Clermont County Office of Environmental Quality
2008 Water Quality Sampling Final Report

March 3, 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 thirteenth year of the program, the 2008 sampling schedule was designed with these goals in mind, and consisted of two components. The first component, Pepper Ridge sampling, was designed to investigate the source of occasionally elevated levels of total phosphorus (TP) and *E. coli* in Hall Run. Samples were collected from Hall Run and an unnamed tributary to Hall Run (Pepper Ridge Tributary) and analyzed for nitrite-nitrate (NO_2-NO_3), dissolved ortho-phosphates (ortho-P), total phosphorus (TP), five-day carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS), and bacterial pollution (*E. coli*). Pepper Ridge sampling consisted of two sampling subcomponents-the original sampling design, with wet and dry weather sampling, and an extended sampling design, with additional dry weather sampling in Pepper Ridge Tributary. The original sampling design was created under the assumption that any contamination from home sewage treatment systems in the Pepper Ridge Subdivision would be highest during base flow conditions, due to minimal dilution effects, where as contamination from sewer system exfiltration would exist primarily during wet weather events. The extended sampling design was created at the end of the season and was aimed at determining sources of pollution in Pepper Ridge Tributary.

The second component involved 24-hour (diurnal) monitoring of dissolved oxygen (DO) above and below the effluent outfall of four wastewater treatment plants (WWTP) that discharge into the East Fork of the Little Miami River-Batavia, Middle East Fork, Lower East Fork and Milford WWTPs. 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 DO profiles above and below the plants' outfall should indicate whether nutrient loading is leading to DO depletion downstream of WWTPs, which could, in turn, impact the river's biological health. The County's ability to monitor DO has recently increased due to the acquisition of two additional multi-parameter data sondes with internal memory. In 2008 the Office of Environmental Quality (OEQ) was able to simultaneously monitor upstream and downstream sampling locations. Since variations in weather can impact DO levels, simultaneous monitoring provides an extra level of control and eliminates the uncertainty associated with comparing data collected on different dates. Sites were monitored during summer base flow conditions to maximize any impacts from high temperatures and nutrients on DO concentrations.

This report summarizes the results from these two components of the County's 2008 sampling program. No biological sampling was performed by Clermont County in 2008.

Pepper Ridge Survey

Subcomponent One - Original Sampling (Dry and Wet Weather)

Sampling Design

As mentioned in the introduction, 2007 sampling revealed high levels of bacterial and nutrient pollution in Hall Run. The Pepper Ridge Subdivision (located west of Beechwood Road) has approximately 50 discharging home sewage treatment systems (HSTS) that are possible pollutant sources since many were installed in the 1970s. In addition, there is a large sanitary sewer line located adjacent to Hall Run which could be contributing pollutant loadings to the stream due to exfiltration during rain events. Sampling in 2008 was aimed at determining the major source of pollutants in Hall Run. OEQ sampled the Pepper Ridge Tributary (PRTRIB), which enters Hall Run at river mile 1.4, and Hall Run upstream (HALL1.5) and downstream (HALL1.4) of the tributary's mouth (Figure 1, Table 1). Samples were taken in these three locations during two wet weather and three dry weather events. Dry events were characterized as having no more than 0.1 inch of rain within the last 72 hours and wet events were characterized as having greater than 0.1 inches of rain, on a day that had no rainfall within the previous 72 hours (Table 2). During the wet weather event on August 5th, two sampling events were conducted. One series of samples was collected during the rising limb of the Hall Run hydrograph, and the second series of samples was collected during the peak of the Hall Run hydrograph (Figure 2). Parameter measurements from these two sampling events were averaged when reporting mean wet weather values and conducting statistical analyses. A late summer drought prevented sample collection for the third wet weather event proposed in the sampling plan.

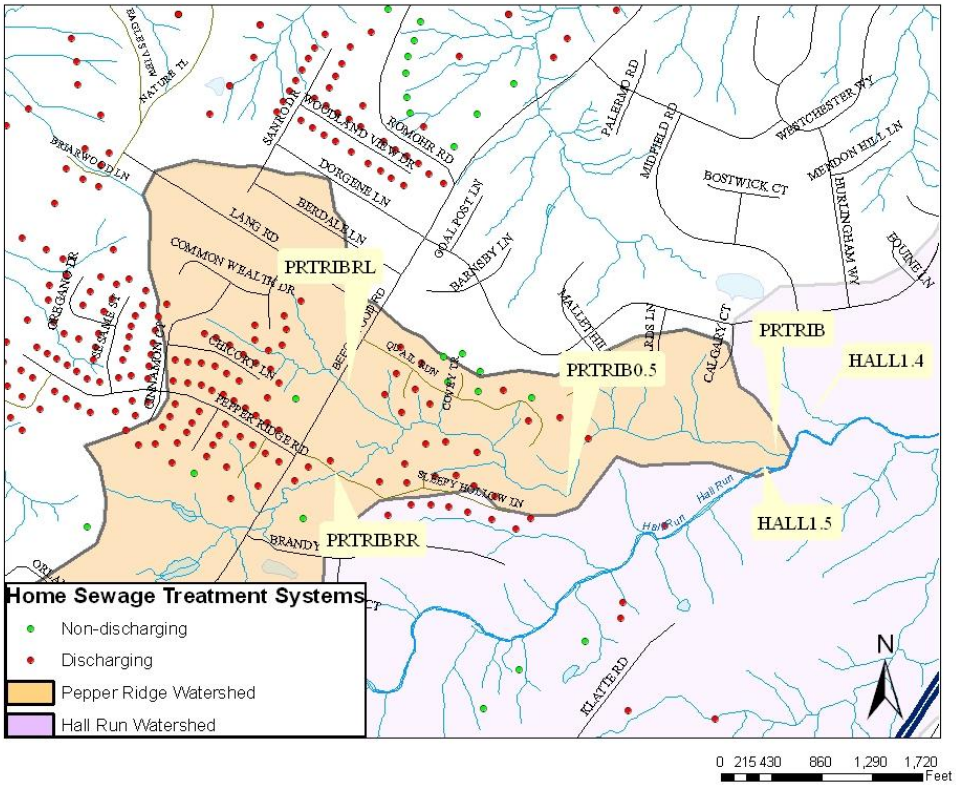

Figure 1 Map of sampling sites for the Pepper Ridge Survey.

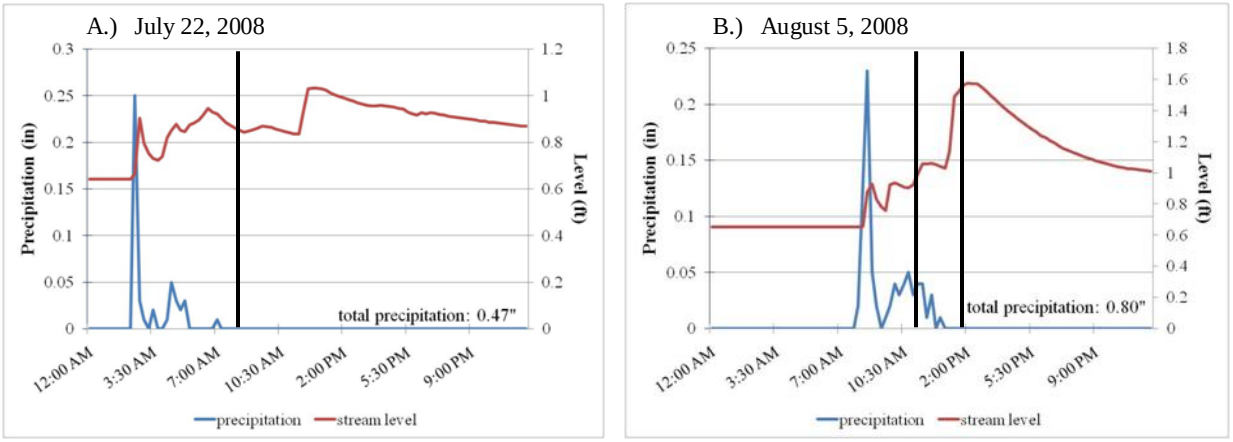

Figure 2 Rainfall and stream level during the Pepper Ridge Wet Weather Sampling events. Data is from the Hall Run monitoring station at river mile 0.2. Vertical lines denote the time of sample collection.

Table 1 List of Pepper Ridge Survey Subcomponent One (Wet and Dry Weather) sample IDs and locations.

Location	Sample ID
Hall Run, u/s Confluence of Tributary	HALL1.5
Hall Run, d/s Confluence of Tributary	HALL1.4
Pepper Ridge Tributary, just u/s Confluence	PRTRIB

Table 2 Sample dates and weather categories along with total precipitation at Hall Run river mile 0.2, within 72 hours prior to the sampling event.

Sample Date	Sample Time	Sample Category	Precipitation (in)
7/17/2008	10:08 AM	Dry	0.00
7/22/2008	8:33 AM	Wet	0.47
7/25/2008	9:50 AM	Dry	0.00
8/5/2008[t]	10:58 AM	Wet	0.80
8/5/2008[t]	1:28 PM	Wet	0.80
8/14/2008	9:33 AM	Dry	0.02

[t]wet weather event with two sampling events

Results

During dry weather none of the sampling locations had nitrogen concentrations above the Ohio EPA recommended criteria value of 1.0 mg/l for wadeable streams designated as warm water habitat (WWH; *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams*, Ohio EPA Technical Bulletin MAS/1999-1-1; Table 3). However, during wet weather, both HALL1.4 and PRTRIB had nitrogen concentrations exceeding the recommended limit of 1.0 mg/l and concentrations in PRTRIB and HALL1.4 were significantly higher than in HALL1.5 (Table, Figure 3). This indicates that Pepper Ridge Tributary is a significant source of nitrogen for Hall Run, as nitrogen concentrations increased above the recommended limit of 1.0 mg/l downstream of its confluence with Pepper Ridge Tributary.

Ortho-phosphate levels were higher in PRTRIB than in the Hall Run sites, and concentrations increased in Hall Run downstream of the confluence with Pepper Ridge Tributary (Table 3). There is no Ohio EPA proposed in-stream criteria value for ortho-phosphate, but on all wet weather events and two out of three dry weather events, ortho-phosphate concentrations in PRTRIB were above the *total phosphorus* criteria value of 0.10 mg/l (0.17-0.28 mg/l; 0.09-0.11 mg/l; Table 3). Pepper Ridge Tributary had the highest concentrations of total phosphorus as well. During dry weather, total phosphorus concentrations only exceeded the Ohio EPA proposed criteria value of 0.10 mg/l in the Pepper Ridge Tributary (Table 3). Though total phosphorus levels were significantly higher in HALL1.4 than in HALL1.5, total phosphorus concentrations at both Hall Run sites were still lower than 0.10 mg/l and ranged between 0.05

and 0.06 mg/l (Table 3, Figure 3). During wet weather events, PRTRIB and HALL1.4 both had phosphorus concentrations significantly higher than HALL1.5 (Figure 3). During storm events, Pepper Ridge tributary was contributing enough phosphorus to Hall Run to substantially increase the concentration of total phosphorus downstream of the confluence. However, despite the significant phosphorus contributions of Pepper Ridge Tributary to Hall Run, it should be noted that concentrations of phosphorus upstream of the confluence were already above the proposed value of 0.10 mg/l prior to merging with the tributary.

There is bacterial contamination in Hall Run both from HSTSs in the Pepper Ridge subdivision and from unknown sources in Hall Run upstream of PRTRIB. During dry weather, all three sampling locations had *E.coli* concentrations below the Ohio EPA standards for waters designated as Primary Contact Recreational Use (126 c.f.u. /100ml; Table 4). During rain events however, all three locations greatly exceeded these standards, with *E. coli* concentrations in the thousands. It is likely that failing HSTSs in the Pepper Ridge Subdivision are contributing disproportional amounts of bacterial pollution to Hall Run since Pepper Ridge Tributary had the highest concentrations of *E.coli* among the three sampling sites. However, these concentrations were not significantly higher than those found in Hall Run (Figure 3). Concentrations in Hall Run also increased downstream of the Pepper Ridge tributary. Yet high concentrations during wet weather events both upstream and downstream of Pepper Ridge Tributary indicate that bacterial pollution cannot be pinned solely on discharging HSTS in the Pepper Ridge Subdivision. Other potential sources of bacterial pollution in Hall Run upstream of Pepper Ridge Tributary include non-point source pollutants, a result of run-off from suburban areas or farms, or exfiltration from the sewer system.

During dry weather, carbonaceous biochemical oxygen demand was higher in PRTRIB. However, this difference was not significant, and therefore measureable increases in oxygen demand were not found in HALL1.4 (Table 5; Figure 3). Wet weather $CBOD_5$ was lower in Pepper Ridge Tributary than in both Hall Run sampling locations (Figure 3). Total suspended solids were lower in Hall Run than in Pepper Ridge Tributary during dry weather, but were higher in Hall Run than in Pepper Ridge Tributary during wet weather (Table 5). Ohio EPA has not published proposed criteria values for $CBOD_5$ or TSS.

Table 3 Means and ranges of nutrient concentrations (reported in mg/l) for all sample locations during wet and dry sampling events. Concentrations reported in red text indicate concentrations above the Ohio EPA's recommended criteria for nutrients in Warm Water Habitats. There are no recommended criteria for ortho-phosphate.

		Nitrite - Nitrate	Ortho-Phosphorus	Total Phosphorus
HALL1.5				
Dry	mean	0.24	0.02	0.05
	range	0.04-0.60	0.02-0.03	0.05-0.06
Wet	mean	0.71	0.05	0.24
	range	0.51-0.92	0.02-0.10	0.06-0.58
PRTRIB				
Dry	mean	0.29	0.10	0.13
	range	0.10-0.68	0.09-0.11	0.13-0.14
Wet	mean	1.88	0.22	0.44
	range	1.62-2.07	0.17-0.28	0.26-0.56
HALL1.4				
Dry	mean	0.23	0.03	0.06
	range	0.05-0.58	0.02-0.03	0.05-0.06
Wet	mean	1.62	0.10	0.34
	range	1.40-2.02	0.09-0.11	0.21-0.56

Table 4 *E.coli* concentrations reported in colony forming units (c.f.u.)/100 ml. Not Applicable (N/A) was reported for values where the mean could not be accurately determined due to some samples being above the maximum detection limit. Concentrations reported in red text indicate concentrations above the Ohio EPA's standard for *E.coli* in Primary Contact Recreational Waters.

	DRY		WET	
	geo. mean	**range**	**geo. mean**	**range**
HALL1.5	79	38-120	N/A	1200->8000
PRTRIB	23	8-38	N/A	6800->8000
HALL1.4	81	62-100	N/A	4100->8000

Table 5 Means and ranges of 5-Day Carbonaceous Biochemical Oxygen demand ($CBOD_5$) and Total Suspended Solids (TSS) for all sample locations during wet and dry sampling events. Both parameters are reported in mg/l. Not Applicable (N/A) was reported for values where the mean could not be accurately determined due to some samples being above the maximum detection limit (2.0 mg/l $CBOD_5$ and 1.0 mg/l TSS). There are no Ohio EPA criteria for TSS or $CBOD_5$.

		$CBOD_5$	TSS
HALL1.5			
Dry	mean	N/A	N/A
	range	<2.0-2.5	<1.0-2.5
Wet	mean	3.2	71.3
	range	2.7-1.4	2.8-201.0
PRTRIB			
Dry	mean	N/A	N/A
	range	<2.0-5.5	<1.0-9.7
Wet	mean	2.8	69.5
	range	2.7-2.9	14.2-124.0
HALL1.4			
Dry	mean	N/A	N/A
	range	<2.0-2.5	<1.0-2.1
Wet	mean	3.1	80.0
	range	2.7-3.9	15.8-149.0

Conclusions

During wet weather, high levels of nutrients leaving Pepper Ridge Tributary appeared to elevate nutrient levels in Hall Run above the Ohio EPA recommended standards for obtaining WWH designation. Bacteria levels in Pepper Ridge Tributary were also very high. Contrary to what OEQ had predicted, impacts from PRTRIB were strongest during wet weather events. Low pollutant concentrations during dry weather were probably observed because Pepper Ridge Tributary becomes intermittent during the summer and therefore has limited connection to Hall Run during dry weather, meaning many of the HSTS contaminants are possibly being contained in the upper reaches of the stream until a large rain event occurs and washes the contaminants downstream. To further investigate sources of pollutants in Pepper Ridge Tributary, OEQ designed an additional sampling event discussed in the following section of this report.

Although Pepper Ridge Tributary typically had the highest concentrations of pollutants, bacteria and total phosphate concentrations were above Ohio EPA standards in Hall Run above and below the confluence with Pepper Ridge Tributary during wet weather as well. This indicates that during wet weather, Pepper Ridge Tributary is a source of pollutant loads to Hall Run, but other sources upstream of the tributary, such as sanitary sewer exfiltration or non-point sources pollutants are contributing to Hall Run pollution as well.

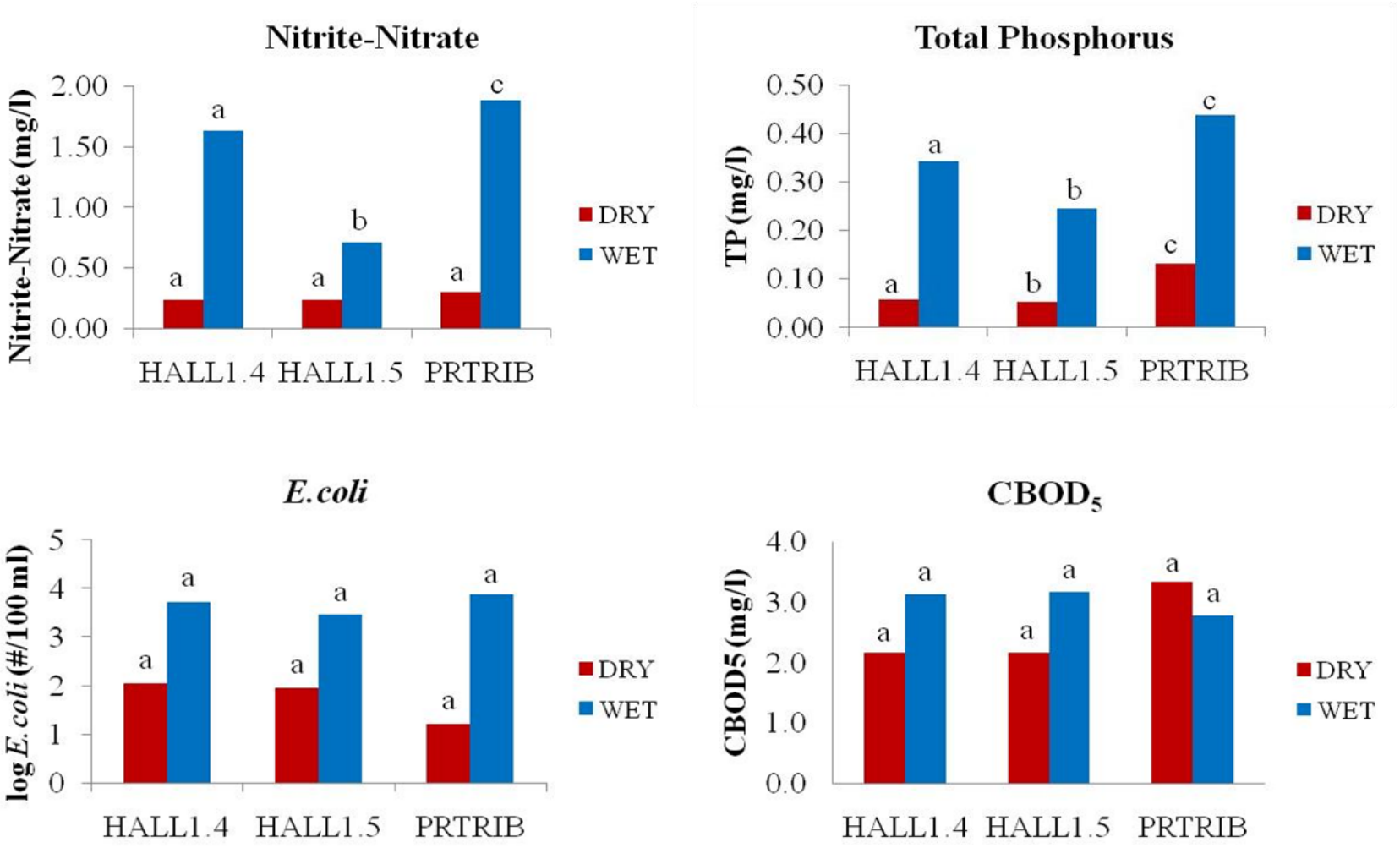

Figure 3 Comparison of selected parameters between sites on dry and wet weather sampling events. Different letters above bars indicate significantly different concentrations from the other sites (ANOVA, Tukey's test). Statistical analyses were conducted separately for wet and dry weather events. DF = 8 for dry weather events and 5 for wet weather events

Subcomponent Two - Extended Sampling (Dry Weather in Pepper Ridge Tributary)

Sampling Design

The original sampling plan discussed in the previous section was adapted to include one additional dry weather sampling event. This sampling event was conducted in order to determine whether pollutants from HSTSs were being contained in the upper reaches of Pepper Ridge Tributary during dry weather. Samples were collected at three additional locations in Pepper Ridge Tributary upstream of the PRTRIB sampling location (Figure 1; Table 6). Since Pepper Ridge Tributary is reduced to interstitial flow or isolated pools during dry weather, OEQ sampled sites further upstream (closer to the discharging HSTSs in Pepper Ridge Subdivision) to ensure that samples taken from the PRTRIB sampling location during dry weather events were indeed capturing any pollution from HSTSs. The PRTRIBRR site was located immediately downstream of the Pepper Ridge Subdivision and drained more of the HSTSs than the PRTRIBRL site drained. The PRTRIB0.5 site was located on the main stem of Pepper Ridge Tributary and drained all of the Pepper Ridge Subdivision plus some HSTSs servicing properties east of Beechwood Road.

Table 6 List of Pepper Ridge Survey Subcomponent Two (Pepper Ridge Dry Weather) sample IDs and locations. Samples were collected around 10:11 A.M. on October 13, 2008 with 0.00 inches of precipitation during the previous 72-hours.

Location	Sample ID
Hall Run, u/s Confluence of Tributary	HALL1.5
Hall Run, d/s Confluence of Tributary	HALL1.4
Pepper Ridge Tributary, just u/s Confluence	PRTRIB
Pepper Ridge Tributary, 0.5 RM u/s Confluence	PRTRIB0.5
River Right Tributary to Pepper Ridge Tributary, d/s of Beechwood Rd.	PRTRIBRR
River Left Tributary to Pepper Ridge Tributary, d/s of Beechwood Rd.	PRTRIBRL

Results

During dry weather, nutrients in Pepper Ridge Tributary were concentrated in the upper reaches of the stream due to the lack of flow carrying the pollutants downstream. Total phosphate and ortho-phosphate concentrations were similar in PRTRIBRR and PRTRIBRL and were well above the Ohio EPA WWH total phosphate standard of 0.1 mg/l (Figure 4). The concentration of total phosphate was lower in sample locations further downstream from the HSTSs in the Pepper Ridge Subdivision because phosphate particles adsorb to the soil particles and are typically transported best during high flows.

All sampling locations had nitrite-nitrate concentrations below the Ohio EPA standard for WWH nitrite-nitrate concentration of 1.0 mg/l. Interestingly, nitrite-nitrate was highest at

PRTRIB0.5. Since nitrates are more mobile than phosphates and can reach streams through groundwater connections, it's possible this high value during dry weather is a result of some non-point source of nitrogen in the watershed. However, OEQ is unsure of the accuracy of this result and would need to collect duplicate samples to verify this finding.

The three upstream locations in Pepper Ridge Tributary exhibited higher concentrations of bacteria than PRTRIB (Figures 5). Since bacteria often adsorbs to soil particles, this was probably due to the lack of stream flow carrying pollutants from discharging HSTSs downstream to PRTRIB during dry weather. HALL1.4, HALL1.5, and PRTRIB were only slightly above the Ohio EPA standards for waters designated as Primary Contact Recreational Use (126 c.f.u /100ml; Figure 5) whereas PRTRIB1.5, PRTRIBRR, and PRTRIBRL all had *E.coli* concentrations much higher than 126 c.f.u./100ml. These results suggest that HSTSs are a major source of bacterial contamination during dry weather and likely contribute high bacterial loads to Hall Run when flow resumes in the tributary.

PRTRIBRR, the tributary to Pepper Ridge Tributary with the highest density of HSTSs, had higher $CBOD_5$ than PRTRIBRL and PRTRIB (Figures 6). All of the sites in Pepper Ridge Tributary had lower $CBOD_5$ than HALL1.4 and HALL1.5 (Figure 6). OEQ was unable to determine the sources of elevated $CBOD_5$ in Hall Run during this study.

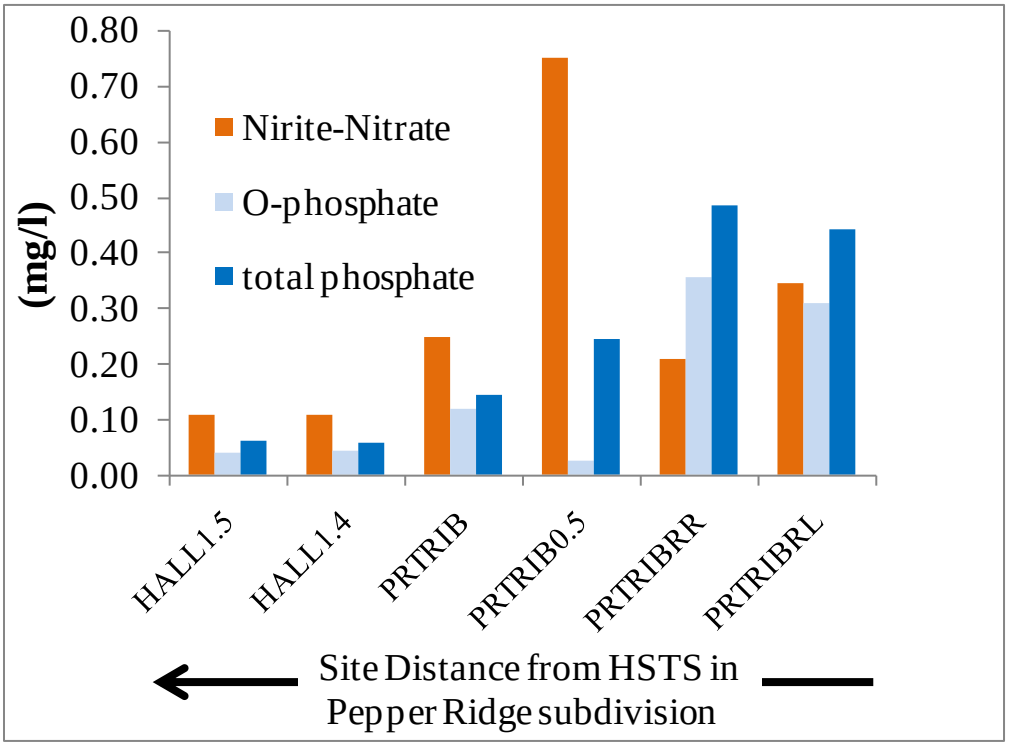

Figure 4 Chemical parameters collected from the single dry weather sampling event of additional locations in Pepper Ridge Tributary, along with standard sample sites.

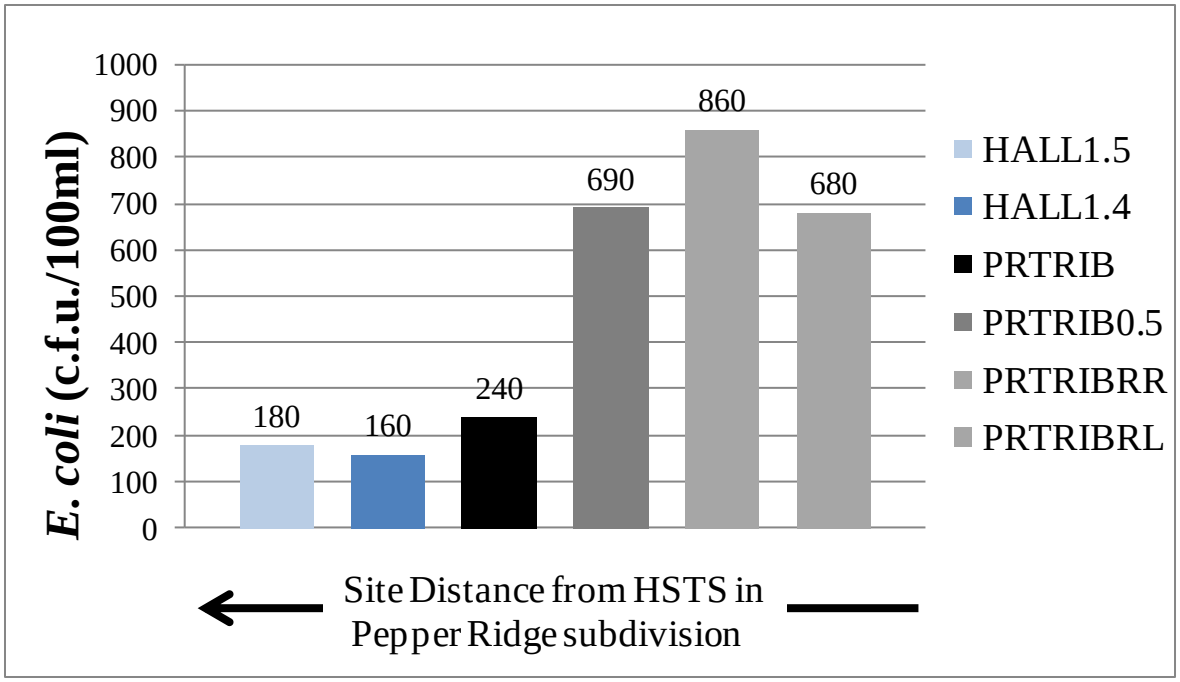

Figure 5 *E.coli* concentrations collected from the single dry weather sampling event of additional locations in Pepper Ridge Tributary, along with standard sample sites.

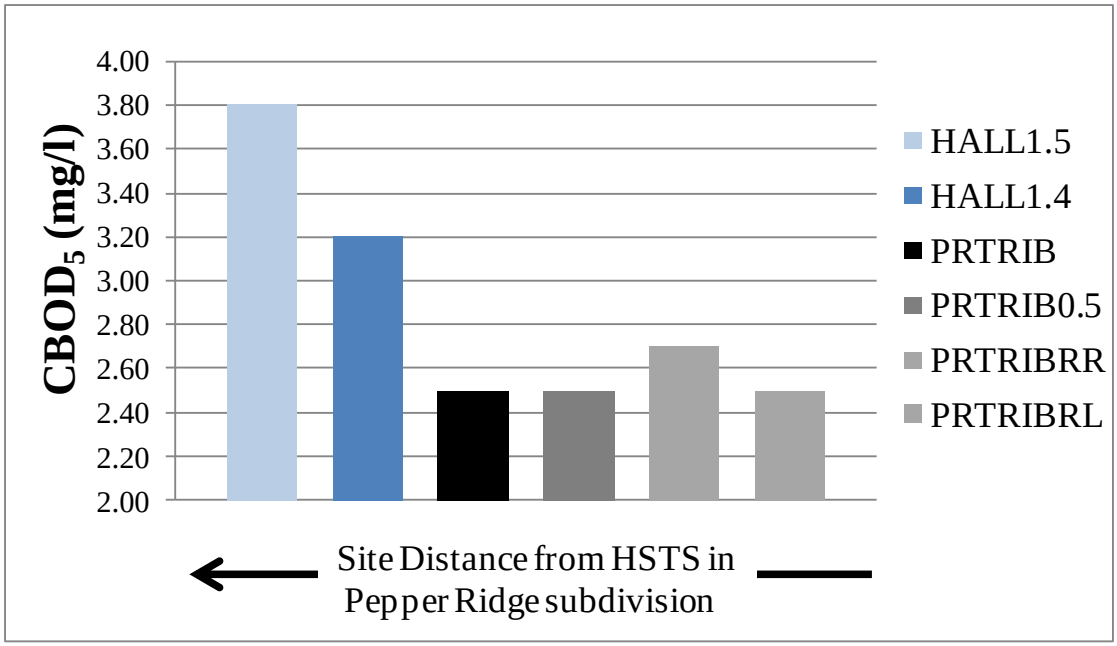

Figure 6 Five-Day Carbonaceous Biochemical Oxygen Demand collected from the single dry weather sampling event of additional locations in Pepper Ridge Tributary, along with standard sample sites.

Conclusions

Overall, pollutant concentrations in Hall Run were low during dry weather, indicating that dry weather sewer exfiltration is not occurring on a large scale. On the contrary, pollutant concentrations at sites in the Pepper Ridge Tributary near the HSTSs are high and generally above Ohio EPA standards. Although these pollutants are trapped in isolated pools in the upper reaches of Pepper Ridge Tributary during dry weather, these pollutants are flushed out during rain events and contribute to the very high pollutant concentrations found in PRTRIB and HALL1.4 during wet weather events (Figure 3 & Tables 3-5). These results suggest OEQ's original sampling design (Subcomponent One) was unlikely to fully capture a large part of the pollution coming from failing HSTSs during dry weather; and further implicate Pepper Ridge HSTSs as a great source of pollution to Hall Run. Further sampling could directly target the outfall of the discharging HSTSs in Pepper Ridge Subdivision.

Diurnal DO Profiles

Sampling Design

In 2008, Clermont County monitored dissolved oxygen concentrations in the East Fork of the Little Miami River (EFLMR) upstream and downstream of the outfalls of four wastewater treatment plants-Batavia (BAT), Middle East Fork (MEF), Lower East Fork (LEF) and Milford (MIL), which discharge into the EFLMR. The same location was used for the upstream site at the Middle East Fork WWTP and the downstream site at the Batavia WWTP, and was therefore monitored twice. Similar monitoring occurred in 2007; however an additional monitoring site was added in 2008 at the Milford WWTP. Also the acquisition of two new multi-parameter data sondes allowed simultaneous DO monitoring above and below the effluent, improving the level of control in the 2008 sampling design.

This sampling design was created to determine if BOD and nutrient loads from treated sewage are having an impact on dissolved oxygen concentrations in the EFLMR. DO levels naturally swing from high levels during the day to lower levels at night. This is due to aquatic algae photosynthesizing (producing oxygen) during the day and respiring (consuming oxygen) at night. However, high nutrient loading promotes excessive algal growth, which can lead to greater swings in DO levels and allow nighttime levels to dip dangerously low for the aquatic biota. Also, effluent from WWTPs can contribute organic materials that increase oxygen demand during biodegradation. Diurnal DO monitoring above and below wastewater treatment plants should identify any impact from WWTP effluent on DO concentrations.

Results

Average DO concentrations at each site were well above Ohio EPA's water quality standards for DO, which requires a minimum 24 hour average concentration of 6.0 mg/l in Exceptional Warm Water Habitats (EWH; Table 7). DO concentrations did exhibit greater swings downstream of WWTPs. However this difference is not great, with all downstream sites having diurnal DO swings no more than 0.50 mg/l higher than their upstream counterparts (Table 7).

DO levels downstream of WWTP outfalls were lower than DO concentrations upstream of the WWTP outfalls (Table 7). Individual DO profiles showed that dissolved oxygen levels dip below 6 mg/l for a few hours over night both upstream and downstream of the outfall at the the MEF WWTP, and downstream of the outfall at the LEF WWTP (Figure 7). The other two WWTP's have minimum DO concentrations above 6.0 mg/l, with the minimum concentration being 6.75 mg/l downstream of both Batavia's and Milford's outfall (Figure 7). Observed differences in minimum DO concentrations between upstream and downstream locations are likely not biologically significant, since all minimum concentrations are well above 5.0 mg/l, the Ohio EPA's water quality standards for point samples in EWH streams.

Table 7 Summary of DO monitoring conducted upstream and downstream of WWTP outfalls discharging to the East Fork of the Little Miami River.

	Diel Variation (mg/l)		**Minimum DO (mg/l)**		**Average DO (mg/l)**	
WWTP	upstream	downstream	upstream	downstream	upstream	downstream
BAT	2.47	2.75*	7.24	6.76*	8.41	7.96*
MEF	2.63*	3.04	5.97*	5.42	7.04*	6.82
LEF	1.96	2.37	6.09	5.77	6.97	6.87
MIL	1.66	1.80	7.40	6.75	8.17	7.56

*same sampling location

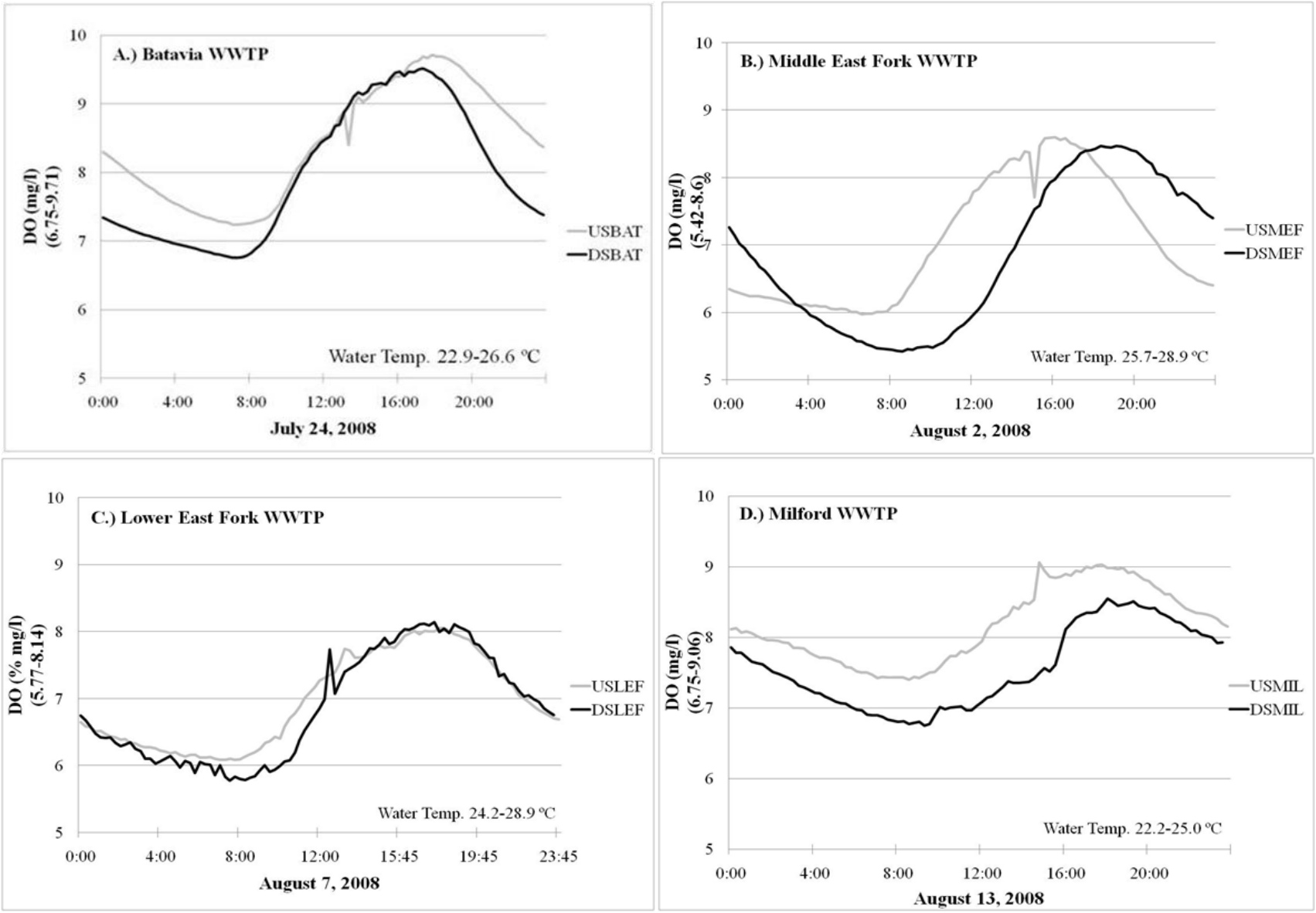

Figure 7 Dissolved Oxygen (DO) diurnal profiles upstream and downstream of the effluent outfall from A.) Batavia WWTP, B.) Middle East Fork WWTP, C.) Lower East Fork WWTP, and D.) Milford WWTP. Water temperature and DO ranges are reported for each profile.

Conclusions

The collected DO profiles indicate that nutrients from the WWTPs have not significantly contributed to declines in dissolved oxygen concentrations and concentrations of DO in the EFLMR are well above Ohio EPA standards for DO. However, DO concentrations were variable across monitoring sites. One possible reason for the lower DO concentrations found at MEF and LEF is the difference in water temperature at the time of sampling (Figure 7). The concentration of dissolved oxygen in water is inversely related to water temperature, meaning that warmer waters hold less oxygen. This explanation is especially apparent when considering that DO was monitored at the same location for both BAT downstream and MEF upstream, yet DO concentrations were very different depending on the date of sampling. This location had a mean DO concentration of 7.04 mg/l when the maximum stream temperature was 28.94°C, and a mean DO concentration 7.96 mg/l when the maximum temperature was only 26.63°C (Figure 7).

Recommendations

We recommend that further DO monitoring occur at WWTP sites during more similar weather conditions to reduce the impacts from variable temperature observed in 2008. Additionally, we recommend that DO be monitored simultaneously at multiple locations downstream of the WWTP to determine the impacts of variable habitat and mixing on DO concentrations in the river. Clermont County OEQ plans to purchase more sondes to allow simultaneous monitoring at multiple sites in 2009.