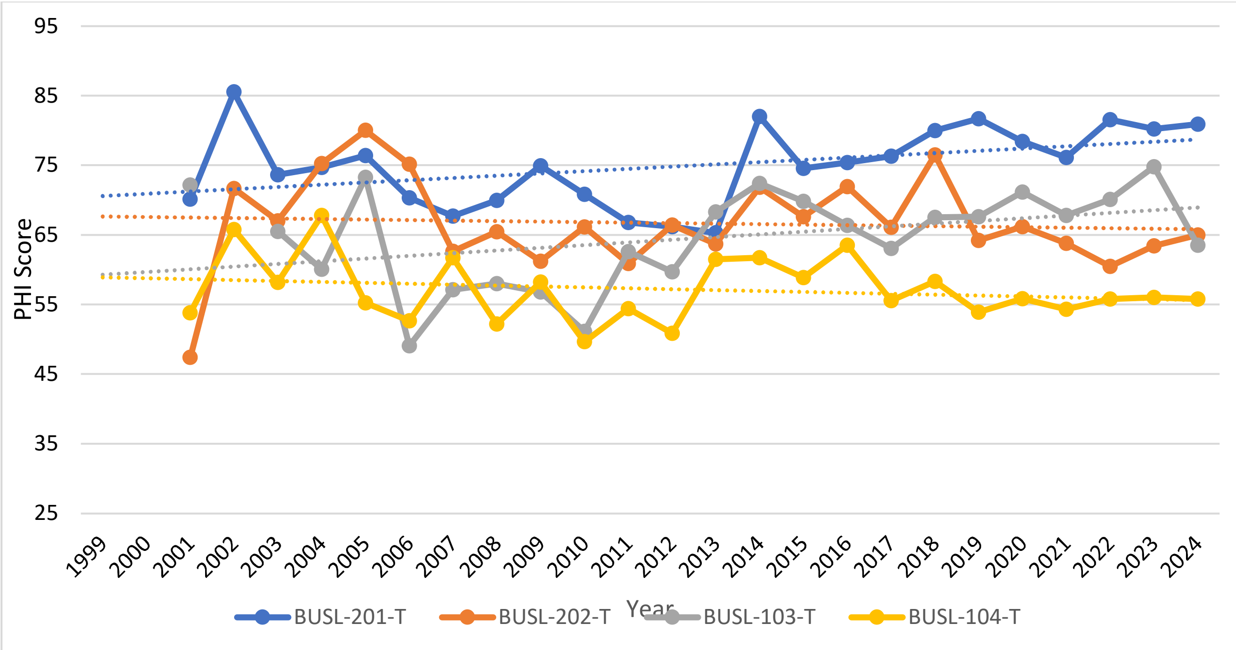

Figure 2-19. PHI Scores from 2001-2024.

2.4.4 Improvements to Long-Term Monitoring

In FY2018, Frederick County invested significant resources in replacing all the automated storm event sampling equipment in October 2017. As discussed earlier, many watershed stormwater BMPs were retrofit in 2018 and 2019, future monitoring will determine the impact of those retrofits on stormwater quality and channel stability. In FY24, Frederick County invested significant resources in replacing the existing Teledyne Isco sondes with new In-Situ multi parameter sondes. The In-Situ sondes were deployed continuously at the in-stream station and intermittently at the pond station (only during the eight sampled storm events due to no baseflow present) during FY24 and record temperature, pH, dissolved oxygen, and conductivity. Starting with the Fall quarter of FY24, the only significant changes anticipated to the monitoring elements described in Table 2-20 are several stormwater and baseflow representative samples parameters added or removed from monitoring, following the Quality Assurance Project Plan (QAPP) developed in response to changed permit requirements (Drescher, 2020).

Table 2-20. Summary of changes to Frederick County's long term monitoring efforts

Monitoring Effort	Location	Plans
Chemical Storm Event Monitoring	Peter Pan Run: instream and outfall stations	Per Permit No. 22-DP-3321, TKN, Copper, Lead, Zinc, Hardness, and TPH parameters were removed, and Chloride, Orthophosphate, Total Nitrogen, and Total Ammonia were added. Will continue to sample 8 events (2/quarter) based on the County's MS4 permit.
Biological and Physical Monitoring	4 stream stations in Peter Pan Run	No change to current monitoring procedures. Will continue with annual biological and physical monitoring, and surveying of geomorphic cross-sections.

Table 2-20. Summary of changes to Frederick County's long term monitoring efforts		
Stormwater Management Assessment	4 stream stations in Peter Pan Run	Survey geomorphic longitudinal profiles beginning in FY2016, as well as hydrologic and/or hydraulic modeling completed in FY2018, the 4th year of the permit. No changes planned for the future.

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APPENDIX A

SUMMARY OF BIOLOGICAL AND PHYSICAL MONITORING DATA FOR PETER PAN RUN

APPENDIX A

Biological Monitoring

Table A-2. Summary of benthic macroinvertebrate data from Peter Pan Run using MBSS 2005 IBI

Station ID	Date Sampled	Number of Taxa	Benthic IBI Score	Benthic IBI Rating	Station ID	Date Sampled	Number of Taxa	Benthic IBI Score	Benthic IBI Rating
BUSL-201-T	4/23/2001	20	1.50	Very Poor	BUSL-103-T	4/23/2001	32	3.50	Fair
	3/21/2002	38	3.25	Fair		3/21/2002	29	3.75	Fair
	3/26/2003	17	2.25	Poor		3/26/2003	14	1.75	Very Poor
	4/29/2004	21	1.50	Very Poor		4/29/2004	24	2.50	Poor
	3/4/2005	25	2.50	Poor		3/4/2005	26	3.25	Fair
	3/1/2006	34	2.50	Poor		3/3/2006	29	2.75	Poor
	4/9/2007	16	2.00	Poor		4/13/2007	29	2.50	Poor
	4/23/2008	25	2.50	Poor		4/23/2008	38	3.00	Fair
	3/10/2009	28	2.25	Poor		3/11/2009	31	2.25	Poor
	3/24/2010	29	3.00	Fair		3/24/2010	23	2.75	Poor
	4/6/2011	31	2.25	Poor		4/6/2011	28	3.25	Fair
	3/21/2012	22	2.00	Poor		3/20/2012	19	2.00	Poor
	3/11/2013	37	3.25	Fair		3/11/2013	27	3.00	Fair
	4/9/2014	25	2.50	Poor		4/14/2014	31	2.75	Poor
	3/20/2015	27	2.00	Poor		3/13/2015	20	1.75	Very Poor
	3/7/2016	35	2.00	Poor		3/7/2016	32	2.25	Poor
	3/21/2017	35	3.25	Fair		3/21/2017	30	2.50	Poor
	3/8/2018	26	2.50	Poor		3/8/2018	28	2.50	Poor
	4/16/2019	27	2.00	Poor		4/16/2019	18	1.50	Very Poor
	3/92020	16	1.50	Very Poor		3/10/2020	8	1.25	Very Poor
	3/12/2021	23	2.00	Poor		3/12/2021	21	1.75	Very Poor
	3/25/2022	28	2.00	Poor		3/25/2022	23	1.75	Very Poor
	3/8/2023	31	3.00	Fair		3/8/2023	25	2.00	Poor
	3/21/2024	31	2.25	Poor		3/21/2024	23	2.25	Poor
BUSL-202-T	4/23/2001	19	2.00	Poor	BUSL-104-T	4/23/2001	25	2.00	Poor
	3/21/2002	33	3.25	Fair		3/22/2002	23	2.50	Poor
	3/26/2003	22	2.25	Poor		3/26/2003	31	2.00	Poor
	4/29/2004	26	2.00	Poor		4/29/2004	11	1.75	Very Poor
	3/4/2005	32	2.75	Poor		3/4/2005	18	2.00	Poor
	3/1/2006	39	2.25	Poor		3/3/2006	34	2.50	Poor
	4/9/2007	20	2.25	Poor		4/13/2007	17	2.00	Poor
	4/23/2008	39	3.50	Fair		4/23/2008	29	2.25	Poor
	3/11/2009	34	2.25	Poor		3/10/2009	22	1.50	Very Poor
	3/24/2010	33	3.50	Fair		3/24/2010	32	2.25	Poor
	4/6/2011	25	2.75	Poor		4/6/2011	22	1.75	Very Poor
	3/21/2012	33	2.25	Poor		3/20/2012	20	1.50	Very Poor
	3/11/2013	33	3.50	Fair		3/13/2013	15	2.25	Poor
	4/9/2014	18	2.00	Poor		4/14/2014	22	2.00	Poor
	3/20/2015	26	2.75	Poor		3/13/2015	20	2.00	Poor
	3/7/2016	39	2.25	Poor		3/7/2016	25	1.75	Very Poor
	3/21/2017	22	2.25	Poor		3/21/2017	15	1.75	Very Poor
	3/8/2018	22	2.25	Poor		3/8/2018	34	2.50	Poor
	4/16/2019	24	2.00	Poor		4/16/2019	21	1.75	Very Poor
	3/92020	17	1.50	Very Poor		3/10/2020	16	2.00	Poor
	3/12/2021	26	2.00	Poor		3/12/2021	27	2.00	Poor
	3/25/2022	25	2.00	Poor		3/25/2022	28	2.00	Poor
	3/8/2023	22	2.25	Poor		3/8/2023	26	2.25	Poor
	3/21/2024	29	2.50	Poor		3/21/2024	26	2.00	Poor

Project Name: 2024 Peter Pan Run
Project Number: 172203794.12
Prepared by: NJH
Prepared date: 8/15/2024
Checked by: AJB
Checked date: 8/29/2024
2024_PPR_BIBI_Combined_Highlands_v2.xlsx
Version: 1
Site Name:

Metric	BUSL-103-T-2024	BUSL-104-T-2024	BUSL-201-T-2024	BUSL-202-T-2024
Raw Scores	**Raw Scores**			
Total Number of Taxa	23	26	31	29
Number of EPT Taxa	5	2	5	5
Number of Ephemeroptera Taxa	1	0	1	1
Percent Intolerant Urban	4.88	0.84	10.71	2.84
Percent Tanytarsini	13.82	10.92	11.43	7.80
Percent Scrapers	14.63	0.84	9.29	39.72
Percent Swimmers	0.00	0.00	0.00	0.71
Percent Diptera	64.23	71.43	75.00	78.72
BIBI Scores	**BIBI Scores**			
Total Number of Taxa	3	5	5	5
Number of EPT Taxa	1	1	1	1
Number of Ephemeroptera Taxa	1	1	1	1
Percent Intolerant Urban	1	1	1	1
Percent Tanytarsini	5	5	5	5
Percent Scrapers	5	1	3	5
Percent Swimmers	1	1	1	1
Percent Diptera	1	1	1	1
BIBI Score	***2.25***	***2.00***	***2.25***	***2.50***
Narrative Rating	***Poor***	***Poor***	***Poor***	***Poor***

Combined Highlands		Score	
Metric	**5**	**3**	**1**
Total Number of Taxa	≥24	> 24 - 15	<15
Number of EPT Taxa	≥14	< 14 - 8	<8
Number Ephemeroptera Taxa	≥5	< 5 - 3	<3
Percent Intolerant Urban	≥80	< 80 - 38	<38
Percent Tanytarsini	≥4	< 4 - 0.1	<0.1
Percent Scrapers	≥13	< 13 - 3	<3
Percent Swimmers	≥18	< 18 - 3	<3
Percent Diptera	≤26	> 26 - 50	>50

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2024_PPR_BIBI_Combined_Highlands_v2.xlsx
Version: 1
Site Name: BUSL-201-T-2024

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	AMPHINEMURA	I	11	Shredder	sp, cn	3
Insecta	Ephemeroptera	Caenidae	Caenis	CAENIS	I	1	Collector	sp	2.1
Insecta	Trichoptera	Philopotamidae	Chimarra	CHIMARRA	I	1	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Cladotanytarsus	CLADOTANYTARSUS	I	1	Filterer	-	6.6
Insecta	Diptera	Empididae	Clinocera	CLINOCERA	I	6	Predator	cn	7.4
Insecta	Diptera	Chironomidae	Corynoneura	CORYNONEURA	I	1	Collector	sp	4.1
Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	CRANGONYX	N/A	2	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cricotopus	CRICOTOPUS	I	1	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Diamesa	DIAMESA	I	2	Collector	sp	8.5
Insecta	Odonata	Gomphidae	not identified	GOMPHIDAE	I	1	Predator	bu	2.2
Insecta	Diptera	Empididae	Hemerodromia	HEMERODROMIA	I	1	Predator	sp, bu	7.9
Insecta	Diptera	Chironomidae	Hydrobaenus	HYDROBAENUS	I/P	9	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	HYDROPSYCHE	I	1	Filterer	cn	7.5
Oligochaeta	Lumbricina	not identified	not identified	LUMBRICINA	N/A	1	Collector	bu	na
Oligochaeta	Haplotaxida	Naididae	not identified	NAIDIDAE	N/A	11	Collector	bu	8.5
Insecta	Trichoptera	Uenoidae	Neophylax	NEOPHYLAX	I	1	Scraper	cn	2.7
Insecta	Diptera	Empididae	Neoplasta	NEOPLASTA	I	1	Predator	0	na
Insecta	Coleoptera	Elmidae	Optioservus	OPTIOSERVUS	I	2	Scraper	cn	5.4
Insecta	Diptera	Chironomidae	not identified	ORTHOCLADIINAE	P	1	Collector	0	7.6
Insecta	Diptera	Chironomidae	Orthocladius	ORTHOCLADIUS	I/P	53	Collector	sp, bu	9.2
Insecta	Coleoptera	Elmidae	Oulimnius	OULIMNIUS	A	1	Scraper	cn	2.7
Insecta	Diptera	Chironomidae	Parametriocnemus	PARAMETRIOCNEMUS	I/P	2	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paratanytarsus	PARATANYTARSUS	I	1	Collector	sp	7.7
Insecta	Diptera	Chironomidae	Polypedilum	POLYPEDILUM	I	6	Shredder	cb, cn	6.3
Enopla	Hoplonemertea	Tetrastemmatidae	Prostoma	PROSTOMA	N/A	2	Predator	0	7.3
Insecta	Diptera	Chironomidae	Rheocricotopus	RHEOCRICOTOPUS	I	1	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	RHEOTANYTARSUS	I	2	Filterer	cn	7.2
Insecta	Diptera	Chironomidae	Stempellinella	STEMPELLINELLA	I	3	Collector	cb, sp, cn	4.2
Insecta	Diptera	Chironomidae	Sublettea	SUBLETTEA	P	1	Collector	-	10
Insecta	Diptera	Chironomidae	Tanytarsus	TANYTARSUS	I	8	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia gr	THIENEMANNIMYIA GROUP	I	3	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	TVETENIA	I	2	Collector	sp	5.1

1 Life Stage, I - Immature, L - Larva, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

Project Name: 2024 Peter Pan Run
Project Number: 172203794.12
Prepared by: NJH   Checked by: AJB
Prepared date: 8/15/2024   Checked date: 8/29/2024

2024_PPR_BIBI_Combined_Highlands_v2.xlsx
Version: 1
Site Name: BUSL-202-T-2024

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Ceratopogonidae	not identified	CERATOPOGONINAE	I	1	0	0	na
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	CHEUMATOPSYCHE	I	2	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	CHIMARRA	I	3	Filterer	cn	4.4
Insecta	Diptera	Empididae	Clinocera	CLINOCERA	I	4	Predator	cn	7.4
Insecta	Diptera	Chironomidae	Corynoneura	CORYNONEURA	I	1	Collector	sp	4.1
Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	CRANGONYX	N/A	1	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cricotopus	CRICOTOPUS	I	1	Shredder	cn, bu	9.6
Insecta	Diptera	Ceratopogonidae	Dasyhelea	DASYHELEA	I	1	Collector	sp	3.6
Insecta	Diptera	Chironomidae	Diamesa	DIAMESA	I	2	Collector	sp	8.5
Insecta	Coleoptera	Dytiscidae	not identified	DYTISCIDAE	I	1	Predator	sw, dv	5.4
Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	EURYLOPHELLA	I	1	Scraper	cn, sp	4.5
Insecta	Trichoptera	Glossosomatidae	Glossosoma	GLOSSOSOMA	I	1	Scraper	cn	0
Insecta	Diptera	Chironomidae	Hydrobaenus	HYDROBAENUS	I/P	40	Scraper	sp	7.2
Oligochaeta	Haplotaxida	Naididae	not identified	NAIDIDAE	N/A	7	Collector	bu	8.5
Insecta	Trichoptera	Uenoidae	Neophylax	NEOPHYLAX	I	1	Scraper	cn	2.7
Insecta	Coleoptera	Elmidae	Optioservus	OPTIOSERVUS	I/A	2	Scraper	cn	5.4
Insecta	Diptera	Chironomidae	Orthocladius	ORTHOCLADIUS	I/P	28	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parakiefferiella	PARAKIEFFERIELLA	I/P	2	Collector	sp	2.1
Insecta	Diptera	Chironomidae	Parametriocnemus	PARAMETRIOCNEMUS	I	7	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paraphaenocladius	PARAPHAENOCLADIUS	I	1	Collector	sp	4
Insecta	Diptera	Chironomidae	Polypedilum	POLYPEDILUM	I	6	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	RHEOCRICOTOPUS	I	1	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Stempellinella	STEMPELLINELLA	I	7	Collector	cb, sp, cn	4.2
Insecta	Coleoptera	Elmidae	Stenelmis	STENELMIS	I/A	11	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Stictochironomus	STICTOCHIRONOMUS	I	1	Collector	bu	9.2
Insecta	Diptera	Chironomidae	Tanytarsus	TANYTARSUS	I	4	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemanniella	THIENEMANNIELLA	I	1	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia gr	THIENEMANNIMYIA GROUP	I/P	2	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	TVETENIA	P	1	Collector	sp	5.1

1 Life Stage, I - Immature, L - Larva, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

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Prepared date: 8/15/2024 Checked date: 8/29/2024

2024_PPR_BIBI_Combined_Highlands_v2.xlsx
Version: 1
Site Name: BUSL-103-T-2024

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	AMPHINEMURA	I	4	Shredder	sp, cn	3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	CHEUMATOPSYCHE	I	3	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	CHIMARRA	I	24	Filterer	cn	4.4
Insecta	Diptera	Empididae	Clinocera	CLINOCERA	I	11	Predator	cn	7.4
Insecta	Diptera	Chironomidae	Corynoneura	CORYNONEURA	I	3	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Diamesa	DIAMESA	I/P	3	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Diplocladius	DIPLOCLADIUS	I	1	Collector	sp	5.9
Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	EURYLOPHELLA	I	4	Scraper	cn, sp	4.5
Turbellaria	Tricladida	Dugesiidae	Girardia	GIRARDIA	N/A	1	Predator	sp	9.3
Insecta	Diptera	Chironomidae	Hydrobaenus	HYDROBAENUS	I	9	Scraper	sp	7.2
Insecta	Collembola	Isotomidae	not identified	ISOTOMIDAE	N/A	1	0	0	4.8
Insecta	Diptera	Chironomidae	Microtendipes	MICROTENDIPES	I	1	Filterer	cn	4.9
Oligochaeta	Haplotaxida	Naididae	not identified	NAIDIDAE	N/A	2	Collector	bu	8.5
Insecta	Trichoptera	Uenoidae	Neophylax	NEOPHYLAX	I	1	Scraper	cn	2.7
Insecta	Diptera	Chironomidae	Orthocladius	ORTHOCLADIUS	I/P	15	Collector	sp, bu	9.2
Insecta	Coleoptera	Elmidae	Oulimnius	OULIMNIUS	I	1	Scraper	cn	2.7
Insecta	Diptera	Chironomidae	Parametriocnemus	PARAMETRIOCNEMUS	I/P	7	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	POLYPEDILUM	I	5	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Stempellinella	STEMPELLINELLA	I	3	Collector	cb, sp, cn	4.2
Insecta	Coleoptera	Elmidae	Stenelmis	STENELMIS	I/A	3	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Tanytarsus	TANYTARSUS	I	14	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia gr	THIENEMANNIMYIA GROU	I/P	4	Predator	sp	8.2
Insecta	Diptera	Tipulidae	Tipula	TIPULA	I	3	Shredder	bu	6.7

1 Life Stage, I - Immature, L - Larva, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

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2024_PPR_BIBI_Combined_Highlands_v2.xlsx
Version: 1
Site Name: BUSL-104-T-2024

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Odonata	Calopterygidae	Calopteryx	CALOPTERYX	I	2	Predator	cb	8.3
Insecta	Diptera	Ceratopogonidae	not identified	CERATOPOGONINAE	I	1	0	0	na
Insecta	Diptera	Chironomidae	Chaetocladius	CHAETOCLADIUS	I	4	Collector	sp	7
Insecta	Trichoptera	Philopotamidae	Chimarra	CHIMARRA	I	1	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Cricotopus/Orthoclad	CRICOTOPUS/ORTHOCLADIU	I	1	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	DIAMESA	I	7	Collector	sp	8.5
Malacostraca	Amphipoda	Gammaridae	Gammarus	GAMMARUS	I	4	Shredder	sp	6.7
Turbellaria	Tricladida	Dugesiidae	Girardia	GIRARDIA	N/A	6	Predator	sp	9.3
Insecta	Trichoptera	Limnephilidae	Ironoquia	IRONOQUIA	I	1	Shredder	sp	4.9
Insecta	Diptera	Chironomidae	Limnophyes	LIMNOPHYES	I	1	Collector	sp	8.6
Oligochaeta	Lumbricina	not identified	not identified	LUMBRICINA	N/A	2	Collector	bu	na
Gastropoda	Basommatophor	Planorbidae	Menetus	MENETUS	N/A	1	Scraper	cb	7.6
Oligochaeta	Haplotaxida	Naididae	not identified	NAIDIDAE	N/A	7	Collector	bu	8.5
0	0	0	not identified	NEMATODA	N/A	3	0	0	na
Insecta	Diptera	Chironomidae	Nilotanypus	NILOTANYPUS	I	6	Predator	sp	6.6
Insecta	Diptera	Chironomidae	Orthocladius	ORTHOCLADIUS	I	5	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	PARAMETRIOCNEMUS	I	2	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paratanytarsus	PARATANYTARSUS	P	1	Collector	sp	7.7
Bivalvia	Veneroida	Pisidiidae	Pisidium	PISIDIUM	I	3	Filterer	bu	5.7
Insecta	Diptera	Chironomidae	Polypedilum	POLYPEDILUM	I/P	41	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Rheotanytarsus	RHEOTANYTARSUS	I	4	Filterer	cn	7.2
Insecta	Diptera	Chironomidae	Stictochironomus	STICTOCHIRONOMUS	I	2	Collector	bu	9.2
Insecta	Odonata	Gomphidae	Stylogomphus	STYLOGOMPHUS	I	1	Predator	bu	2.2
Insecta	Diptera	Chironomidae	Tanytarsus	TANYTARSUS	I/P	8	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia gr	THIENEMANNIMYIA GROUP	I	1	Predator	sp	8.2
Oligochaeta	Tubificida	Tubificidae	not identified	TUBIFICIDAE	N/A	3	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	TVETENIA	I	1	Collector	sp	5.1

1 Life Stage, I - Immature, L - Larva, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

Table A-3. Summary of fish data from Peter Pan Run using MBSS 2005 IBI

Station ID	Date Sampled	Number of Taxa	Number of Fish Captured	Percent of Tolerant Individuals	Fish IBI Score	Fish IBI Rating
BUSL-201-T	10/12/1999	9	373	81.23	3.33	Fair
	9/28/2000	10	390	77.69	3.67	Fair
	7/12/2001	5	684	66.96	3.67	Fair
	8/22/2002	5	429	74.13	3.67	Fair
	7/17/2003	12	424	53.3	4.33	Good
	9/24/2004	11	1166	71.44	3.67	Fair
	6/23/2005	12	1033	58.57	4.33	Good
	6/6/2006	11	1059	57.98	4	Good
	7/3/2007	10	901	60.6	4	Good
	8/7/2008	14	645	66.82	3.67	Fair
	9/9/2009	12	703	74.96	3.67	Fair
	8/19/2010	12	772	69.04	3.67	Fair
	7/13/2011	13	706	56.94	3.67	Fair
	8/20/2012	15	680	60.15	3.67	Fair
	8/19/2013	17	672	45.39	4.33	Good
	7/22/2014	15	896	39.96	4.67	Good
	7/1/2015	12	527	50.47	3.67	Fair
	7/1/2016	15	954	49.9	3.67	Fair
	6/28/2017	17	1166	48.03	4.33	Good
	6/26/2018	16	689	56.6	3.67	Fair
	9/19/2019	18	672	32.59	4.67	Good
	7/8/2020	18	723	41.08	4.67	Good
	6/17/2021	18	768	41.15	4.67	Good
	9/19/2022	25	1337	42.71	4	Good
	7/13/2023	20	810	58.77	3.67	Fair
	9/10/2024	27	1101	30.06	4.33	Good
BUSL-202-T	10/6/1999	*	*	*		Not Rated
	10/6/2000	*	*	*		Not Rated
	7/25/2001	9	767	74.97	3.67	Fair
	8/22/2002	9	555	89.91	3.33	Fair
	7/17/2003	10	319	70.22	3.67	Fair
	9/27/2004	12	1013	64.96	3.67	Fair
	6/23/2005	8	678	63.42	4	Good
	6/6/2006	10	560	63.57	3.67	Fair
	7/3/2007	9	405	60.99	4	Good
	8/7/2008	14	350	61.14	3.67	Fair
	9/9/2009	13	320	55.94	3.67	Fair
	8/27/2010	15	1047	61.6	3.67	Fair
	7/13/2011	16	772	54.79	4.33	Good
	8/20/2012	14	400	58.75	3.67	Fair
	8/16/2013	16	570	51.05	4	Good
	7/22/2014	11	489	54.19	3.67	Fair
	7/1/2015	14	551	56.26	3.67	Fair
	7/8/2016	12	765	61.83	3.67	Fair
	6/28/2017	15	1051	56.52	3.67	Fair
	7/12/2018	13	681	66.52	3.67	Fair
	9/19/2019	14	675	38.81	4.67	Good
	7/8/2020	13	499	46.29	4.67	Good
	6/17/2021	13	769	56.18	3.67	Fair
	9/28/2022	22	1271	45.32	4	Good
	7/13/2023	18	822	68.37	3.67	Fair
	9/10/2024	22	1113	32.61	4.33	Good

Station ID	Date Sampled	Number of Taxa	Number of Fish Captured	Percent of Tolerant Individuals	Fish IBI Score	Fish IBI Rating
BUSL-103-T	10/6/1999	2	36	94.44	2.33	Poor
	9/23/2000	5	260	94.23	3.00	Fair
	7/11/2001	5	403	86.85	3.33	Fair
	2002	*	*	*		*
	7/18/2003	3	157	80.89	3.33	Fair
	9/24/2004	5	607	88.14	3.33	Fair
	6/23/2005	7	574	86.24	3.33	Fair
	6/9/2006	5	521	79.27	3.67	Fair
	6/26/2007	6	446	77.35	3.67	Fair
	8/15/2008	5	545	76.88	3.67	Fair
	9/15/2009	4	590	82.54	3.33	Fair
	8/19/2010	9	583	81.65	3.33	Fair
	7/14/2011	8	726	67.63	3.67	Fair
	7/25/2012	7	389	69.92	3.67	Fair
	8/16/2013	8	732	55.05	4.33	Good
	7/17/2014	7	726	47.11	4.33	Good
	6/17/2015	4	513	61.6	4.00	Good
	6/30/2016	4	585	75.38	3.67	Fair
	7/26/2017	6	774	56.98	4.33	Good
	6/28/2018	11	590	68.47	3.67	Fair
	7/30/2019	9	501	52.5	4.33	Good
	7/1/2020	7	453	45.25	4.33	Good
	6/16/2021	6	532	56.95	4.33	Good
	6/20/2022	7	616	56.82	4.33	Good
	6/20/2023	8	485	80.41	3.33	Fair
	7/30/2024	7	463	81.86	3.33	Fair
BUSL-104-T	10/7/1999	*	*	*		Not Rated
	10/3/2000	1	12	100	1.00	Very Poor
	7/10/2001	2	63	100	1.33	Very Poor
	8/22/2002	2	54	100	1.67	Very Poor
	7/18/2003	4	79	100	1.67	Very Poor
	8/27/2004	2	118	100	1.67	Very Poor
	6/23/2005	3	52	100	1.33	Very Poor
	6/9/2006	3	147	98.64	2.00	Poor
	6/26/2007	3	55	94.55	2.00	Poor
	8/15/2008	4	249	98.8	2.00	Poor
	9/9/2009	3	135	100	1.67	Very Poor
	8/27/2010	4	177	99.44	1.67	Very Poor
	7/14/2011	3	104	98.08	2.00	Poor
	7/25/2012	5	227	97.8	2.00	Poor
	8/15/2013	3	343	99.42	1.67	Very Poor
	8/14/2014	5	259	90.35	2.67	Poor
	6/17/2015	2	191	98.43	2.00	Poor
	6/30/2016	3	229	98.69	2.00	Poor
	7/26/2017	3	135	99.26	1.67	Very Poor
	6/28/2018	3	58	98.28	1.67	Very Poor
	7/30/2019	5	284	98.59	2.00	Poor
	7/1/2020	3	240	99.17	2.00	Poor
	6/16/2021	2	197	100	1.67	Very Poor
	6/20/2022	5	172	99.42	2.00	Poor
	6/20/2023	0	0	0	1.00	Very Poor
	7/30/2024	3	58	98.28	2.00	Poor

* Fish data not collected

Project Name: Peter Pan Run Monitoring - 2024
Project Number: 172203794.12
Prepared by: MLA
Prepared date: 9/10/2024

Checked by: AJB
Checked date: 9/11/2024

FIBI_Warmwater_Highlands_v2_PPR_2024.xlsx
Version: 1
Site Name:

Metric	BUSL-103-T-2024	BUSL-104-T-2024	BUSL-201-T-2024	BUSL-202-T-2024
Raw Scores	**Raw Scores**			
Abundance per square meter	4.41	0.52	4.48	4.40
Adjusted Number of Benthic species	1.95	-8.38	3.15	1.99
% Tolerant	81.86%	98.28%	30.06%	32.61%
% Generalist, Omnivores, Invertivores	84.45%	98.28%	86.19%	90.93%
% Insectivores	12.31%	1.72%	7.72%	3.95%
% Abundance of Dominant Taxa	76.03%	79.31%	23.43%	25.61%
FIBI Scores	**FIBI Scores**			
Abundance per square meter	5	3	5	5
Adjusted Number of Benthic species	5	1	5	5
% Tolerant	1	1	5	5
% Generalist, Omnivores, Invertivores	3	1	3	3
% Insectivores	3	3	3	3
% Abundance of Dominant Taxa	3	3	5	5
FIBI Score	***3.33***	***2.00***	***4.33***	***4.33***
Narrative Rating	***Fair***	***Poor***	***Good***	***Good***

Warmwater Highland		**Score**	
Metric	**5**	**3**	**1**
Abundance per square meter	≥ 0.65	< 0.65 - 0.31	< 0.31
Adjusted Number of Benthic species	≥ 0.25	< 0.25 - 0.11	< 0.11
% Tolerant	≤ 39	> 39 - 80	> 80
% Generalist, Omnivores, Invertivores	≤ 61	> 61 - 96	> 96
% Insectivores	≥ 33	< 33 - 1	< 1
% Abundance of Dominant Taxa	≤ 38	> 38 - 89	> 89

Project Name: Peter Pan Run Monitoring - 2024
Project Number: 172203794.12
Prepared by: MLA Checked by: AJB
Prepared date: 9/10/2024 Checked date: 9/11/2024

FIBI_Warmwater_Highlands_v2_PPR_2024.xlsx
Version: 1
Site Name: BUSL-201-T-2024

KCI TECHNOLOGIES

Final ID	Scientific Name	No. Organisms	Tolerance	Trophic Status	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	% Insect	% Dominant Taxa	Abundance per Square Meter	Adjusted No. Benthic Species
Blacknose Dace	*Rhinichthys atratulus*	145	T	OM	NOTYPE	145	145	0	0	0.59	0
Bluntnose Minnow	*Pimephales notatus*	83	T	OM	NOTYPE	83	83	0	0	0.34	0
Longear Sunfish	*Lepomis megalotis*	9	NOTYPE	IV	NOTYPE	0	9	0	0	0.04	0
Bluehead Chub	*Nocomis leptocephalus*	26	I	OM	NOTYPE	0	26	0	0	0.11	0
Greenside Darter	*Etheostoma blennioides*	1	NOTYPE	IS	B	0	0	1	0	0.00	1
Brown Trout	*Salmo trutta*	1	NOTYPE	TP	NOTYPE	0	0	0	0	0.00	0
Creek Chub	*Semotilus atromaculatus*	40	T	GE	NOTYPE	40	40	0	0	0.16	0
Golden Redhorse	*Moxostoma erythrurum*	1	NOTYPE	OM	R	0	1	0	0	0.00	0
Mimic Shiner	*Notropis volucellus*	258	I	IV	NOTYPE	0	258	0	258	1.05	0
Blue Ridge Sculpin	*Cottus caeruleomentum*	62	I	IS	B	0	0	62	0	0.25	1
Central Stoneroller	*Campostoma anomalum*	61	I	AL	NOTYPE	0	0	0	0	0.25	0
Potomac Sculpin	*Cottus girardi*	14	NOTYPE	IS	B	0	0	14	0	0.06	1
Bluegill	*Lepomis macrochirus*	3	T	IV	NOTYPE	3	3	0	0	0.01	0
Rosyside Dace	*Clinostomus funduloides*	28	NOTYPE	IV	NOTYPE	0	28	0	0	0.11	0
Largemouth Bass	*Mictopterus salmoides*	5	T	TP	NOTYPE	5	0	0	0	0.02	0
Common Shiner	*Luxilus cornutus*	*27*	I	OM	NOTYPE	0	27	0	0	0.11	0
Rosyface Shiner	*Notropis rubellus*	*24*	NOTYPE	IV	NOTYPE	0	24	0	0	0.10	0
Fantail Darter	*Etheostoma flabellare*	*7*	NOTYPE	IS	B	0	0	7	0	0.03	1
Longnose Dace	*Rhinichthys cataractae*	*17*	NOTYPE	OM	NOTYPE	0	17	0	0	0.07	0
Silverjaw Minnow	*Notropis buccatus*	*6*	NOTYPE	OM	NOTYPE	0	6	0	0	0.02	0
White Sucker	*Catostomus commersonii*	*28*	T	OM	NOTYPE	28	28	0	0	0.11	0
Redbreast Sunfish	*Lepomis auritus*	*5*	NOTYPE	GE	NOTYPE	0	5	0	0	0.02	0
Northern Hogsucker	*Hypentelium nigricans*	*3*	I	IV	R	0	3	0	0	0.01	0
Spotfin Shiner	*Cyprinella spiloptera*	219	I	IV	NOTYPE	0	219	0	0	0.89	0
Pumpkinseed	*Lepomis gibbosus*	20	T	IV	NOTYPE	20	20	0	0	0.08	0
Rainbow Darter	*Etheostoma caeruleum*	1	NOTYPE	IS	B	0	0	1	0	0.00	1
Green Sunfish	*Lepomis cyanellus*	7	T	GE	NOTYPE	7	7	0	0	0.03	0
	Total count	1101				30.06%	86.19%	7.72%	23.43%	4.48	3.15
	Total Biomass (g)	5425									

Project Name:	Peter Pan Run Monitoring - 2024		
Project Number:	172203794.12		
Prepared by:	MLA	Checked by:	AJB
Prepared date:	9/10/2024	Checked date:	9/11/2024

FIBI_Warmwater_Highlands_v2_PPR_2024.xlsx
Version: 1
Site Name: BUSL-202-T-2024

Final ID	Scientific Name	No. Organisms	Tolerance	Trophic Status	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	% Insect	% Dominant Taxa	Abundance per Square Meter	Adjusted No. Benthic Species
Blacknose Dace	*Rhinichthys atratulus*	172	T	OM	NOTYPE	172	172	0	0	0.68	0
Creek Chub	*Semotilus atromaculatus*	56	T	GE	NOTYPE	56	56	0	0	0.22	0
Spotfin Shiner	*Cyprinella spiloptera*	285	I	IV	NOTYPE	0	285	0	285	1.13	0
Mimic Shiner	*Notropis volucellus*	214	I	IV	NOTYPE	0	214	0	0	0.85	0
Rosyside Dace	*Clinostomus funduloides*	52	NOTYPE	IV	NOTYPE	0	52	0	0	0.21	0
Common Shiner	*Luxilus cornutus*	19	I	OM	NOTYPE	0	19	0	0	0.08	0
Bluntnose Minnow	*Pimephales notatus*	78	T	OM	NOTYPE	78	78	0	0	0.31	0
Largemouth Bass	*Mictopterus salmoides*	5	T	TP	NOTYPE	5	0	0	0	0.02	0
Bluehead Chub	*Nocomis leptocephalus*	44	I	OM	NOTYPE	0	44	0	0	0.17	0
Pumpkinseed	*Lepomis gibbosus*	17	T	IV	NOTYPE	17	17	0	0	0.07	0
Central Stoneroller	*Campostoma anomalum*	51	I	AL	NOTYPE	0	0	0	0	0.20	0
Rosyface Shiner	*Notropis rubellus*	13	NOTYPE	IV	NOTYPE	0	13	0	0	0.05	0
Redbreast Sunfish	*Lepomis auritus*	4	NOTYPE	GE	NOTYPE	0	4	0	0	0.02	0
White Sucker	*Catostomus commersonii*	20	T	OM	NOTYPE	20	20	0	0	0.08	0
Fantail Darter	*Etheostoma flabellare*	9	NOTYPE	IS	B	0	0	9	0	0.04	1
Bluegill	*Lepomis macrochirus*	3	T	IV	NOTYPE	3	3	0	0	0.01	0
Smallmouth Bass	*Micropterus dolomieu*	1	NOTYPE	TP	NOTYPE	0	0	0	0	0.00	0
Blue Ridge Sculpin	*Cottus caeruleomentum*	30	I	IS	B	0	0	30	0	0.12	1
Longnose Dace	*Rhinichthys cataractae*	17	NOTYPE	OM	NOTYPE	0	17	0	0	0.07	0
Longear Sunfish	*Lepomis megalotis*	6	NOTYPE	IV	NOTYPE	0	6	0	0	0.02	0
Potomac Sculpin	*Cottus girardi*	5	NOTYPE	IS	B	0	0	5	0	0.02	1
Green Sunfish	*Lepomis cyanellus*	12	T	GE	NOTYPE	12	12	0	0	0.05	0
	Total count	1113				32.61%	90.93%	3.95%	25.61%	4.40	1.99

Project Name:	Peter Pan Run Monitoring - 2024		
Project Number:	172203794.12		
Prepared by:	MLA	Checked by:	AJB
Prepared date:	7/31/2024	Checked date:	8/29/2024

FIBI_Warmwater_Highlands_v2_PPR_2024.xlsx
Version: 1
Site Name: BUSL-103-T-2024

KCI TECHNOLOGIES

Final ID	Scientific Name	No. Organisms	Tolerance	Trophic Status	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	% Insect	% Dominant Taxa	Abundance per Square Meter	Adjusted No. Benthic Species
Blacknose Dace	*Rhinichthys atratulus*	352	T	OM	NOTYPE	352	352	0	352	3.35	0
Creek Chub	*Semotilus atromaculatus*	27	T	GE	NOTYPE	27	27	0	0	0.26	0
Central Stoneroller	*Campostoma anomalum*	15	I	AL	NOTYPE	0	0	0	0	0.14	0
Blue Ridge Sculpin	*Cottus caeruleomentum*	25	I	IS	B	0	0	25	0	0.24	1
Longnose Dace	*Rhinichthys cataractae*	8	NOTYPE	OM	NOTYPE	0	8	0	0	0.08	0
Rosyside Dace	*Clinostomus funduloides*	4	NOTYPE	IV	NOTYPE	0	4	0	0	0.04	0
Fantail Darter	*Etheostoma flabellare*	32	NOTYPE	IS	B	0	0	32	0	0.30	1
	Total count	463				81.86%	84.45%	12.31%	76.03%	4.41	1.95

Project Name: Peter Pan Run Monitoring - 2024
Project Number: 172203794.12
Prepared by: MLA Checked by: AJB
Prepared date: 7/31/2024 Checked date: 8/29/2024

FIBI_Warmwater_Highlands_v2_PPR_2024.xlsx
Version: 1
Site Name: BUSL-104-T-2024

Final ID	Scientific Name	No. Organisms	Tolerance	Trophic Status	Composition	% Tolerant	% Generalists, Omnivores, Invertivores	% Insect	% Dominant Taxa	Abundance per Square Meter	Adjusted No. Benthic Species
Blacknose Dace	*Rhinichthys atratulus*	46	T	OM	NOTYPE	46	46	0	46	0.42	0
Creek Chub	*Semotilus atromaculatus*	11	T	GE	NOTYPE	11	11	0	0	0.10	0
Fantail Darter	*Etheostoma flabellare*	1	NOTYPE	IS	B	0	0	1	0	0.01	1
	Total count	58				98.28%	98.28%	1.72%	79.31%	0.52	-8.38

Table A-5. Qualitative habitat scores using MBSS protocols for Peter Pan Run.

Station ID	Date Sampled	Instream Habitat (0-20)	Epifaunal Substrate (0-20)	Velocity-Depth Diversity (0-20)	Pool-Glide Quality (0-20)	Riffle-Run Quality (0-20)	Embeddedness (%)	Shading (%)	Physical Habitat Index Score	Physical Habitat Index Rating
BUSL-201-T	10/12/1999	7	13	*	*	*	50	63		Not Rated
	9/28/2000	12	15	*	*	*	70	51		Not Rated
	7/12/2001	13	11	13	8	13	25	90	70.15	Partially Degraded
	8/22/2002	10	14	6	7	8	35	85	85.53	Minimally Degraded
	7/17/2003	10	12	14	12	13	30	70	73.64	Partially Degraded
	9/24/2004	17	12	13	13	14	50	60	74.67	Partially Degraded
	6/23/2005	13	11	14	14	13	50	65	76.39	Partially Degraded
	6/6/2006	13	10	14	13	10	45	60	70.34	Partially Degraded
	7/3/2007	12	9	13	12	13	50	65	67.68	Partially Degraded
	8/7/2008	12	10	14	13	12	50	70	69.95	Partially Degraded
	9/9/2009	16	15	15	14	14	60	65	74.94	Partially Degraded
	8/19/2010	14	13	14	15	13	50	50	70.84	Partially Degraded
	7/13/2011	10	9	13	13	13	60	60	66.78	Partially Degraded
	8/20/2012	12	10	14	13	13	50	50	66.19	Partially Degraded
	8/19/2013	14	13	13	14	17	55	40	65.29	Degraded
	7/22/2014	14	15	12	13	15	35	70	81.99	Minimally Degraded
	7/1/2015	10	12	15	16	13	50	75	74.53	Partially Degraded
	7/1/2016	14	14	14	17	14	40	60	75.39	Partially Degraded
	6/28/2017	13	11	12	16	12	50	85	76.31	Partially Degraded
	6/26/2018	13	12	13	14	12	40	75	80	Partially Degraded
	9/19/2019	14	13	12	12	13	40	75	81.7	Minimally Degraded
	7/8/2020	14	12	12	13	13	40	80	78.4	Partially Degraded
	6/17/2021	13	12	13	13	14	25	75	76.1	Partially Degraded
	9/19/2022	15	13	14	16	13	30	80	81.5	Minimally Degraded
	7/13/2023	14	12	12	13	11	35	80	80.2	Partially Degraded
	9/9/2024	14	13	12	14	14	0	75	80.9	Partially Degraded
BUSL-202-T	10/6/1999	10	13	*	*	*	53	60		Not Rated
	10/6/2000	10	13	*	*	*	43	57		Not Rated
	7/25/2001	7	12	14	10	10	70	20	47.43	Severely Degraded
	8/22/2002	8	12	6	7	8	30	75	71.67	Partially Degraded
	7/17/2003	11	8	14	12	8	30	75	66.99	Partially Degraded
	9/27/2004	17	12	13	13	14	50	55	75.26	Partially Degraded
	6/23/2005	13	11	13	13	12	60	65	80.02	Partially Degraded
	6/6/2006	12	9	13	13	10	40	70	75.16	Partially Degraded
	7/3/2007	10	8	8	9	11	50	65	62.63	Degraded
	8/7/2008	11	9	12	12	11	45	65	65.45	Degraded
	9/9/2009	14	13	14	13	13	60	65	61.23	Degraded
	8/27/2010	11	11	13	13	10	60	70	66.14	Partially Degraded
	7/13/2011	12	6	12	10	12	50	60	60.88	Degraded
	8/20/2012	10	9	13	11	13	55	60	66.42	Partially Degraded
	8/16/2013	14	13	14	12	15	35	60	63.68	Degraded
	7/22/2014	14	11	13	12	14	35	65	71.83	Partially Degraded
	7/1/2015	8	8	13	13	10	45	65	67.61	Partially Degraded
	7/8/2016	11	11	13	13	14	35	70	71.91	Partially Degraded
	6/28/2017	11	9	12	16	11	50	50	66.1	Partially Degraded
	7/12/2018	15	13	12	13	15	40	90	76.5	Partially Degraded
	9/19/2019	13	12	11	11	12	40	75	64.2	Degraded
	7/8/2020	6	7	7	7	9	60	75	66.2	Partially Degraded
	6/17/2021	11	10	12	12	12	40	75	63.8	Degraded
	9/28/2022	12	11	13	11	12	30	60	60.5	Degraded
	7/13/2023	11	9	12	12	9	20	85	63.4	Degraded
	9/9/2024	12	12	11	11	13	20	70	65	Degraded

Station ID	Date Sampled	Instream Habitat (0-20)	Epifaunal Substrate (0-20)	Velocity-Depth Diversity (0-20)	Pool-Glide Quality (0-20)	Riffle-Run Quality (0-20)	Embeddedness (%)	Shading (%)	Physical Habitat Index Score	Physical Habitat Index Rating
BUSL-103-T	10/6/1999	11	12	*	*	*	63	67		Not Rated
	9/23/2000	11	15	*	*	*	30	53		Not Rated
	7/11/2001	9	10	11	10	9	20	95	72.16	Partially Degraded
	2002	*	*	*	*	*	*	*		Not Rated
	7/18/2003	8	7	10	6	8	35	90	65.49	Degraded
	9/24/2004	13	11	9	8	8	45	40	60.07	Degraded
	6/23/2005	12	11	8	9	8	60	70	73.26	Partially Degraded
	6/9/2006	12	8	8	10	7	50	60	49.08	Severely Degraded
	6/26/2007	13	10	8	8	11	60	65	57.13	Degraded
	8/15/2008	11	8	8	8	9	70	65	57.97	Degraded
	9/15/2009	12	11	9	9	13	55	50	56.81	Degraded
	8/19/2010	12	10	8	9	11	65	40	51.15	Degraded
	7/14/2011	13	13	8	7	14	50	70	62.58	Degraded
	7/25/2012	12	12	8	8	14	55	60	59.67	Degraded
	8/16/2013	12	11	8	6	13	40	75	68.3	Partially Degraded
	7/17/2014	13	15	9	8	14	25	70	72.38	Partially Degraded
	6/17/2015	8	11	8	8	9	30	75	69.82	Partially Degraded
	6/30/2016	9	9	9	7	12	35	70	66.34	Partially Degraded
	7/26/2017	8	7	7	6	12	45	65	63.05	Degraded
	6/28/2018	11	10	11	11	8	70	75	67.5	Partially Degraded
	7/30/2019	11	11	8	9	7	35	75	67.6	Partially Degraded
	7/1/2020	12	13	10	10	13	35	80	71.1	Partially Degraded
	6/16/2021	11	11	9	8	8	30	80	67.8	Partially Degraded
	6/20/2022	11	12	7	7	9	20	85	70.1	Partially Degraded
	6/20/2023	13	14	8	7	8	10	90	74.8	Partially Degraded
	7/30/2024	8	10	7	6	10	0	80	63.5	Degraded
BUSL-104-T	10/7/1999	7	12	*	*	*	17	90		Not Rated
	10/3/2000	8	16	*	*	*	70	87		Not Rated
	7/10/2001	9	8	6	2	12	30	95	53.81	Degraded
	8/22/2002	7	15	6	6	10	25	95	65.77	Degraded
	7/18/2003	7	8	7	6	9	45	95	58.17	Degraded
	8/27/2004	12	12	8	8	10	45	95	67.8	Partially Degraded
	6/23/2005	7	5	7	6	6	75	90	55.21	Degraded
	6/9/2006	12	11	7	8	7	50	85	52.64	Degraded
	6/26/2007	9	11	7	5	7	70	90	61.71	Degraded
	8/15/2008	9	5	8	8	7	75	90	52.21	Degraded
	9/9/2009	11	11	7	8	7	60	90	58.23	Degraded
	8/27/2010	10	8	7	7	8	70	85	49.66	Severely Degraded
	7/14/2011	8	8	7	7	8	70	80	54.41	Degraded
	7/25/2012	8	7	7	7	9	70	85	50.86	Severely Degraded
	8/16/2013	10	9	9	8	11	45	90	61.48	Degraded
	8/14/2014	12	13	8	8	12	40	75	61.72	Degraded
	6/17/2015	8	7	6	8	6	35	80	58.86	Degraded
	6/30/2016	7	11	8	7	9	40	90	63.49	Degraded
	7/26/2017	7	8	7	6	7	65	80	55.56	Degraded
	6/28/2018	4	4	7	5	7	30	85	58.3	Degraded
	7/30/2019	4	5	6	6	8	30	90	53.9	Degraded
	7/1/2020	11	11	12	13	11	55	70	55.8	Degraded
	6/16/2021	5	6	7	5	6	55	90	54.3	Degraded
	6/20/2022	5	6	6	6	9	40	95	55.8	Degraded
	6/20/2023	5	6	6	3	7	35	90	56.0	Degraded
	7/30/2024	4	6	6	6	7	10	90	55.8	Degraded

* - Data not collected

Project Name: Frederick County Peter Pan Run - 2024
Project Number:
Prepared by: NJH
Prepared date: 9/18/2024
Checked by: MLA
Checked date: 9/27/2024
2024_PeterPanRun_PHI_Highlands_v2.xlsx
Version:

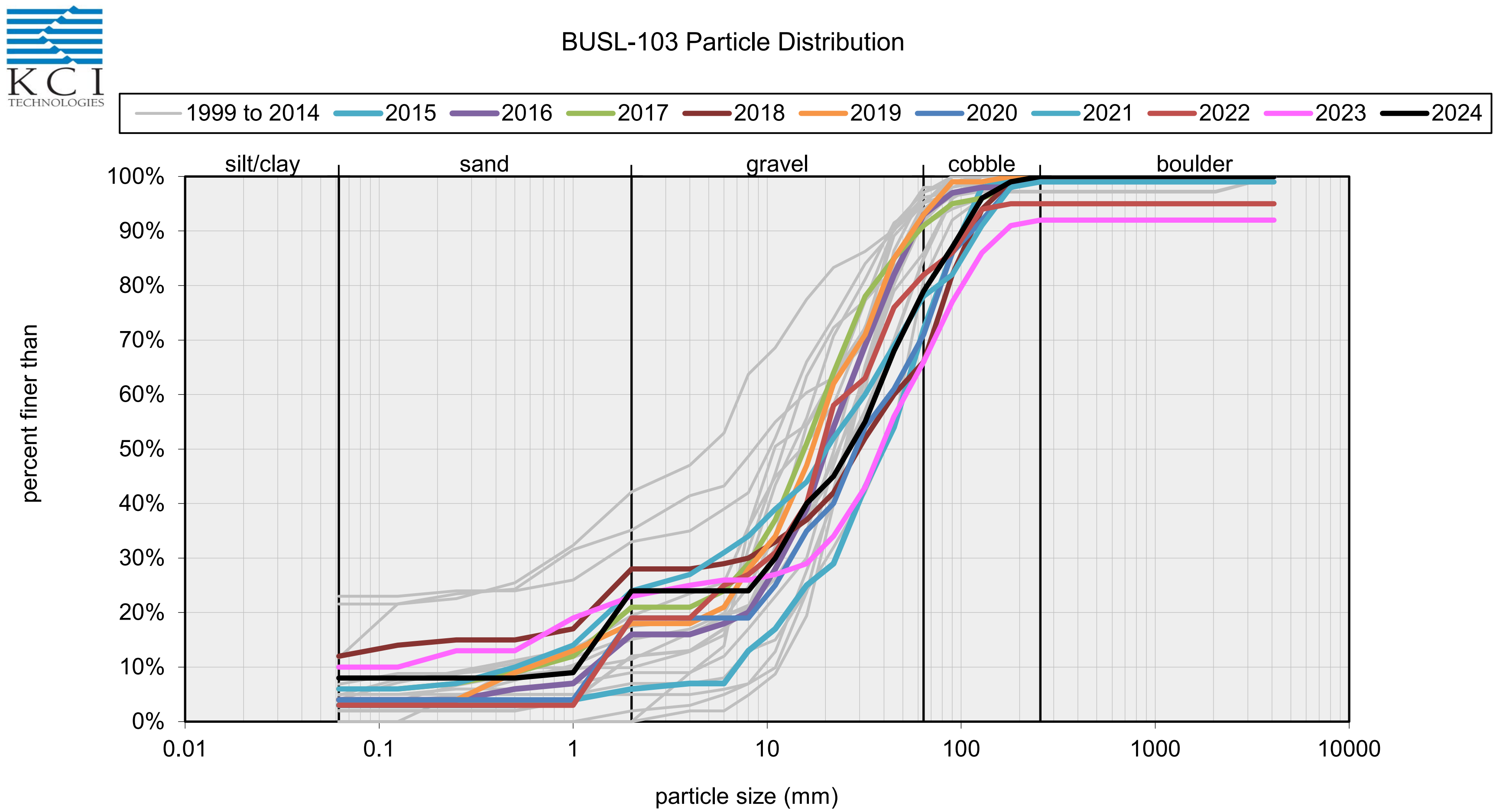
		Raw Data					Scaled Metrics					Scores	
Site	Subshed Area (ac)	Epifaunal Substrate	Bank Stab (0-20)	Percent Shading	Riparian Width	Remoteness Score	Epifaunal Substrate	Bank Stability	Percent Shading	Riparian Width	Remoteness	PHI	PHI Rating
BUSL-103-T-2024	556.592	10	8	80	50	7	55.56	50.60	75.25	100.00	35.86	63.5	Degraded
BUSL-104-T-2024	65.097	6	8	90	38	6	33.33	53.17	87.37	76.00	28.99	55.8	Degraded
BUSL-201-T-2024	1584.969	13	12	75	50	18	72.22	70.97	70.13	100.00	90.96	80.9	Partially Degraded
BUSL-202-T-2024	1377.333	12	5	70	50	11	66.67	37.71	65.34	100.00	55.16	65.0	Degraded

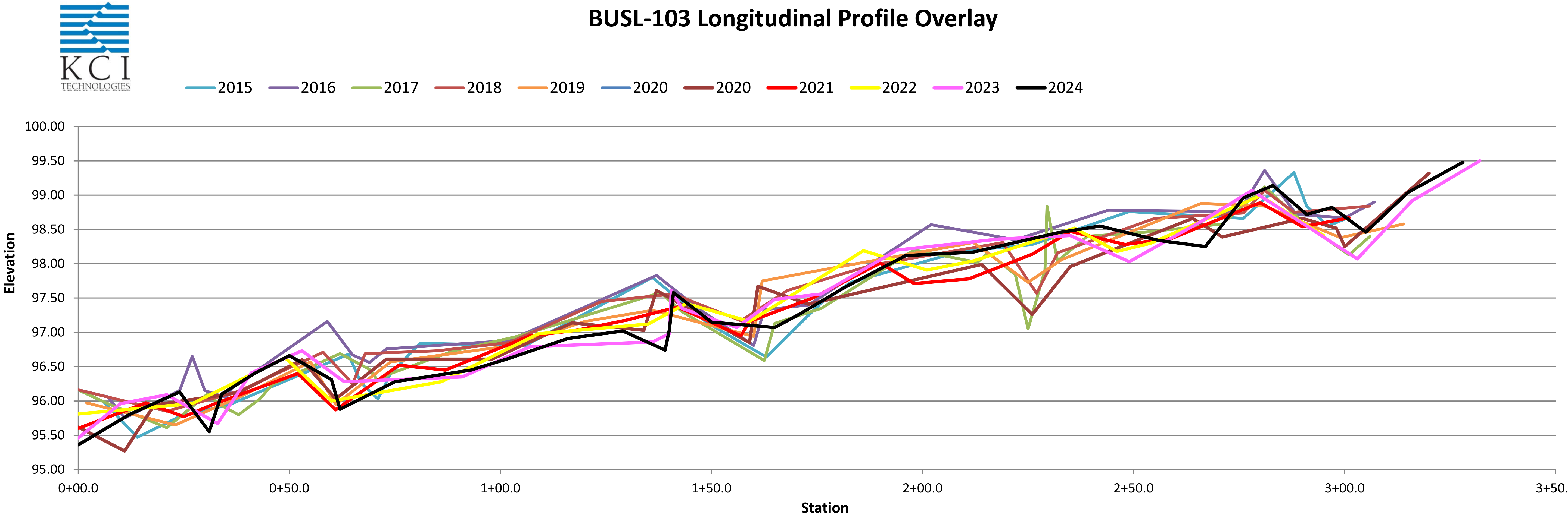
Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Notes on use and calculations:
Severity scores - 1=1, 2=1.5, 3=2
Riparian Width is the avg of the 2 banks

APPENDIX A

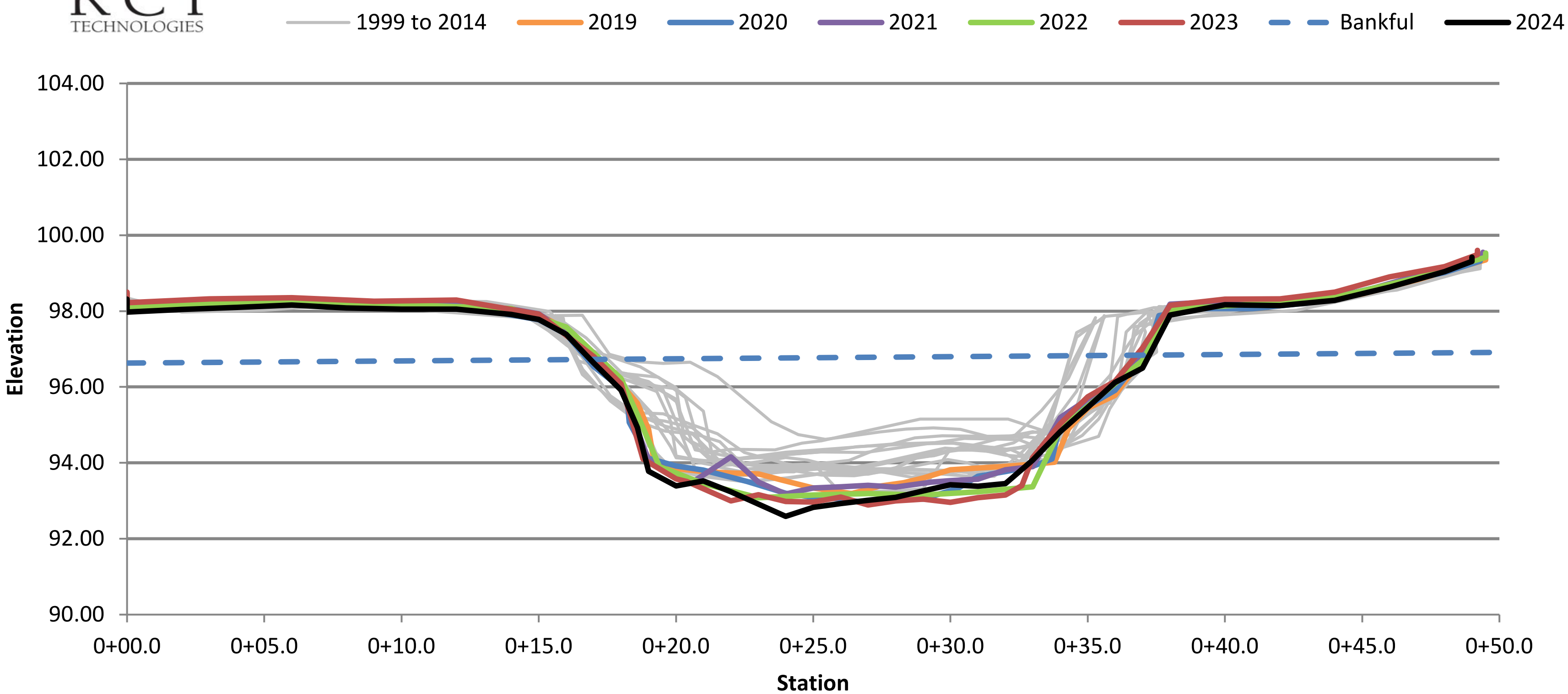
Physical Monitoring


KCI TECHNOLOGIES
BUSL-103 Particle Distribution
1999 to 2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
silt/clay
sand
gravel
cobble
boulder
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
percent finer than
0.01
0.1
1
10
100
1000
10000
particle size (mm)

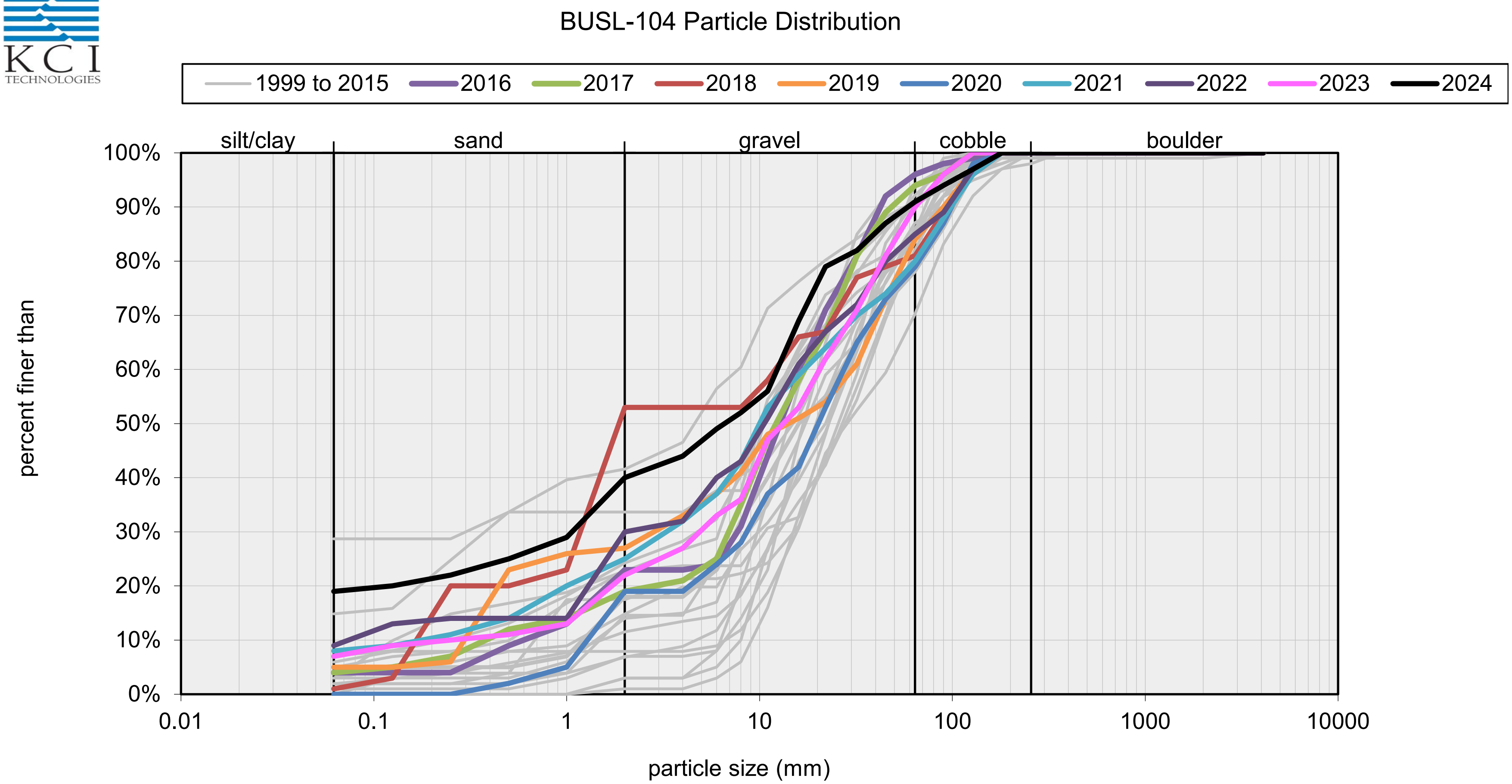


BUSL-103 Longitudinal Profile Overlay
2015
2016
2017
2018
2019
2020
2020
2021
2022
2023
2024
Elevation
100.00
99.50
99.00
98.50
98.00
97.50
97.00
96.50
96.00
95.50
95.00
0+00.0
0+50.0
1+00.0
1+50.0
2+00.0
2+50.0
3+00.0
3+50.0
Station

BUSL-103

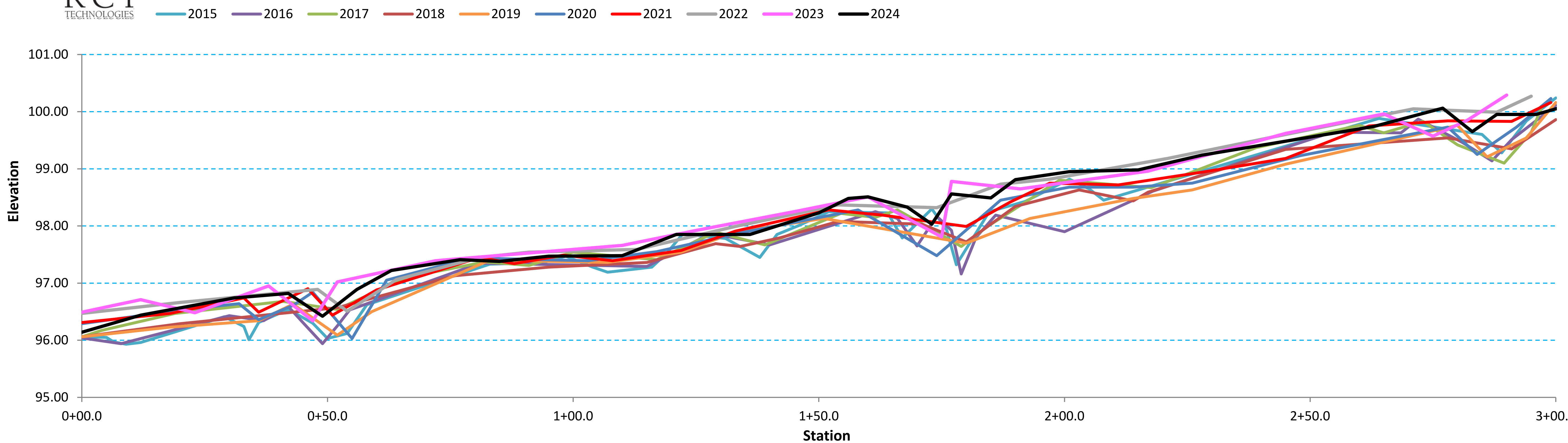


BKFL/TOB ELEV= 94.82	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	13.5	0.9	11.9	15.3	27.5
2019	15.2	1.1	17.2	13.5	46.2
2020	15.5	1.3	20.4	11.7	64.9
2021	15.2	1.3	19.2	12.1	57.4
2022	15.2	1.5	23.1	10.0	79.2
2023	14.2	1.0	13.8	14.6	36.1
2024	14.1	0.9	12.0	16.5	23.7

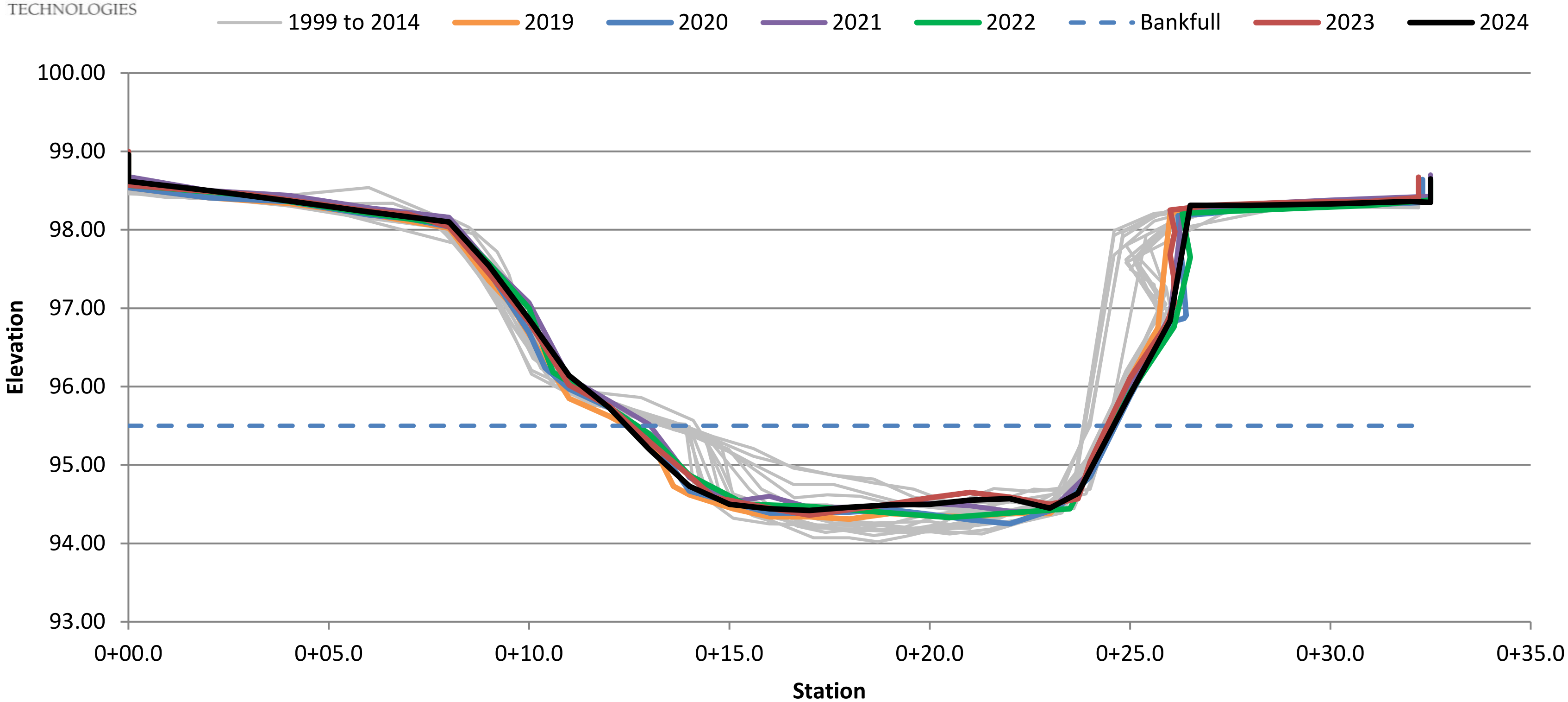


BUSL-104 Particle Distribution
1999 to 2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
silt/clay
sand
gravel
cobble
boulder
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
percent finer than
0.01
0.1
1
10
100
1000
10000
particle size (mm)

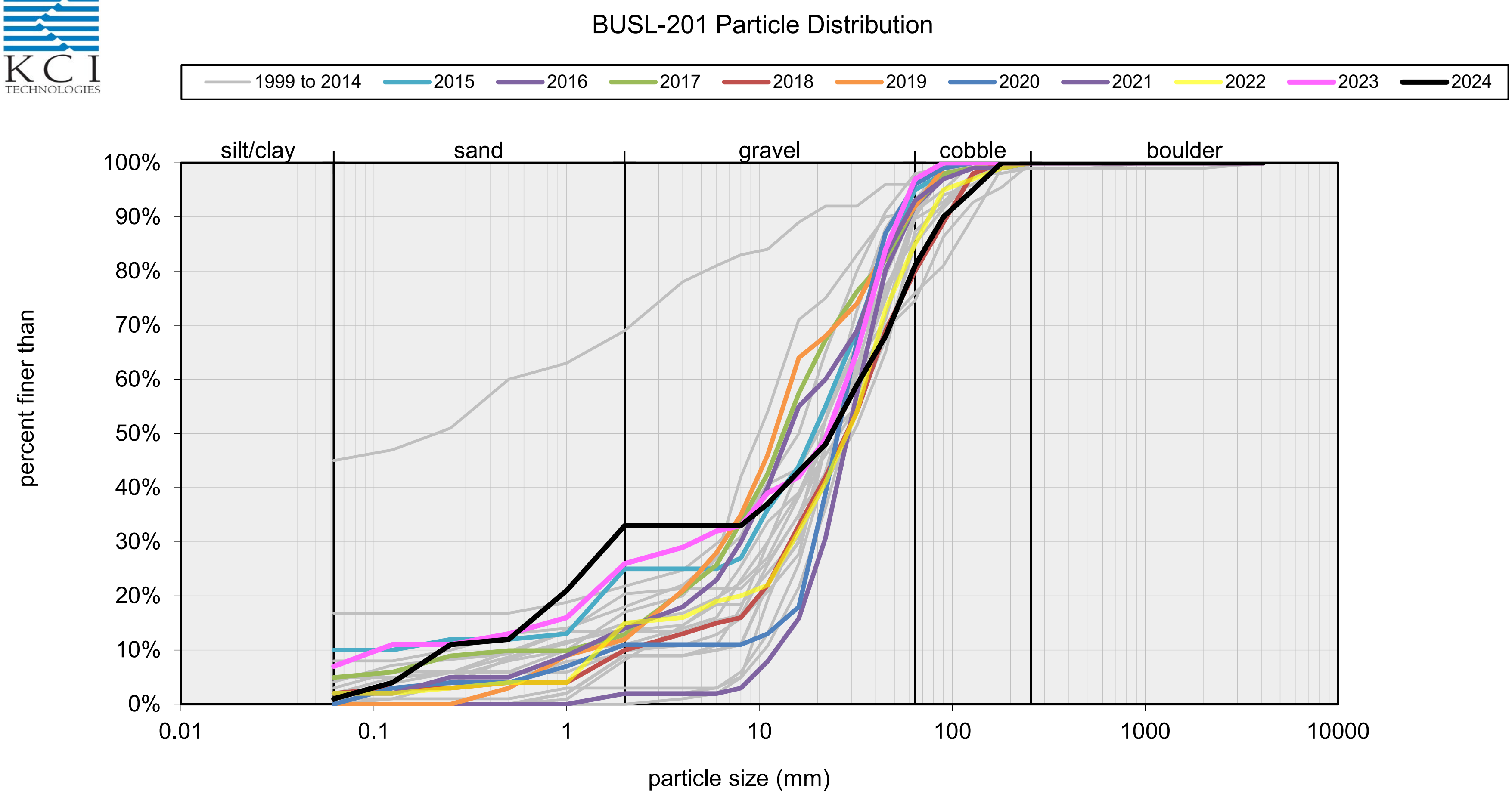
BUSL-104 Longitudinal Profile Overlay



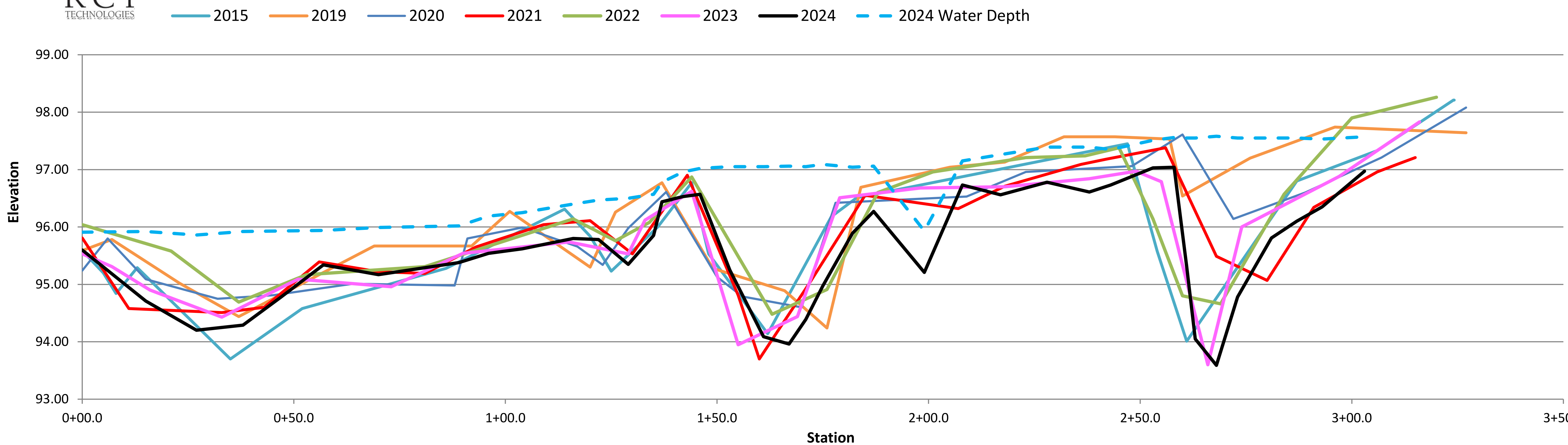
BUSL-104



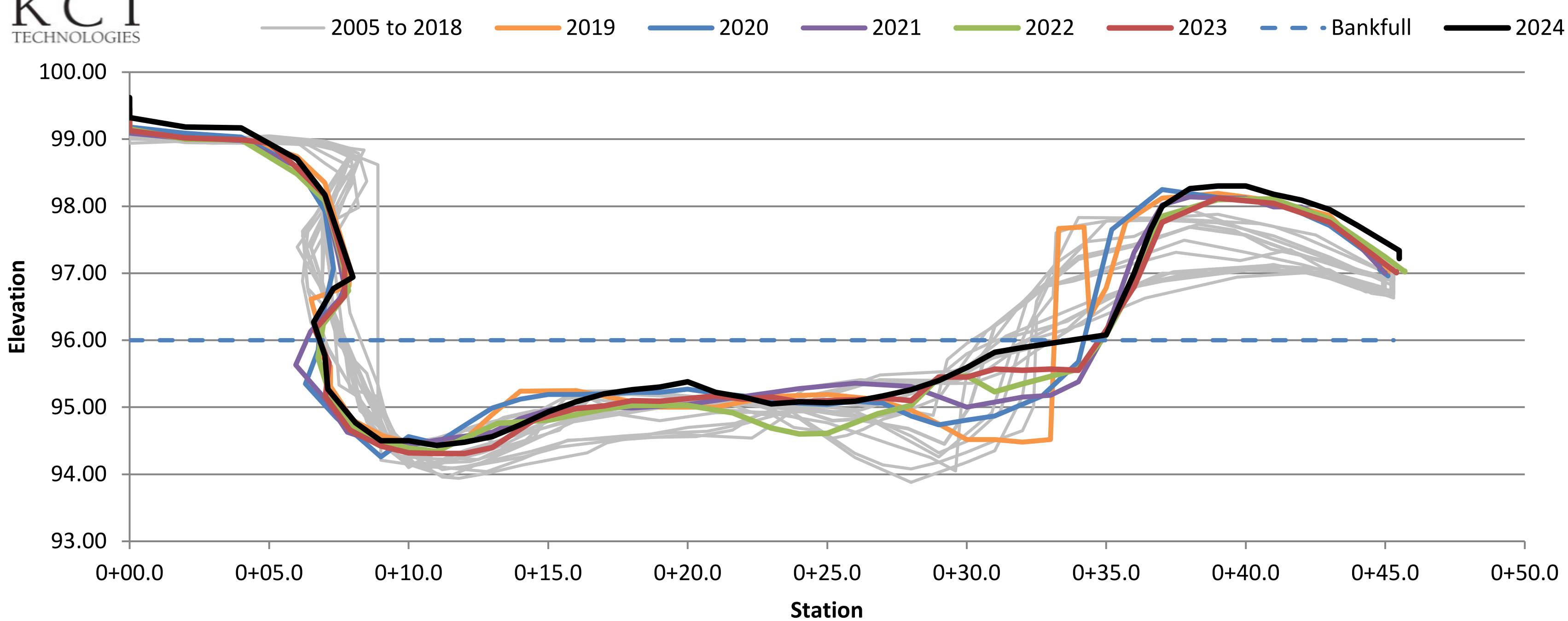
BKFL/TOB ELEV= 95.5	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	10.4	0.6	6.4	17.0	19.5
2019	12.0	1.0	11.8	12.3	49.1
2020	12.0	1.0	11.5	12.4	47.5
2021	11.9	1.0	11.4	12.4	43.9
2022	12.0	0.9	11.4	12.7	43.3
2023	12.7	1.0	13.3	12.1	57.6
2024	12.8	1.1	13.5	12.2	55.2


BUSL-201 Particle Distribution
1999 to 2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
silt/clay
sand
gravel
cobble
boulder
percent finer than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
10000
particle size (mm)

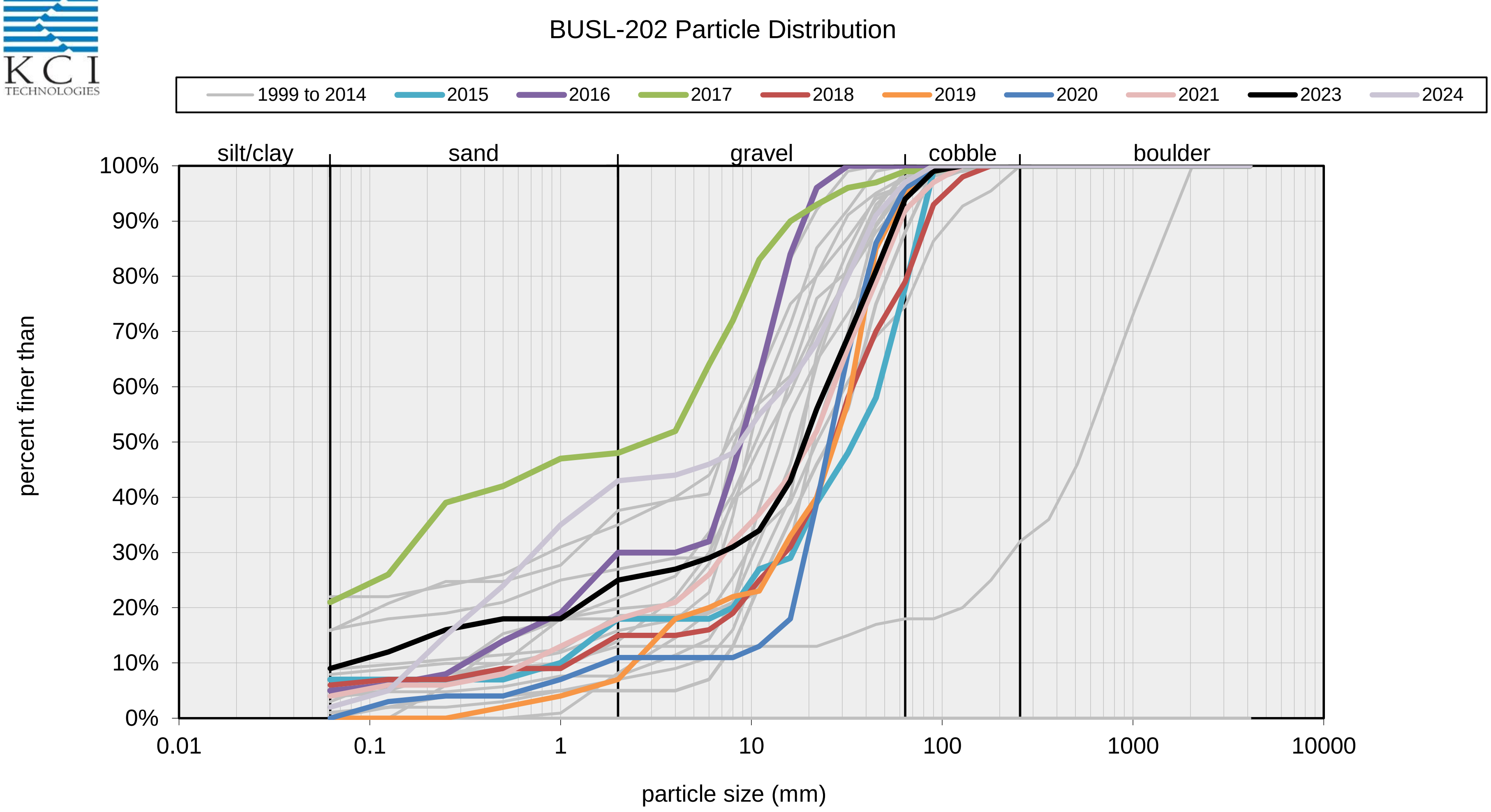
BUSL-201 Longitudinal Profile Overlay

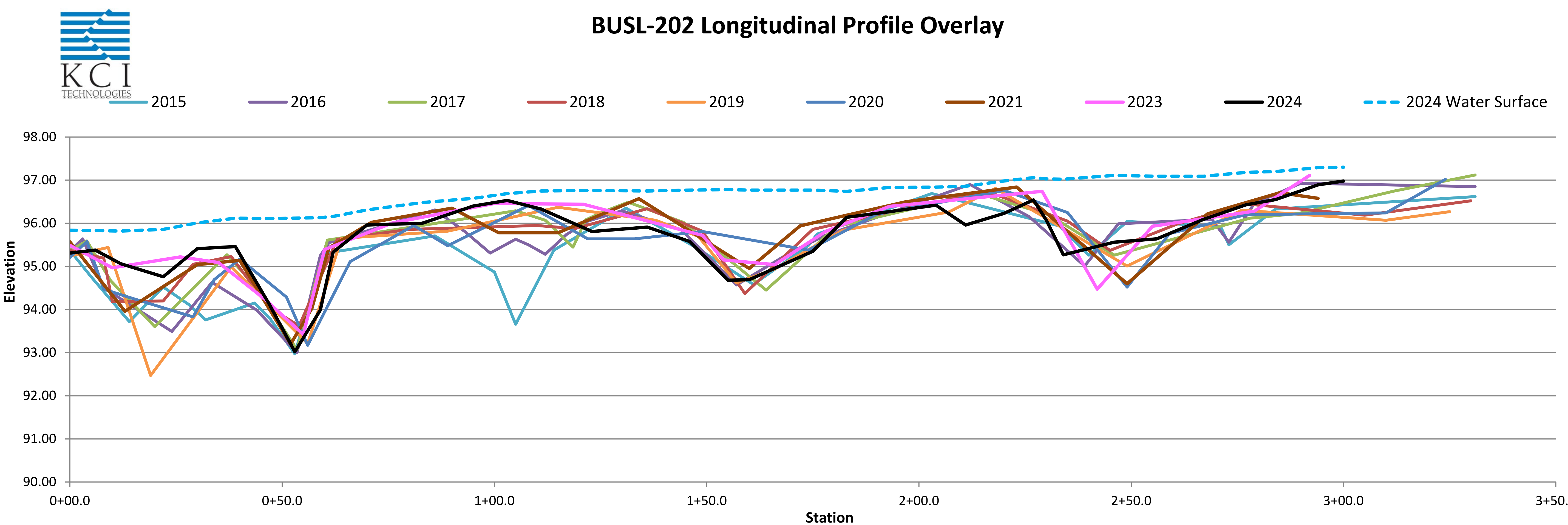


BUSL-201



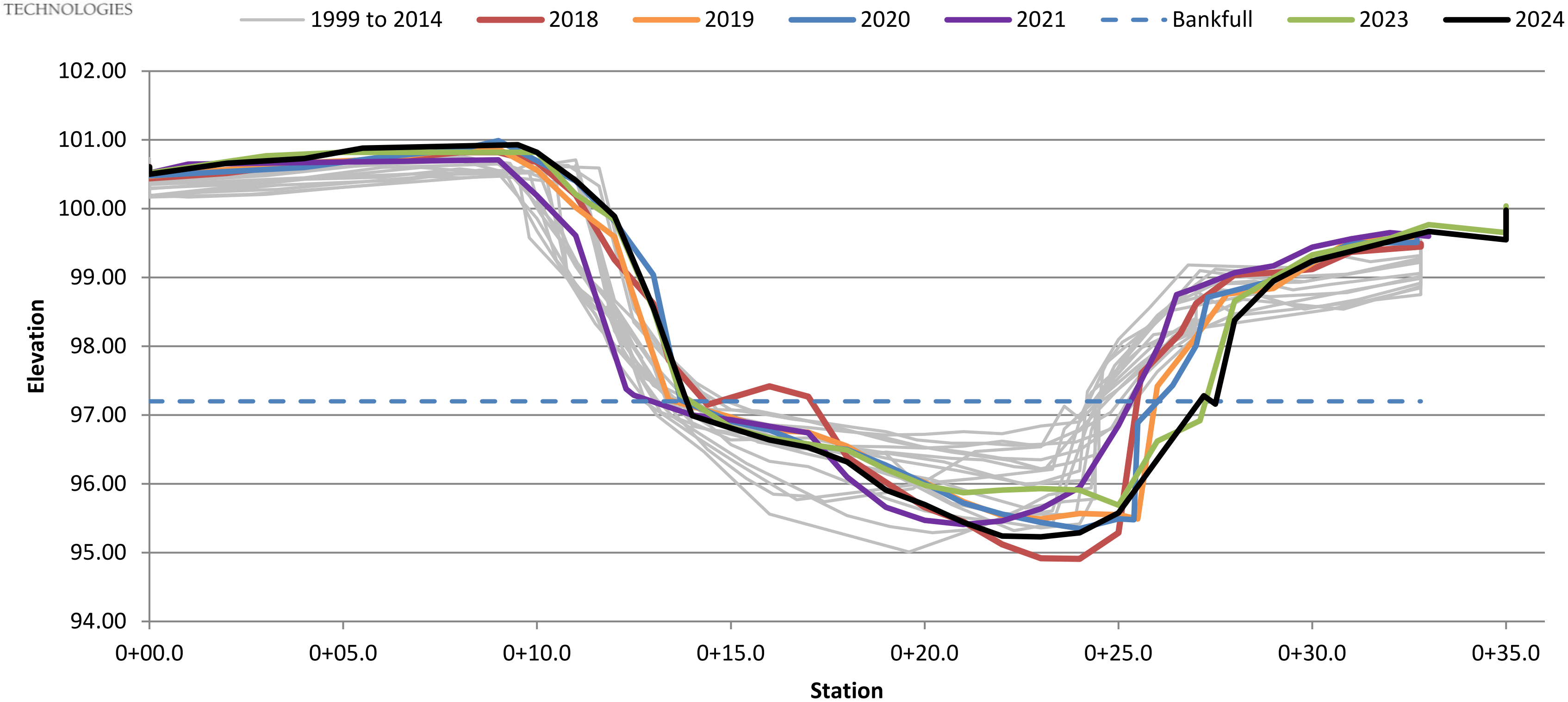
BKFL/TOB ELEV= 96	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
2005	23.4	1.2	28.1	19.4	100.4
2018	24.8	1.3	31.8	19.4	108.0
2019	26.4	1.1	28.3	24.0	83.8
2020	27.4	1.0	27.7	27.1	88.0
2021	28.5	1.1	31.6	25.9	91.6
2022	28.0	1.1	29.7	26.4	106.4
2023	28.0	1.0	27.0	29.0	50.4
2024	28.2	0.9	25.6	31.1	37.3


BUSL-202 Particle Distribution
1999 to 2014
2015
2016
2017
2018
2019
2020
2021
2023
2024
silt/clay
sand
gravel
cobble
boulder
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
percent finer than
0.01
0.1
1
10
100
1000
10000
particle size (mm)



BUSL-202 Longitudinal Profile Overlay
2015
2016
2017
2018
2019
2020
2021
2023
2024
2024 Water Surface
Elevation
98.00
97.00
96.00
95.00
94.00
93.00
92.00
91.00
90.00
0+00.0
0+50.0
1+00.0
1+50.0
2+00.0
2+50.0
3+00.0
3+50.0
Station

BUSL-202



BKFL/TOB ELEV= 97.2	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	11.2	0.5	6.1	20.7	10.3
2018	8.8	1.5	13.3	5.8	39.5
2019	12.4	1.0	12.5	12.4	35.8
2020	12.2	1.0	12.7	11.8	36.3
2021	12.3	1.0	12.2	12.5	33.9
2023	13.9	1.9	17.4	11.1	30.2
2024	14.3	1.7	23.6	8.6	46.2

APPENDIX B

METHODS FOR ESTIMATING POLLUTANT LOADING IN PETER PAN RUN

Methods for Estimating Pollutant Loading in Peter Pan Run

Calculation factors used to estimate pollutant loadings at Peter Pan Run and at Pond-R Outfall were determined as follows:

- Stage data were measured from July 1, 2023 to June 30, 2024 by an ISCO 730 Bubbler Flow Module. Flow rate data (in cfs) were estimated by comparing stage data to a rating curve specific to each station. The rating curve at the instream station was formed using field stage (ft) and discharge (cfs) measurements taken between 2017 and 2018. A stilling well for the instream station instrument was installed on November 26, 2018 and a new rating curve was established with field measurements. The rating curve at the outfall station was formed using Manning's equation with a roughness coefficient of 0.013, pipe slope of 0.0213 ft/ft, and pipe diameter of 3.5 ft. Additional flow measurements were taken in the field at the instream station during FY2024 and the rating curve was updated. The instream stilling well rating curve does not fit stage values of less than 0.45 feet well. Therefore, a second curve was generated for the instream station to better match stage values of less than 0.45 feet. All rating curves followed second order polynomial equations with R^2 values of 0.956 for the instream station high stage curve, 0.999 for the instream station low stage curve, and 1.000 for the outfall station. Intermediate values were estimated via interpolation. The rating curves were used to estimate the discharge (cfs) from the stage values measured at both stations.
- At the instream station, stormflow and baseflow were separated by noting where the hydrograph increased due to rain and then decreased to a base level. Stormflows were considered flows that occurred during periods of elevated level due to rain. Baseflows were the flows measured at all other times. Baseflow was not observed during FY2024 at the outfall station. All flow at the pond's outfall station (POND-R) was considered stormflow.
- Flow volumes were calculated for each reading by averaging the flow (cfs) over the five-minute interval and then multiplying the averaged flow by 5 minutes using the proper conversions.
- The average flow rates, total flow volume, and days of flow for stormflow and baseflow were calculated for each season and the reporting year. The proportion of discharge characterized as baseflow and stormflow are given in Table B-1.

Table B-1. Proportion of discharge characterized as baseflow and stormflow at both Peter Pan Run stations FY2024

Location	Percent Baseflow	Percent Stormflow	Days Baseflow	Days Stormflow	Volume Baseflow (ac-ft)	Volume Stormflow (ac-ft)
Instream*	68%	32%	249	117	305	1304
Outfall*	0%	12%	0	43	0	19

*Due to Flow Module malfunction at the stations, erroneous data were corrected based on assumptions derived from the accurate periods of record.

- With the total volume of water calculated per storm event, season, and the reporting year, the total pollutant loads were calculated by multiplying the EMC or MC by the cumulative volume of water over the identified period and then converted to pounds.
- Some pollutant concentrations were below the detection limit for the method used to analyze the pollutant in the sample. In these cases, a range of values are offered. The lower value was calculated assuming the pollutant concentration was zero. The higher value was calculated assuming the pollutant concentration was the concentration of the detection limit.