FREDERICK COUNTY ASSESSMENT OF CONTROLS: PETER PAN RUN MONITORING JULY 2018 - JUNE 2019

Prepared for

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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. This 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 in force during this reporting period (July 1, 2018 – June 30, 2019). This monitoring report documents the monitoring activities at Peter Pan Run to meet requirements under the MS4 permit.

The Peter Pan Run monitoring meet's Frederick County's NPDES MS4 permit obligations under Part IV, Standard Permit Conditions, Subpart F, Assessment of Controls. Specifically the monitoring meets IV.F.1 – Watershed Restoration Assessment, as the watershed is 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. Further, the monitoring satisfies permit section IV.F.2 – Stormwater Management Assessment, as changes in condition have been monitored over time as the drainage area was developed. The monitoring program in Peter Pan Run was designed to build a long-term database (currently 1999 to 2019) of water quality and biological conditions and to assess the cumulative effects of both stormwater runoff stemming from development and the application 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 2019 (FY2019), construction of the PUD is complete 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 during the fiscal year in the PUD. Figure 1-1 and 1-2 provide a series of aerial photographs illustrating changes in land use that have occurred within the catchment 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, pre-construction conditions in the catchment and subsequently to

monitor conditions as development progresses within the Peter Pan Run watershed in order to assess potential long-term impacts associated with the new 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). In particular, monitoring is focused on the long-term problems commonly associated with residential development, which could 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 catchment upstream of the Peter Pan Run instream monitoring station and the Pond R (BMP NPDES 199) outfall station. Data on catchment area, land uses, and station location are provided in the geodatabase that comprises the County's 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 90 structural SWM facilities (21 extended detention dry ponds, 27 extended detention wet ponds, 15 bioretentions, nine sand filters, six underground filters, four permeable pavements, two grass swales, two shallow marshes, one micropool extended detention pond, one infiltration trench, one wet pond, and one bio-swale) have been constructed within the Peter Pan Run catchment area. Additional stormwater BMPs that may be constructed 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 enhanced surface sand filters depending on the high infiltration rates to achieve water quality benefits in the Peter Pan Run catchment area. Retrofits are being performed on BMP NPDES 39, 46, 47, 60, 77, 78, 186, 197, 199, 200, 662, 663, 928, 922, and 924. One of the fifteen ponds is Pond R (NPDES 199) which serves as the outfall station. The retrofits of the 15 ponds continued throughout the FY2019 reporting year with an anticipated completion of fall 2019. During FY2019, construction of five of these retrofits were complete (NPDES 39, 60, 77, 78, and 199). As these retrofits are constructed and become functional, this study will look at the cumulative effect that the retrofits will have on the Peter Pan Run catchment area. All monitoring data associated with the FY2019 report will be assessed with the caveat that it was collected during the County's active construction of 15 stormwater pond retrofits. The County looks forward to FY2020 where the data of pre- and post-retrofits will be compared.

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 NPDES 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* (Jones and Roth 2005), and *Quality Assurance Project Plan for Biological and Physical Monitoring in Peter Pan Run and Other Selected Watersheds* (Morgan and Roth 2005).

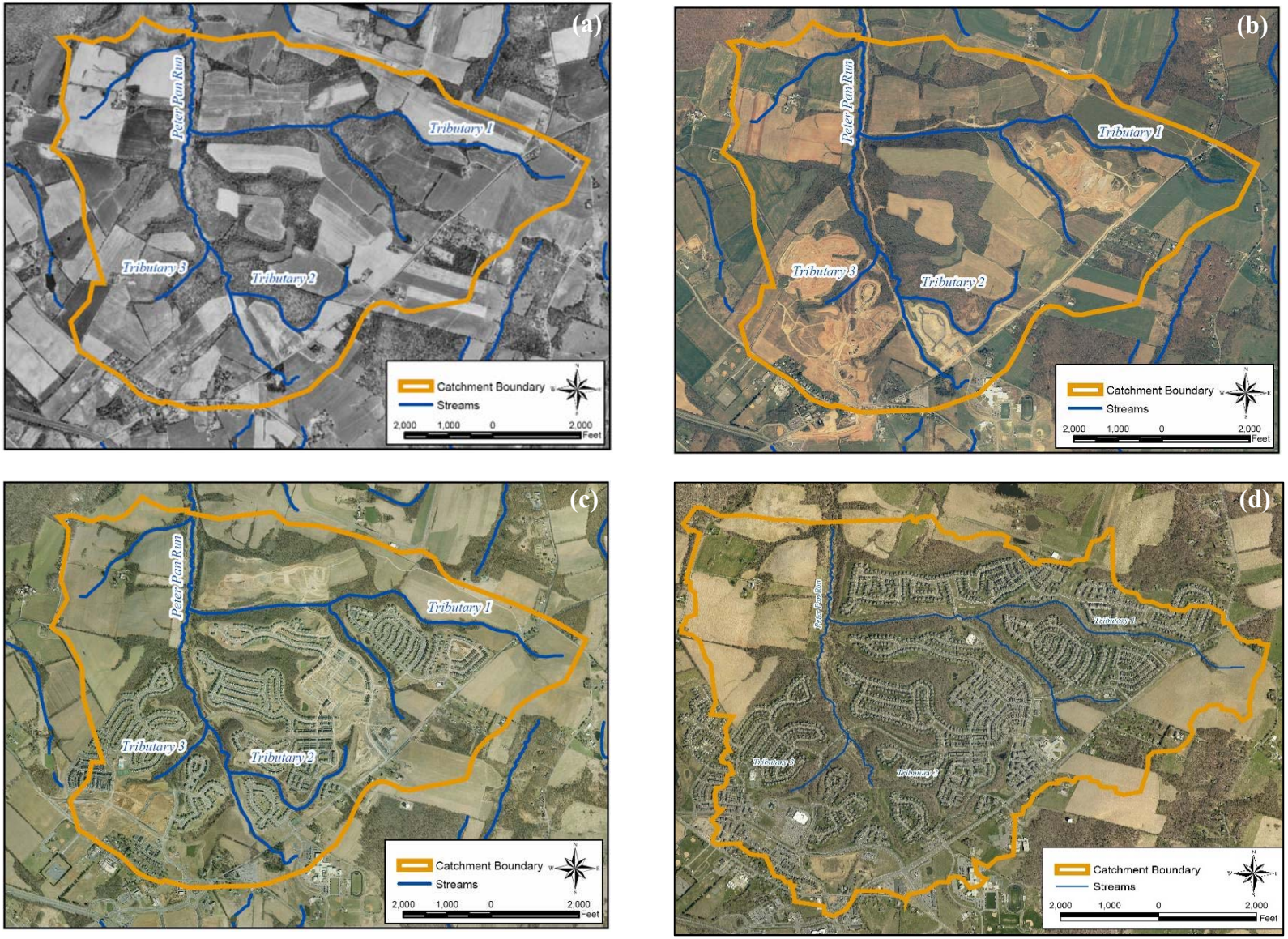

Figure 1-1. Aerial photographs of the Urbana Planned Unit Development (PUD) showing changes in the area over time. (a.) predevelopment conditions in April 1988 (Source: USGS), (b.) initial stages of development in March 2000 (Source: Frederick County), (c.) conditions in March-April 2005 (Source: Frederick County), and (d.) conditions in 2014 (Source: Frederick County).

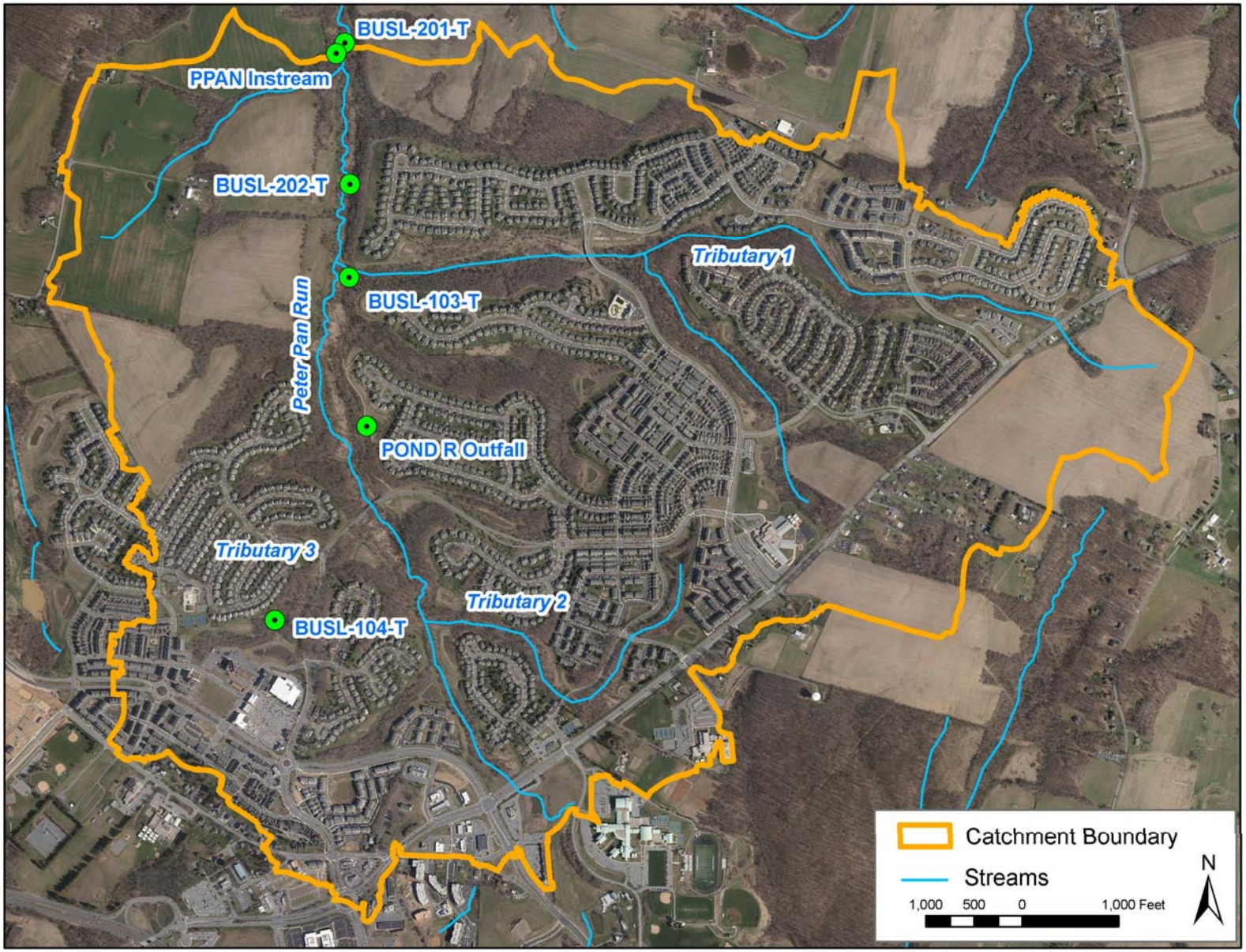

Figure 1-2. Annotated aerial photograph of Peter Pan Run in Lower Bush Creek watershed, Frederick County, Maryland showing the Peter Pan Run monitoring stations. (Image source: Maryland iMAP Image Service, 2017)

1.4 MONITORING METHODS

Currently, and as approved by Maryland Department of the Environment (MDE), the methodologies used to assess streams in Frederick County are comparable to that used by other counties in Maryland, 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 (Stranko et al. 2014) are a regional application of EPA's Rapid Bioassessment Protocols (RBP, Plafkin et al. 1989, Barbour et al. 1999). Methods developed by Montgomery County Department of Environmental Protection were also employed from 1999 through 2006, in part, for quantitative physical habitat assessments. 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 Tables 1-1 and 1-2.

Table 1-1. 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 macroinvertebrates	Biological monitoring: • fish

Table 1-2. Annual stream 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 Peter Pan Run instream and SWM pond outfall stations. Frederick County invested heavily in upgrading the water quality monitoring equipment to ensure the permit monitoring requirements are 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 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 2-2a) and an associated in-stream 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.

Peter Pan Run Instream Station

Long-term chemical monitoring has continued at the Peter Pan Run instream monitoring station (located at PPAN-01) since May 1999. Photographs of the monitoring equipment as set up by KCI and related site features are presented in Figures 2-1, 2-2a, and 2-2b. In November 2018, KCI installed a PVC stilling well in a pool feature of Peter Pan Run to monitor water levels within the channel. Historically, water level data was collected in a riffle approximately 15' 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. The instream station includes sample intake tubing located near a stilling well at the center of the stream, a staff gauge and flow meter sensor against the left bank, and a "storm box" located in a clearing near the bank. Photograph taken November 24, 2018.

Land use immediately surrounding the Peter Pan Run instream station remains primarily agricultural; however, construction within the Urbana PUD has occurred within approximately 500 yards of the station. The instream station is located on the west 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, 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

Within the Urbana PUD, Pond-R (Figure 2-2a and 2-2b) 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. Initial monitoring characterized water quality at the outfall of the basin during residential construction. Conversion of the Pond R sediment trap to a functional dry 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 2-2a. Villages of Urbana "Pond-R" outfall water chemistry monitoring station and rain gauge. Photograph taken October 16, 2017.

Figure 2-2b. Bubbler flow module located at the midpoint of the Pond R outfall pipe sampling stage data for the Pond-R station. Photo taken November 8, 2017.

Land use upstream of Pond R consists of medium-density residential housing comprising 30.4 acres (38.8%) of the total 78.4 acres of the Village VII section of the Urbana PUD.

2.1.1 Chemistry Monitoring Procedures

As part of the program, Frederick County conducted monthly baseflow monitoring at both the Peter Pan Run 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 preservative. Calibrated field instruments were used to measure basic physical water quality parameters (e.g., water temperature, dissolved oxygen, specific conductivity, and pH). Field notes and data were recorded on preprinted, project-specific field sheets. During weekly inspections of the monitoring stations, field teams checked equipment for proper operation 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 during FY2018 and FY2019.

Beginning in 2015, the MS4 permit required eight storms to be sampled per year; a new storm event frequency was implemented to capture two events per quarter. 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 stage meters in FY2018). Storm event monitoring at PPAN-01 and POND-R began in May 1999 and February 2003, respectively. 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. Manual grab samples were collected for “first flush” parameters (oil and grease, total petroleum

hydrocarbons (TPH), phenols, and fecal coliform) using dedicated bottles containing preservative. Starting in FY2018, TPH and fecal coliform were tested throughout the storm. 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 rate 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 level, flow, and rainfall measurements were downloaded at least twice monthly.

Following NPDES permit guidelines, 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 (BOD) (5-day)	2 – 2.7 mg/L	SM 5210 B
Total Kjeldahl Nitrogen (TKN)	0.2 – 0.5 mg/L	SM4500NH3-C
Nitrate and Nitrite	0.01 – 0.05 mg/L	SM 4500NO3-H
Total Phosphorus	0.01 mg/L	SM 4500P-E
Total Suspended Solids (TSS)	1 mg/L	SM 2540 D
Copper	2 µg/L	EPA 200.8
Lead	2 – 5 µg/L	EPA 200.8
Zinc	2 – 20 µg/L	EPA 200.8
Hardness	580 – 1000 µg/L	SM 2340C
Total Petroleum Hydrocarbons (TPH)	2.7 – 5 mg/L	EPA 1664
E. coli	1 MPN/100 mL	SM 9223B

2.1.2 Storm Information

Frederick County reached out to MDE via email regarding a small gap in the monitoring data located at the pond outfall due to active retrofit construction activities. Safety of monitoring staff and the validity of the results were the primary concerns for not collecting samples during this period. MDE responded that a small gap was permissible and to prorate the months of active construction versus the amount of storm events required. Fortunately, weather patterns allowed Frederick County to meet its required eight storm events at the Peter Pan Run instream and Pond-R outfall stations during the sampling period, October 24, 2018 through July 23, 2019, as the site was only under active construction from August through mid-October. The final storm event was sampled in July 2019 to achieve the total number of eight storm events. Baseflow monitoring was

carried out at a monthly rate between July 2018 and June 2019 at the Peter Pan Run instream station accounting for twelve samples. Due to the active retrofit construction occurring within the Peter Pan Run catchment, the collected data for FY2019 may not reflect the anticipated cumulative post-retrofit condition.

Other challenges during the course of the reporting year included water quality sonde malfunctions for pH and temperature, Pond R stage height equipment damage from construction activities, the instream station icing over during the winter months, variable Pond R water levels, and rodent infestations including mice chewing through bubbler and intake tubing. During retrofit construction of Pond R (July 2018 – October 2018) the facility was frequently dewatered to a filter bag downstream of the outfall station set up. Therefore, flow rates during this time are not representative of either the dry extended detention condition or new wet extended detention condition of the pond outfall. For the instream station, pH data could not be recovered from the malfunctioning sonde for the peak and falling limb samples during the November 24, 2018 storm. For the Pond R station, water temperature data could not be recovered from the malfunctioning sonde for all samples during the April 13, 2019 storm.

As presented in Table 2-2, rainfall measured on site from sampled storms ranged in quantity from 0.56 to 3.04 inches during qualifying events, and in duration from 7.25 hours to 30.83 hours. Average rainfall intensities from sampled storms ranged from 0.07 to 0.23 inches/hour.

Table 2-2. Summary of storm events monitored in FY2019* at Peter Pan Run

Date	Start Time	Rainfall Duration (hrs)	Rainfall** (in)	Avg. Intensity (in/hr)	Storm as % of Total Rainfall for Month
11/24/2018	10:50	7.42	1.69	0.23	22%
12/15/2018	18:45	30.83	2.69	0.09	47%
3/10/2019	22:00	7.25	0.56	0.08	11%
3/21/2019	3:15	21.75	3.04	0.14	61%
4/12/2019	12:15	14.83	1.53	0.10	36%
4/19/2019	12:15	12.92	0.91	0.07	21%
6/13/2019	22:30	18.42	1.33	0.07	44%
7/22/2019	13:55	18.00	1.59	0.09	24%

* FY denotes "Fiscal Year," defined as July to June. For this report, FY2019 refers to the period July 1, 2018 to July 23, 2019 to successfully monitor 8 storm events.

** For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station data.

Because variation in pollutant loads and even changes in channel geometry can result from variable weather and 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 2019). 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 2-3. Note that the project rain gauge was located at Peter Pan Run instream station until early 2003 when the rain gauge was relocated to the Pond R outfall station.

For the twelve-month monitoring period in FY2019, total annual rainfall near the site, as recorded at NOAA's Clarksburg gauge (71.25 inches) was 76% above normal compared to the long-term

annual average of 40.40 inches recorded in Frederick County (Figure 2-4). Total annual rainfall data was used from the NOAA Emmitsburg rainfall gauge from 1991 to 2007 and the NOAA Clarksburg rainfall gauge from WY 2007 to FY2018. 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 FY2019, the in-situ rain gauge located at Pond-R recorded 67.70 inches between July 2018 and June 2019, 68% above the normal average depth in Frederick County for the same time period (Figure 2-5). Total discharge volume at the Peter Pan Run instream monitoring station between July 2018 and June 2019 was 237.2% higher than in the prior fiscal year (July 2018 – June 2019) (Figure 2-6b).

Table 2-3. FY2019 Rainfall data (totals by month; inches)

Month	In-situ ISCO[a]	Clarksburg[b]	Emmitsburg[b]	Normal[c]	In-situ Departure from Normal
July-18	8.38	11.07	10.09	3.70	4.68
August-18	6.77	6.85	6.15	3.50	3.27
September-18	12.30	10.07	15.23	3.60	8.70
October-18	2.52	2.36	3.18	3.10	-0.58
November-18	7.83	7.93	8.4	3.30	4.53
December-18	5.68	6.13	5.44	2.90	2.78
January-19	2.75	3.87	4.29	2.80	-0.05
February-19	3.04	3.86	3.57	2.70	0.34
March-19	4.97	5.23	4.87	3.30	1.67
April-19	4.27	2.72	5.21	3.30	0.97
May-19	6.14	6.03	7.76	4.30	1.84
June-19	3.05	5.13	4.95	3.90	-0.85
July-19	6.63	7.33	6.06	3.70	2.93

[a] For periods where the rain gauge malfunctioned, rainfall was supplemented with Weather Underground Urbana Highlands Station 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.

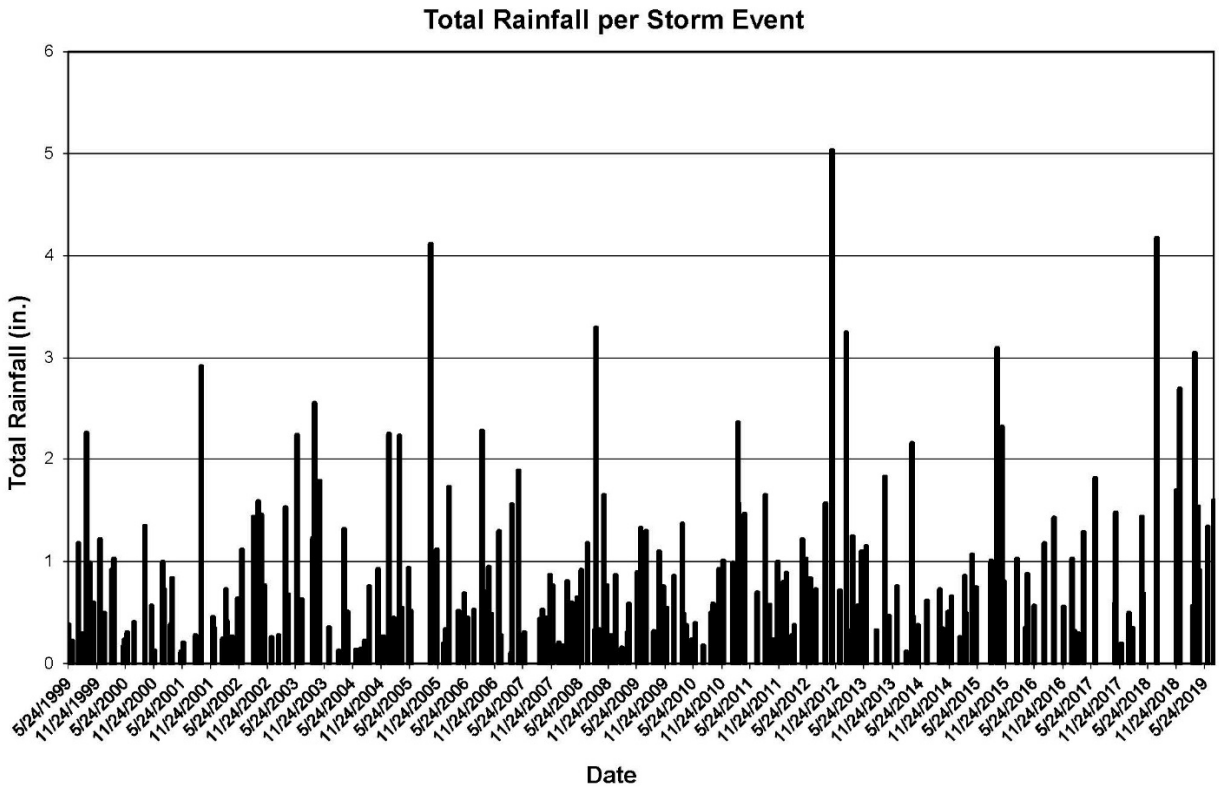

Figure 2-3. Rainfall totals for sampled storm events (May 1999 to July 2019)

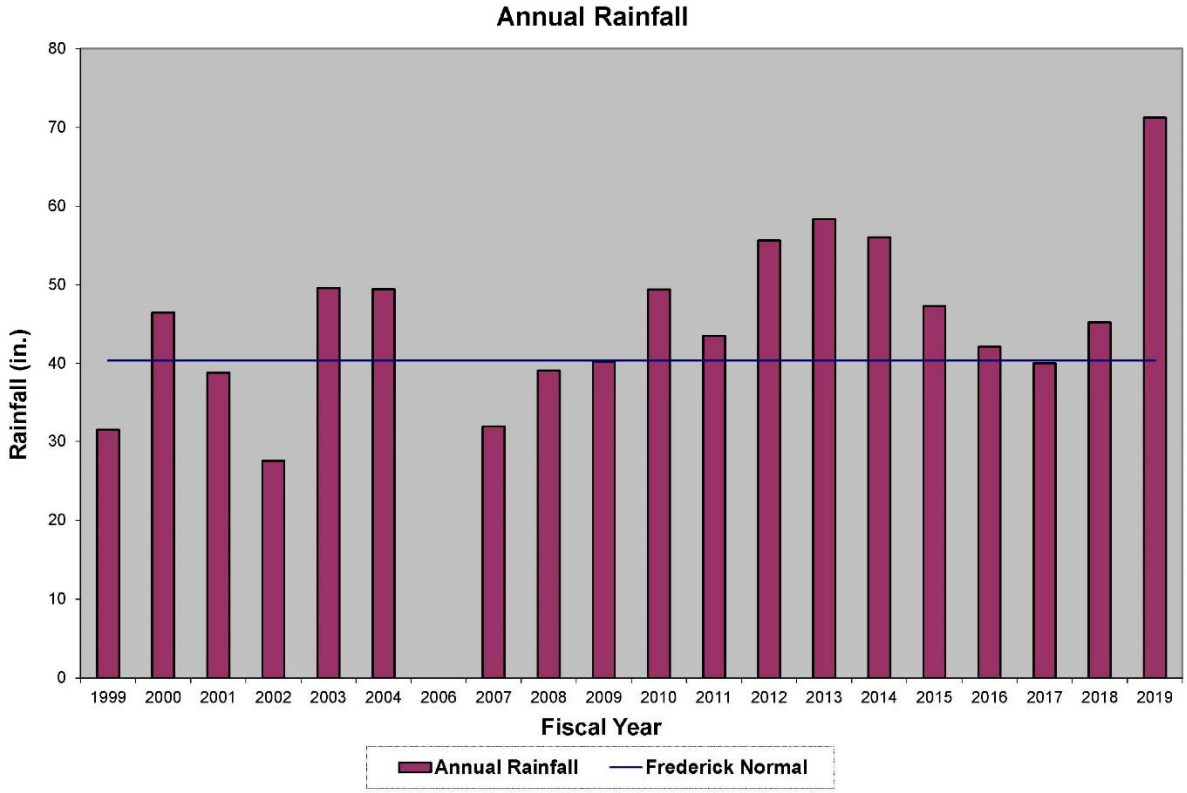

Figure 2-4. Annual rainfall recorded at NOAA's Emmitsburg, MD station, FY1999-2008 (no data for FY2006) and at NOAA's Clarksburg, MD station, FY2009-2019. Note: Emmitsburg data for FY2007 do not include July 2006 and June 2007.

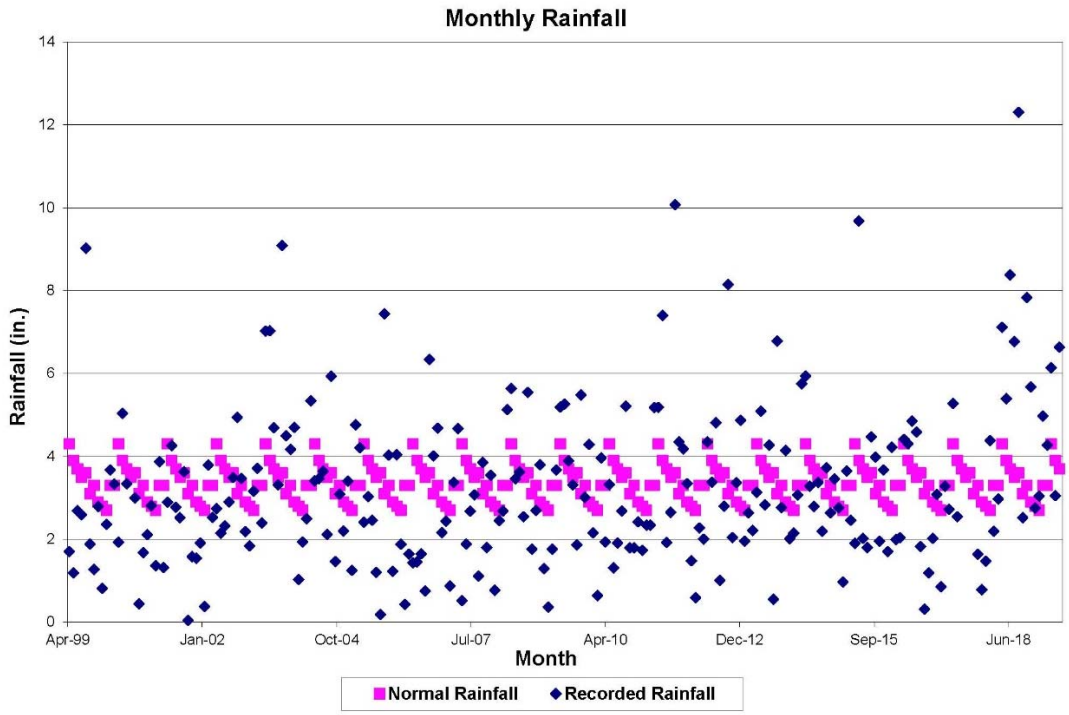

Figure 2-5. Monthly rainfall recorded at the Peter Pan site (at instream station prior to early 2003; at Pond-R after early 2003) and NOAA's long-term Frederick County regional average monthly (i.e., normal) rainfall, April 1999 – July 2019.

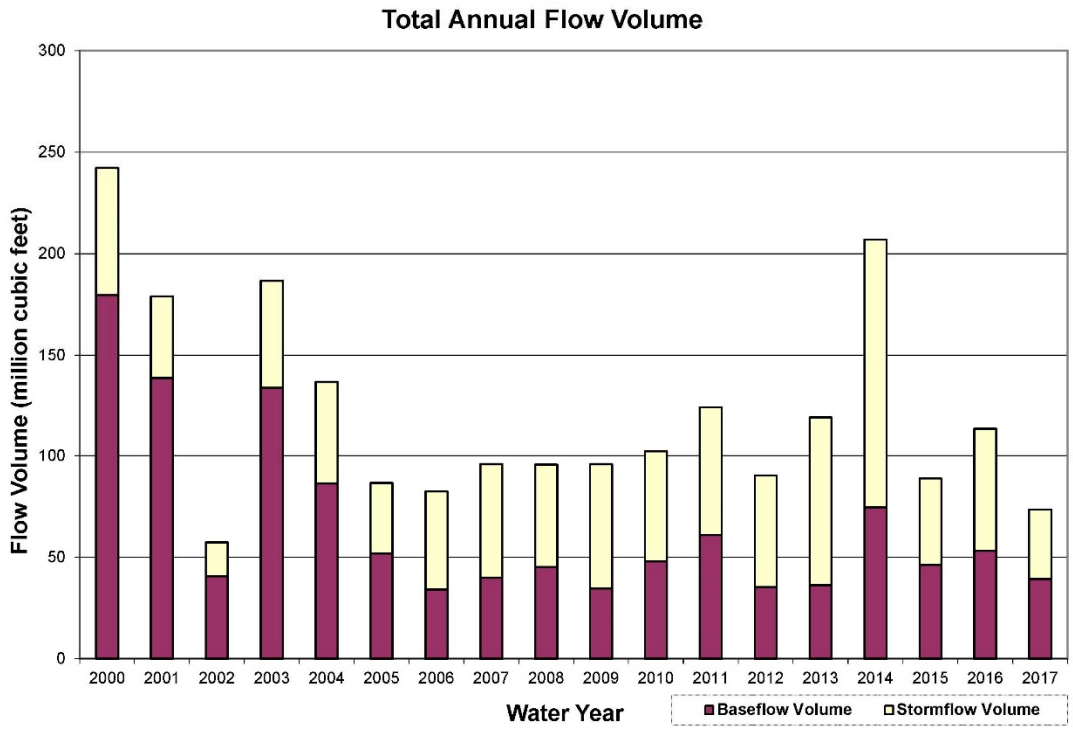

Figure 2-6a. Annual discharge volume measured at the Peter Pan Run instream monitoring station, WY2000 – WY2017.

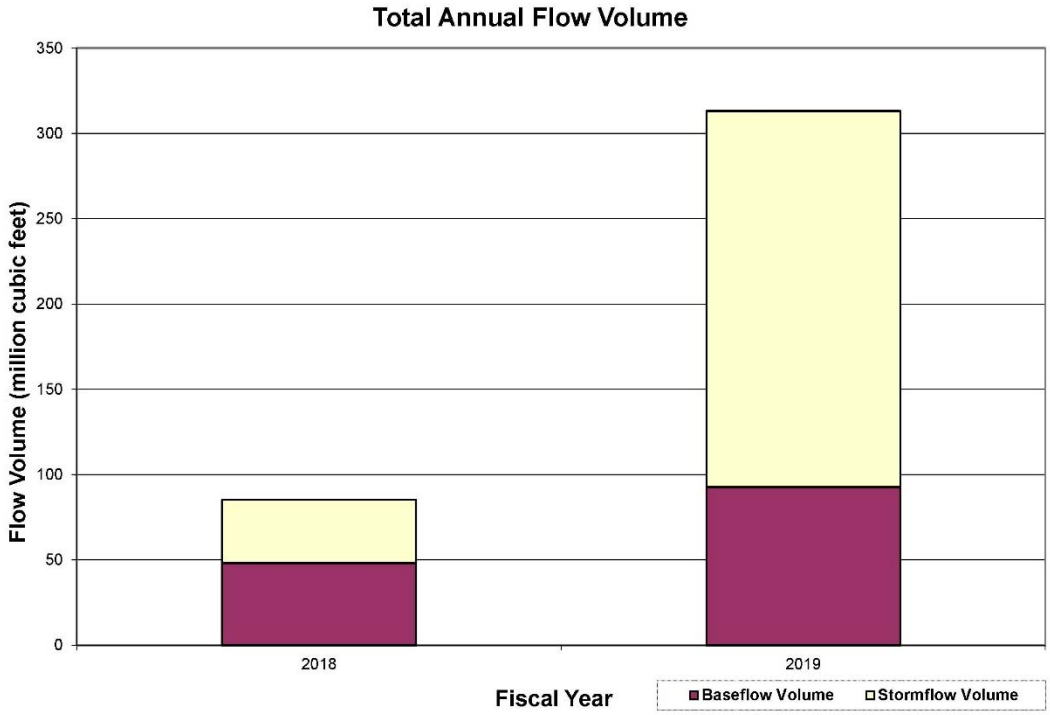

Figure 2-6b. Annual discharge volume measured at the Peter Pan Run instream monitoring station, FY2018 – FY2019.

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 Peter Pan Run instream station and Pond-R outfall station from July 2018 through July 2019 are shown in Tables 2-4a through 2-4c. Baseflow monitoring analytical results from the Peter Pan Run instream station includes twelve samples during the period of July 2018 to June 2019.

Table 2-4a. FY2019 water chemistry results for instream storm event monitoring at Peter Pan Run

Date	Sampling Period	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
11/24/2018	Rising	< 2	0.2	2.80	0.14	120	76	< 2.0	< 2.0	13.7	< 2.7	2420
	Peak	2	1.0	1.00	0.39	47	430	7.4	8.4	36.8	< 2.7	7120
	Falling	< 2	0.2	1.40	0.09	67	28	3.0	< 2.0	13.6	3.4	2420
12/15/2018	Rising	4	0.2	2.90	0.04	140	15	< 2.0	< 2.0	12.0	< 2.7	285
	Peak	< 2	0.4	0.97	0.47	48	250	5.5	5.4	27.7	< 2.7	2420
	Falling	< 2	0.4	1.40	0.07	63	25	< 2.0	< 2.0	12.1	< 2.7	1120
3/10/2019	Rising	< 2	< 0.2	3.30	0.05	160	36	2.6	< 2.0	14.2	5.1	285
	Peak	< 2	< 0.2	1.80	0.13	150	190	3.4	3.0	22.5	5.6	727
	Falling	< 2	0.3	2.10	0.03	130	8	< 2.0	< 2.0	11.6	< 2.7	124
3/21/2019	Rising	4	< 0.2	3.00	0.07	140	210	3.8	3.2	23.8	< 2.7	687
	Peak	5	0.2	2.00	0.66	64	1800	35.4	37.3	175.0	< 2.7	1200
	Falling	< 2	1.8	1.80	0.16	80	120	4.5	2.8	21.0	< 2.7	238
4/13/2019	Rising	< 2	< 0.2	3.20	0.02	150	27	< 2.0	< 2.0	11.3	7.9	687
	Peak	2	0.3	1.70	0.18	88	190	4.8	4.6	25.5	4.9	1990
	Falling	< 2	0.3	1.90	0.03	110	15	< 2.0	< 2.0	12.4	< 2.7	687
4/19/2019	Rising	< 2	0.6	2.70	0.08	130	110	4.5	2.3	16.8	< 2.7	921
	Peak	< 2	0.8	1.50	0.10	96	96	4.0	< 2.0	16.4	2.8	921
	Falling	< 2	0.6	1.60	0.04	110	6	2.4	< 2.0	9.6	< 2.7	179
6/13/2019	Rising	2	0.2	3.00	0.05	150	53	4.7	< 2.0	18.7	6.1	2420
	Peak	6	1.7	1.80	0.84	120	870	17.9	15.4	83.9	5.4	10100
	Falling	6	0.3	1.40	0.12	100	78	4.3	< 2.0	17.4	< 2.7	2420
7/22/2019	Rising	8	1.7	4.00	2.70	130	92	58.8	57.2	240.0	5.9	130000
	Peak	4	1.6	1.20	0.36	92	680	10.4	7.9	52.7	4.7	7380
	Falling	5	1.0	0.97	0.32	92	520	12.4	9.0	49.5	< 2.7	1990

Results are in mg/L except *E. coli* results are in MPN/ 100 mL. Metals results are in µg/L.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Shaded values indicate results that exceeded Maryland surface water quality acute criteria as depicted in Table 2-5.

Table 2-4b. FY2019 water chemistry results for baseflow monitoring at instream Peter Pan Run

Date	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
7/30/2018	< 2	< 0.2	2.60	0.09	120	24	< 2.0	< 5.0	< 2.0	< 2.7	411
8/27/2018	< 2	< 0.2	2.90	0.03	140	1	< 2.0	< 5.0	< 2.0	< 2.7	179
9/21/2018	< 2	< 0.2	3.10	0.02	140	1	< 2.0	< 2.0	4.0	3.6	261
10/5/2018	< 2	0.3	3.10	0.02	130	1	< 2.0	< 2.0	9.7	< 2.7	435
11/30/2018	< 2	0.2	3.00	0.02	130	< 1	< 2.0	< 2.0	12.0	2.7	45
12/14/2018	< 2	0.2	3.50	< 0.01	150	< 1	< 2.0	< 2.0	8.4	< 2.7	42
1/11/2019	< 2	0.2	3.60	< 0.01	140	< 1	< 2.0	< 2.0	8.8	< 2.7	34
2/15/2019	< 2	0.3	2.80	0.01	160	2	< 2.0	< 2.0	8.3	3.2	52
3/19/2019	< 2	0.2	3.60	< 0.01	160	2	< 2.0	< 2.0	9.2	2.9	22
4/5/2019	< 2	< 0.2	3.40	< 0.01	150	1	< 2.0	< 2.0	16.0	< 2.7	44
5/22/2019	< 2	< 0.2	3.20	0.03	140	3	< 2.0	< 2.0	8.9	< 2.7	173
6/17/2019	< 2	0.2	3.10	0.02	160	3	< 2.0	< 2.0	12.1	< 2.7	219

Results are in mg/L except *E. coli* results are in MPN/100 ml. Metals results are in µg/l.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Table 2-4c. FY2019 water chemistry results for outfall storm event monitoring at Pond-R

Date	Sampling Period	BOD	TKN	Nitrate+Nitrite	Total Phosphorus	Hardness	TSS	Copper	Lead	Zinc	TPH	*E. coli*
11/24/2018	Rising	3	0.6	0.13	0.31	61	130	5.6	3.3	30.4	8.0	142
	Peak	5	0.2	0.15	0.23	31	47	3.7	< 2.0	17.9	< 2.7	2810
	Falling	4	0.4	0.16	0.20	23	42	5.7	< 2.0	18.2	< 2.7	2430
12/15/2018	Rising	< 2	0.2	0.07	0.31	42	9	4.8	< 2.0	28.7	< 2.7	70
	Peak	< 2	0.2	0.13	0.14	24	16	3.9	< 2.0	10.6	< 2.7	1200
	Falling	< 2	0.2	0.20	0.12	22	11	5.4	< 2.0	14.9	< 2.7	1300
3/10/2019	Rising	2	< 0.2	0.08	0.07	64	22	6.7	< 2.0	20.5	< 2.7	3
	Peak	< 2	0.3	0.07	0.04	49	6	2.3	< 2.0	15.3	< 2.7	2
	Falling	< 2	< 0.2	< 0.05	0.04	47	6	< 2.0	< 2.0	15.6	< 2.7	< 1
3/21/2019	Rising	< 2	1.1	0.05	0.05	44	11	3.3	< 2.0	19.2	< 2.7	2
	Peak	< 2	3.1	0.32	0.11	28	21	3.7	< 2.0	18.5	3.3	770
	Falling	3	0.8	0.24	0.07	25	15	5.0	< 2.0	17.4	< 2.7	866
4/13/2019	Rising	< 2	0.3	0.14	0.10	40	17	5.6	< 2.0	24.7	4.8	17
	Peak	< 2	0.2	0.22	0.07	29	8	3.6	< 2.0	15.9	4.0	770
	Falling	< 2	0.3	0.24	0.06	31	6	3.1	< 2.0	13.4	8.5	1120
4/19/2019	Rising	2	1.6	0.06	0.14	58	8	8.7	< 2.0	15.4	< 2.7	53
	Peak	< 2	1.1	0.08	0.09	43	5	5.8	< 2.0	12.6	2.7	44
	Falling	< 2	1.1	0.07	0.12	56	8	5.7	< 2.0	15.0	< 2.7	93
6/13/2019	Rising	16	1.9	0.20	0.38	100	120	8.5	3.6	71.0	< 2.7	435
	Peak	7	0.8	0.16	0.19	110	12	4.9	< 2.0	22.4	2.8	1050
	Falling	6	< 0.2	0.40	0.11	64	9	4.2	< 2.0	19.4	4.9	1300
7/22/2019	Rising	< 2	1.5	0.16	0.20	50	3	3.0	< 2.0	32.8	5.3	2420
	Peak	< 4	0.9	0.22	0.09	33	13	2.3	< 2.0	19.0	4.6	1990
	Falling	< 2	0.9	0.13	0.09	35	7	< 2.0	< 2.0	17.0	< 2.7	1550

Results are in mg/L except *E. coli* results are in MPN/100 mL. Metals results are in µg/L.[1]

[1] Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

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 Peter Pan instream and the Pond-R outfall monitoring stations. Rating curves were developed using in-situ flow and stage measurements at the Peter Pan 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 2-5 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 many 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 the purpose of discussion, EMCs and baseflow mean concentrations (MCs) were calculated with non-detectible results set to zero.

[1]In the electronic database 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 (e.g., AQ700 multi-parameter sonde) 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 2-5. Comparison of annual average Peter Pan Run event mean concentrations (EMCs) from storms sampled between July 1, 2018 and July 23, 2019, 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	1.1 – 2.6	1.1 – 2.6	14.44	9	9	4.34	N/A	N/A	N/A
TKN	0.4	0.6	1.94	1.5	1.5	1.03	N/A	N/A	N/A
Nitrate + Nitrite	1.58	0.30	0.85	0.6	0.68	N/A	N/A	N/A	N/A
Total Phosphorus	0.33	0.13	0.33	0.31	0.33	0.13	N/A	N/A	N/A
Hardness	78	31	N/A	32	N/A	N/A	N/A	N/A	N/A
TSS	464	15	66.57	49	100	15.21	N/A	N/A	N/A
Copper	0.0092 – 0.0095	0.005	0.0179	0.012	0.034	0.0095	0.013	0.009	1.3
Lead	0.0082 – 0.0092	0.0000 – 0.0028	0.0125	0.012	0.144	0.0046	0.065	0.0025	0.015
Zinc	0.0452	0.0121	0.1433	0.073	0.16	0.0644	0.12	0.12	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

During FY2019, the County actively retrofitted 5 stormwater ponds within the catchment to the instream site. Results at the instream station may have been skewed due to the stormwater pond retrofit construction activities within the catchment and may not be comparable to pre- or post-restoration conditions. All 15 stormwater pond retrofits will be completed in fall 2019. Data comparisons of pre- and post-retrofit activities will be evaluated beginning in FY2020. Average annual storm EMCs for all pollutants, except for hardness, increased from FY2018 levels. During baseflow conditions, hardness and copper decreased from FY2018 levels where all other pollutants increased. Average BOD storm flow concentration in FY2019 was 161% higher than in FY2018. BOD was not detected in baseflow samples for an eighth consecutive year. Average hardness concentrations have remained consistent since FY2012 with a 17% decrease in baseflow mean concentrations and a 29% decrease in EMCs since FY2018. Average hardness concentrations are lower during storm events in comparison to baseflow. TPH was detected in several storm event and baseflow samples taken at the instream station during FY2019. Whereas in FY2018, TPH was only detected in one storm event sample.

Average baseflow concentrations of combined nitrate and nitrite steadily increased between FY2009 and FY2015, reduced in FY2017, and began to increase in FY2018 with a further increase by 27% in FY2019. The average annual storm EMC for combined nitrate and nitrite remained at a fairly consistent level since FY2009 with a 19% increase for FY2019 since FY2018. Average baseflow concentrations of nitrate and nitrite are consistently higher than average storm flow concentrations for the entire sampling period. This is likely caused by active and legacy agricultural land use within the watershed and nitrate and nitrite leaching into groundwater during baseflow conditions. TKN average baseflow concentrations have remained consistently low since FY2012. TKN was not detected in baseflow samples in FY2018 but concentrations increased slightly in FY2019. Average storm EMCs of TKN have been measured on an increasing trend since FY1999 until the beginning of a decreasing trend in FY2017. However, storm runoff TKN levels in FY2019 increased by 65% compared to FY2018. Average baseflow TKN concentrations have followed a similar trend with consistent, low concentrations measured since FY2012 (Figure 2-7).

Excluding a spike in concentration level in FY2009, average baseflow phosphorus concentrations have shown an overall declining trend since FY2004 with consistently low concentrations measured since FY2013. The baseflow mean phosphorus concentration increased by 71% since FY2018. However, the FY2019 baseflow mean phosphorus concentration is still considered low. The average storm event concentration of phosphorus in FY2018 was 102% higher than the average in FY2019. Phosphorus storm event mean concentrations peaked between FY2008 and FY2011 but have not shown any other trend. The average phosphorus storm event concentration decreased significantly in FY2012 and has remained fairly consistent ever since (Figure 2-8).

Storm runoff and baseflow TSS concentrations increased by 373% and 30% respectively in comparison to FY2018. TSS average baseflow concentrations have been negligible compared to average storm event concentrations for the entire sampling period. TSS EMCs have largely fluctuated over the sampling period and had been on a decreasing trend until FY2010 where the

averages began an increasing trend that peaked in FY2016 (Figure 2-8). The annual EMCs began to decrease but increased for FY2019.

E. coli was detected in all baseflow and storm event samples at the Peter Pan Run instream station. Average *E. coli* baseflow and stormflow concentrations decreased by 27% and 52% respectively since FY 2018. *E. coli* concentrations were typically higher during peak storm samples. The lowest concentrations of *E. coli* are generally found during the colder months. Sample analytical results for *E. coli* are within the same range or slightly higher than in FY2016 and FY2017. 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).

Annual storm EMCs for copper and zinc increased from FY2018 values by 132% and 527% respectively. Lead annual storm EMCs also increased in FY2019. Copper and lead storm EMCs have measured at consistent levels since FY2000 while zinc has fluctuated since FY2005 after a decreasing trend. The EMCs for all three metals have followed a decreasing trend since FY2016 until increasing in FY2019. Corresponding annual mean concentrations of metals in baseflow have remained consistently low or not detected since FY1999 (Figure 2-9). Three copper concentration results exceeded the freshwater acute criterion of 0.013 mg/L (3/21/2019, 6/13/2019, 7/22/2019) and two zinc results exceeded the freshwater acute criterion of 0.12 mg/L at the instream station in FY2019 (3/21/2019, 7/22/2019; Figure 2-10).

Calculated EMCs for metals may be compared to the standards listed in Table 2-5. However, it is important to note that Maryland State water quality criteria for metals are presented in terms of dissolved metals only and results are reported as total metals. Only the dissolved portion of metals is readily available for biological uptake. Because metals tend to sorb to suspended solids and organic matter, the portion of the particulate form of the metal is often larger than the portion of the dissolved form. NPDES stormwater samples are analyzed for total metal concentrations (as required by the NPDES permit and MDE's recommended protocols) making it more difficult to draw a direct comparison. Therefore, our analysis is not meant to specifically determine whether these constituents meet State water quality standards. Rather we present this information to provide a general indication of overall stream quality. All average annual storm EMCs and average annual MCs for metals did not exceed their respective acute and chronic criteria. No storm runoff sample metals concentration results exceeded their respective Maryland freshwater criteria at the instream station.

Home construction, natural sources, and automobile use are likely primary contributors to high metal concentrations in watershed runoff. Atmospheric deposition is a source of copper and zinc. Zinc and cadmium are deposited on surfaces as a result of tire wear. Wear on brake pad linings contributes to copper in runoff. Vehicle emissions are a primary source of lead in storm runoff (San Diego Regional Water Quality Control Board 2000). Used motor oil contains zinc, cadmium, lead, and other heavy metals (USDHHS 1997).

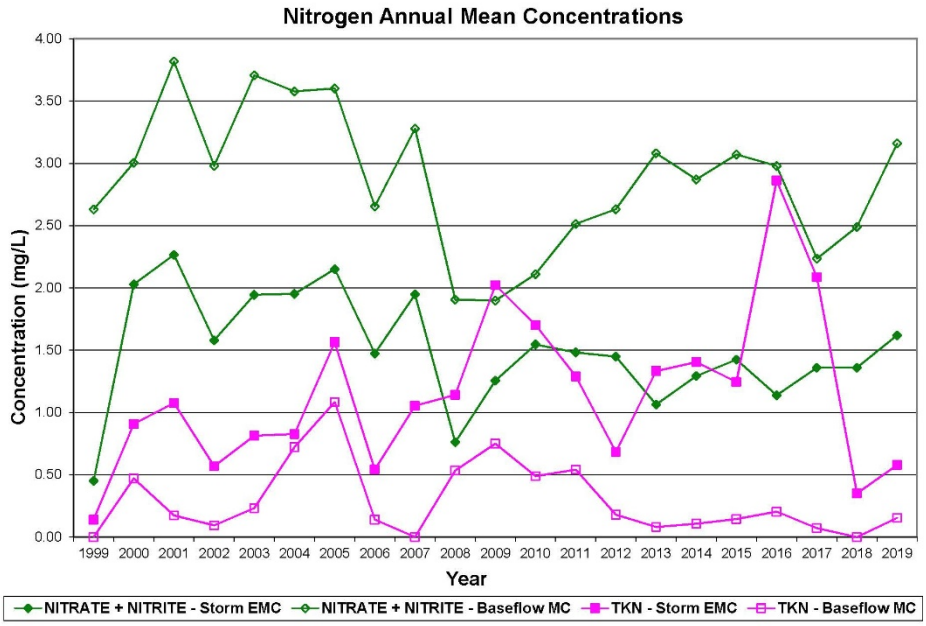

Figure 2-7. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Peter Pan Run instream site (FY1999 – FY2019). FY2019 data may not be comparable to other years due to pond retrofits occurring within the catchment during the monitoring period.

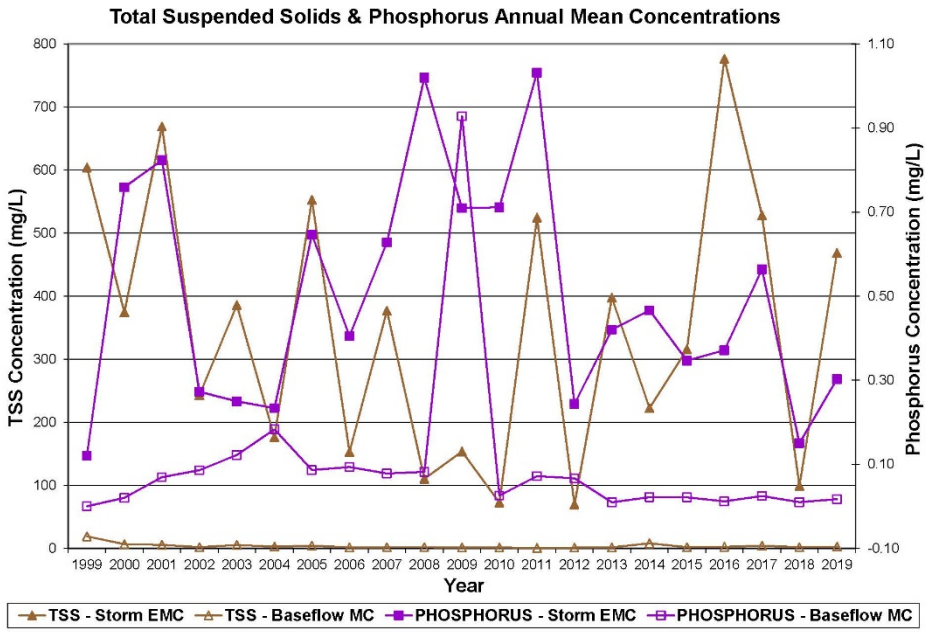

Figure 2-8. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at the Peter Pan Run instream station (FY1999 – FY2019). FY2019 data may not be comparable to other years due to pond retrofits occurring within the catchment during the monitoring period.

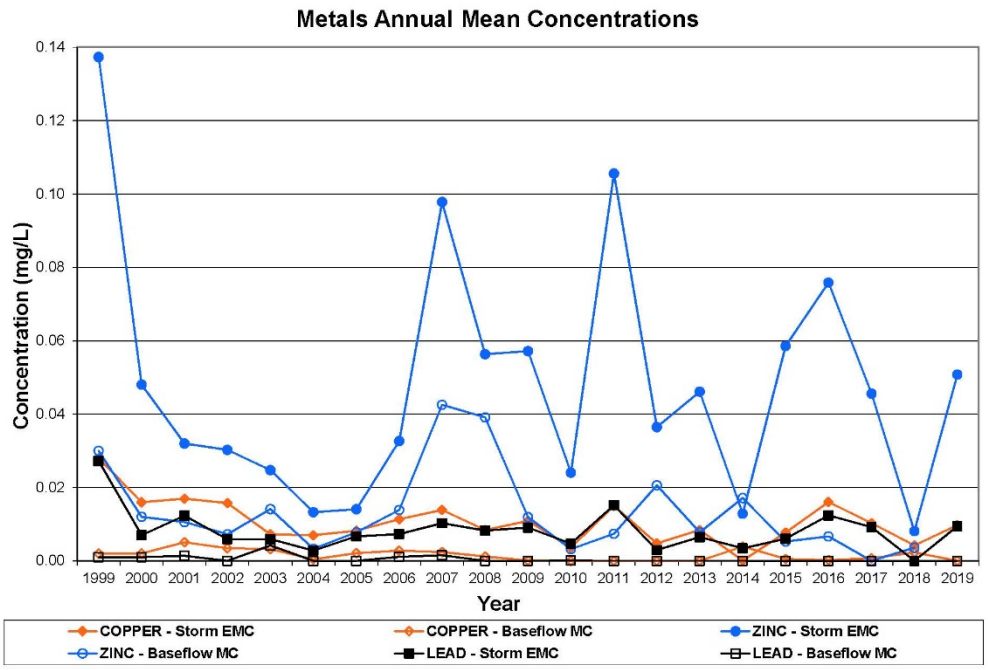

Figure 2-9. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper, zinc, and lead at the Peter Pan Run instream station (FY1999 – FY2019). FY2019 data may not be comparable to other years due to pond retrofits occurring within the catchment during the monitoring period.

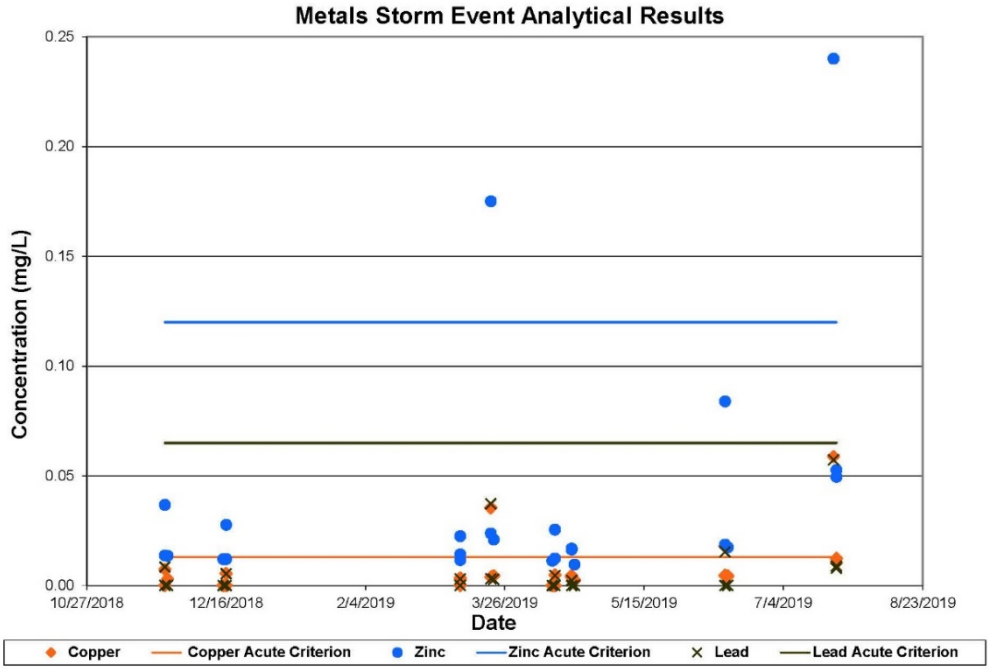

Figure 2-10. Copper, Zinc, and lead analytical results in storm runoff at the instream station (FY2019) compared to acute criteria.

Outfall Event Mean Concentrations

The County retrofit of Pond R was substantially complete in October of 2018. Monitoring resumed in November 2018; however, results at this station may be skewed due to the active construction activities as well as the newly retrofitted condition of the pond and data may not be correlated to pre or post restoration conditions. Monitored results at this station prior to FY2019 represent a dry extended detention stormwater BMP. Whereas results in FY2019 represent a wet extended detention stormwater BMP design and may not correlate to historical data. Data comparisons of pre- and post-retrofit will be evaluated beginning in FY2020. Average annual storm EMCs at the outfall in FY2019 increased or stayed about the same for all parameters except nitrate and nitrite, copper, zinc, and *E. coli* compared to FY2018. The average annual storm EMC for BOD and hardness increased by 118% and 1% respectively in FY2019 compared to FY2018. TPH was detected during all FY2019 storms except the December 15, 2018 and March 10, 2019 storms. TPH has been minimally or not been detected in storm samples since 2010. *E. coli* was detected in all FY2019 storm samples except the falling peak of the March 10, 2019 storm and the average annual storm EMC for *E. coli* was 91% lower than in FY2018. TKN, phosphorus, and TSS, annual EMCs have been generally lower at the Pond R outfall in comparison to EMCs measured at the instream station for the entire study period.

Average concentrations of combined nitrate and nitrite carried by stormflow at the Pond-R outfall decreased slightly by 51% in FY2019 compared to FY2018, continuing a decreasing trend and staying at a consistent concentration level. The annual storm EMC for TKN increased by 521%, reversing a significant decreasing trend over the past five years (Figure 2-11). TKN EMCs declined shortly after the conversion of Pond R from a sediment basin to an extended dry detention pond in July 2004. The pond retrofit completed in November 2019 may have affected the processing of TKN in the facility.

The average annual storm EMC for phosphorus at the Pond-R site increased by 10% in FY2019, following a level trend after a significant spike in EMC in FY2008. The average annual storm EMC for TSS increased by 145% in FY2019, reversing a decreasing trend over the past three years. The pond retrofit completed in November 2019 may have contributed to the increase of TSS at this site. 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, EMCs dropped significantly but have been variable ever since (Figure 2-12).

The average annual storm EMC's for copper and zinc were 3% and 17% lower, respectively, in FY2019 than in FY2018 (Figure 2-13). Storm EMCs of copper have remained consistent since FY2009. After a spike in FY2008, zinc EMCs dropped to a consistent concentration until FY2016 when the EMC dropped even further. No metals concentration results exceeded the freshwater acute criterion at the pond outfall in FY2019 (Figure 2-14). Lead was only detected in the November 24, 2018 and June 13, 2019 rising samples in FY2019. Lead has been minimally or not been detected in the pond outfall storm samples since 2016.

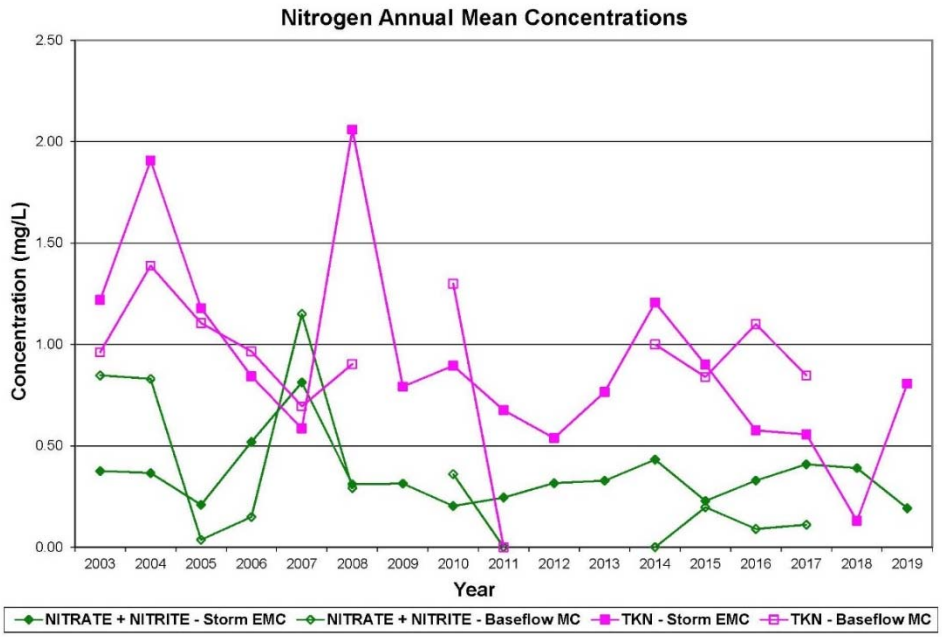

Figure 2-11. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TKN and nitrate and nitrite at the Pond-R outfall site (FY2003 – FY2019). FY2019 data may not be comparable to other years due to pond retrofit condition during the monitoring period.

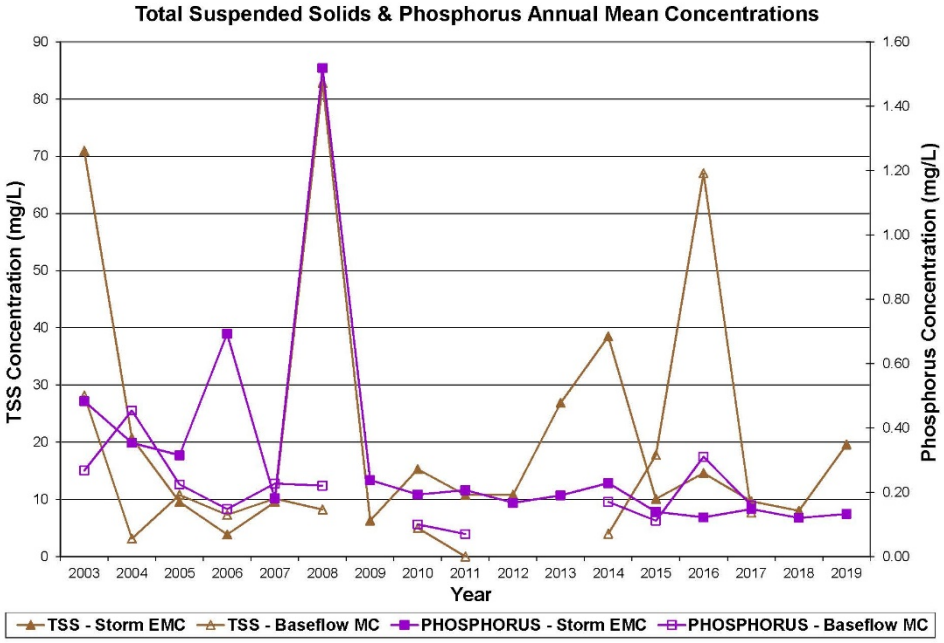

Figure 2-12. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of TSS and phosphorus at the Pond-R outfall station (FY2003 – FY2019). FY2019 data may not be comparable to other years due to pond retrofit condition during the monitoring period.

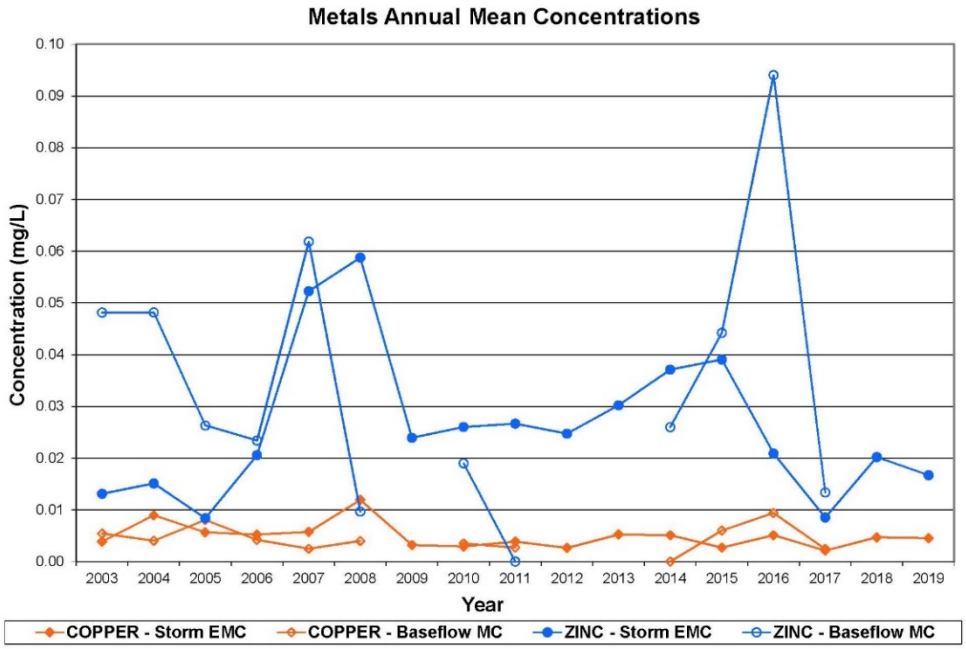

Figure 2-13. Annual flow-weighted average of baseflow mean concentrations and storm event mean concentrations of copper and zinc at Pond-R outfall station (FY2003 – FY2019). FY2019 data may not be comparable to other years due to pond retrofit condition during the monitoring period. Note: Lead EMCs have been measured less than 0.0093 mg/L and are not shown.

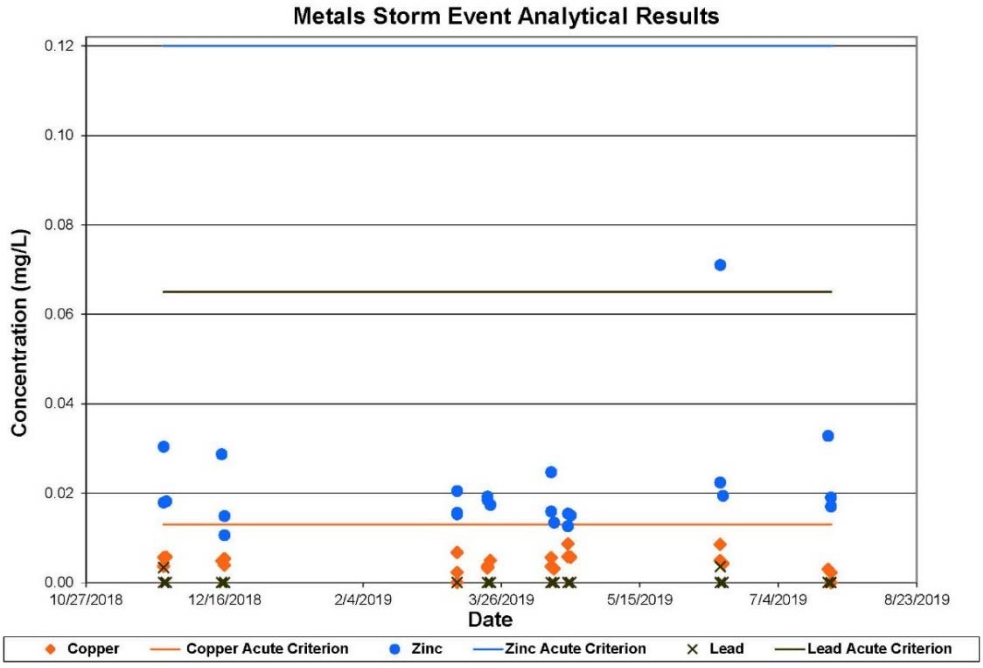

Figure 2-14. Copper, zinc, and lead analytical results in storm runoff at the Pond-R outfall station (FY2019) compared to acute criteria

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

Pollutant loading estimates, as required by the conditions of this MS4 permit, were calculated for each storm event for both the instream and outfall stations (Tables 2-6a and 2-6b). 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. As noted before, results at these stations may be skewed due to active construction activities associated with the 15 pond retrofits all occurring within the catchment area and may not be correlated to pre or post restoration conditions.

Annual and seasonal loading estimates were calculated using estimated flow and analyzed concentration data from both the Peter Pan Run instream station and the Pond-R outfall station over an eight-month twelve-day period (July 1, 2018 through June 30, 2019). The July 21, 2018 storm sampled during the FY18 reporting year was used in the seasonal and annual calculations. The final July 22, 2019 storm was not used in the seasonal or annual calculations and will be used in the reporting for FY2020. Tables 2-6a and 2-6b show comparative estimated results of stormflow pollutant loadings at the Peter Pan Run 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 Tables 2-7a and 2-7b. 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 amount of storms that occurred in the watershed. Storm characteristics (i.e., size, duration, intensity, time of year, antecedent dry time) of the storms actually monitored may affect loading calculations in a given year.

Table 2-6a. Storm event flow volume 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	Copper	Lead	Zinc	TPH	*E. coli*
11/24/2018	4,455,254	102.28	282.33 – 556.26	168.56	349.15	67.96	65,093.49	1.42 – 1.44	1.19 – 1.47	7.06	426.26 – 838.72	$6.06x10^{12}$
12/15/2018	9,586,348	220.07	112.01 – 1,253.91	233.78	749.56	162.25	82,853.34	1.67 – 2.26	1.64 – 2.23	11.97	0.00 – 1615.83	$4.72x10^{12}$
3/10/2019	1,704,973	39.14	0.00 – 212.88	18.05 – 27.30	218.53	7.35	8,359.90	0.15 – 0.27	0.12 – 0.25	1.69	256.16 – 418.02	$1.75x10^{11}$
3/21/2019	10,065,261	231.07	1,953.74 – 2,416.65	489.85 – 496.00	1241.16	280.84	693,303.32	14.11	14.41	69.67	0.00 – 1696.55	$2.34x10^{12}$
4/12/2019	2,978,456	68.38	208.08 – 371.88	53.78 – 55.11	341.16	21.12	21,076.40	0.50 – 0.66	0.47 – 0.64	3.66	562.59 – 765.67	$1.19x10^{12}$
4/19/2019	1,620,158	37.19	0.00 – 202.29	70.99	162.63	7.35	5,806.86	0.33	0.01 – 0.20	1.36	144.27 – 278.24	$2.74x10^{11}$
6/13/2019	1,579,786	36.27	572.08	119.21	171.68	57.84	58,550.64	1.30	0.99 – 1.06	6.00	377.57 – 456.78	$3.32x10^{12}$
7/22/2019	1,562,583	35.87	451.81	127.99	116.11	41.54	56,658.76	1.28	1.00	5.65	239.94 – 367.93	$4.08x10^{12}$

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 2-6b. Storm event flow volume and event mean concentrations 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	Copper	Lead	Zinc	TPH	*E. coli*
11/24/2018	76,976	1.77	20.45	1.68	0.76	1.00	209.94	0.02	0.00 – 0.01	0.09	0.17 – 13.09	$5.49x10^{10}$
12/15/2018	124,440	2.86	0.00 – 15.54	1.55	1.23	1.14	99.44	0.04	0.00 – 0.02	0.11	0.00 – 20.98	$4.00x10^{10}$
3/10/2019	12,614	0.29	0.04 – 1.57	0.17 – 0.21	0.04 – 0.05	0.03	5.07	0.00	0.00	0.01	0.00 – 2.13	$5.42x10^{6}$ - $6.33x10^{6}$
3/21/2019	108,297	2.49	8.57 – 16.38	13.90	1.87	0.61	122.41	0.03	0.00 – 0.01	0.12	12.08 – 20.45	$2.40x10^{10}$
4/13/2019	35,871	0.82	0.00 – 4.48	0.54	0.49	0.16	17.86	0.01	0.00	0.04	11.11	$8.23x10^{9}$
4/19/2019	15,923	0.37	0.18 – 1.99	1.14	0.08	0.10	5.83	0.01	0.00	0.01	1.91 – 2.68	$2.46x10^{8}$
6/13/2019	15,208	0.35	6.83	0.63 – 0.68	0.21	0.17	15.55	0.00	0.00	0.02	3.00 – 3.12	$4.65x10^{9}$
7/22/2019	35,147	0.81	0.00 – 7.60	2.01	0.43	0.20	24.76	0.00	0.00	0.04	7.71 – 9.14	$1.89x10^{10}$

Flow volume in cubic feet and acre-feet and pollutant loads in pounds (*E. coli* in MPN)
*Where concentrations reported below detection limit, loads are presented as range of possible values setting concentrations to either zero or the detection limit.

Table 2-7a. Seasonal and FY2019 baseflow and stormflow concentrations and loads at the instream Peter Pan Run station.*

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Copper	Lead	Zinc	TPH	*E. coli*
Summer (Jul. – Sep. 2018)	Average Storm EMC (mg/L)	0.00 - 2.00	0.00 - 0.20	1.47	0.39	452	0.0077	0.0047 - 0.0065	0.0300 - 0.0306	3.27 - 4.33	10,254
	Estimated Total Storm Load (lbs)	0 - 11,491	0 - 1,149	8,469	2,250	2,599,750	44.15	27.10 - 37.06	172.40 - 175.77	18,766 - 24,860	$2.67x10^{14}$
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.00 - 0.20	2.88	0.05	9.36	0.0000 - 0.0020	0.0000 - 0.0037	0.0017 - 0.0028	1.52 - 3.08	298
	Estimated Total Baseflow Load (lbs)	0 - 1,794	0 - 179	2,579	43	8,394	0.00 - 1.79	0.00 - 3.35	1.51 - 2.55	1,360 - 2,762	$1.21x10^{12}$
	Total Estimated Seasonal Load (lbs)	0 - 13,285	0 - 1,329	11,048	2,293	2,608,144	44.15 - 45.95	27.10 - 40.41	173.92 - 178.32	20,126 - 27,622	$2.68x10^{14}$
Fall (Oct. – Dec. 2018)	Average Storm EMC (mg/L)	0.45 - 2.06	0.46	1.25	0.26	169	0.0035 - 0.0042	0.0032 - 0.0042	0.0217	0.49 - 2.80	2,712
	Estimated Total Storm Load (lbs)	1,585 - 7,272	1,617	4,416	925	594,703	12.39 - 14.86	11.37 - 14.84	76.47	1,713 - 9,867	$4.33x10^{13}$
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.23	3.17	0.01 - 0.02	0.28 - 1.00	0.0000 - 0.0020	0.0000 - 0.0020	0.0103	1.17 - 2.70	152
	Estimated Total Baseflow Load (lbs)	0 - 2,830	322	4,488	20 - 24	393 - 1,415	0.00 - 2.83	0.00 - 2.83	14.61	1,662 - 3,821	$9.79x10^{11}$
	Total Estimated Seasonal Load (lbs)	1,585 - 10,103	1,940	8,904	946 - 950	595,096 - 596,118	12.39 - 17.69	11.37 - 17.67	91.08	3,375 - 13,687	$4.43x10^{13}$
Winter (Jan. – Mar. 2019)	Average Storm EMC (mg/L)	2.66 - 3.58	0.69 - 0.71	1.99	0.39	955	0.0194 - 0.0196	0.0198 - 0.0200	0.0971	0.35 - 2.88	754
	Estimated Total Storm Load (lbs)	6,120 - 8,237	1,591 - 1,639	4,572	903	2,197,912	44.69 - 45.06	45.51 - 45.93	223.53	802 - 6,624	$7.87x10^{12}$
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.25	3.21	0.00 - 0.01	1.42 - 1.71	0.0000 - 0.0020	0.0000 - 0.0020	0.0086	2.20 - 2.99	40
	Estimated Total Baseflow Load (lbs)	0 - 4,215	523	6,773	10 - 21	2,992 - 3,604	0.00 - 4.22	0.00 - 4.22	18.20	4,644 - 6,295	$3.82x10^{11}$
	Total Estimated Seasonal Load (lbs)	6,120 - 12,452	2,114 - 2,162	11,346	913 - 924	2,200,905 - 2,201,516	44.69 - 49.28	45.51 - 50.14	241.73	5,447 - 12,919	$8.25x10^{12}$

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 2-7a. (Continued)

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Copper	Lead	Zinc	TPH	*E. coli*
Spring (Apr. – Jun. 2019)	Average Storm EMC (mg/L)	2.02 - 2.97	0.63 - 0.64	1.75	0.22	222	0.0055 - 0.0060	0.0038 - 0.0049	0.0286	2.81 - 3.89	2,740
	Estimated Total Storm Load (lbs)	4,447 - 6,534	1,391 - 1,398	3,850	492	487,002	12.17 - 13.10	8.42 - 10.84	62.84	6,182 - 8,554	$2.73x10^{13}$
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.04 - 0.20	3.26	0.02 - 0.02	2.25	0.0000 - 0.0020	0.0000 - 0.0020	0.0121	0.00 - 2.70	133
	Estimated Total Baseflow Load (lbs)	0 - 2,726	49 - 273	4,439	23 - 28	3,069	0.00 - 2.73	0.00 - 2.73	16.54	0 - 3,680	$8.23x10^{11}$
	Total Estimated Seasonal Load (lbs)	4,447 - 9,260	1,440 - 1,671	8,290	515 - 520	490,071	12.17 - 15.83	8.42 - 13.56	79.38	6,182 - 12,235	$2.81x10^{13}$
FY2019 (Jul. 2018 – Jun. 2019)	Average Storm EMC (mg/L)	1.15 - 2.58	0.42 - 0.48	1.58	0.33	464	0.0092 - 0.0095	0.0082 - 0.0092	0.0452 - 0.0454	1.52 - 3.38	4,212
	Estimated Total Storm Load (lbs)	15,783 - 35,565	5,823 - 6,647	21,760	4,497	6,388,901	126.69 - 131.22	112.44 - 126.02	622.47 - 624.63	20,978 - 46,606	$2.63x10^{14}$
	Average Baseflow MC (mg/L)	0.00 - 2.00	0.15 - 0.22	3.16	0.02 - 0.02	2.55 - 2.85	0.0000 - 0.0020	0.0000 - 0.0023	0.0088 - 0.0090	1.28 - 2.85	134
	Estimated Total Baseflow Load (lbs)	0 - 11,566	884 - 1,292	18,267	99 - 118	14,743 - 16,455	0.00 - 11.57	0.00 - 13.15	51.15 - 52.21	7,419 - 16,498	$3.52x10^{12}$
	Total Estimated FY2019 Load (lbs)	15,783 - 47,131	6,708 - 7,939	40,027	4,596 - 4,616	6,403,645 - 6,405,357	126.69 - 142.78	112.44 - 139.16	673.62 - 676.84	28,398 - 63,104	$2.67x10^{14}$

* 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 2-7b. Seasonal and FY2019 stormflow concentrations and loads at the Pond-R Outfall station.*

		BOD	TKN	Nitrate + Nitrite	Total Phosphorus	TSS	Copper	Lead	Zinc	TPH	*E. coli*
Summer (Jul. – Sep. 2018)	Average Storm EMC (mg/L)	0 - 2	0.00 - 0.20	0.59	0.13	4	0.0062	0.000 - 0.005	0.000 - 0.002	4.30 - 5.29	24,900
	Total Estimated Seasonal Load (lbs)	0 – 96	0 - 10	29	6	202	0.30	0.00 - 0.24	0.00 - 0.10	207 - 254	5.44×10^{12}
Fall (Oct. – Dec. 2018)	Average Storm EMC (mg/L)	1.63 - 2.86	0.26	0.16	0.17	25	0.0049	0.000 - 0.002	0.0160	0.01 - 2.71	1,660
	Total Estimated Seasonal Load (lbs)	34 – 60	5	3	4	513	0.10	0.00 - 0.04	0.33	0 - 56	1.57×10^{11}
Winter (Jan. – Mar. 2019)	Average Storm EMC (mg/L)	1.14 - 2.38	1.86 - 1.87	0.25	0.09	17	0.0040	0.000 - 0.002	0.0178	1.60 - 2.99	701
	Total Estimated Seasonal Load (lbs)	19 – 41	32	4	1	288	0.07	0.00 - 0.03	0.30	27 - 51	5.43×10^{10}
Spring (Apr. – Jun. 2019)	Average Storm EMC (mg/L)	1.67 - 3.18	0.55 - 0.56	0.19	0.10	9	0.0045	0.000 - 0.002	0.0171	3.83 - 4.04	691
	Total Estimated Seasonal Load (lbs)	32 – 61	11	4	2	179	0.09	0.00 - 0.04	0.33	73 - 77	6.00×10^{10}
FY2019 (Jul. 2018 – Jun. 2019)	Average Storm EMC (mg/L)	1.08 - 2.56	0.58 - 0.64	0.30	0.13	15	0.0050	0.0000 - 0.0028	0.0121 - 0.0127	2.02 - 3.65	7,721
	Total Estimated FY2019 Load (lbs)	113 – 269	61 - 68	32	14	1,614	0.53	0.00 - 0.30	1.27 - 1.33	213 – 384	3.68×10^{12}

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 FY2019 compared to FY2018. This is largely due to the significant increase in rainfall and stormflow in FY2019 and the shorter sampling period in FY2018. The total discharge sampled in FY2019 was greater than the total discharge measured in FY2018 by 267%. The overall greater volume of runoff in the watershed produced greater pollutant loadings in the stream. Annual estimated pollutant loadings at the pond outfall station increased for BOD, TKN, and TSS, decreased for nitrate and nitrite, lead, and zinc, and stayed the same for phosphorus, copper, TPH, and *E. coli* during FY2019 compared to FY2018. 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, causing the difference in pollutant concentration trends in comparison to the overall concentration increase at the instream site. However, future monitoring will 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. For parameters that were detected in outfall samples during FY2019, the estimated contribution of Pond R to the total loading of the watershed ranged from between 0.03% (TSS) and 1.4% (*E. coli*).

2.2 BIOLOGICAL MONITORING RESULTS FOR PETER PAN RUN

Frederick County annually monitors biological conditions within Peter Pan Run's approximately 3-square mile catchment. 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 Peter Pan Run stream monitoring stations in 2019 (Figure 1-2), with sites named PPAN-01 to 04 (also known as BUSL-201, 202, 103 and 104, 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 April 16, 2019. Quantitative geomorphic assessments surveys, including cross-sectional measurements, longitudinal profiles, and pebble counts, were conducted on August 20, 2019. Summer sampling was conducted within the MBSS Summer Index Period on July 30 and September 19, 2019, and included *in situ* 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 (Morgan and Roth 2005) was followed 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 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 when questions arise about field or laboratory procedures.

Benthic macroinvertebrate and fish data were collected and used to calculate 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 catchment. 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 theBIBI 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 2-10.

Table 2-8. Narrative rating and score range for the Indices of Biotic Integrity used by the MBSS indices.

Rating	Range
Good	4.00 - 4.99
Fair	3.00 - 3.99
Poor	2.00 - 2.99
Very Poor	1.00 - 1.99

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 2-9). 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 2-9. 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 2019 are summarized in Table 2-10. The biological communities in Peter Pan Run have experienced land use-related impacts due to previous agriculture and current 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).

Table 2-10. Summary of 2019 results from Peter Pan Run using the MBSS 2005 IBIs

Station	Benthic IBI Score	Benthic IBI Rating	Fish IBI Score	Fish IBI Rating	MPHI Score	MPHI Rating
BUSL-201-T	1.75	Very Poor	4.67	Good	81.7	Minimally Degraded
BUSL-202-T	2.00	Poor	4.67	Good	64.2	Degraded
BUSL-103-T	1.50	Very Poor	4.33	Good	67.6	Partially Degraded
BUSL-104-T	1.75	Very Poor	2.00	Poor	53.9	Degraded

Table 2-11. Summary of 2019 *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	4/16/2019	14.0	10.60	7.73	446.5	4.8
	9/19/2019	15.1	8.89	7.63	524.4	3.2
BUSL-202-T	4/16/2019	15.5	10.10	7.71	462.5	13.6
	9/19/2019	16.9	7.81	7.82	561.1	4.1
BUSL-103-T	4/16/2019	15.4	10.16	7.72	482.5	2.6
	7/30/2019	21.3	9.22	7.40	513.0	2.3
BUSL-104-T	4/16/2019	16.4	8.43	7.37	403.7	10.1
	7/30/2019	21.1	8.24	7.44	604.0	9.2

BUSL-201-T

This site is the most downstream site along Peter Pan Run with a drainage area of 1,585 acres. In both 2018 and 2019, the BIBI rating was 'Poor' (score of 2.50 in 2018 and 2.00 in 2019), which was a decrease from a 'Fair' rating in 2017. The slight decline in BIBI score between 2018 and 2019 can be attributed to a decrease in EPT and Ephemeroptera taxa, as well as a drastic increase in percent Diptera (from 39.0% in 2018 to 80.6% in 2019). The FIBI score decreased from 4.33, or 'Good', in 2017 to 3.67, or 'Fair', in 2018, but then increased to 4.67, or 'Good', in 2019. A similar total number of fish were caught in 2019 when compared to 2018; 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. The lowest percent of 'Tolerant' fish out of all years of monitoring was found in 2019, at just 32.59%. The highest total number of taxa was also observed in 2019; a total of 18 species were encountered. The MPHI score indicates this site is in a 'Minimally Degraded' habitat condition. All WQ parameters in both spring and summer were within COMAR standards. Specific conductivity levels were above the 247 µS/cm threshold as described by Morgan et al. (2007) at both sampling events indicating chronic stress throughout the year for the benthic and fish communities.

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 2018, the benthic results were the exact same as in 2017 with a BIBI score of 2.25, a rating of 'Poor' and 22 taxa present in the sample. The score declined slightly in 2019 to 2.00, but received a consistent rating of 'Poor'. The slight decline is a result of a decrease in EPT and Ephemeroptera taxa in the sample, as well as a decrease in percent Tanytarsini and Scrapers. A constant FIBI score of 3.67, or 'Fair', was given to this site between 2014 and 2018. The score increased to 4.67, or 'Good', in 2019. Similar to BUSL-201-T, a very similar number of fish were caught in 2018 and 2019; however it is noted that the number of fish observed annually has varied and ranges from near 300 to over 1,000. The MPHI score decreased slightly to a rating of 'Degraded' in 2019, but still falls within the same range of scores found in the past several years of monitoring. All WQ parameters in both spring and summer were within COMAR standards. The specific conductivity levels were slightly greater at this site than the downstream BUSL-201-T. Continued exposure of levels greater than 247 µS/cm as described by Morgan et al. (2007) is stressful for the biotic community and is likely impacting the BIBI scores at this site.

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. There was no change in BIBI score or rating from 2017 to 2018, which was a score of 2.50, and rating of 'Poor', but a decrease occurred in 2019 with a score of 1.50 and a rating of 'Very Poor'. A large decrease in total number of taxa occurred, with 28 taxa found in the 2018 sample and only 18 taxa found in the 2019 sample. BUSL-103-T had the greatest changes in FIBI score and rating between 2016 and 2019, fluctuating between a score of 3.67, or 'Fair', in 2016 and 2018, and 4.33, or 'Good', in 2017 and 2019. There were 2 less species present in 2019 than in 2018, and 89 fewer individuals. However, a decrease of 16.0% in percent tolerant fish of can be attributed to the increase in FIBI score. The number of fish observed annually varies and it appears that the 2019 results are in line with the normal observation of between 500-600 individuals. The MPHI rating remained almost exactly the same as found in 2018, with a rating of 'Partially Degraded'. All water quality parameters in both spring and summer with within the COMAR standards. Similar to the previous sites, both spring and summer specific conductivity values were greater than the threshold described by Morgan et al. (2007) indicating year round stress for the biological communities.

BUSL-104-T

This site is on an 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 declined from a score of 2.50 and rating of 'Poor' in 2018, to a score of 1.75 and a rating of 'Very Poor' in 2019. This decline was primarily caused by a decrease in total number of taxa, falling from 34 taxa in 2018 to 21 taxa in 2019, as well as an increase in percent Diptera. Only five species of fish were found and of the individuals encountered, 99% were considered tolerant. These factors resulted in a FIBI score of 2.00 and rating of 'Poor', a slight improvement from the 'Very Poor' rating of 2018. MPHI values indicate similar results with a rating of 'Degraded' for 2019. Although the biological and habitat scores were low, the water quality parameters were all within the COMAR standards while specific conductivity values were elevated as described by Morgan et al. (2007) year round.

2.3 PHYSICAL STREAM ASSESSMENTS

Physical stream conditions within Peter Pan Run in 2019 were generally similar to those in years past, although certain stream parameters are beginning to show a pattern of incremental change over time. A summary of historical and current data is provided in Appendix A. Field surveys are typically performed at least 24 hours after a major storm event and when conditions approximate baseflow. Representative site photographs can be found in Appendix A.

2.3.1 Longitudinal Profile Analysis

In December 2015, longitudinal profiles were established at each site. 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 profile 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 2019.

At BUSL-103 the pool at the beginning of the longitudinal profile partially filled with sediment between 2017 and 2018 and has remained the same in 2019. The long riffles upstream of the cross section location have moved slightly upstream, which could be due to the increased sediment deposition in bar features. The pool nearest station 1+52 has also partially filled with sediment, but the downstream riffle is in good condition. The greatest change in the profile is near station 2+30 where a down tree was noted in 2017, 2018, and 2019. This created a short, deep scour pool in the 2017 profile, which has decreased in depth and has lengthened slightly in 2019. 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 five years, slope has remained consistent between 0.9% and 1.0%.

The BUSL-104-T profile depicts that the pool near station 0+50 has re-scoured out while the pool near 2+00 has remained similar to 2018 where sediment accumulated and features have changed from pools in 2015 and 2016 to riffles in 2017, 2018 and 2019. Between station 1+50 and 2+15 sediment has been transported into the pools causing pools noted in 2015 and 2016 to become shallower and less defined in the 2017 through 2019 profiles. The bed elevation remained consistent from 2018 to 2019 from station 2+50 to 3+00. Slope at BUSL-104 has remained stable at approximately 1.4% for the past 14 years.

The longitudinal profile of BUSL-201-T demonstrates that some of the pools are continuing to accumulate sediment while some are now beginning to deepen. Increased deposition on point bars

was noted in 2017 and continues in 2019, which caused an increase in sinuosity, which in turn caused features to move slightly upstream. The pool originally located nearest station 1+25 in 2015 decreased in depth in 2018 but has now increased in depth in 2019. The pool around station 1+70 accumulated sediment in 2018 but has since increased in depth and length in 2019. The pool located near station 2+75 has seen a major increase in deposition between 2018 and 2019 with a one-foot decrease in depth and 10-foot decrease in length. Stream gradient has been mostly stable at BUSL-201-T during the past ten years, with a slight decrease in 2019 from 0.8% to 0.58%.

At BUSL-202-T the greatest change between 2018 and 2019 was the deepening of the pool at station 0+20. The pool has lengthened some but the most significant change is the increase in depth of over one foot between the two years. Besides the changes in the previously noted pool, few changes along the thalweg occurred between 2018 and 2019. The pool at station 1+05 in 2015/2016 became a riffle in 2017 and continues to be a riffle in 2019. The pool near station 2+40 has shifted upstream slightly and the pool near station 2+75 has completely filed in with sediment in 2018. In 2001, BUSL-202-T appeared to have aggraded. Since that time and continuing through 2019, stream slope has remained stable between 0.4% and 0.5%.While these vertical changes along the longitudinal profile demonstrate the amount of sediment moving through the stream, the cross section comparisons discussed below show the long-term lateral changes in the system.

2.3.2 Cross Section Analysis

Cross-sectional surveys were conducted at monumented locations at each station; overlays of the cross sections are located in Appendix A, which includes the cross section data from 1999 to 2019 and photos of the cross sections can be found in Appendix A. The only exception is at BUSL-201, 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, making the overlay not accurate from 1999 to 2004.

Only minor changes to the channel occurred at BUSL-103-T between 2018 and 2019. While left and right bank erosion is observed from 1999 to 2016, only slight changes were observed between 2016 and 2019. The channel thalweg had shifted slightly to the left in 2014, but in 2019 the bottom of the channel was primarily flat with a slight scour in the middle of the channel. A slightly 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. The channel width increased only slightly between 2018 and 2019 by 0.4 feet.

Cross-sectional surveys of BUSL-104-T suggest only minor 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. In 2019 the thalweg is along the middle of the channel as sediment has built up on the left bank and the right bank experienced minor downcutting. 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 cross-sectional survey at BUSL-201-T illustrates channel widening, as it expanded 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 2018. In 2019 the left bank scour was similar to 2018, but the top of bank is continuing 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 recognized in the 2018 survey, where the thalweg was more so along the right bank. In 2019 however, major deposition of one foot occurred. A downed tree on the right bank slope has begun to erode behind the tree 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.

At BUSL-202-T, 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 back from 2018 has been scoured while the pool on the right side of the channel has seen deposition of 0.5 feet of material. The thalweg is still along the right bank, with vertical banks until the bankfull elevation, then less steep banks up to the top of bank. Bank erosion has continued on the right bank.

2.3.3 Particle Distribution Analysis

Representative Wolman pebble counts were conducted at each cross section location from 1999 to 2019 (see Table 2-12 for stream particle categories). Particle size distribution overlays from 1999 and 2018 are available in Appendix A and Table 2-13 compares the D_{16}, D_{50}, and D_{84} of all pebble count data.

Table 2-12. Stream particle grain-size classifications			
		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 the meidan particle size (D_{50}) has ranged from 16mm to 40mm between 2014 and 2019, which ranges between Coarse and Very Coarse Gravel. A slight increase in larger material was observed in 2019, which can be observed in the particle distribution overlay (Appendix A), which has caused the D_{16} to increase slightly, but the D_{84} in 2018 was 63mm, which is similar to the last 4 years. Overall although minor shifts in the distribution have occurred, the particle size has remained relatively stable over time.

At BUSL-104 the D_{50} remained in the Medium or 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_{84} is similar to 2018 at 64 mm and falls within the Cobble range.

At BUSL-201 the D_{50} in 2019 was 12mm, falling in the Medium Gravel category. This is similar to previous years, where the D_{50} primarily falls in the Medium or Coarse Gravel category. The particle overlay is located in Appendix A, and shows that the particle distribution has been stable from 1999 to 2019.

At BUSL-202 the D_{50} in 2019 was 27mm, which falls in the Coarse Gravel category. This is an increase from the 2016 and 2017 D_{50} (8.8mm and 2.8mm respectively) but is similar to 2014, 2015 and 2018 D_{50}. 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 2-13. Cross Section Particle Distribution Comparison

METRIC	BUSL-103							BUSL-104						
	'99	'14	'15	'16	'17	'18	'19	'99	'14	'15	'16	'17	'18	'19
D_{16}	0.084	5.4	10	4	1.4	1.3	6.8	0.37	1.8	4.9	1.2	1.3	0.21	0.38
D_{50}	8.6	26	40	20	16	35	25	10	16	17	13	12	1.9	14
D_{84}	50	63	86	48	43	99	63	50	64	83	35	36	73	64

METRIC	BUSL-201							BUSL-202						
	'99	'14	'15	'16	'17	'18	'19	'99	'14	'15	'16	'17	'18	'19
D_{16}	1.4	9.2	1.2	16	2.6	8	2.7	0.062	8.7	1.7	0.66	0.062	6	3.5
D_{50}	9.9	23	19	29	13	28	12	8.2	26	34	8.8	2.8	27	27
D_{84}	34	55	45	50	48	74	45	27	57	71	16	12	72	44

2.4 INTEGRATED ANALYSIS OF FIELD RESULTS

Frederick County has collected and analyzed considerable 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 three very dry (FYs 1999, 2002, and 2007) and ten very wet years (FYs 2000, 2003, 2004, 2010, 2012, 2013, 2014, 2015, 2018, and 2019).

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 catchment. It should also be noted that the on-going development 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 catchment are also evident. Starting in 2018, fifteen extended detention dry ponds within the watershed will be retrofit to extended detention wet ponds or sand filters. One of these retrofit ponds is the Pond R monitoring site.

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 chemistry monitoring, statistical analysis was performed on the individual storm EMC data from FY1999 to present. A Kendall's Tau correlation for trends (Kendall 1948) on the individual storm EMC data showed a statistically significant upward trend for TKN ($\tau = 0.152$, $p = 0.0013$) and statistically significant downward trends for combined nitrate and nitrite ($\tau = -0.230$, $p = <0.0001$) and copper ($\tau = -0.121$, $p = 0.010$) at the instream station (Figures 2-15 through 2-18).

For both baseflow and stormflow conditions at the instream station, concentrations of nitrogen measured as combined nitrate and nitrite have nearly always been greater than 1 mg/l, (Figure 2-15). This concentration level indicates nitrogen contributions from anthropogenic sources (Roth et al. 1999). Individual storm EMCs for copper and combined nitrate and nitrite have gradually, but significantly, declined since 1999 as shown by the Kendall's Tau-b statistical analysis. Storm EMCs for TKN, conversely, have gradually increased. The nitrate and nitrite reduction and TKN increase 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, and increases urban stormwater runoff, a major source of TKN or ammonia and organic nitrogen (EPA, 2015). As in the case of TSS, lead, and zinc, EMCs at the instream station have been variable with no statistically significant trend (Figures 2-16, 2-17, and 2-18).

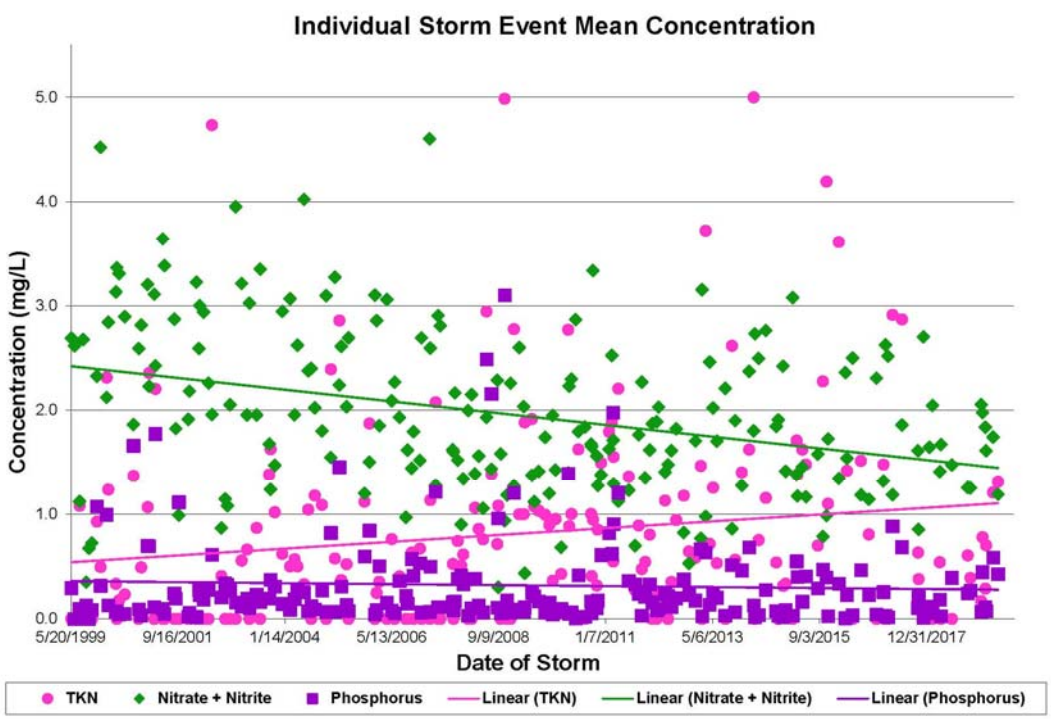

Figure 2-15. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2019) at the instream station. Values below detection limit are set to zero.

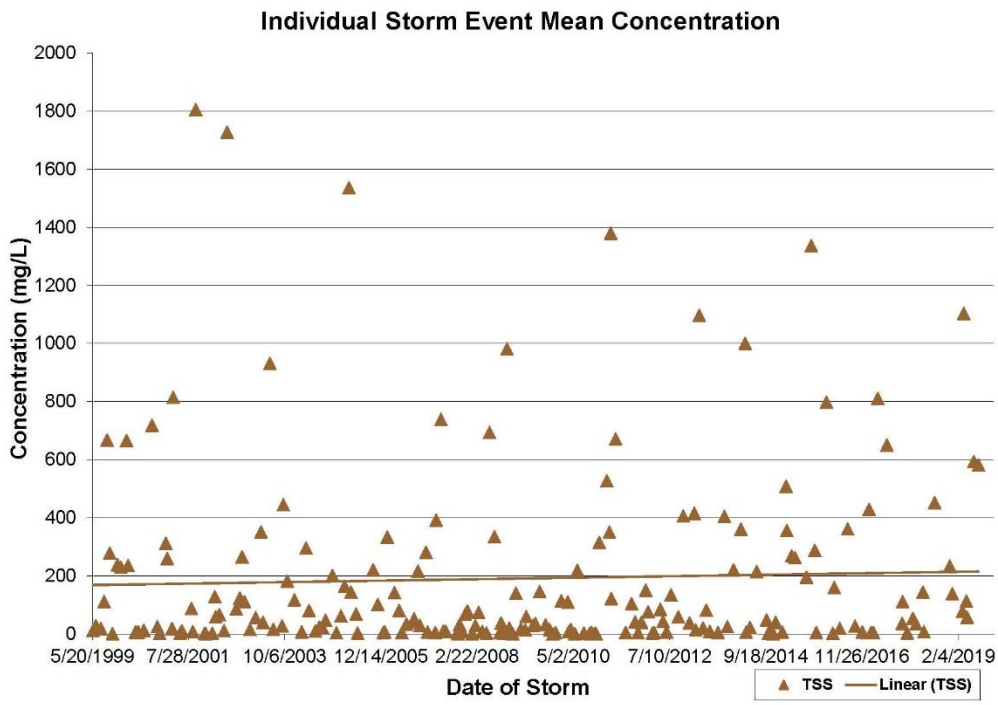

Figure 2-16. Storm event mean concentrations for TSS (May 1999 to July 2019) at the instream station.

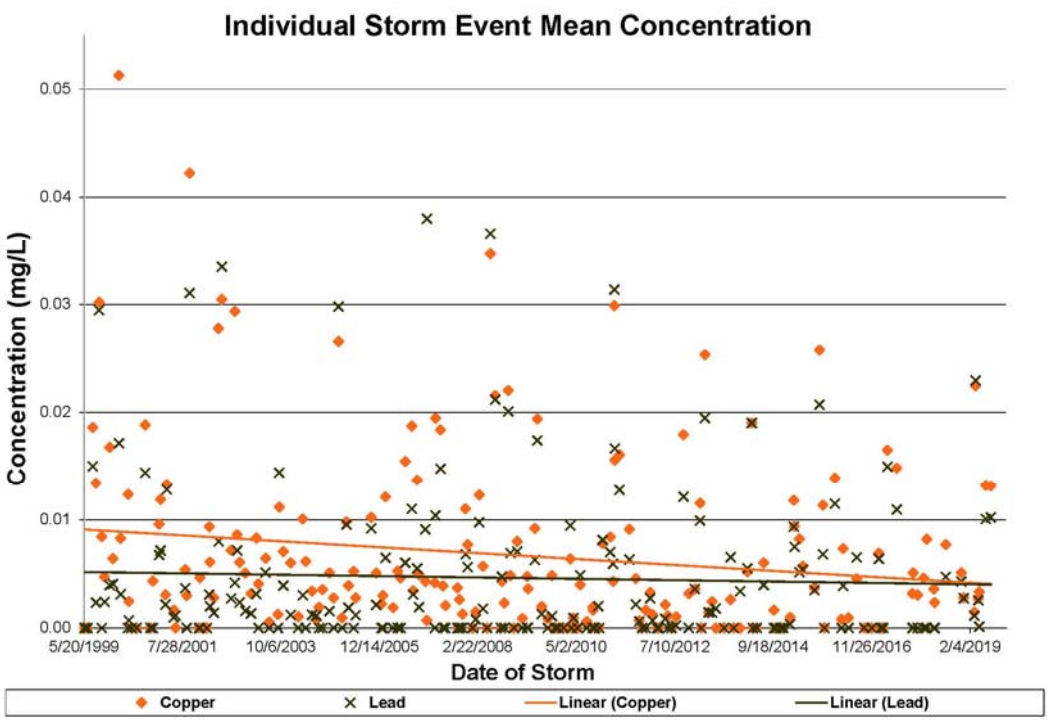

Figure 2-17. Storm event mean concentrations for copper and lead (May 1999 to July 2019) at the instream station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

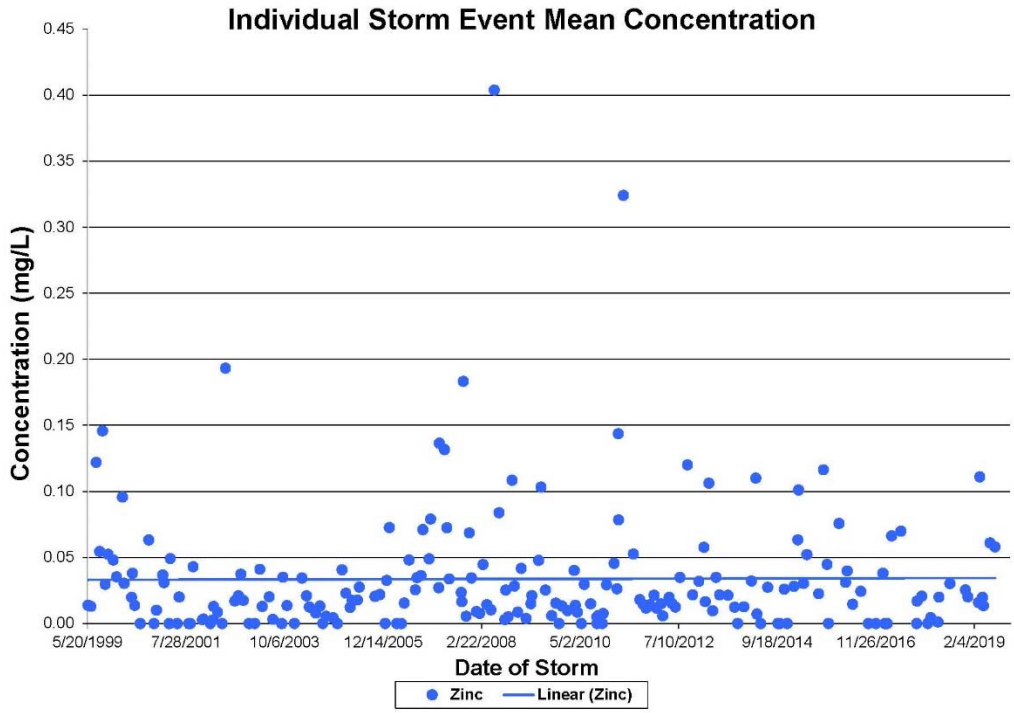

Figure 2-18. Storm event mean concentrations for zinc (May 1999 to July 2019) at the instream station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

Individual storm EMC data showed statistically significant downward trends for BOD ($\tau = -0.153$, $p = 0.004$), TKN ($\tau = -0.125$, $p = 0.018$), nitrate and nitrite ($\tau = -0.112$, $p = 0.035$), phosphorus ($\tau = -0.248$, $p = <0.0001$), copper ($\tau = -0.113$, $p = 0.033$), lead ($\tau = -0.128$, $p = 0.016$), and zinc ($\tau = -0.111$, $p = 0.035$) at the outfall station (Figures 2-19 through 2-22). TSS measured at the outfall station strongly correlated with TKN ($\tau = 0.269$, $p = <0.0001$), phosphorus ($\tau = 0.145$, $p = 0.006$), copper ($\tau = 0.267$, $p = <0.0001$), lead ($\tau = 0.245$, $p = <0.0001$), and zinc ($\tau = 0.126$, $p = 0.017$), indicating that metals and nutrients are bound to suspended soil particles. TKN EMCs have decreased over time inversely to the TKN instream EMCs while combined nitrate and nitrite has decreased over time in concurrence with the stream. Copper EMCs at the outfall station have decreased concurrently with the instream station. BOD, phosphorus, lead, and zinc EMCs have followed decreasing trends at the outfall station in comparison to no statistically significant trends at the instream station.

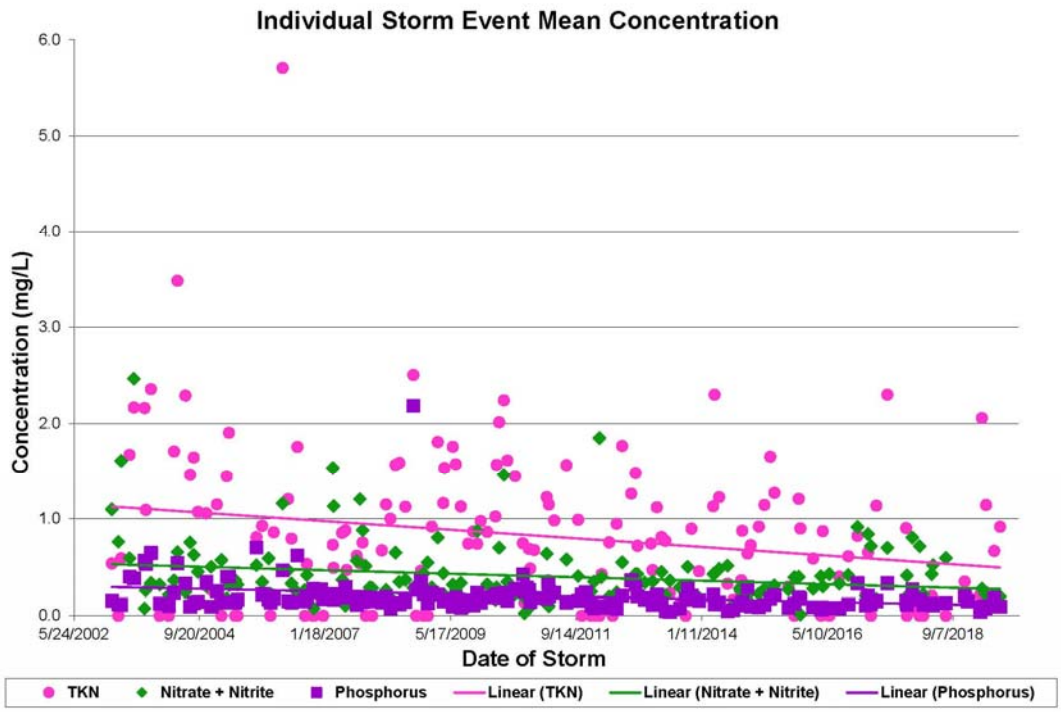

Figure 2-19. Storm event mean concentrations for nitrate and nitrite, TKN, and phosphorus (May 1999 to July 2019) at the outfall station. Values below detection limit are set to zero.

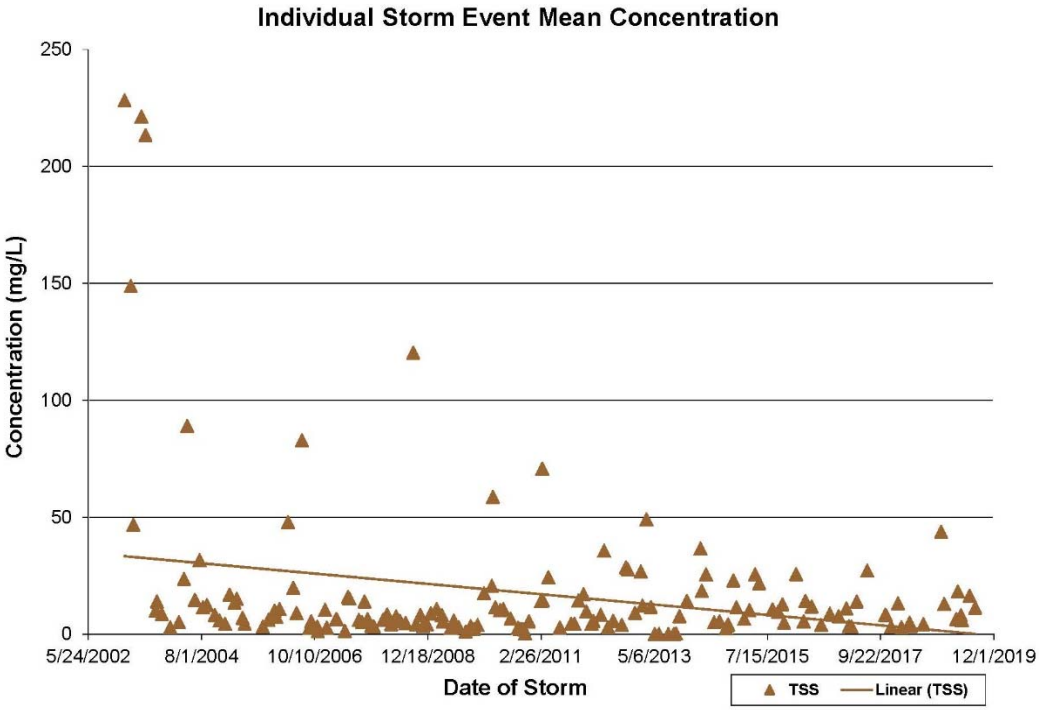

Figure 2-20. Storm event mean concentrations for TSS (May 1999 to July 2019) at the outfall station

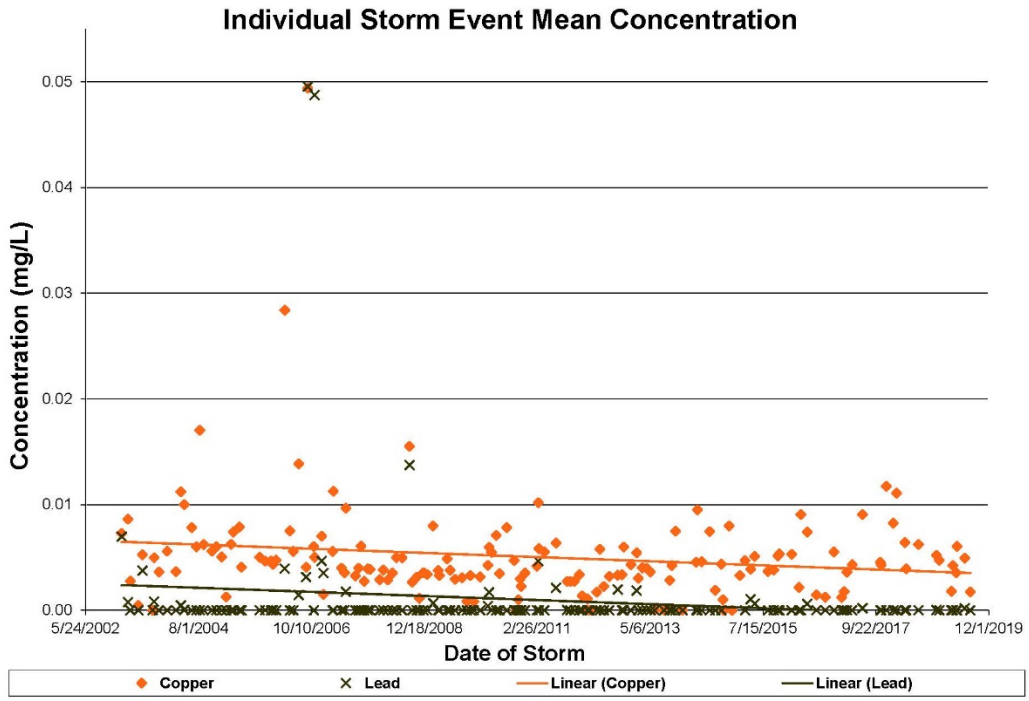

Figure 2-21. Storm event mean concentrations for copper and lead (May 1999 to July 2019) at the outfall station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

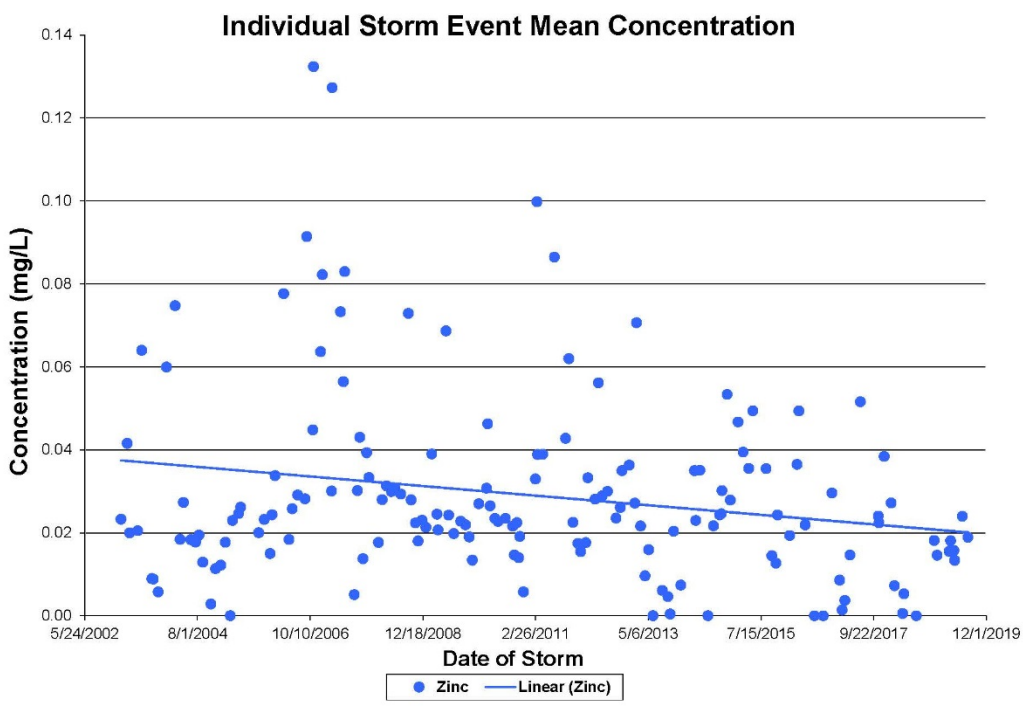

Figure 2-22. Storm event mean concentrations for zinc (May 1999 to July 2019) at the outfall station. Values below detection limit are set to zero. Note that zinc is presented separately so that the scale is appropriate for the concentration range.

2.4.2 Biological Indicators

Dating back to 1999, BIBI and FIBI scores during the pre-construction period fell short of the top category for biological integrity (e.g., FIBI scores were in the 'Poor' to 'Fair' range). This likely indicates that prior to development the agricultural land use within the watershed was having a negative impact on the stream biota. All benthic scores decreased in 2019 when compared to 2018 scores, and ratings this year were 'Very Poor' at two sites (BUSL-103-T and BUSL-104-T) and 'Poor' at two sites (BUSL-201-T and BUSL-202-T). These results fall below the long-term average scores, which have oscillated between the 'Fair' and 'Poor' categories at BUSL-201-T, BUSL-202-T, and BUSL-103-T, and between the 'Poor' and 'Very Poor' categories at BUSL-104-T (Figure 2-). During a period of 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-). The continued year-to-year fluctuations of the benthic IBI scores (between the 'Fair' and 'Very Poor' rating categories) reflect the noted changes in physical habitat, in particular the highly mobile substrate and 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 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.

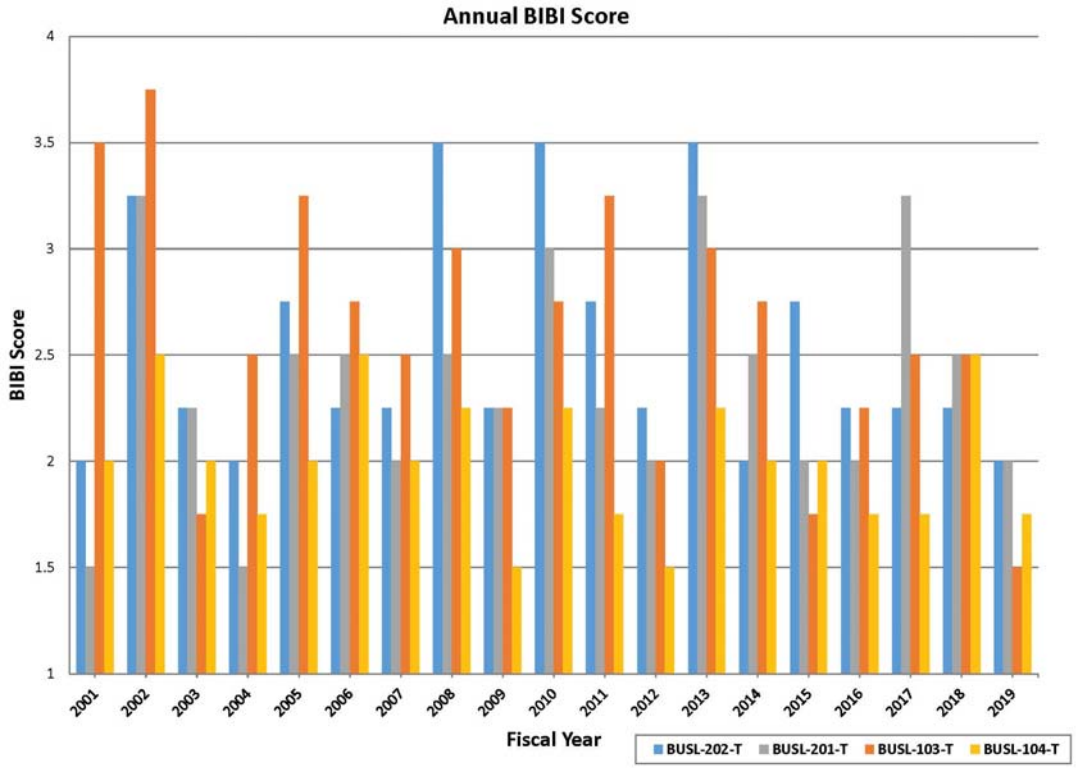

Figure 2-23. BIBI Score from FY2001-FY2019

This year's FIBI score ratings were 'Good' for BUSL-201-T, BUSL-202-T, BUSL-103-T and 'Poor' for BUSL-104-T (Figure 2-). Over the 20 years of sampling, FIBI scores have remained relatively constant 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 for the BIBI scores. FIBI scores have usually varied by less than 1 IBI unit from year to year. Since fish are more mobile and somewhat less dependent on bottom substrate for cover than macroinvertebrates, are slightly more tolerant of frequent disturbances to the stream bed and depositional processes.

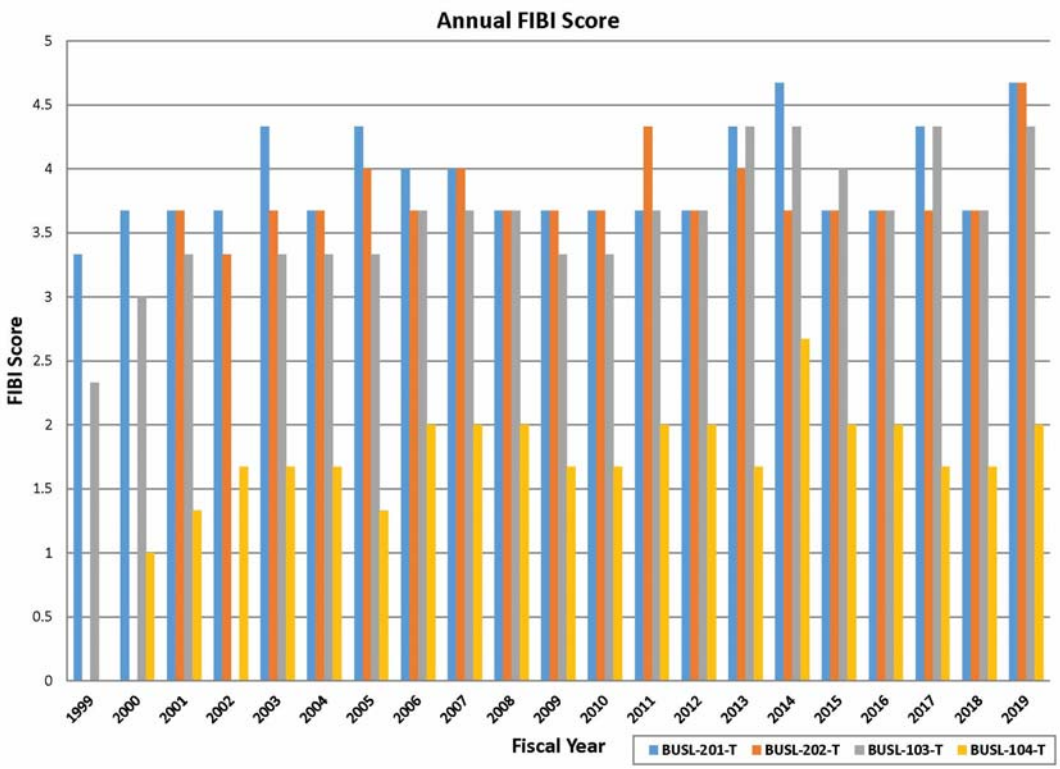

Figure 2-24 FIBI Score FY1999-FY2019

2.4.3 Physical Habitat

Physical habitat, especially increased bank erosion and sediment deposition, is the most obvious sign that the stream has suffered negative impacts as a result of disturbance due to upstream land use conversion to suburban development. While the most intensive phases of construction in the Urbana PUD have been completed, and the amount of construction in the watershed was minor this year relative to previous years, 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 or the subjective nature of the physical habitat scoring methods. The channel does not presently appear to be morphologically stable. Historical and pre-development land use activities within the catchment also continue to impact current stream conditions (Figure 2-).

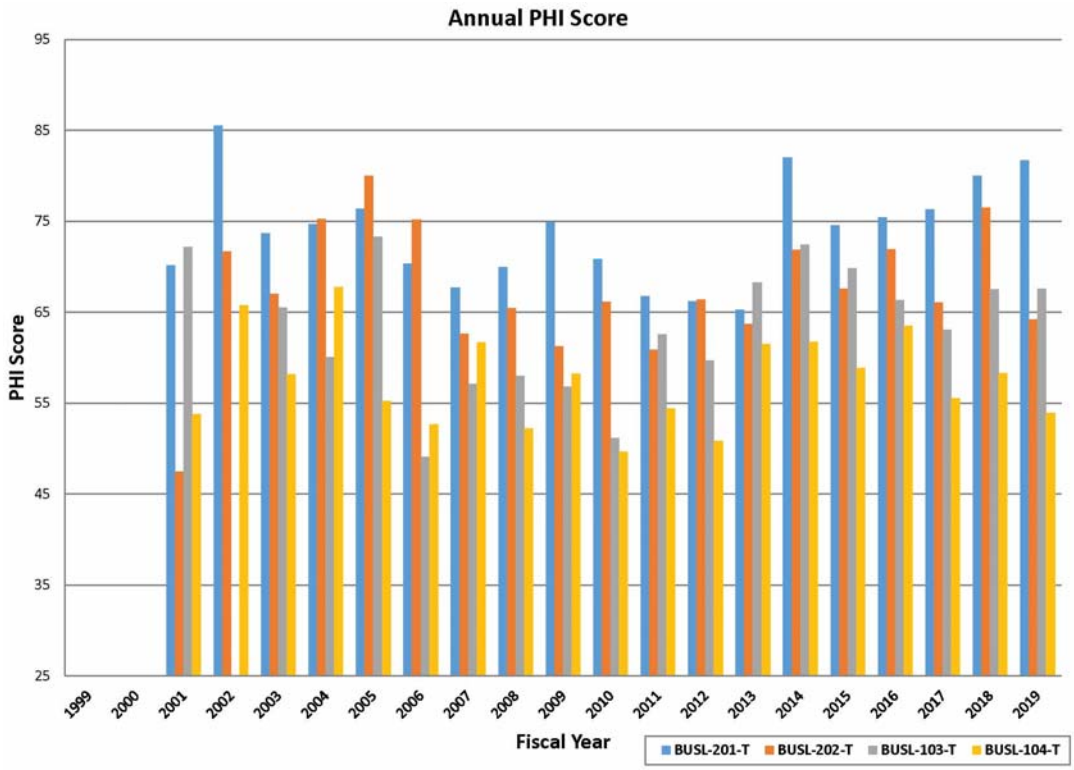

Figure 2-25. PHI Score from FY2001-FY2019

2.4.4 Plans for Future Long-Term Monitoring

In FY2018, Frederick County invested significant resources in replacing all of the automated storm event sampling equipment in October 2017. As discussed earlier, many watershed stormwater BMPs are undergoing retrofit in 2018, future monitoring will determine the impact of those retrofits on stormwater quality and channel stability. No significant changes are anticipated to the monitoring elements described in Table 2-14.

Table 2-14. 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	No change to current storm event monitoring procedures. Will continue to sample 8 events (2/quarter) based on the County's NPDES 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.
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

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
BUSL-201-T	4/23/2001	20	1.5	Very Poor
	3/21/2002	38	3.25	Fair
	3/26/2003	17	2.25	Poor
	4/29/2004	21	1.5	Very Poor
	3/4/2005	25	2.5	Poor
	3/1/2006	34	2.5	Poor
	4/9/2007	16	2	Poor
	4/23/2008	25	2.5	Poor
	3/10/2009	28	2.25	Poor
	3/24/2010	29	3	Fair
	4/6/2011	31	2.25	Poor
	3/21/2012	22	2	Poor
	3/11/2013	37	3.25	Fair
	4/9/2014	25	2.5	Poor
	3/20/2015	27	2	Poor
	3/7/2016	35	2	Poor
	3/21/2017	35	3.25	Fair
	3/8/2018	26	2.5	Poor
	4/16/2019	27	2	Poor
BUSL-202-T	4/23/2001	19	2	Poor
	3/21/2002	33	3.25	Fair
	3/26/2003	22	2.25	Poor
	4/29/2004	26	2	Poor
	3/4/2005	32	2.75	Poor
	3/1/2006	39	2.25	Poor
	4/9/2007	20	2.25	Poor
	4/23/2008	39	3.5	Fair
	3/11/2009	34	2.25	Poor
	3/24/2010	33	3.5	Fair
	4/6/2011	25	2.75	Poor
	3/21/2012	33	2.25	Poor
	3/11/2013	33	3.5	Fair
	4/9/2014	18	2	Poor
	3/20/2015	26	2.75	Poor
	3/7/2016	39	2.25	Poor
	3/21/2017	22	2.25	Poor
	3/8/2018	22	2.25	Poor
	4/16/2019	24	2.00	Poor

Station ID	Date Sampled	Number of Taxa	Benthic IBI Score	Benthic IBI Rating
BUSL-103-T	4/23/2001	32	3.5	Fair
	3/21/2002	29	3.75	Fair
	3/26/2003	14	1.75	Very Poor
	4/29/2004	24	2.5	Poor
	3/4/2005	26	3.25	Fair
	3/3/2006	29	2.75	Poor
	4/13/2007	29	2.5	Poor
	4/23/2008	38	3	Fair
	3/11/2009	31	2.25	Poor
	3/24/2010	23	2.75	Poor
	4/6/2011	28	3.25	Fair
	3/20/2012	19	2	Poor
	3/11/2013	27	3	Fair
	4/14/2014	31	2.75	Poor
	3/13/2015	20	1.75	Very Poor
	3/7/2016	32	2.25	Poor
	3/21/2017	30	2.5	Poor
	3/8/2018	28	2.5	Poor
	4/16/2019	18	1.5	Very Poor
BUSL-104-T	4/23/2001	25	2	Poor
	3/22/2002	23	2.5	Poor
	3/26/2003	31	2	Poor
	4/29/2004	11	1.75	Very Poor
	3/4/2005	18	2	Poor
	3/3/2006	34	2.5	Poor
	4/13/2007	17	2	Poor
	4/23/2008	29	2.25	Poor
	3/10/2009	22	1.5	Very Poor
	3/24/2010	32	2.25	Poor
	4/6/2011	22	1.75	Very Poor
	3/20/2012	20	1.5	Very Poor
	3/13/2013	15	2.25	Poor
	4/14/2014	22	2	Poor
	3/13/2015	20	2	Poor
	3/7/2016	25	1.75	Very Poor
	3/21/2017	15	1.75	Very Poor
	3/8/2018	34	2.5	Poor
	4/16/2019	21	1.75	Very Poor

Project Name: 2019 Peter Pan Run
Project Number: 171701239.26
Prepared by: SKB
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Checked by: AJB
Checked date: 10/11/2019

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Version: 1
Site Name:

KCI TECHNOLOGIES

Metric	BUSL-103-T-2019	BUSL-104-T-2019	BUSL-201-T-2019	BUSL-202-T-2019
Raw Scores	**Raw Scores**			
Total Number of Taxa	18	21	27	24
Number of EPT Taxa	2	3	6	5
Number of Ephemeroptera Taxa	0	0	0	0
Percent Intolerant Urban	6.06	5.93	12.95	6.62
Percent Tanytarsini	3.79	5.93	5.04	3.68
Percent Scrapers	2.27	0.00	0.72	3.68
Percent Swimmers	0.00	0.00	0.00	0.00
Percent Diptera	81.06	50.37	80.58	71.32
BIBI Scores	**BIBI Scores**			
Total Number of Taxa	3	3	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	3	5	5	3
Percent Scrapers	1	1	1	3
Percent Swimmers	1	1	1	1
Percent Diptera	1	1	1	1
BIBI Score	***1.50***	***1.75***	***2.00***	***2.00***
Narrative Rating	***Very Poor***	***Very Poor***	***Poor***	***Poor***

Combined Highlands		Score	
Metric	**5**	**3**	**1**
Total Number of Taxa	≥24	15 - 23	<15
Number of EPT Taxa	≥14	8 - 13	<8
Number Ephemeroptera Taxa	≥5	3 - 4	<3
Percent Intolerant Urban	≥80	38 - 79	<38
Percent Tanytarsini	≥4	0.1 - 3.9	<0.1
Percent Scrapers	≥13	3 - 12	<3
Percent Swimmers	≥18	3 - 17	<3
Percent Diptera	≤26	27 - 49	>50

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Prepared by: SKB Checked by: AJB
Prepared date: 8/30/2019 Checked date: 10/11/2019

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Version: 1
Site Name: BUSL-201-T-2019

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	5	Collector	bu	8.5
Malacostraca	Amphipoda	Gammaridae	Gammarus	Gammarus	U	3	Shredder	sp	6.7
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	2	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	13	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	6	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	1	Scraper	sp	7.2
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	2	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	3	Collector	cb, sp	2.1
Insecta	Diptera	Chironomidae	Nilotanypus	Nilotanypus	I	1	Predator	sp	6.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	44	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	4	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	14	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	P	1	Filterer	cn	7.2
Insecta	Diptera	Chironomidae	Thienemannimyia gr	Thienemannimyia Group	I	1	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	9	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	I	1	Predator	sp	5.3
Insecta	Diptera	Empididae	Clinocera	Clinocera	I	2	Predator	cn	7.4
Insecta	Diptera	Empididae	not identified	Empididae	P	1	Predator	sp, bu	7.5
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	2	Filterer	cn	5.7
Insecta	Diptera	Tipulidae	Antocha	Antocha	I	1	Collector	cn	8
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Insecta	Plecoptera	Leuctridae	Leuctra	Leuctra	I	1	Shredder	cn	0.4
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	9	Shredder	sp, cn	3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	3	Filterer	cn	6.5
Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	I	2	Filterer	cn	2.7
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	1	Filterer	cn	4.4
Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	I	3	Filterer	cn	1.7
Insecta	Diptera	Chironomidae	Neostempellina	Nematoda	U	3	0	0	na

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: 2019 Peter Pan Run
Project Number: 171701239.26
Prepared by: SKB Checked by: AJB
Prepared date: 8/30/2019 Checked date: 10/11/2019

2019_PPR_BIBI_Combined_Highlands_v2_sorted.xlsx
Version: 1
Site Name: BUSL-202-T-2019

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Oligochaeta	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	U	1	Collector	bu	9.1
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	U	2	Collector	bu	6.6
Malacostraca	Amphipoda	Gammaridae	Gammarus	Gammarus	U	24	Shredder	sp	6.7
Insecta	Coleoptera	Elmidae	Dubiraphia	Dubiraphia	A	1	Scraper	cn, cb	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Ceratopogonidae	not identified	Ceratopogonidae	I	1	Predator	sp, bu	3.6
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I/P	17	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	2	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	3	Scraper	sp	7.2
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	4	Collector	cb, sp	2.1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	44	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	3	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	9	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	1	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia Group	I	1	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I/P	4	Collector	sp	5.1
Insecta	Diptera	Empididae	Clinocera	Clinocera	I	1	Predator	cn	7.4
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	6	Filterer	cn	5.7
Insecta	Plecoptera	Chloroperlidae	Haploperla	Haploperla	I	1	Predator	cn	1.6
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	4	Filterer	cn	6.5
Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	I	2	Filterer	cn	2.7
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	1	Filterer	cn	7.5
Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	I	2	Filterer	cn	1.7
Insecta	Diptera	Chironomidae	Neostempellina	Nematoda	U	1	0	0	na

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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2019_PPR_BIBI_Combined_Highlands_v2_sorted.xlsx
Version: 1
Site Name: BUSL-103-T-2019

KCI TECHNOLOGIES

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	10	Collector	bu	8.5
Oligochaeta	Lumbriculida	Lumbriculidae	not identified	Lumbriculidae	U	2	Collector	bu	6.6
Oligochaeta	Tubificida	Tubificidae	not identified	Tubificidae	U	2	Collector	cn	8.4
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I/A	2	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	1	Collector	sp	7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I/P	26	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	1	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	1	Scraper	sp	7.2
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	1	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	4	Collector	cb, sp	2.1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	62	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I/P	3	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Thienemannimyia gr	Thienemannimyia Group	I	1	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I/P	3	Collector	sp	5.1
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	3	Filterer	cn	5.7
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	5	Filterer	cn	4.4
Insecta	Trichoptera	Philopotamidae	Dolophilodes	Dolophilodes	I	4	Filterer	cn	1.7
Insecta	Diptera	Chironomidae	Neostempellina	Nematoda	U	1	0	0	na

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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2019_PPR_BIBI_Combined_Highlands_v2_sorted.xlsx
Version: 1
Site Name: BUSL-104-T-2019

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Oligochaeta	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	U	2	Collector	bu	9.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	U	7	Collector	bu	8.5
Oligochaeta	Lumbricina	not identified	not identified	Lumbricina	I	2	Collector	bu	na
Malacostraca	Amphipoda	Gammaridae	Gammarus	Gammarus	U	40	Shredder	sp	6.7
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	4	Collector	sp	7
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	I	1	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I/P	4	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	4	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	11	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	5	Collector	cb, sp	2.1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I/P	11	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	1	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I/P	3	Shredder	cb, cn	6.3
Insecta	Diptera	Chironomidae	Thienemannimyia gr	Thienemannimyia Group	I/P	16	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	3	Collector	sp	5.1
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	1	Filterer	cn	5.7
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	12	Filterer	cn	6.5
Insecta	Trichoptera	Hydropsychidae	Diplectrona	Diplectrona	I	3	Filterer	cn	2.7
Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	I	1	Shredder	sp	4.9
Insecta	Diptera	Chironomidae	Neostempellina	Nematoda	U	3	0	0	na

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
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

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	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	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
BUSL-104-T	10/7/1999	*	*	*	*	Not Rated
	10/3/2000	1	12	100	1	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	Poor
	6/26/2007	3	55	94.55	2	Poor
	8/15/2008	4	249	98.8	2	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	Poor
	7/25/2012	5	227	97.8	2	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	Poor
	6/30/2016	3	229	98.69	2	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	Poor

* Fish data not collected

Project Name: Peter Pan Run Monitoring - 2019
Project Number: 171701239.26
Prepared by: SKB
Prepared date: 8/26/2019

Checked by: AJB
Checked date: 10/9/2019

FIBI_Warmwater_Highlands_v2_PPR_2019.xlsx
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KCI TECHNOLOGIES

Metric	BUSL-103-T-2019	BUSL-104-T-2019	BUSL-201-T-2019	BUSL-202-T-2019
Raw Scores	**Raw Scores**			
Abundance per square meter	3.38	2.57	2.11	2.83
Adjusted Number of Benthic species	2.92	-8.38	1.89	1.99
% Tolerant	52.50%	98.59%	32.59%	38.81%
% Generalist, Omnivores, Invertivores	55.69%	99.30%	41.96%	48.74%
% Insectivores	43.91%	0.70%	55.95%	48.74%
% Abundance of Dominant Taxa	47.70%	85.21%	44.35%	40.59%
FIBI Scores	**FIBI Scores**			
Abundance per square meter	5	5	5	5
Adjusted Number of Benthic species	5	1	5	5
% Tolerant	3	1	5	5
% Generalist, Omnivores, Invertivores	5	1	5	5
% Insectivores	5	1	5	5
% Abundance of Dominant Taxa	3	3	3	3
FIBI Score	***4.33***	***2.00***	***4.67***	***4.67***
Narrative Rating	***Good***	***Poor***	***Good***	***Good***

Warmwater Highland		**Score**	
Metric	**5**	**3**	**1**
Abundance per square meter	≥ 0.65	0.31 – 0.64	< 0.31
Adjusted Number of Benthic species	≥ 0.25	0.11 – 0.24	< 0.11
% Tolerant	≤ 39	40 – 80	> 80
% Generalist, Omnivores, Invertivores	≤ 61	62 – 96	> 96
% Insectivores	≥ 33	1 – 32	< 1
% Abundance of Dominant Taxa	≤ 38	39 - 89	> 89

Project Name: Peter Pan Run Monitoring - 2019
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Prepared by: SKB Checked by: AJB
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Version: 1
Site Name: BUSL-201-T-2019

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
Potomac Sculpin	*Cottus girardi*	32	NOTYPE	IS	B	0	0	32	0	0.10	1
Blue Ridge Sculpin	*Cottus caeruleomentum*	298	I	IS	B	0	0	298	298	0.93	1
Blacknose Dace	*Rhinichthys atratulus*	154	T	OM	NOTYPE	154	154	0	0	0.48	0
Pumpkinseed	*Lepomis gibbosus*	5	T	IV	NOTYPE	5	5	0	0	0.02	0
Creek Chub	*Semotilus atromaculatus*	33	T	GE	NOTYPE	33	33	0	0	0.10	0
Rosyside Dace	*Clinostomus funduloides*	7	NOTYPE	IV	NOTYPE	0	7	0	0	0.02	0
Common Shiner	*Luxilus cornutus*	4	I	OM	NOTYPE	0	4	0	0	0.01	0
Largemouth Bass	*Mictopterus salmoides*	3	T	TP	NOTYPE	3	0	0	0	0.01	0
Smallmouth Bass	*Micropterus dolomieu*	1	NOTYPE	TP	NOTYPE	0	0	0	0	0.00	0
Central Stoneroller	*Campostoma anomalum*	10	I	AL	NOTYPE	0	0	0	0	0.03	0
Longnose Dace	*Rhinichthys cataractae*	18	NOTYPE	OM	NOTYPE	0	18	0	0	0.06	0
White Sucker	*Catostomus commersonii*	21	T	OM	NOTYPE	21	21	0	0	0.07	0
Bluehead Chub	*Nocomis leptocephalus*	36	I	OM	NOTYPE	0	36	0	0	0.11	0
Fantail Darter	*Etheostoma flabellare*	46	NOTYPE	IS	B	0	0	46	0	0.14	1
Bluntnose Minnow	*Pimephales notatus*	1	T	OM	NOTYPE	1	1	0	0	0.00	0
Silverjaw Minnow	*Ericymba buccata*	1	NOTYPE	OM	NOTYPE	0	1	0	0	0.00	0
Bluegill	*Lepomis macrochirus*	1	T	IV	NOTYPE	1	1	0	0	0.00	0
Green Sunfish	*Lepomis cyanellus*	1	T	GE	NOTYPE	1	1	0	0	0.00	0
	Total count	672				32.59%	41.96%	55.95%	44.35%	2.11	1.89
	Total Biomass (g)	2756									

Project Name: Peter Pan Run Monitoring - 2019
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Version: 1
Site Name: BUSL-202-T-2019

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
Potomac Sculpin	*Cottus girardi*	17	NOTYPE	IS	B	0	0	17	0	0.07	1
Blue Ridge Sculpin	*Cottus caeruleomentum*	274	I	IS	B	0	0	274	274	1.15	1
Blacknose Dace	*Rhinichthys atratulus*	201	T	OM	NOTYPE	201	201	0	0	0.84	0
Longnose Dace	*Rhinichthys cataractae*	14	NOTYPE	OM	NOTYPE	0	14	0	0	0.06	0
Creek Chub	*Semotilus atromaculatus*	23	T	GE	NOTYPE	23	23	0	0	0.10	0
Rosyside Dace	*Clinostomus funduloides*	24	NOTYPE	IV	NOTYPE	0	24	0	0	0.10	0
Bluehead Chub	*Nocomis leptocephalus*	36	I	OM	NOTYPE	0	36	0	0	0.15	0
Central Stoneroller	*Campostoma anomalum*	9	I	AL	NOTYPE	0	0	0	0	0.04	0
White Sucker	*Catostomus commersonii*	13	T	OM	NOTYPE	13	13	0	0	0.05	0
Fantail Darter	*Etheostoma flabellare*	38	NOTYPE	IS	B	0	0	38	0	0.16	1
Largemouth Bass	*Mictopterus salmoides*	7	T	TP	NOTYPE	7	0	0	0	0.03	0
Smallmouth Bass	*Micropterus dolomieu*	1	NOTYPE	TP	NOTYPE	0	0	0	0	0.00	0
Pumpkinseed	*Lepomis gibbosus*	16	T	IV	NOTYPE	16	16	0	0	0.07	0
Bluegill	*Lepomis macrochirus*	2	T	IV	NOTYPE	2	2	0	0	0.01	0
	Total count	675				38.81%	48.74%	48.74%	40.59%	2.83	1.99

Project Name: Peter Pan Run Monitoring - 2019
Project Number: 171701239.26
Prepared by: JSM Checked by: SKB
Prepared date: 8/19/2019 Checked date: 8/26/2019

FIBI_Warmwater_Highlands_v2_PPR_2019.xlsx
Version: 1
Site Name: BUSL-103-T-2019

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*	239	T	OM	NOTYPE	239	239	0	239	1.61	0
Creek Chub	*Semotilus atromaculatus*	23	T	GE	NOTYPE	23	23	0	0	0.16	0
Longnose Dace	*Rhinichthys cataractae*	8	NOTYPE	OM	NOTYPE	0	8	0	0	0.05	0
Rosyside Dace	*Clinostomus funduloides*	9	NOTYPE	IV	NOTYPE	0	9	0	0	0.06	0
Central Stoneroller	*Campostoma anomalum*	1	I	AL	NOTYPE	0	0	0	0	0.01	0
Potomac Sculpin	*Cottus girardi*	15	NOTYPE	IS	B	0	0	15	0	0.10	1
Blue Ridge Sculpin	*Cottus caeruleomentum*	192	I	IS	B	0	0	192	0	1.30	1
Fantail Darter	*Etheostoma flabellare*	13	NOTYPE	IS	B	0	0	13	0	0.09	1
Largemouth Bass	*Mictopterus salmoides*	1	T	TP	NOTYPE	1	0	0	0	0.01	0
	Total count	501				52.50%	55.69%	43.91%	47.70%	3.38	2.92

Project Name: Peter Pan Run Monitoring - 2019
Project Number: 171701239.26
Prepared by: JSM Checked by: SKB
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FIBI_Warmwater_Highlands_v2_PPR_2019.xlsx
Version: 1
Site Name: BUSL-104-T-2019

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*	242	T	OM	NOTYPE	242	242	0	242	2.19	0
Creek Chub	*Semotilus atromaculatus*	38	T	GE	NOTYPE	38	38	0	0	0.34	0
Goldfish	*Carassius auratus*	1	NOTYPE	OM	NOTYPE	0	1	0	0	0.01	0
Bluehead Chub	*Nocomis leptocephalus*	1	I	OM	NOTYPE	0	1	0	0	0.01	0
Fantail Darter	*Etheostoma flabellare*	2	NOTYPE	IS	B	0	0	2	0	0.02	1
	Total count	284				98.59%	99.30%	0.70%	85.21%	2.57	-8.38

Table A-4. Summary of *in situ* water quality data for Peter Pan Run

Station ID	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductivity (µS/cm)	Turbidity (NTU)
BUSL-201-T	6/11/1999	19.26	8.74	7.53	0.25	4.1
	10/12/1999	10.19	10.92	7.43	0.151	12.3
	4/20/2000	10.6	7.51	7.01	0.19	4
	9/28/2000	11.63	10.93	6.97	0.224	19.5
	4/23/2001	14.26	11.78	8.16	0.245	0.6
	7/12/2001	16.6	11.2	7.4	0.244	14.4
	3/21/2002	6.8	12.02	5.08	0.226	19.7
	8/22/2002	20.2	7.36	6.89	0.282	4.9
	3/26/2003	*	*	*	*	*
	7/17/2003	17.87	3.9	6.77	0.288	0
	4/29/2004	16.52	*	7.69	0.265	*
	9/24/2004	16.3	8.7	6.6	0.284	9.2
	3/4/2005	4.7	12	6.98	0.318	96.1
	6/23/2005	15.7	9.2	7.52	0.318	19.2
	3/1/2006	5.33	13.91	8.6	0.286	3.2
	6/6/2006	18.2	9.6	7.54	0.652	2.3
	4/9/2007	3.4	15.1	6.12	0.632	5.7
	7/3/2007	15.4	9.7	6.47	0.73	10.5
	4/23/2008	12.6	10.1	7.53	0.331	23
	8/7/2008	19.1	8.1	7.85	0.377	11.5
	3/10/2009	5.9	7.8	7.46	0.469	13.1
	9/9/2009	17.8	8.7	7.74	0.414	16
	3/24/2010	7.8	*	7.07	0.353	*
	8/19/2010	20.4	8.8	7.66	0.38	-11
	4/6/2011	6.3	14.2	7.09	0.322	7.7
	7/13/2011	20.7	8.7	7.7	0.413	16.4
	3/21/2012	13.49	9.52	7.99	0.379	6.1
	8/20/2012	19	9.1	7.38	0.348	9.2
	3/11/2013	6.6	12.3	6.93	0.517	25.2
	8/19/2013	17	9	7.42	0.437	15.9
	4/9/2014	7.2	12.8	8.03	0.598	1.1
	7/22/2014	18.7	7.82	7.42	0.466	7.4
	3/20/2015	4	12.7	7.66	0.675	3.5
	7/1/2015	18	8.7	7.57	0.488	4.7
	3/7/2016	5.6	13.6	7.89	0.488	1
	7/1/2016	17.2	8.79	7.5	0.452	3.5
	3/21/2017	8	12.3	7.63	0.626	0.2
	6/28/2017	13.5	9.64	7.66	0.482	5.5
	3/8/2018	6.7	16.44	8.62	614.8	1.8
	6/26/2018	19.6	9.45	7.7	450.9	3.8
	4/16/2019	14	10.6	7.73	446.5	4.8
	9/19/2019	15.1	8.89	7.63	524.4	3.2
BUSL-202-T	6/8/1999	20.68	8.27	7.37	0.252	32.5
	10/6/1999	10.37	11	7.26	0.159	13.3
	4/20/2000	8.1	6.76	7.04	0.193	8.1
	10/6/2000	17.97	8.17	7.97	0.299	8.5
	4/23/2001	14.19	11.62	8.06	0.254	13.3
	7/25/2001	24.5	9.1	7.56	0.261	11.4
	3/21/2002	9.99	11.19	5.54	0.242	18.3
	8/22/2002	22	8.27	6.68	0.271	9.4
	3/26/2003	*	*	*	*	*
	7/17/2003	21.07	5.13	6.83	0.307	0.9
	4/29/2004	18.75	*	7.6	0.275	*
	9/27/2004	16.4	8.8	6.83	0.336	11.6
	3/4/2005	4.6	12.4	6.57	0.552	83.1
	6/23/2005	21.2	11.4	7.84	0.332	73.9
	3/1/2006	3.02	12.9	7.72	0.342	3.2
	6/6/2006	15.6	9.8	7.38	0.682	18.7
	4/9/2007	3.3	15.7	6.08	0.626	5.9
	7/3/2007	18.8	10.5	7.72	1.121	11.7
	4/23/2008	13.4	10	7.5	0.346	21.2
	8/7/2008	20.7	8.4	7.91	0.392	11.5
	3/11/2009	7.2	12.5	7.99	0.329	16.4
	9/9/2009	19.3	8.6	7.93	0.435	29.8
	3/24/2010	8.2	*	7.44	0.377	*
	8/27/2010	16.5	9.3	7.63	0.459	15.3
	4/6/2011	7.5	13.9	7.13	0.531	4.3
	7/13/2011	22.3	9.5	7.89	0.435	16.2
	3/21/2012	13.84	9.82	8.09	0.4	7.6
	8/20/2012	19.8	9.9	7.65	0.356	10.3
	3/11/2013	7.9	14.4	7.8	0.541	37.9
	8/16/2013	17.2	10.3	7.64	0.446	31.5
	4/9/2014	10.7	13.4	8.54	0.631	1.9
	7/22/2014	19.9	7.88	7.7	0.5	4.1
	3/20/2015	4	13.3	7.63	0.743	6.6
	7/1/2015	19.5	8.7	7.67	0.525	4.4
	3/7/2016	6.9	13.7	7.85	0.519	1.7
	7/8/2016	20.8	8.64	7.63	0.49	7.3
	3/21/2017	8.8	12.2	7.86	0.667	8.1
	6/28/2017	16.2	10.06	7.77	0.503	5.5
	3/8/2018	7.2	15.8	8.57	646.3	2.3
	7/12/2018	19.4	8.91	8.09	523	4.2
	4/16/2019	15.5	10.1	7.71	462.5	13.6
	9/19/2019	16.9	7.81	7.82	561.1	4.1

Station ID	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductivity (µS/cm)	Turbidity (NTU)
BUSL-103-T	6/8/1999	18.25	7.14	7.1	0.2	172
	10/6/1999	11.32	11.25	7.47	0.136	2.2
	4/19/2000	14.8	8.37	7.13	0.181	4.9
	9/23/2000	14.75	9.87	6.85	0.229	4.1
	4/23/2001	13.95	12.05	7.8	0.232	0.6
	7/11/2001	18.9	5.8	6.65	0.143	10.6
	3/21/2002	11.26	10.73	5.76	0.218	10.3
	8/22/2002	**	**	**	**	**
	3/26/2003	*	*	*	*	*
	7/18/2003	18.02	13.5	6.78	0.26	0
	4/29/2004	21.65	*	7.54	0.26	*
	9/24/2004	16.1	13	6.83	0.281	4.6
	3/4/2005	4.8	11.7	6.59	0.302	56.6
	6/23/2005	17	9.7	6.96	0.3	15.5
	3/3/2006	2.99	13.88	7.19	0.292	4.1
	6/9/2006	16.5	8.2	7.45	0.318	6.8
	4/13/2007	7.1	12.3	6.28	0.558	8.5
	6/26/2007	19	9	7.61	1.072	15.2
	4/23/2008	15.7	10	7.52	0.348	26.5
	8/15/2008	18.8	8.2	7.45	0.369	29
	3/11/2009	8.4	13.3	8.06	0.324	15.2
	9/15/2009	16.6	8.1	7.65	0.432	14.9
	3/24/2010	10.8	*	7.66	0.36	*
	8/19/2010	21.5	8.6	7.56	0.417	8.8
	4/6/2011	10.2	13.8	7.42	0.479	3.5
	7/14/2011	19.1	8.9	7.71	0.345	11.7
	3/20/2012	15.07	10.31	7.7	0.496	8.4
	7/25/2012	20.1	9	7.49	0.379	2.7
	3/11/2013	9.4	14.5	8.53	0.461	28.4
	8/16/2013	15.5	10.4	7.99	0.416	27
	4/14/2014	15	10.9	8.04	0.536	1
	7/17/2014	18.7	8.51	7.36	0.49	2
	3/13/2015	4.1	14.1	7.32	0.789	2.2
	6/17/2015	18.6	8.6	7.78	0.597	2.6
	3/7/2016	5.1	14.3	7.77	0.488	0.8
	6/30/2016	17.6	9.09	7.76	0.456	0.8
	3/21/2017	7.2	12.3	7.17	0.631	6.9
	7/26/2017	16.3	9.24	7.15	0.454	6.1
	3/8/2018	6.4	16.56	8.76	608.9	1.5
	6/28/2018	19.1	8.87	8.27	465	2.5
	4/16/2019	15.4	10.16	7.72	482.5	2.6
	7/30/2019	21.3	9.22	7.4	513	2.3
BUSL-104-T	6/24/1999	14.04	8.89	7.4	0.197	7.9
	10/7/1999	13.99	9.97	7.51	0.124	164
	4/19/2000	9.93	12.87	7.03	0.166	25
	10/3/2000	18.22	8.23	7.77	0.16	57.8
	4/23/2001	12.77	11.53	7.85	0.22	14.4
	7/10/2001	23.1	6.5	6.82	0.112	44.3
	3/22/2002	4.46	11.94	5.03	0.341	261.8
	8/22/2002	21.3	7.7	6.63	0.222	14.4
	3/26/2003	*	*	*	*	*
	7/18/2003	16.86	8.4	6.69	0.224	8.3
	4/29/2004	17.13	*	7.32	0.205	*
	8/27/2004	19.1	10	6.84	0.241	37.6
	3/4/2005	5.6	12.9	6.44	0.576	75.6
	6/23/2005	17.1	11.1	7.33	0.257	20.4
	3/3/2006	6.31	13.45	7.63	0.216	5.6
	6/9/2006	16.3	8.9	7.49	0.273	17
	4/13/2007	8.4	12.3	5.64	0.558	437.7
	6/26/2007	18.9	6.2	7.69	1.106	21.2
	4/23/2008	16.6	9	7.47	0.276	5.3
	8/15/2008	22	7.8	7.6	0.173	25.5
	3/10/2009	8.2	14.5	7.64	0.403	23.8
	9/9/2009	19	8.3	8	0.272	24.2
	3/24/2010	11.2	*	7.08	0.616	*
	8/27/2010	18.1	9.2	7.76	0.38	12
	4/6/2011	10.4	12.7	7.28	0.71	10.2
	7/14/2011	22.2	8	7.65	0.466	13.5
	3/20/2012	16.4	9.61	7.23	0.813	9.3
	7/25/2012	21.5	8.6	7.6	0.358	5.6
	3/13/2013	9.3	11.1	7.48	0.338	156.2
	8/15/2013	17.8	9.8	7.75	0.423	31.3
	4/14/2014	14.8	10.5	7.82	0.65	4.1
	8/14/2014	18.7	7.87	7.37	0.363	7.2
	3/13/2015	4.7	12.6	7.1	0.9	11.3
	6/17/2015	20	8.2	7.69	0.413	20.1
	3/7/2016	6.5	12.9	7.75	0.599	2.1
	6/30/2016	16.6	8.69	7.64	0.442	8.7
	3/21/2017	9	12.2	7.43	0.942	8.1
	7/26/2017	17.8	8.86	7.65	0.418	4.9
	3/8/2018	7.9	12.06	8.07	616.9	5.1
	6/28/2018	18.9	7.28	7.87	496.7	8.2
	4/16/2019	16.4	8.43	7.37	403.7	10.1
	7/30/2019	21.1	8.24	7.44	604	9.2

* - Data not collected due to equipment malfunction.
** - Stream was dry.

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
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

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
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

* - Data not collected

Project Name: Frederick County Peter Pan Run - 2019
Project Number: 171701239.26
Prepared by: SKB
Prepared date: 9/23/2019

2019_PeterPanRun_PHI_Highlands_v2.xlsx

Checked by: AJB
Checked date: 10/9/2019

Version:
Site Name:

		Raw Data					Scaled Metrics				
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**
BUSL-103-T-2019	556.592	11	12	75	50	7	61.11	70.69	70.13	100.00	35.86
BUSL-104-T-2019	65.097	5	9	90	35.0	6	27.78	55.33	87.37	70.00	28.99
BUSL-201-T-2019	1584.969	13	13	75	50	18	72.22	75.04	70.13	100.00	90.96
BUSL-202-T-2019	1377.333	12	12	75	29.0	11	66.67	70.97	70.13	58.00	55.16

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

APPENDIX A

Representative Site Photographs

BUSL-103
Representative Site Photographs

2019 station 0+00 facing downstream

2019 station 0+00 facing upstream

2019 station 0+50 facing downstream

2019 station 0+50 facing upstream

2019 station 1+00 facing downstream

2019 station 1+00 facing upstream at cross-section

2019 station 1+50 facing downstream at cross-section

2019 station 1+50 facing upstream

2019 station 2+00 facing downstream

2019 station 2+00 facing upstream

2019 station 2+50 facing downstream

2019 station 2+50 facing upstream

2019 station 3+00 facing downstream

2019 station 3+00 facing upstream

BUSL-104
Representative Site Photographs

2019 station 0+00 facing downstream

2019 station 0+00 facing upstream

2019 station 0+50 facing downstream

2019 station 0+50 facing upstream

2019 station 1+00 facing downstream

2019 station 1+00 facing upstream

2019 station 1+50 facing downstream

2019 station 1+50 facing upstream

2019 station 2+00 facing downstream

2019 station 2+00 facing upstream

2019 station 2+50 facing downstream

2019 station 2+50 facing upstream

2019 station 3+00 facing downstream

2019 station 3+00 facing upstream

2019 station 3+41 facing downstream

2019 station 3+41 facing upstream

2019 BUSL-104 Cross Section facing downstream

2019 BUSL-104 Cross Section facing upstream

2019 BUSL-104 Cross Section facing left bank

2019 BUSL-104 Cross Section facing right bank

BUSL-201
Representative Site Photographs

2019 station 0+00 facing downstream

2019 station 0+00 facing upstream

2019 station 0+50 facing downstream

2019 station 0+50 facing upstream

2019 station 1+00 facing downstream

2019 station 1+00 facing upstream

2019 station 1+30 facing downstream

2019 station 1+30 facing upstream

2019 station 1+80 facing downstream

2019 station 1+80 facing upstream

2019 station 2+30 facing downstream

2019 station 2+30 facing upstream

2019 station 2+85 facing downstream

2019 station 2+85 facing upstream

2019 station 3+10 facing downstream

2019 station 3+10 facing upstream

2019 BUSL-201 Cross Section facing downstream

2019 BUSL-201 Cross Section facing upstream

2019 BUSL-201 Cross Section facing left bank

2019 BUSL-201 Cross Section facing right bank

BUSL-202
Representative Site Photographs

2019 station 0+00 facing downstream

2019 station 0+00 facing upstream

2019 station 0+40 facing downstream

2019 station 0+40 facing upstream

2019 station 0+85 facing downstream

2019 station 0+85 facing upstream

2019 station 1+35 facing downstream

2019 station 1+35 facing upstream

2019 station 1+80 facing downstream

2019 station 1+80 facing upstream

2019 station 2+30 facing downstream

2019 station 2+30 facing upstream

2019 station 2+80 facing downstream

2019 station 2+80 facing upstream

2019 station 3+30 facing downstream

2019 station 3+30 facing upstream

2019 BUSL-202 Cross Section facing downstream

2019 BUSL-202 Cross Section facing upstream

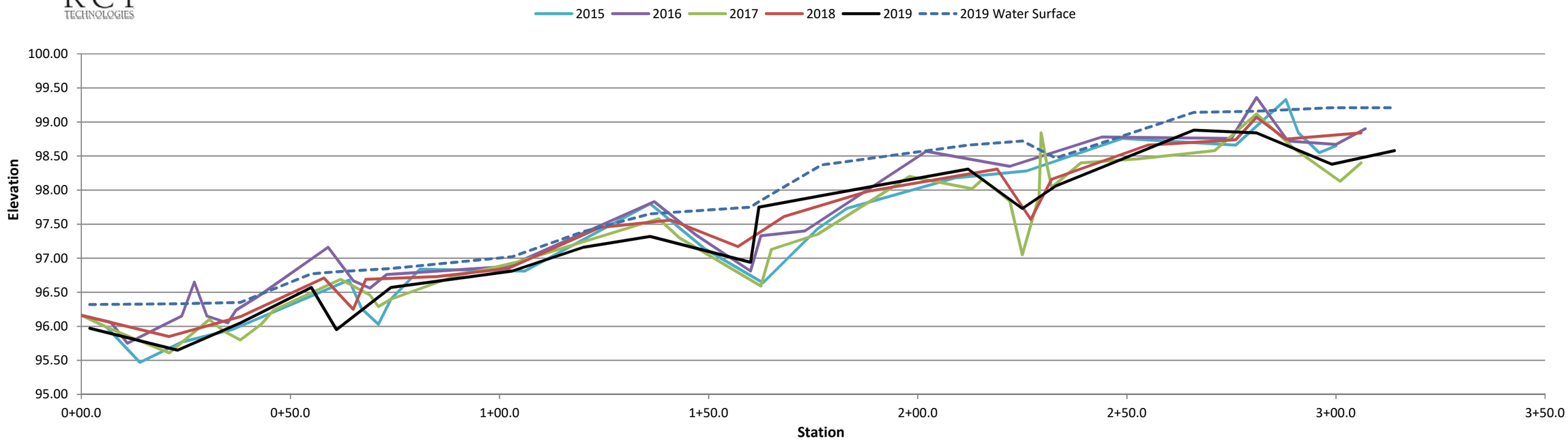
2019 BUSL-202 Cross Section facing left bank

2019 BUSL-202 Cross Section facing right bank

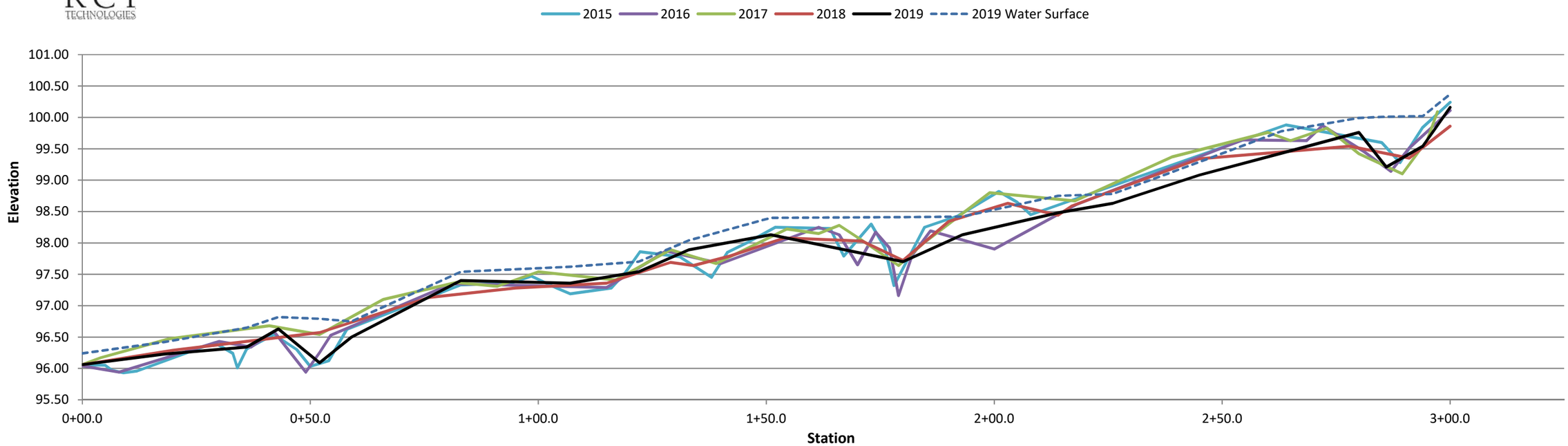
APPENDIX A

Longitudinal Profile Overlays

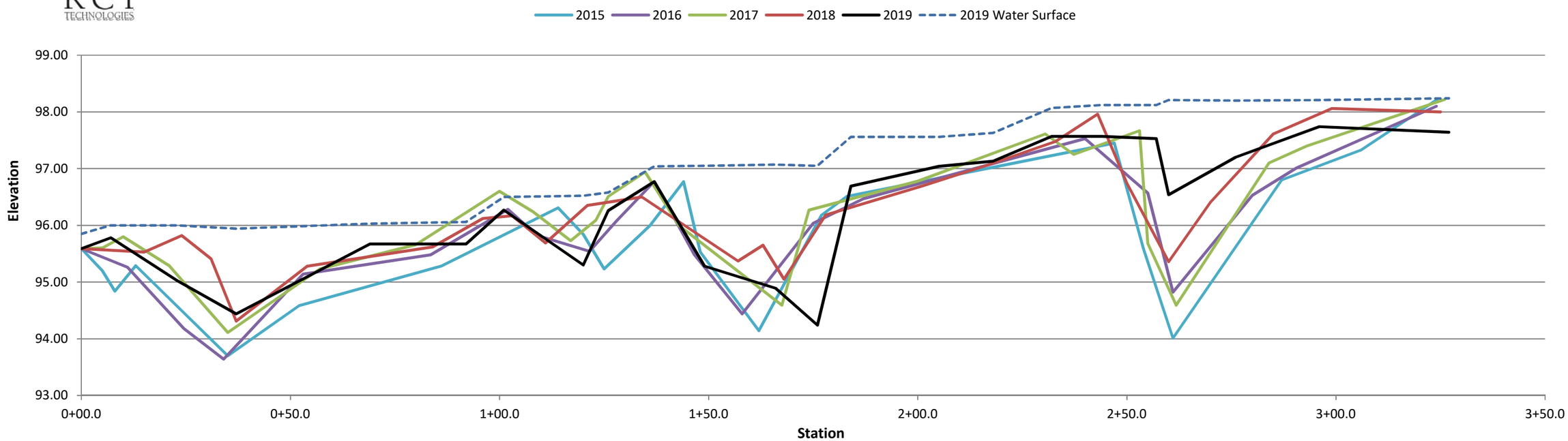
BUSL-103 Longitudinal Profile Overlay



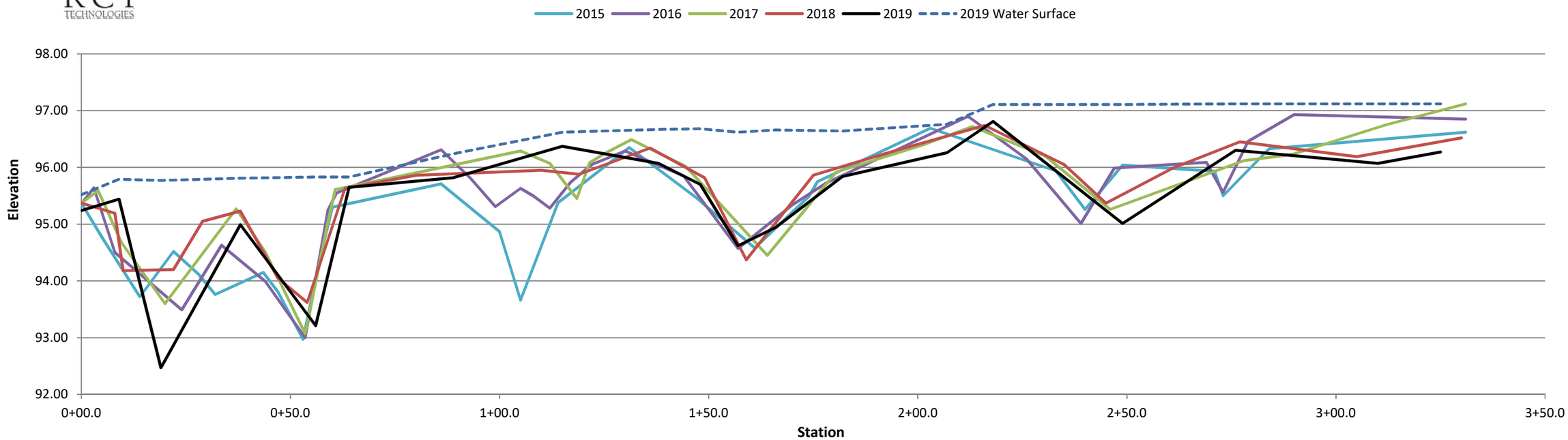
BUSL-104 Longitudinal Profile Overlay



BUSL-201 Longitudinal Profile Overlay



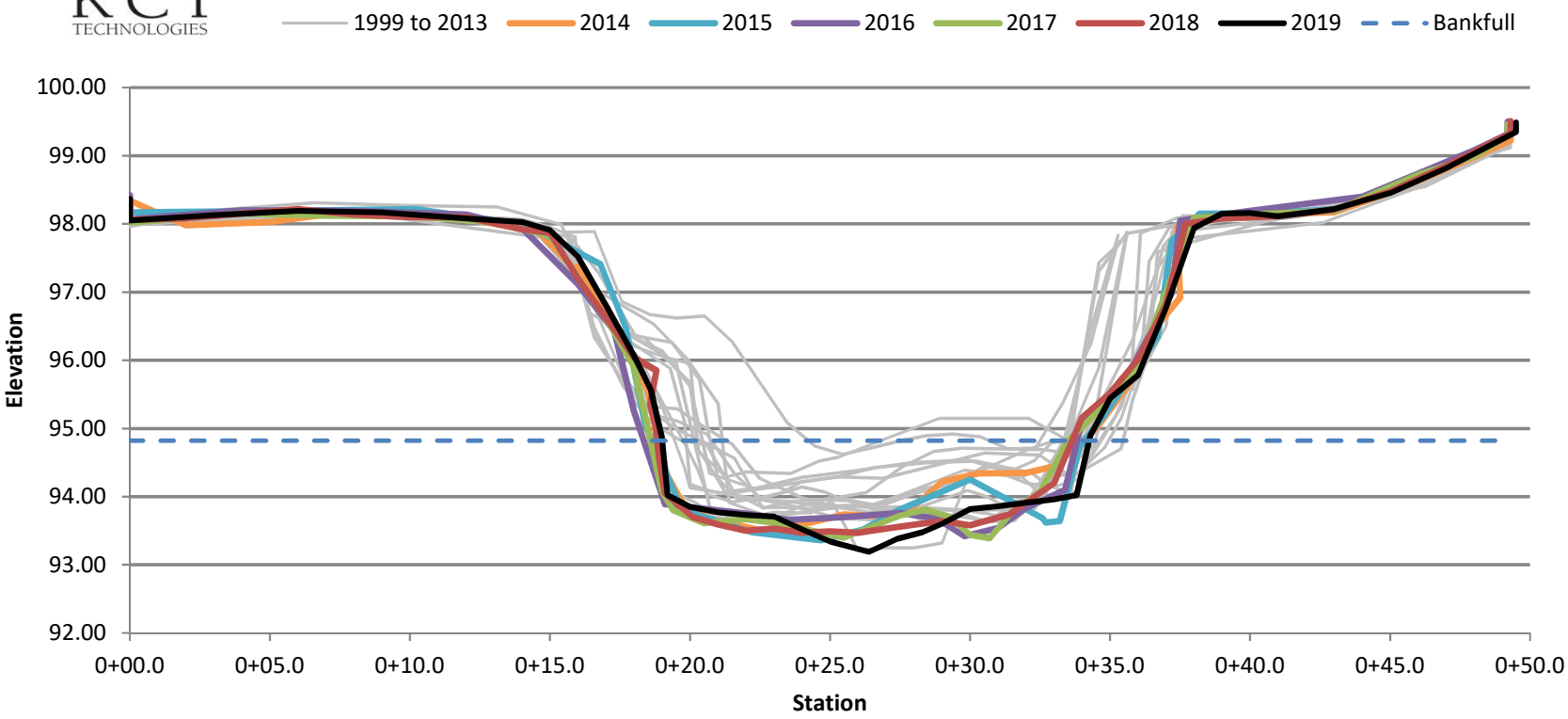
BUSL-202 Longitudinal Profile Overlay



APPENDIX A

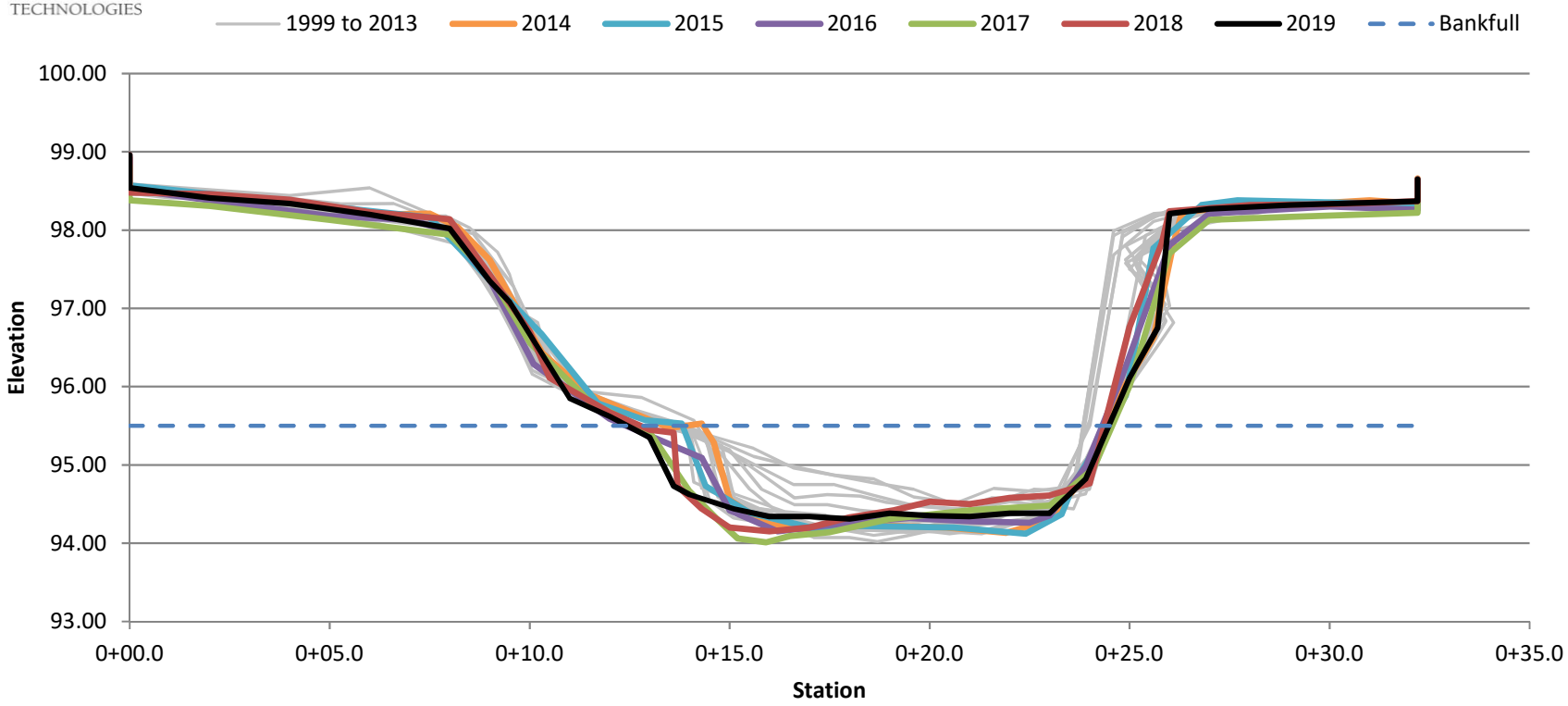
Cross Section Overlays

BUSL-103



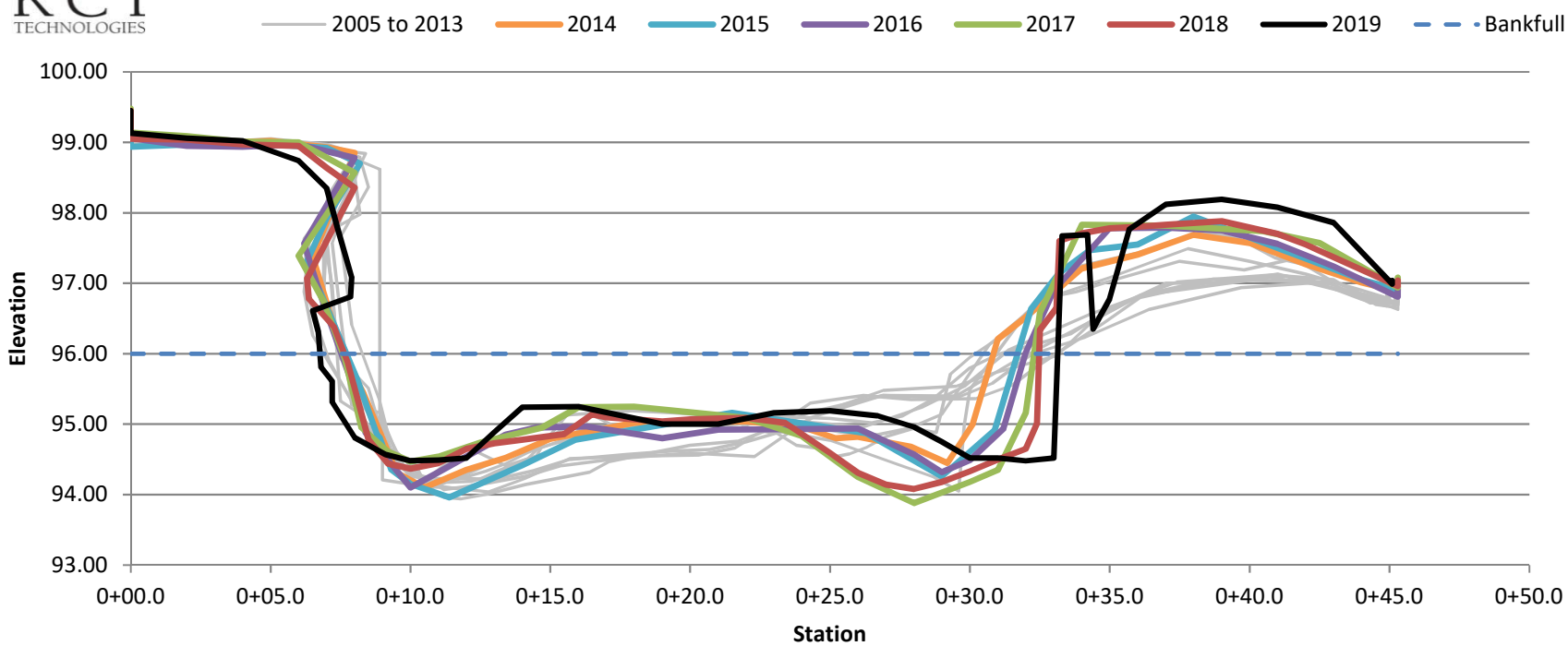
BKFL/TOB ELEV= 94.82	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	13.5	0.9	11.9	15.3	27.5
2014	15.2	0.9	12.9	17.8	29.5
2015	15.4	1.0	15.9	15.0	40.6
2016	15.5	1.0	16.2	14.8	41.3
2017	14.9	1.1	16.5	13.5	43.9
2018	14.8	1.1	16.9	13.0	46.0
2019	15.2	1.1	17.2	13.5	46.2

BUSL-104



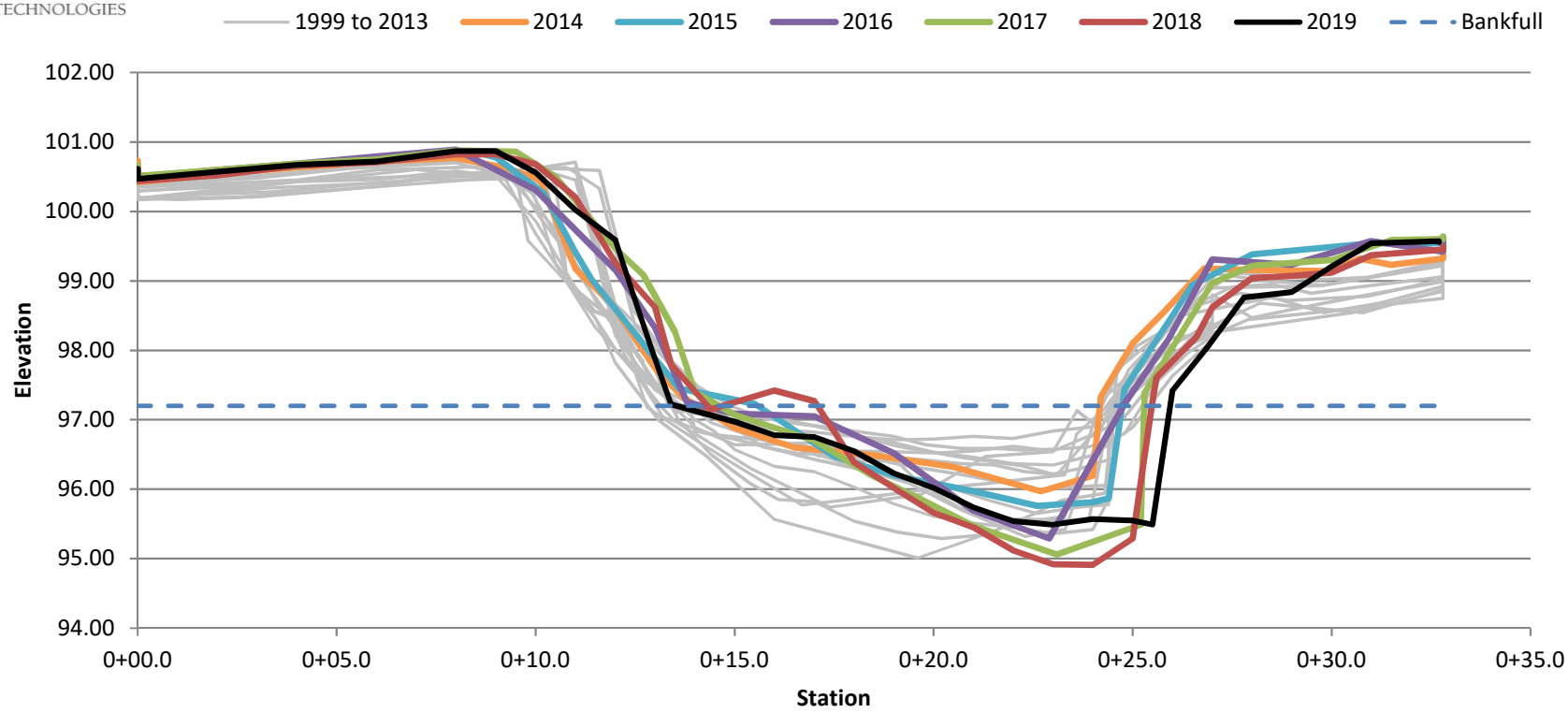
BKFL/TOB ELEV= 95.5	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	10.4	0.6	6.4	17.0	19.5
2014	10.6	1.1	11.4	9.8	49.8
2015	10.6	1.1	11.9	9.5	53.1
2016	11.9	1.0	11.6	12.2	48.2
2017	11.9	1.0	12.4	11.4	50.7
2018	11.6	1.0	11.3	11.9	45.9
2019	12.0	1.0	11.8	12.3	49.1

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
2014	23.3	1.2	27.6	19.7	97.3
2015	24.0	1.3	30.1	19.2	110.0
2016	24.5	1.2	29.4	20.4	104.7
2017	24.7	1.2	30.7	19.9	105.1
2018	24.8	1.3	31.8	19.4	108.0
2019	26.4	1.1	28.3	24.6	83.8

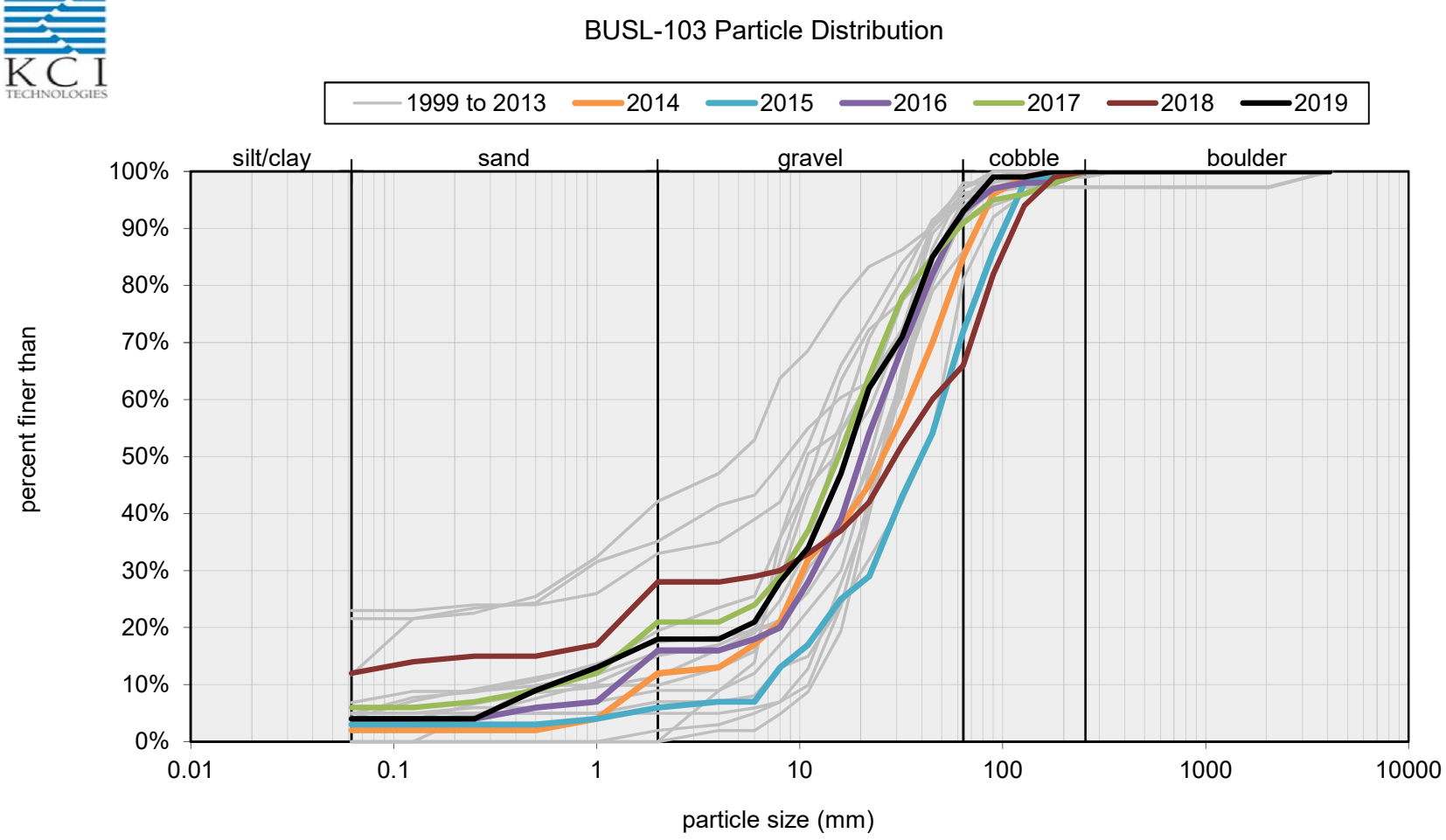
BUSL-202

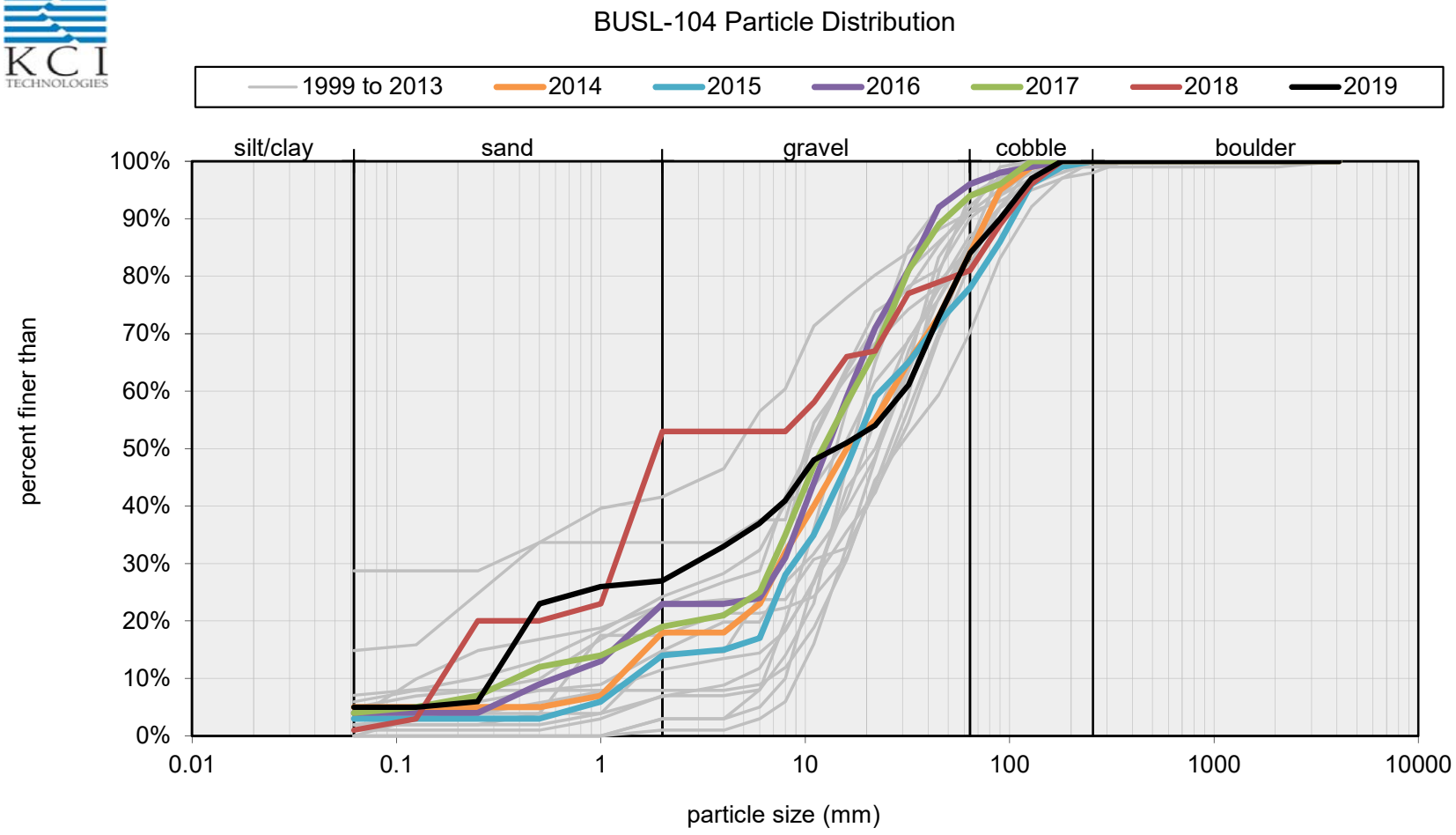


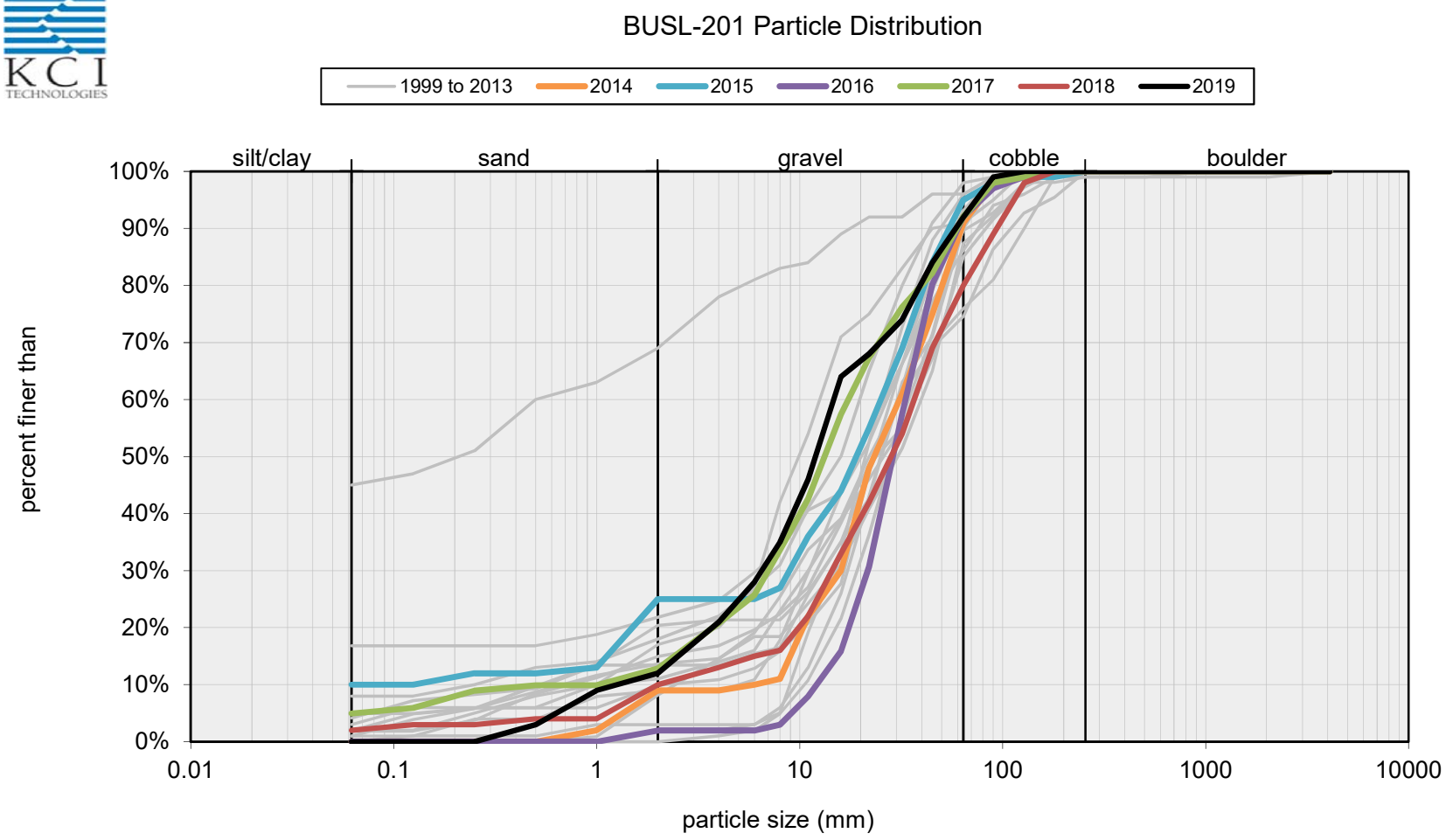
BKFL/TOB ELEV= 97.2	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
1999	11.2	0.5	6.1	20.7	10.3
2014	10.1	0.8	7.6	13.5	15.3
2015	9.2	1.0	9.1	9.2	21.6
2016	10.6	0.8	8.4	13.4	17.3
2017	10.7	1.3	13.4	8.5	36.0
2018	8.8	1.5	13.3	5.8	39.5
2019	12.4	1.0	12.5	12.4	35.8

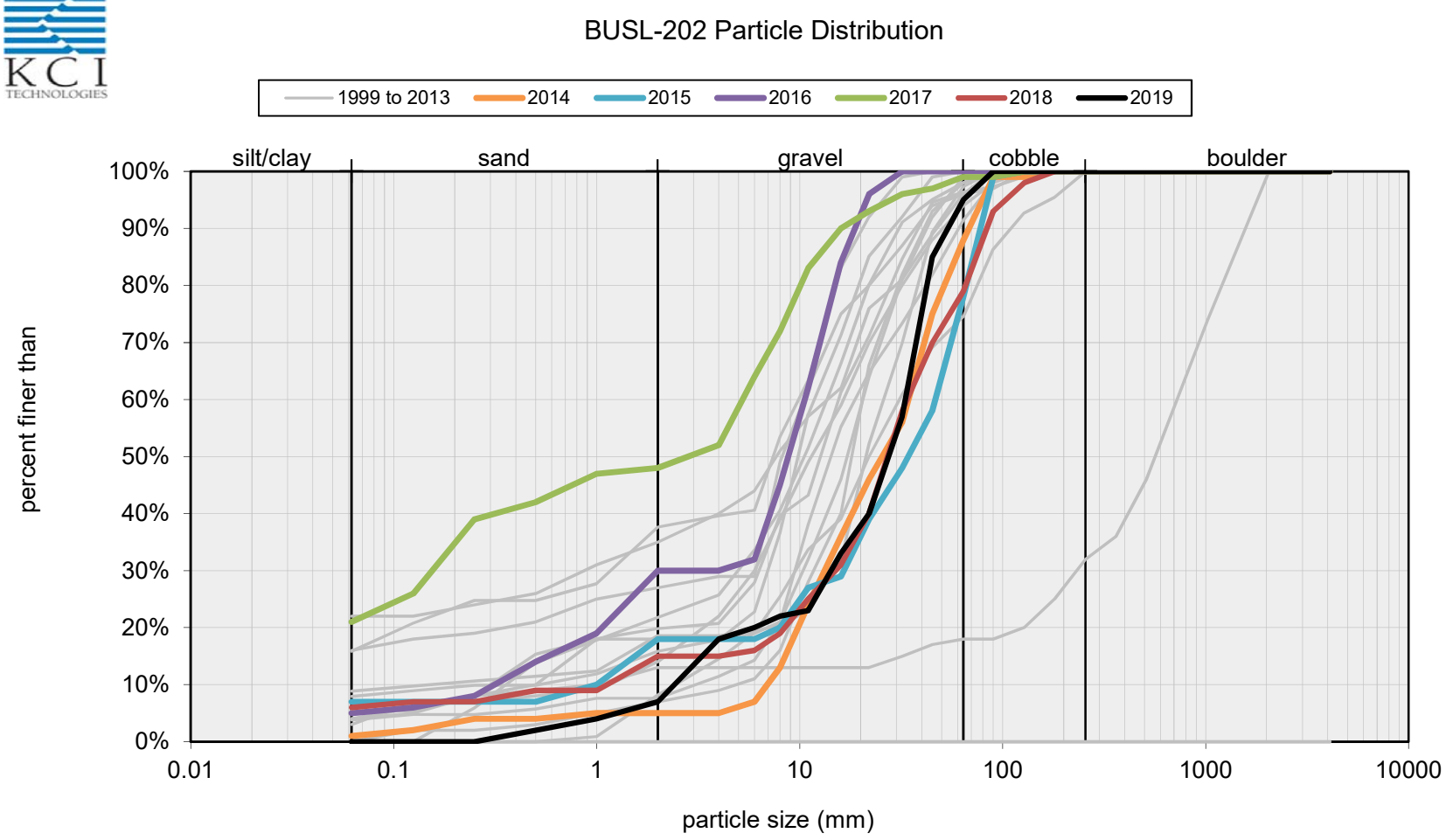
APPENDIX A

Particle Distribution Overlays


BUSL-103 Particle Distribution
1999 to 2013
2014
2015
2016
2017
2018
2019
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 Particle Distribution
1999 to 2013
2014
2015
2016
2017
2018
2019
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-201 Particle Distribution
1999 to 2013
2014
2015
2016
2017
2018
2019
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 Particle Distribution
1999 to 2013
2014
2015
2016
2017
2018
2019
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)

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, 2018 to June 30, 2019 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. Both curves followed second order polynomial equations with R^2 values of 0.99, 0.95 and 1.00 for the instream and outfall stations, respectively. Values were estimated via interpolation.
- 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 FY2019 at the outfall station. All flow at the outfall station 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 FY2019

Location	Percent Baseflow	Percent Stormflow	Days Baseflow	Days Stormflow	Volume Baseflow (ac-ft)	Volume Stormflow (ac-ft)
Instream*	71%	29%	258	107	2,127	5,064
Outfall*	0%	21%	0	77	0	39

*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.