Clermont County Office of Environmental Quality
2009 Water Quality Monitoring Final Report

December 22, 2009

Introduction

In 1996, Clermont County established a monitoring program to characterize surface water quality within the County. Data collected through this program allow the County to analyze watershed conditions, identify potential water quality problems, support planning and management programs, and track trends and progress over time. Marking the fourteenth year of the program, the 2009 study plan was designed with these goals in mind, and consisted of three project components. The first component, ambient phosphorus sampling, was designed to investigate the source of occasionally elevated phosphorus concentrations downstream of Harsha Lake. Samples were collected from tributaries and the mainstem of the East Fork of the Little Miami River (EFLMR) and analyzed for ortho-phosphorus and total-phosphorus.

The second component involved 24-hour (diurnal) monitoring of dissolved oxygen (D.O.) concentrations above and below the effluent outfall of four wastewater treatment plants (WWTP) that discharge into the EFLMR – Batavia, Middle East Fork (MEF), Lower East Fork (LEF) and Milford WWTPs and O'Bannon Wastewater Treatment Plant, which discharges into O'Bannon Creek. High nutrient loads, often associated with WWTP effluent, can cause algal blooms, which can subsequently lead to oxygen depletion due to overnight respiration and eventual algal decomposition. Comparison of diurnal D.O. profiles above and below the plants' outfall should indicate whether nutrient loading is leading to D.O. depletion downstream of WWTPs, which could, in turn, impact the river's biological health. In 2008, the County monitored one site upstream and one site downstream of the effluent from the Batavia, MEF, LEF, and Milford WWTPs. In 2009, the County expanded the sampling design to include four downstream and two upstream monitoring locations surrounding each WWTP. This design will allow the Office of Environmental Quality (OEQ) to determine the effects of habitat and distance from WWTPs on D.O. concentrations. Sites were monitored during summer base flow conditions to maximize any impacts from high temperatures and nutrients on D.O. concentrations.

For the third project component, the County evaluated instream habitat by performing Qualitative Habitat Evaluation Indices (QHEI) or Headwater Habitat Evaluation Indices (HHEI) in four different streams during the summer of 2009. Habitat was assessed in order to compile data in support of current and future stream restoration projects and to supplement data collected by Ohio EPA.

This report summarizes the results from these three components of the County's 2009 sampling program. No biological sampling was performed by Clermont County in 2009.

Table 1. Weather conditions during ambient phosphorus sampling and diurnal dissolved oxygen profiles. Conditions are reported for the day of sampling as well as 24 hrs, 48 hrs, and 72 hrs prior to sample collection. Precipitation is reported in inches and discharge is reported in cubic feet/second.

		Precipitation-Hall Gage* (in)				**Discharge-Perintown Gage (cfs)[ŧ]**			
Sample Date	**Study**	**72 hour**	**48 hour**	**24 hour**	**same day**	**72 hour**	**48 hour**	**24 hour**	**same day**
5/21/2009	ambient phosphorus	0	0	0	0	248	93	71	63
5/27/2009	ambient phosphorus	0	0.31	0.02	0.03	50	54	87	75
5/28/2009	ambient phosphorus	0.31	0.02	0.03	0.18	54	87	75	132
5/29/2009	ambient phosphorus	0.02	0.03	0.18	0.01	87	75	132	508
6/25/2009	ambient phosphorus	0	0	0	0.92	56	53	47	142
6/29/2009	ambient phosphorus	1.8	0	0	0	1,590	948	703	271
6/30/2009	ambient phosphorus	0	0	0	0	948	703	271	135
7/1/2009	ambient phosphorus	0	0	0	0.29	703	271	135	63
7/21/2009	ambient phosphorus	0.04	0	0	0	44	42	42	47
7/22/2009	ambient phosphorus	0	0	0	0.74	42	42	47	57
7/28/2009	ambient phosphorus	0.51	0.01	0	0	237	176	66	57
8/13/2009	Diurnal D.O.	1.02	0.16	0	0	73	85	20	11
8/14/2009	Diurnal D.O.	0.16	0	0	0	85	20	11	8
8/20/2009	Diurnal D.O.	0.09	0.2	0	0.03	123	76	57	57
8/21/2009	Diurnal D.O.	0.2	0	0.03	0	76	57	57	58
8/25/2009	Diurnal D.O.	0	0	0	0	57	56	57	56
8/26/2009	Diurnal D.O.	0	0	0	0	56	57	56	56
8/27/2009	Diurnal D.O.	0	0	0	0	57	56	56	57
9/14/2009	Diurnal D.O.	0	0	0	0	50	47	45	48
9/15/2009	Diurnal D.O.	0	0	0	0	47	45	48	47

*** precipitation data from 5/25/2009-6/30/2009 is from Stonelick Gage**

[ŧ] all discharge data from USGS Perintown gage except for data reported for 8/13-8/14, which is from the USGS O'Bannon Creek Gage

Ambient Phosphorus Study

Sampling Design

To better understand point and nonpoint sources of phosphorus loads to the EFLMR, OEQ collected grab samples from tributaries and the main stem of the EFLMR once per month from May through July of 2009. These data were collected on predetermined dates and each round of sampling was collected across three to four consecutive days where possible. Table 1 summarizes the precipitation occurrences and flow conditions on each sampling event. Grab samples were analyzed for total phosphorus (TP) and ortho-phosphorus (OP). Ohio EPA recommends total phosphorus concentrations remain below 0.05 mg/l for Exceptional Warm-water Habitats (EWH) and 0.10 mg/l for Warm-Water Habitats (WWH) in order to meet aquatic life use designations (Ohio EPA Technical Bulletin MAS/1999-1-1). Field parameters (pH, temperature, specific conductance, and D.O.), were recorded prior to sample collection (Table 2).

Results

Phosphorus concentrations in the EFLMR at river mile (RM) 2.2 were consistently high (OP: 0.33 – 0.64 mg/l, TP: 0.46 – 0.70 mg/l, Table 3). Possible sources of high phosphorus in this section of river include the Milford or Lower East Fork WWTPs, Royal Hills and Orchard Lake package WWTPs, and onsite treatment systems. Wolfpen Run may be a high source of phosphorus to the EFLMR, especially during wet weather (Table 3). OEQ has done extensive survey work here in the past and has determined that high phosphorus loads originate from onsite septic systems and the Royal Hills WWTP. The remaining tributaries downstream of the lake typically had ortho and total phosphorus concentrations below the recommended criteria of 0.10 mg/l total phosphorus in WWH streams. Total phosphorus concentrations exceeded the 0.05 mg/l recommended Ohio EPA criteria for EWH streams at river mile 9.1 (0.17 – 0.42 mg/l) and river mile 13.6 (0.09 – 0.12mg/l) in the EFLMR.

Wet weather samples collected in tributaries downstream of the lake generally had ortho and total phosphorus concentrations below 0.1 mg/l. During wet weather, Wolfpen Run had a total phosphorus concentration of 0.21 mg/l, most likely originating from the high density of onsite sewage treatment systems in this watershed. Four-Mile Run was sampled at river miles 0.2 and 2.0 to determine if either the Bob McEwan Water Treatment Plant or the Elk Lick Golf Course were loading phosphorus to the creek. Both wet weather and dry weather sampling at these locations did not suggest that either facility was a significant source of phosphorus (Table 3).

Sampling events upstream of the lake inadvertently occurred during wet weather more often than sampling events downstream of the lake. Consequentially, phosphorus concentrations upstream of the lake were generally elevated in tributaries and the mainstem of the EFLMR. During wet weather events, ortho-phosphorus concentrations in mainstem EFLMR sites ranged from 0.05 – 0.48 mg/l and total phosphorus concentrations ranged from 0.23 – 1.16 mg/l. At tributaries sites, ortho-phosphorus concentrations ranged from 0.06 – 0.74 mg/l and total phosphorus concentrations ranged from 0.12 – 1.16 mg/l. Total phosphorus concentrations were extremely elevated in two streams during the May sampling event. Concentrations of ortho-phosphorus and total phosphorus in Howard Run were 0.74 mg/l and 0.96 mg/l respectively. Concentrations of ortho-phosphorus and total phosphorus in Five-Mile Creek were 0.67 mg/l and 1.16 mg/l respectively. These two streams continued to have elevated concentrations of phosphorus during the June and July sampling events (Table 3).

During dry weather, total phosphorus was well above the 0.05 mg/l criteria in the mainstem of the EFLMR (RM 28.7: 0.24 mg/l, RM 34.8: 0.29 mg/l, RM 41.0: 0.28 mg/l, RM 44.1: 0.33 mg/l, and RM 46.7: 0.33 mg/l). Possible sources of phosphorus at these sites include the Williamsburg, New Vienna, Lynchburg, St. Martin, and Fayetteville-Perry WWTPs, failing onsite sewage treatment systems, and agricultural non-point sources. During dry weather, Crane Run (OP: 0.12 mg/l, TP: 0.20 mg/l), Four Mile Creek (OP: 0.16 mg/l, TP: 0.23 mg/l), Five Mile Creek (TP: 0.23 mg/l), and Pleasant

Run (OP: 0.11mg/l, TP: 0.16 mg/l) all had phosphorus concentrations greater than 0.1 mg/l, indicating that tributaries are contributing phosphorus to the EFLRM during low flows.

Table 2. Physical parameters collected at ambient sampling sites

Station ID	Sample Date	Specific Conductance (µmho/cm)	Dissolved Oxygen (mg/l)	pH (SU)	Water Temperature (°C)
EFRM2.2	21-May-09	AE	AE	AE	AE
	25-Jun-09	534	6.50	8.10	25.55
	21-Jul-09	501	7.68	8.28	20.89
WLFPN0.1	21-May-09	804	11.40	8.10	16.59
	25-Jun-09	754	7.87	8.36	22.46
	21-Jul-09	761	8.25	8.16	17.21
SUGAR0.2	21-May-09	679	11.27	8.01	16.99
	25-Jun-09	654	10.48	8.27	19.15
	21-Jul-09	686	8.10	8.12	16.14
DRYRN0.1	21-May-09	684	10.10	8.20	16.09
	25-Jun-09	653	8.62	8.12	25.22
	21-Jul-09	709	8.10	8.11	18.07
EFRM9.1	21-May-09	452	11.11	8.36	20.39
	30-Jun-09	335	7.02	7.88	23.01
	21-Jul-09	373	7.99	8.19	21.64
BKBN0.2	21-May-09	633	14.81	8.54	22.18
	29-Jun-09	528	8.15	8.46	17.78
	21-Jul-09	825	9.38	8.12	20.85
EFRM13.6	21-May-09	359	10.89	8.27	21.25
	30-Jun-09	310	7.78	8.17	22.57
	21-Jul-09	296	8.72	8.42	23.45
4MIRN0.2	27-May-09	468	8.89	8.03	19.80
	29-Jun-09	451	8.97	8.28	19.28
	22-Jul-09	380	8.69	8.17	19.80
4MIRN2.0	27-May-09	455	8.60	8.13	20.01
	29-Jun-09	399	8.59	8.40	19.87
	22-Jul-09	341	8.23	8.23	20.56
EFRM28.7	29-May-09	297	7.36	8.08	20.36
	30-Jun-09	357	9.22	8.52	25.54
	28-Jul-09	286	7.41	8.23	22.69
EFRM34.8	27-May-09	509	8.70	8.26	24.08
	01-Jul-09	411	6.54	8.37	22.91
	28-Jul-09	311	7.35	8.15	23.15
CRANE0.2	27-May-09	408	8.65	8.01	21.49
	29-Jun-09	337	8.05	8.29	21.48
	22-Jul-09	463	6.42	8.00	19.05
EFRM41.0	27-May-09	510	8.81	8.15	24.44
	01-Jul-09	447	7.81	8.56	22.99
	28-Jul-09	400	8.57	8.26	23.44
4MILE0.5	28-May-09	372	6.95	7.94	19.40
	29-Jun-09	284	7.87	8.24	21.44
	22-Jul-09	346	6.78	8.10	19.37
PLEAS0.2	28-May-09	541	7.57	7.95	19.50
	29-Jun-09	328	9.46	8.48	24.53
	28-Jul-09	256	9.25	8.43	22.04
5MILE0.5	28-May-09	295	7.16	7.78	20.32
	29-Jun-09	288	8.36	8.18	21.19
	22-Jul-09	367	6.63	8.01	19.23
EFRM44.1	28-May-09	478	6.02	7.88	22.92
	01-Jul-09	399	8.52	8.50	23.06
	28-Jul-09	408	9.10	8.32	23.90
HWRD0.4	28-May-09	430	7.21	7.71	20.06
	01-Jul-09	366	7.75	8.23	20.08
	22-Jul-09	538	5.04	7.69	19.85
GRSSY0.2	29-May-09	549	7.65	7.87	17.70
	01-Jul-09	501	8.61	8.17	19.51
	22-Jul-09	473	7.43	8.09	19.15
EFRM46.7	29-May-09	321	6.72	7.71	20.38
	01-Jul-09	371	7.37	8.14	22.01
	28-Jul-09	414	9.53	8.41	23.81

Table 3. 2009 Ambient grab sampling results for ortho-phosphorus and total phosphorus in milligrams per liter for each month sampled.

		May (21-29)		June 25-July 1		July 21-28	
StationID	Recommended Total-P criteria	ortho-P	Total-P	Ortho-P	Total P	Ortho-P	Total-P
EFRM2.2	**0.05**	**0.33**	**0.46**	**AE**	**0.57**	**0.64**	**0.70**
WLFPN0.1	0.1	0.18	0.28	0.00	0.21	0.10	0.12
SUGAR0.2	0.1	0.03	0.05	AE	0.04	0.01	0.03
DRYRN0.1	0.1	0.03	0.06	0.00	0.08	0.03	0.05
EFRM9.1	**0.05**	**0.16**	**0.20**	**0.05**	**0.17**	**0.29**	**0.42**
BKBN0.2	0.1	0.08	0.14	0.09	0.13	AE	0.05
EFRM13.6	**0.05**	**0.05**	**0.09**	**0.03**	**0.14**	**0.02**	**0.12**
4MIRN0.2	0.1	0.02	0.08	0.02	0.11	0.02	0.04
4MIRN2.0	0.1	0.02	0.04	0.02	0.03	0.02	0.07
EFRM28.7	**0.05**	**0.27**	**0.66**	**0.15**	**0.31**	**0.15**	**0.24**
EFRM34.8	**0.05**	**0.12**	**0.25**	**0.15**	**0.35**	**0.15**	**0.29**
CRANE0.2	0.1	0.24	0.39	0.12	0.20	0.06	0.13
EFRM41.0	**0.05**	**0.20**	**0.33**	**0.08**	**0.26**	**0.08**	**0.28**
4MILE0.5	0.1	0.13	0.21	0.16	0.23	0.09	0.12
PLEAS0.2	0.1	0.13	0.17	0.11	0.16	0.20	0.24
5MILE0.5	0.1	0.67	1.16	AE	0.23	0.21	0.27
EFRM44.1	**0.05**	**0.22**	**0.39**	**0.05**	**0.36**	**0.07**	**0.33**
HWRD0.4	0.1	0.74	0.96	0.14	0.22	AE	AE
GRSSY0.2	0.1	0.22	0.44	0.08	0.14	0.07	0.15
EFRM46.7	**0.05**	**0.48**	**1.16**	**0.09**	**0.30**	**0.07**	**0.23**

Note: AE = analytical error
Phosphorus < 0.1mg/l
Phosphorus 0.1 – 0.19 mg/l
Phosphorus > 0.2 mg/l
Gray shading denotes samples collected within 24 hrs following rain event
Bold font denotes mainstem EFLMR sites

ORTHO PHOSPHORUS DATA

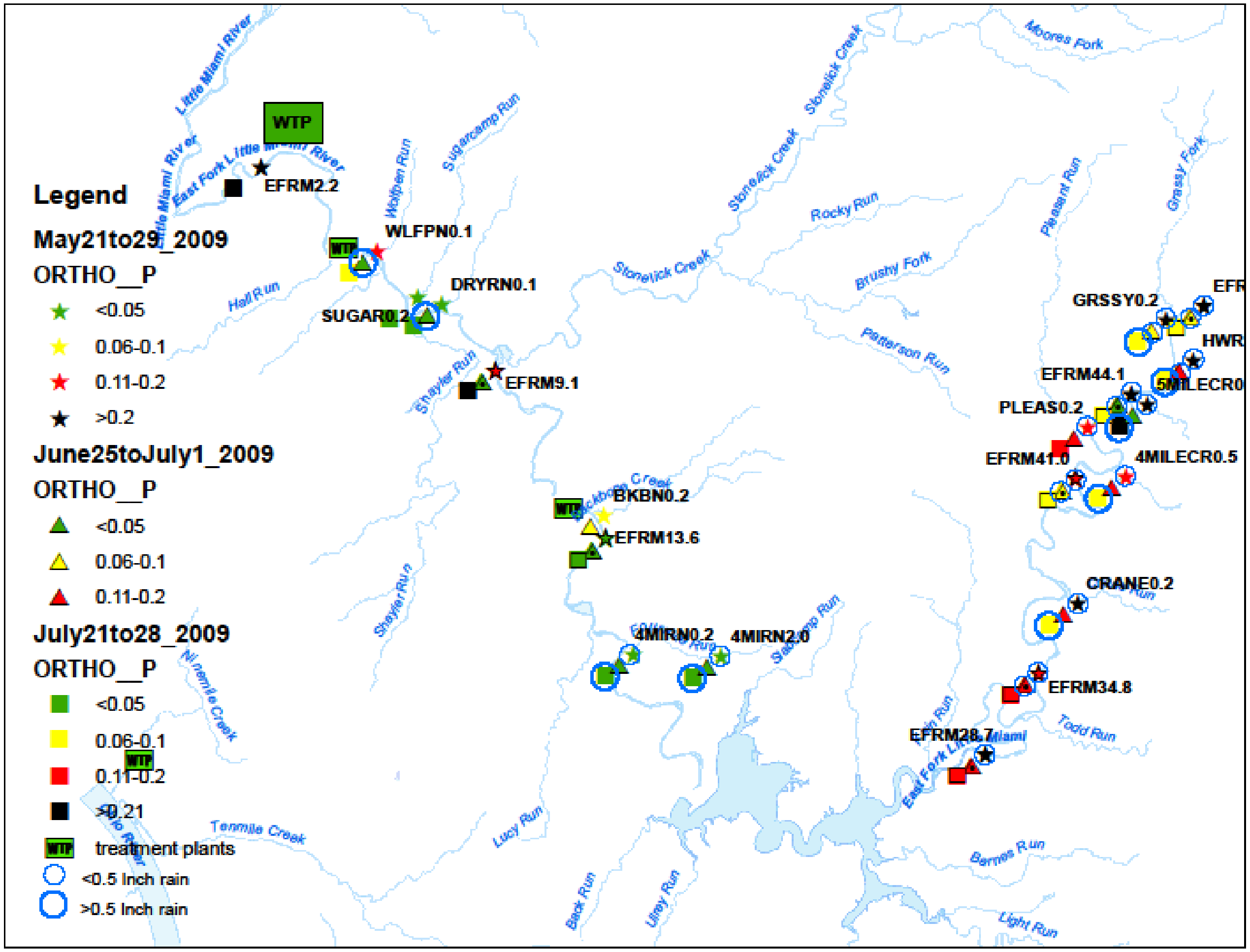


Figure 1. Map of OEQ 2009 ambient sampling sites and USEPA data. Symbol color represents ortho-phosphorus concentrations (mg/l) of monthly grab samples.

TOTAL PHOSPHORUS DATA

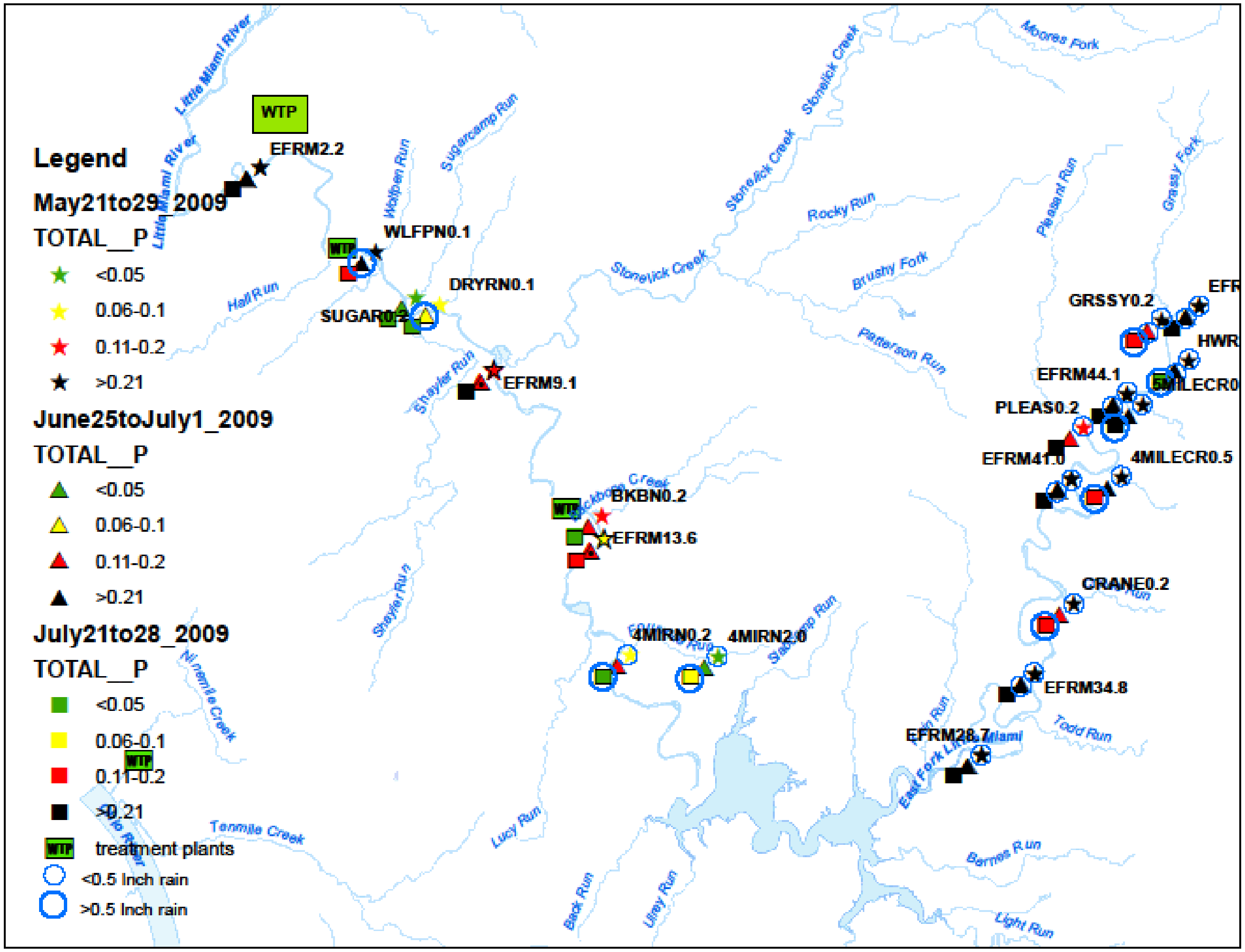


Figure 2. Map of OEQ 2009 ambient sampling sites and USEPA data. Symbol color represents total-phosphorus concentrations of monthly grab samples. Samples taken within 24 hours of a rain event are marked with a blue circle.

Conclusions/Recommendations

With the exception of Wolfpen Run, tributaries downstream of the lake had low phosphorus concentrations even during wet weather events (Figures 1 & 2). High phosphorus concentrations downstream of the lake were found mostly in the mainstem of the EFLMR (Figures 1 & 2). Phosphorus concentrations were high during dry and wet weather in the tributaries and mainstem of the EFLRM upstream of the lake (Figures 1 & 2). However, the dry weather events upstream of the lake all occurred within 72 hours of a precipitation event, which may explain the elevated phosphorus concentrations. These data indicate that Harsha Lake acts as a phosphorus buffer to the lower section of the EFLMR. Because phosphorus has an affinity for soil particles, phosphorus accumulates in the lake sediments resulting in lower phosphorus loads leaving the lake.

OEQ recommends conducting more intensive sampling upstream of the lake in following years to determine specific sources of phosphorus in the watershed. An adaptive sampling plan to increase the sampling frequency and number of sampling sites in tributaries with high phosphorus would help to identify the high non-point source contributors. A collaborative effort with Brown and Clermont County Soil and Water Conservation Districts, National Resource Conservation Service, and property owners to conduct a small-scale pilot watershed management project in a high phosphorus watershed may reduce phosphorus loading to the EFLMR.

Diurnal Dissolved Oxygen Profiles

Sampling Design

OEQ conducted diurnal D.O. studies to investigate the effect of nutrients and organic loads from WWTPs and habitat on D.O. concentrations in the EFLMR and O'Bannon Creek during low flow conditions. D.O. levels naturally swing from high levels during the day to low levels at night. This is due to aquatic algae photosynthesizing (producing oxygen) during the day and respiring (consuming oxygen) at night. High nutrient loading promotes excessive algal growth, which can lead to greater swings in D.O. levels and cause nighttime levels to dip dangerously low for the aquatic biota. Additionally, effluent from WWTPs can contribute organic materials that increase oxygen demand during biodegradation. Diurnal D.O. monitoring above and below wastewater treatment plants helps to identify any impact from WWTP effluent on D.O. concentrations.

Sondes were placed just upstream of riffles (from here on referred to as riffle sites) or in pools to determine if diurnal D.O. patterns vary by habitat. To determine if organic enrichment and nutrient loading from WWTPs affect stream diurnal D.O. concentrations, 24-hour D.O. profiles were monitored simultaneously upstream and downstream from each WWTP and water samples analyzed for five day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$), total phosphorus, and ortho-phosphorus were collected at the time of sonde deployment and sonde retrieval at each riffle D.O. site. The typical monitoring design consisted of one riffle and one pool site upstream of each WWTP, and two riffle and two pool sites downstream of each WWTP (Table 4). Only one riffle site was monitored downstream of the LEF and Milford WWTPs because riffles habitats are less common in the lower section of the EFLMR. Only one riffle and one pool site were included downstream of the Batavia WWTP because of the close proximity between the Batavia and Middle East Forks' outfalls. Instead, D.O. was monitored at two riffle and two pool habitats upstream of the Batavia WWTP, at a riffle and pool site downstream of the Batavia lowhead dam and at a riffle and pool site upstream of the Batavia lowhead dam. Sites were monitored upstream of the dam in order to have a comparison to the highly aerated sites downstream of the dam and to begin collecting data in support of a future lowhead dam removal project.

Table 4. Sample Identifications and descriptions of each sample site monitored in the Dissolved Oxygen Studies.

Location	Sample ID
O'Bannon Creek RM 1.9 Downstream of O'Bannon WWTP – riffle site	DSOB1.9R
O'Bannon Creek RM 2.0 Downstream of O'Bannon WWTP – pool site	DSOB2.0P
O'Bannon Creek RM 2.4 Downstream of O'Bannon WWTP – riffle site	DSOB2.4R
O'Bannon Creek RM 2.5 Downstream of O'Bannon WWTP – pool site	DSOB2.5P
O'Bannon Creek RM 3.1 Upstream of O'Bannon WWTP – riffle site	USOB3.1R
O'Bannon Creek RM 3.2 Upstream of O'Bannon WWTP – pool site	USOB3.2P
EFLMR RM 0.2 Downstream of Milford WWTP – pool site	DSMIL0.2P
EFLMR RM 0.7 Downstream of Milford WWTP – pool site	DSMIL0.7P
EFLMR RM 0.8 Downstream of Milford WWTP – riffle site	DSMIL0.8R
EFLMR RM 2.1 Upstream of Milford WWTP– riffle site	USMIL2.1R
EFLMR RM 2.2 Upstream of Milford WWTP – pool site	USMIL2.2P
EFLMR RM 3.6 Downstream of Lower East Fork WWTP – riffle site	DSLEF3.6R
EFLMR RM 3.7 Downstream of Lower East Fork WWTP – pool site	DSLEF3.7P
EFLMR RM 4.0 Downstream of Lower East Fork WWTP – pool site	DSLEF4.0P
EFLMR RM 4.1 Downstream of Lower East Fork WWTP – riffle site	DSLEF4.1R
EFLMR RM 5.2 Upstream of Lower East Fork WWTP – riffle site	USLEF5.2R
EFLMR RM 5.3 Upstream of Lower East Fork WWTP– pool site	USLEF5.3P
EFLMR RM 11.1 Downstream of Middle East Fork – pool site	DSMEF11.1P
EFLMR RM 11.2 Downstream of Middle East Fork – riffle site	DSMEF11.2R
EFLMR RM 11.9 Downstream of Middle East Fork – riffle site	DSMEF11.9R
EFLMR RM 12.0 Downstream of Middle East Fork – pool site	DSMEF12.0P
EFLRM RM 12.6 Upstream of Middle East Fork WWTP – riffle site	USMEF12.6R
EFLMR RM 12.7 Upstream of Middle East Fork WWTP – pool site	USMEF12.7P
EFLMR RM 12.6 Downstream of Batavia WWTP – riffle site	DSBAT12.6R
EFLMR RM 12.7 Downstream of Batavia WWTP– pool site	DSBAT12.7P
EFLMR RM 13.5 Upstream of Batavia WWTP – riffle site	USBAT13.5R
EFLMR RM 13.6 Upstream of Batavia WWTP – pool site	USBAT13.6P
EFLMR RM 13.9 Upstream of Batavia WWTP and lowhead dam – pool site	USBAT13.9P
EFLMR RM 14.3 Upstream of Batavia WWTP and lowhead dam – riffle site	USBAT14.3R

Results

$CBOD_5$ was 3.2 mg/l at river mile 1.9 in O'Bannon Creek and below the Minimum Detection Limit (MDL, 2.0 mg/l) at the other two locations (Figure 3). Both ortho and total phosphorus concentrations were highest at river mile 2.4 (Figure 3). The D.O. concentrations exhibited the greatest swing at this location as well (Figure 3). With the exception of the far-field downstream sites, D.O. was very similar between riffle and pool habitats in O'Bannon Creek.

The far-field downstream D.O. profile for Milford WWTP was not collected due to technical issues with the YSI multi-parameter sonde. Ortho and total phosphorus and $CBOD_5$ were slightly higher downstream of the WWTP (Figure 4). D.O. concentrations were higher in riffle habitats than in pool habitats and exhibited higher diurnal swings in concentration downstream of the WWTP (Figure 4).

Ortho and total phosphorus concentrations were similar at the EFLRM sites downstream from LEF WWTP (Figure 5). Phosphorus concentrations downstream from the plant were slightly higher than upstream concentrations (Figure 5). $CBOD_5$ concentrations were below the MDL at all three sites (Figure 5). D.O. concentrations ranged from 10.02 and 7.26 mg/l and the profiles were very similar across all sites and habitats (Figure 5).

Ortho and total phosphorus concentrations were similar at the EFLRM sites downstream from the MEF WWTP outfall (Figure 6). Phosphorus concentrations downstream from the plant were higher than the upstream concentrations (Figure 6). $CBOD_5$ was less than the MDL at the near-field downstream site and the upstream site and was 2.45 mg/l at the far-field downstream site (Figure 6). D.O. concentrations were higher in riffle habitats than in pool habitats across all sites (Figure 6). The diurnal D.O. swing was greatest in the near-field downstream site than in the other sites.

Total phosphorus concentrations were similar at sites upstream and downstream of the Batavia WWTP (Figure 7). $CBOD_5$ was less than the minimum detection limit at all three locations (Figure 7). D.O. concentrations downstream from the dam were typically higher than concentrations upstream from the dam and the highest D.O. concentrations were found at the riffle site just immediately downstream of the dam.

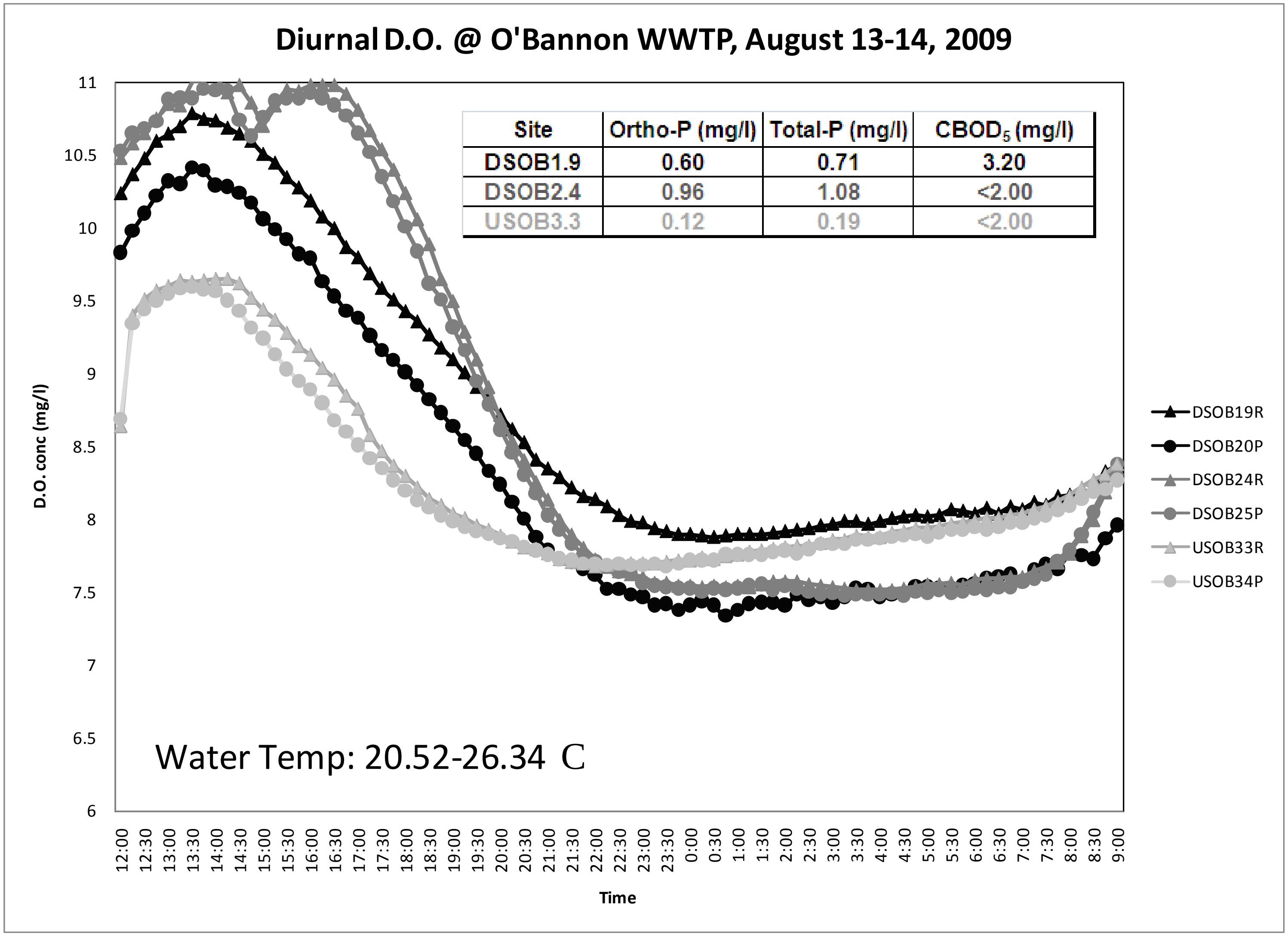


Figure 3. 24-hour Diurnal Dissolved Oxygen profiles in O'Bannon Creek upstream and downstream from the outfall at O'Bannon Creek WWTP. The temperature range and $CBOD_5$, ortho-phosphorus, and total-phosphorus concentrations at each site are reported. The chemistry table text color corresponds to the site name in the graph legend.

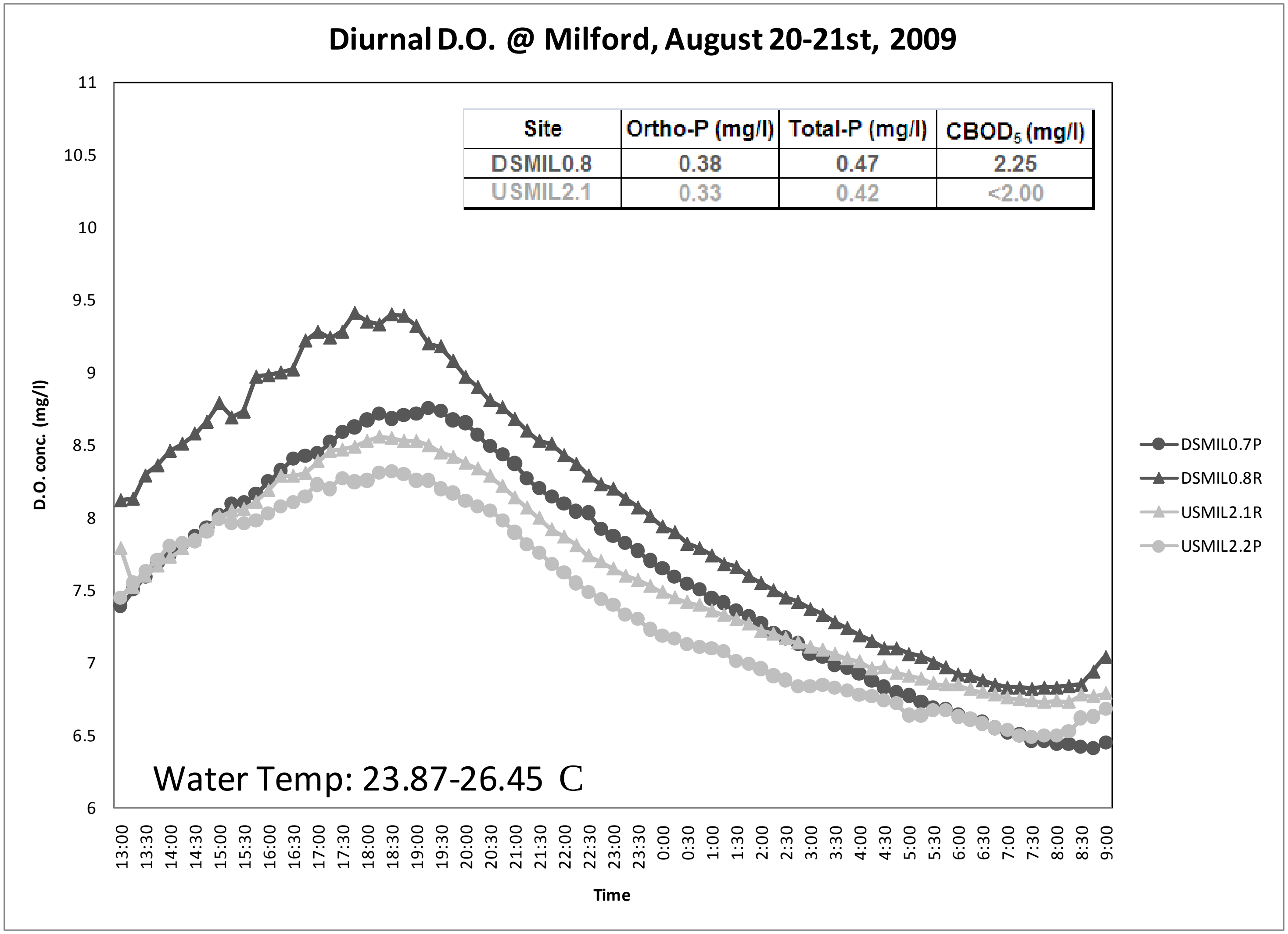


Figure 4. 24-hour Diurnal Dissolved Oxygen profiles in the East Fork of the Little Miami River upstream and downstream from the outfall at Milford WWTP. The temperature range and $CBOD_5$, ortho-phosphorus, and total-phosphorus concentrations at each site are reported. The chemistry table text color corresponds to the site name in the graph legend.

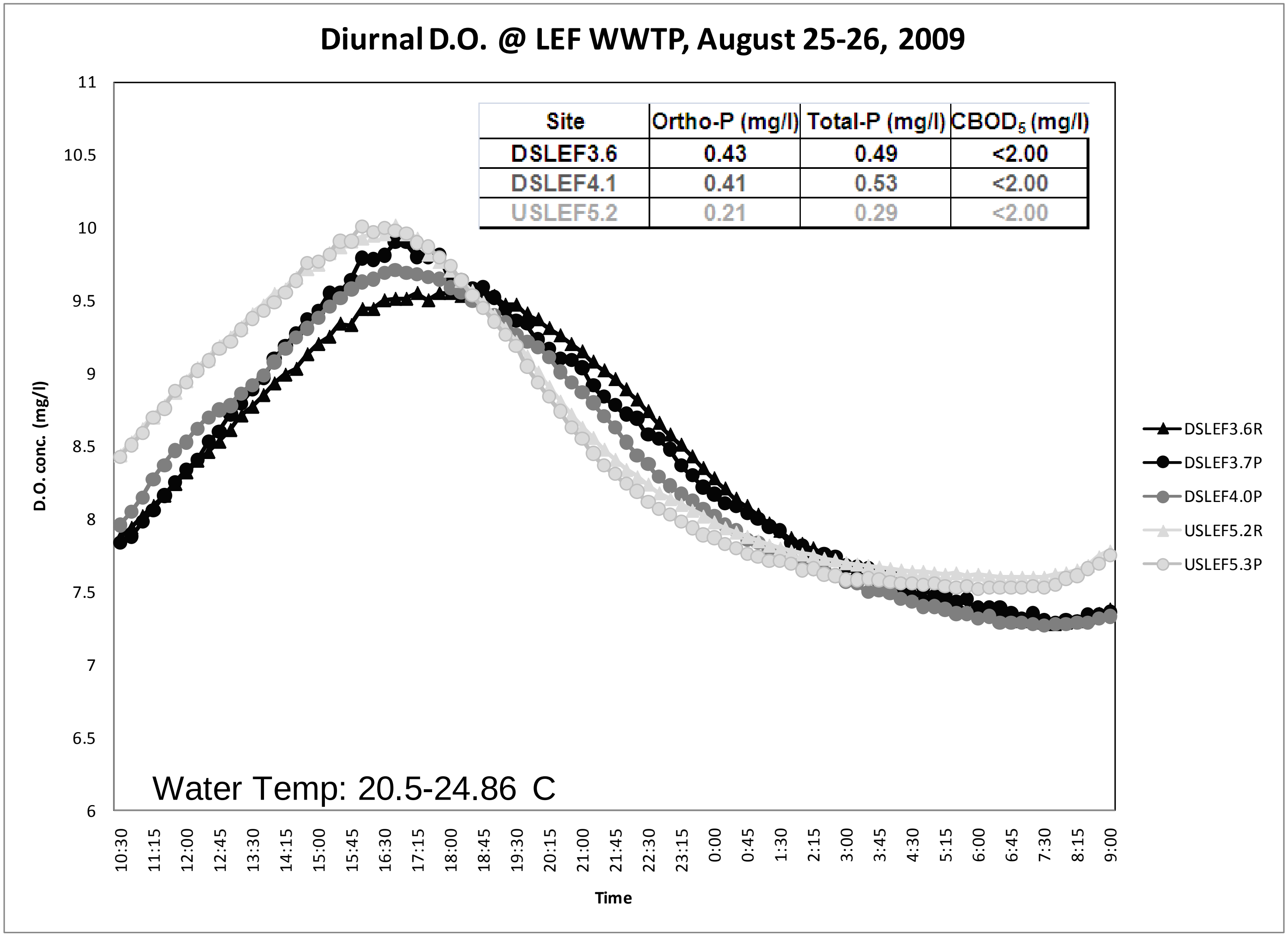


Figure 5. 24-hour Diurnal Dissolved Oxygen profiles in the East Fork of the Little Miami River upstream and downstream from the outfall at Lower East Fork WWTP. The temperature range and $CBOD_5$, ortho-phosphorus, and total-phosphorus concentrations at each site are reported. The chemistry table text color corresponds to the site name in the graph legend.

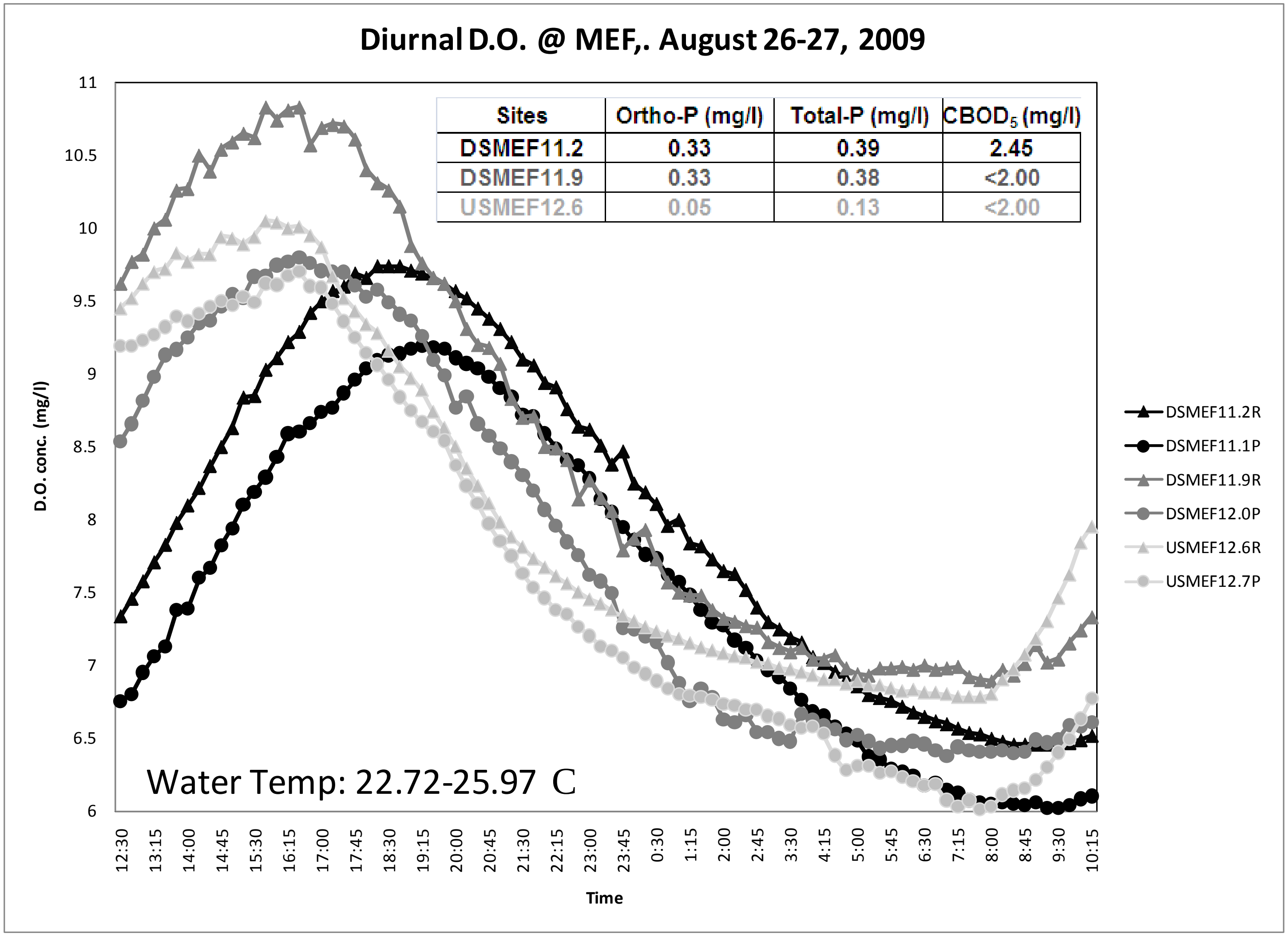
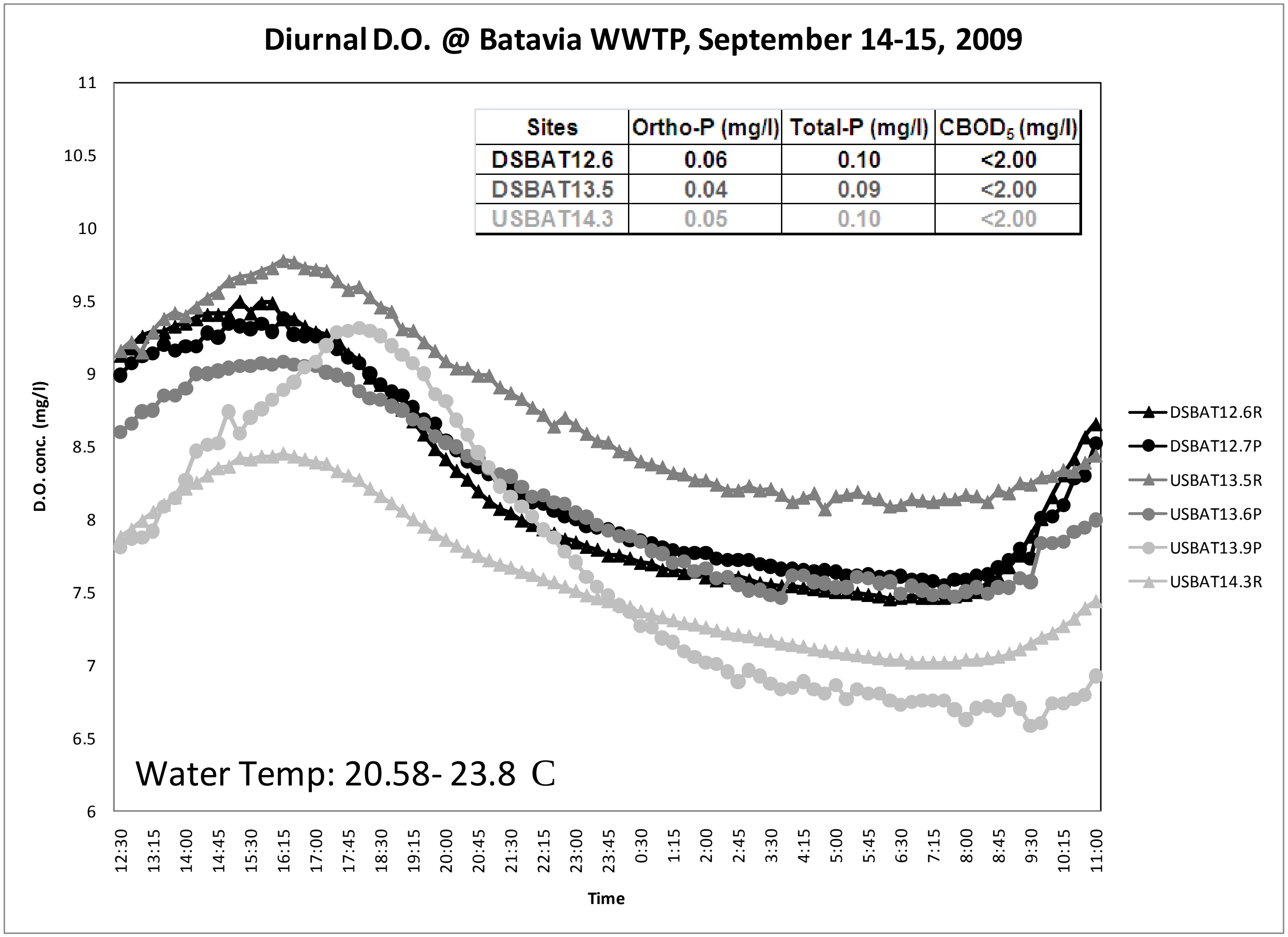


Figure 6. 24-hour Diurnal Dissolved Oxygen profiles in the East Fork of the Little Miami River upstream and downstream from the outfall at Middle East Fork WWTP. The temperature range and $CBOD_5$, ortho-phosphorus, and total-phosphorus concentrations at each site are reported. The chemistry table text color corresponds to the site name in the graph legend.



Sites	Ortho-P (mg/l)	Total-P (mg/l)	$CBOD_5$ (mg/l)
DSBAT12.6	0.06	0.10	<2.00
DSBAT13.5	0.04	0.09	<2.00
USBAT14.3	0.05	0.10	<2.00

Figure 7. 24-hour Diurnal Dissolved Oxygen profiles in the East Fork of the Little Miami River upstream and downstream from the outfall at Batavia WWTP. The temperature range and $CBOD_5$, ortho-phosphorus, and total-phosphorus concentrations at each site are reported. The chemistry table text color corresponds to the site name in the graph legend

Conclusions/Recommendations

Nutrient concentrations were typically higher at sites downstream from WWTPs than at upstream sites and D.O. concentrations were higher in riffle sites than in pool sites. Yet overall, D.O. concentrations were supportive of aquatic life at all sites regardless of habitat, nutrient enrichment, or proximity to WWTP outfalls. The lowest observed D.O. concentration was 6.01 mg/l, which is well above Ohio EPA's criteria of a minimum of 5.0 mg/l D.O. for point observations in EWH streams. The generally high D.O. concentrations may have been a result of the cool, wet summer weather in 2009. According to the National Weather Service, Cincinnati received 19.29 inches of rainfall between June and September in 2009 and 11.6 inches of rainfall during the same months in 2008. More rainfall leads to higher flows and lower water temperatures, conditions which favor higher D.O. concentrations. The impacts of weather on D.O. concentrations can be seen when looking at the lowest D.O. concentrations recorded in each year. D.O. was 5.42 mg/l downstream from the MEF WWTP in 2008; but in 2009, D.O. only dropped to 6.01 mg/l in a pool upstream from the MEF WWTP. OEQ should conduct this study in a year with drier summer conditions to attain the worst case scenario for D.O. concentrations in the EFLMR and O'Bannon Creek.

Habitat Assessments

Sampling Design

The QHEI was developed by scientists at the Ohio EPA to enable rapid assessment of habitat quality in a stream. It is correlated to the biological integrity of fish assemblages and can be used to assign aquatic life uses and assess causes of impairment. Narrative interpretation of the QHEI can be found in Table 5.

Because aquatic life uses assigned to headwater and wadeable streams aren't applicable in primary headwater streams (less than 1 mi^2 watershed or maximum pool depth less than 40cm), the Ohio EPA established aquatic life uses, or "classes", for these streams. Ohio EPA then created the HHEI, which enables rapid determination of primary headwater stream class. Class I streams have ephemeral flow and have limited aquatic life present, Class II streams have perennial or intermittent flow and warm-water adapted fauna, and Class III streams have perennial flow and cold-water adapted fauna (Figure 8).

Previous research has shown that impaired habitats are a primary stressor on biotic communities in the East Fork River and its tributaries. Therefore, improvements to in-stream habitat must be made to meet biological criteria in the East Fork watershed. Clermont County selected four streams as possible restoration candidates and conducted habitat assessments on those four streams to determine their potential for restoration. Lucy Run was chosen for assessment because Ohio EPA reported that habitat impairment is the significant cause of biological impairment. Backbone Creek was assessed because there is significant bank failure and exposed sewer lines in this stream and Ohio EPA does not have physical or biological data for this stream. Shayler Run was chosen because a section of this stream has become channelized, exposing a sanitary sewer line. The Clermont County Sewer District is installing a microtunnel to bypass the exposed sewer line and will abandon the old line once construction is complete. This section of Shayler Run may be a good candidate for restoration to create a more natural meandering channel. Hall Run was chosen for habitat assessment to document the before condition of the reach prior to the natural stream channel design restoration project planned by the Clermont County Stormwater Department. Due to flashy hydrology in this section of Hall Run there is significant down-cutting and erosion, which has exposed a sanitary sewer line.

An HHEI was conducted in Lucy Run because the watershed of the assessment reach is smaller than 1 mi^2 and pools were less than 40 cm deep. A 60-m reach upstream from river mile 2.8 was assessed and methods from the *Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams* were followed exactly. QHEIs were performed on 200 meter reaches of Backbone Creek (RM 0.5), Hall Run (RM 1.7) and Shayler Run (RM 2.4) using *Methods for assessing habitat in flowing waters: Using the*

Qualitative Habitat Evaluation Index (QHEI). Habitat assessments were conducted by a level III certified quality data collector (QDC # 274) between the months of April and August of 2009 and after 72 hours following a rain event (24 hours for HHEI). Exceptionally cloudy days were avoided to ensure accurate visual assessments of habitat.

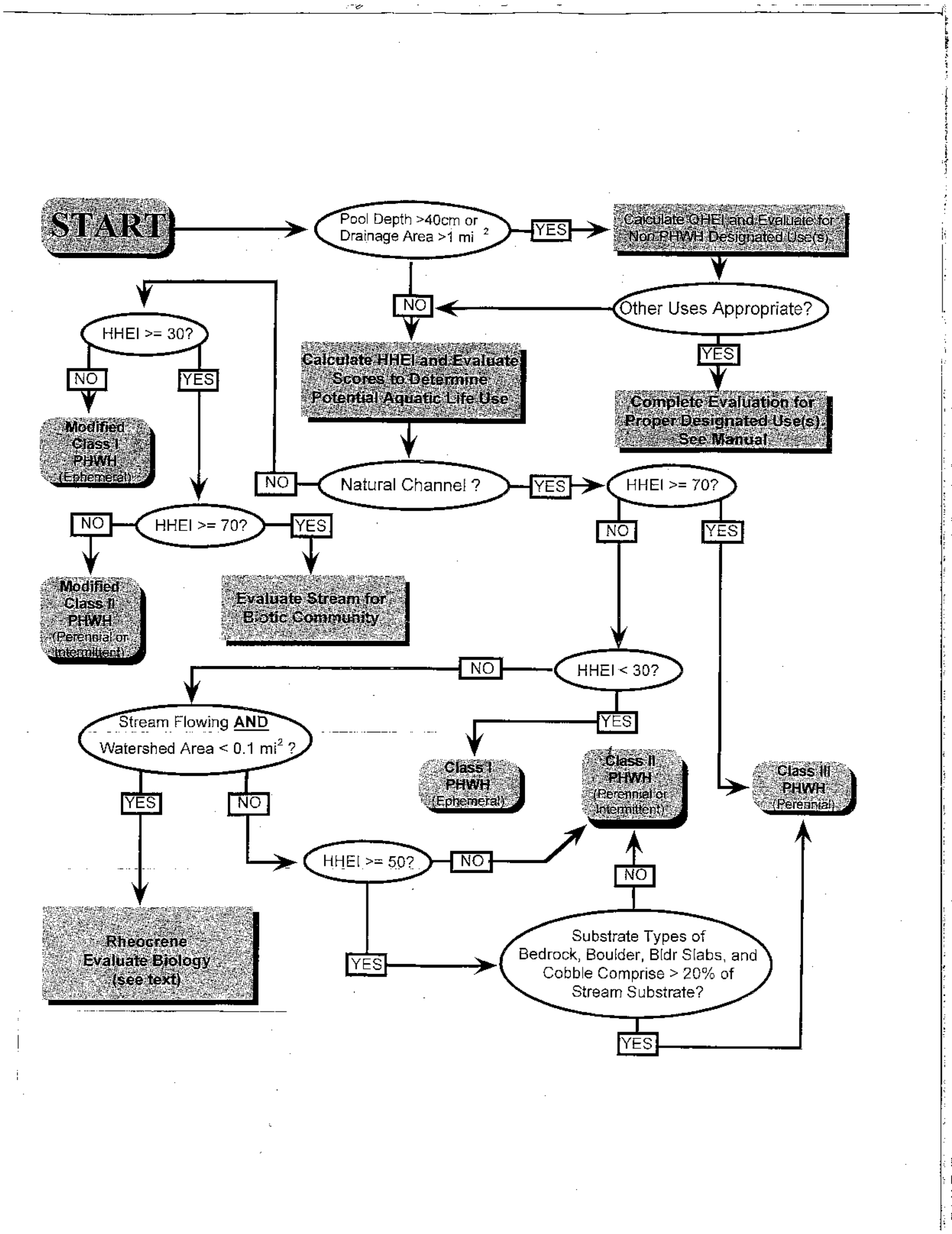


Figure 8. Ohio EPA flow chart used to determine headwater streams class.

Table 5. General narrative ranges assigned to QHEI scores. Ranges vary slightly in headwater streams (≤ 20 sq. mi.) versus larger streams.

Narrative Rating	QHEI RANGE	
	Headwaters	Larger Streams
Excellent	≥ 70	≥ 75
Good	55 – 69	60 –74
Fair	43 –54	45 – 59
Poor	30 – 42	30 – 44
Very Poor	< 30	< 30

Results

Lucy Run substrate consisted predominantly of cobble and gravel (Table 6). Substrate was diverse with boulder slabs, boulders, bedrock, cobble, gravel, sand, and silt comprising some portions of the habitat. Maximum pool depth was approximately 19 cm and bankfull width ranged between 4.5 – 5.4 m (Table 6). The total HHEI score of 83 for Lucy Run indicates it is a class III primary headwater habitat, which is a perennially flowing stream (Figure 8 & Table 6).

Substrate composition and heterogeneity in Backbone Creek was good, with cobble and gravel being the two most dominant substrates (Table 7). Instream cover was low due to sparse cover of only four different cover types (Table 7). Channel morphology was good and bank erosion was high especially on the outside bend of the river right bank where the riparian zone was very narrow (Table 7). Pool habitat quality was good, while current velocity had very little variation (Table 7). Riffle run quality was fair due to the interstitial flow in the riffles (Table 7). Backbone Creek has a very high gradient and therefore scored fair on the gradient metric (Table 7). The total QHEI score for Backbone Creek was 64, indicating good habitat in this reach (Table 7).

The substrate in Hall Run was variable and in some sections was comprised primarily of bedrock shale. Instream cover was low with only five types providing sparse instream cover. The channel morphology metric scored fair/good due to fair/poor channel development. The riparian zone and floodplain were highly forested in this section of

Hall Run, but there was moderate erosion. Pools were wide but shallow and the current had little heterogeneity. Riffle/run quality was scored as fair because flows were low and run habitats were scarce. Hall Run has a steep slope and therefore scored fair on the gradient metric. The total QHEI score for Hall Run was 59.5, indicating good habitat in this reach.

The substrate in Shayler Run was highly variable, being comprised mostly of boulders and cobble. Instream cover was fair because there was only moderate cover from just three types of cover. Channel morphology was good but not great due to the low sinuosity in this reach. There was little bank erosion in this reach and the riparian zone was well forested. Pools were narrow and shallow and there were variable current velocities, which resulted in a fair/poor pool quality metric. Riffle and run quality was good and the gradient was very high in this assessment reach. The total QHEI score for Shayler Run was 70.5, indicating excellent habitat in this reach.

Table 6. Headwater Habitat Evaluation Index (HHEI) results for Lucy Run Headwaters at river mile 2.8.

METRIC	ASSESSMENT	SCORE
SUBSTRATE	Dominant types: Cobble & Gravel	28
MAXIMUM POOL DEPTH	Depth: 19 cm	25
BANK FULL WIDTH	Width: 5.4, 4.5, & 5.4 m	30
TOTAL SCORE	**CLASS III PHWH (perennial)**	**83**

Table 7. Qualitative Habitat Evaluation Index (QHEI) scores broken down by metric for Backbone Creek, Hall Run, and Shayler Run.

Stream	Backbone Creek (RM0.5)		Hall Run (RM 1.7)		Shayler Run (RM 2.4)	
QHEI TOTAL	**GOOD**	**64.0**	**GOOD**	**59.5**	**EXCELLENT**	**70.5**
SUBSTRATE METRIC (20)	18		15.5		20	
dominant	Cobble + Gravel	15	cobble + bedrock	13	boulder + cobble	17
number of best types	four	2	five	2	six	2
origin	limestone	1	limestone	1	limestone	1
silt	normal	0	normal	0	normal	0
embeddedness	normal	0	moderate/normal	-0.5	normal	0
INSTREAM COVER METRIC (20)	9		8		10	
types	undercut banks, overhanging vegetation, pools, boulders	6	shallows, rootwads, boulders, oxbows, woody debris	5	overhanging vegetation, shallows, boulders	3
amount	sparse	3	sparse	3	moderate	7
CHANNEL MORPHOLOGY METRIC (20)	15.5		13		15	
sinuosity	moderate	3	moderate	3	low	2
development	good	5	fair/poor	2	good	5
channelization	none	6	none	6	none	6
stability	moderate	2	moderate	2	moderate	2
BANK EROSION/RIPARIAN ZONE METRIC (10)	6.25		9		8.5	
erosion	moderate	2	moderate	2	RR: none/moderate, RL: moderate	2.25
riparian width	RL: wide, RR:narrow/very narrow	2.75	RL & RR: wide	4	RL & RR: wide	4
floodplain quality	RL: residential/forest, RR: residential	1.5	RL & RR: forest	3	RL: forest/residential, RR: forest/old field	2.25
POOL AND CURRENT QUALITY METRIC (12)	7.5		5		6	
maximum depth	0.7-<1 m	4	0.4-<0.7m	2	0.4-<0.7	2
channel width	pool width>riffle width/pool width = riffle width	1.5	pool width > riffle width	2	pool width < riffle width	0
current velocity	moderate & slow	2	moderate, slow, interstitial	1	very fast, fast, moderate, slow	4
RIFFLE/RUN QUALITY METRIC (8)	4		5		7	
riffle depth	best areas < 5cm	0	best areas 5-10cm	1	best areas > 10 cm	2
run depth	maximum < 50 cm	1	maximum <50cm	1	maximum < 50 cm	1
riffle/run substrate	stable	2	stable	2	stable	2
riffle/run embeddedness	low	1	low	1	none	2
GRADIENT METRIC (10)	4		4		4	
gradient	67 ft/mile		100 ft/mi		100 ft/mi	
drainage area	7.25 mi^2		<9.2 mi^2		11.2 mi^2	

Conclusions/Recommendations

Lucy Run at river mile 2.8 is a class III stream and likely has cold water adapted macroinvertebrate fauna. Class III streams are the headwater stream equivalent of exceptional warm water streams, making them good candidates for restoration and preservation. The year 2000 305 (b) report states that nonpoint source runoff in the headwaters and high bacterial loads threaten aquatic life use attainment. Relocating the stream channel away from the exposed sanitary sewer may protect the stream from potential sewer breaks and resulting impacts on sewage impacts to biological health.

Backbone Creek is also threatened by an exposed sanitary sewer line. The QHEI in this reach scored good, indicating the habitat in this reach should generally support a healthy assemblage of warm-water adapted fish. There is some room for improvement in habitat; but, the necessity of improvement is unknown without knowing whether this stream is in aquatic life use attainment.

Due to the flashy hydrology inflicted by impervious surfaces in the watershed, sections of Hall Run are highly entrenched and disconnected from the floodplain. Such habitat impairments likely contribute to the partial attainment of the WWH aquatic life use designation for Hall Run. Hall Run scored low in the pool quality and instream cover metrics. Bedrock shale dominated the substrate in some sections of the assessed reach. Habitat improvements in this reach would greatly increase substrate diversity, instream cover, and riffle pool variability. Isolating the stream from the exposed sewer line would also reduce the potential for sewer line breaks and the associated detrimental impacts on the biota.

The year 2000 305 (b) report suggests that widespread sewage impacts threaten aquatic life use attainment in Shayler Run. The proposed sanitary sewer microtunnel project will abandon the exposed sewer line from the stream bed and reduce sewage impacts. However, this stream reach will remain channelized unless the habitat is restored. The reach assessed for habitat was located downstream of the channelized section and scored on the lower range of "excellent" with a QHEI score of 70.5. This indicates the channelized reach of Shayler Run has the potential to have high quality habitat similar to the assessed reach, if sinuosity and habitat heterogeneity are improved. A QHEI of the channelized reach should be performed in 2010 to determine the extent of habitat modification in this reach and whether this reach is capable of harboring warm-water fish assemblages.