Pre/Post BMP Monitoring

Introduction

A Section 319 Nonpoint Source Pollution Grant was awarded to The FORUM of Greater Kalamazoo (FORUM) in 2004 to update the existing Portage-Arcadia Creeks Watershed Management Plan (WMP) and generate a nine elements approved WMP for these plans. As part of the project, limited wet weather sampling of stormwater runoff was to be conducted at existing and future Best Management Practice (BMP) sites within the Portage-Arcadia Creek Watershed. The Portage-Arcadia Steering Committee recommended these sampling locations during regular meetings held in 2004 and 2005 to evaluate current BMP treatment effectiveness (and/or opportunity for future treatment) of stormwater runoff for parameters of interest.

The Kalamazoo Water Reclamation Plant (KWRP) agreed to process samples in their laboratory as an in-kind contribution to the project qualifying as local match. The FORUM continues to serve as the local Administering body for the project. All technical elements of the project continue to be conducted through KIESER & ASSOCIATES (K&A), as a subcontractor to the FORUM. All sample collection, sample handling and data analysis has been performed in accordance with the Quality Assurance Project Plan (QAPP) approved by the Michigan Department of Environmental Quality (MDEQ) on November 1, 2005.

Sampling Locations

Multiple locations were sampled during wet weather events including: 1) *Milham Park Runoff*; 2) *AquaSwirl-in*; 3) *AquaSwirl-out*; 4) *Loy Norrix Outfall*; 5) *Maple St. Rain Garden*; and 6) *Pfizer Curb Cut*. Relative locations of each sample site are illustrated in Figure 1. Composite samples were collected from locations *2, 3* and *4* given their relative likelihood of prolonged runoff flows during rain events. Discrete grab samples were collected from locations 1, 5 and 6 to characterize the more infrequent, excess runoff generated from each of these sites. Stormwater runoff from each site was sampled on at lease one occasion. Table 1 provides a summary of information related to each sampling event conducted by K&A at each location. Figures 2 and 3 provide photographs of each sampling site. A general description of each sampling site is presented in the following text.

Site # 1 – Milham Park Runoff

Overland runoff was collected in the City of Kalamazoo's Milham Park in an existing area where surface flow passes over a mowed lawn area and discharges into Portage Creek. The lawn area receives heavy waterfowl traffic, and runoff is suspected to be a significant source of sediment and phosphorus loads to Portage Creek.

Sites #2 and #3 – AquaSwirl-In/Out

Surface stormwater runoff was collected at the inlet (Site #2) to the existing catch basin located with the asphalt parking lot behind the City of Kalamazoo Public Services Building at 415 Stockbridge Avenue. The parking lot serves as a storage location for the City's large utility vehicles and equipment. Runoff that enters this catch basin is pumped (via automated controls) to an Aqua-Swirl™ stormwater treatment structure. Outgoing, treated stormwater was also sampled as it was discharged from the Aqua-Swirl™ structure into nearby Portage Creek (Site #3).

Site # 4 – Loy Norrix Outfall

A significant portion of the stormwater runoff generated at the Loy Norrix High School (from nearly 14 acres of impervious surfaces) is discharged via storm sewers beneath Kilgore Road and into Portage Creek. This stormwater outfall was included in this sampling regime since plans are currently underway for implementation of new onsite stormwater BMPs under a CMI Portage-Arcadia Grant. The analytical results from monitoring this outfall serve to provide estimates of pre-implementation conditions.

Site #5 – Maple Street Rain Garden

The City of Kalamazoo was awarded a Clean Water Act Section 319 grant from the Michigan Department of Environmental Quality. Funds were directed to the Kalamazoo Nature Center to construct a rain garden in the Axtell Creek Watershed, at the Maple Street Magnet School for the Arts, and to hold an educational workshop. A rain garden capable of capturing up to a 2-inch storm event from roof top areas over the gymnasium, cafeteria and some classrooms was designed and constructed in August 2003. Stormwater grab samples collected from this site represent captured runoff that no longer reaches Axtell Creek.

Sites #6 – Pfizer Curb Cut

Sampling runoff from a Pfizer parking lot located in downtown Kalamazoo (400 East Lovell Street; approximately 8.5 acres of impervious area) was attempted in August 2005 as an in-kind, preliminary field reconnaissance effort to determine feasibility under an approved QAPP. Stormwater from a surface curb cut was sampled as runoff exited the parking lot and dissipated into an open lawn area before reaching Portage Creek.

Field-measured parameters of temperature, pH, specific conductance and dissolved oxygen were recorded in the field per QAPP procedures. Flow related data were also collected (where applicable) during each station visit including: 1) pipe exit velocities (averaged) using a handheld Marsh-McBirney portable velocity meter; and, 2) depth of water flow using a tape measure (refer to Figure 5). All grab and composite samples were delivered to the City of Kalamazoo Water Reclamation Plant (KWRP) laboratory for analysis of total phosphorus (TP), total suspended solids (TSS), total petroleum hydrocarbons (TPH), and volatile organics. As necessary and to assist with scheduling, the KWRP forwarded some samples to KAR Laboratories, Inc. (KAR) for analysis. Both laboratories are state-approved and adhere to MDEQ requirements for

quality control. All samples were analyzed within recommended hold-times and in accordance with the methods outlined in the Standard Methods for Examination of Water and Wastewater (APHA, 1998).

A nearby rain gage stationed at the Portage Creek surface water ISCO sampling location (used for previous WMP sampling efforts) was utilized to characterize local rainfall data related to each rain event that was sampled. Rainfall data for each sampling event are listed in Table 1.

Event Mean Concentrations

Water quality analytical data associated with each sampling event and each sampling site are summarized in Table 2. A pre-QAPP, in-kind reconnaissance sampling event was conducted on August 20, 2005, (in accordance with a prior approved April 26, 2001 Portage-Arcadia QAPP) to obtain preliminary information related to grab sampling during first flush conditions at select locations. All subsequent sampling (conducted after November 1, 2005) was focused upon collecting samples throughout the duration of each event and included flow-weighted composite samples (where possible) in order to calculate event mean concentrations (EMCs) for each site.

Flow-proportioned runoff volumes (based on volume and time period between grab samples) were calculated at sites where composite sampling could be utilized. For a given sample site, discrete grab samples were collected at various times throughout the duration of a storm event in individual bottles and a corresponding flow was recorded. Following the storm event, properly proportioned volumes from each grab sample were combined, allowing each percentage volume to represent a particular sample concentration. The proportioned volumes were combined from their individual bottles into the composite sample bottle for laboratory analysis to determine event mean concentrations (EMCs) of each desired parameter. Refer to the following example illustration for the composite sampling strategy utilized:

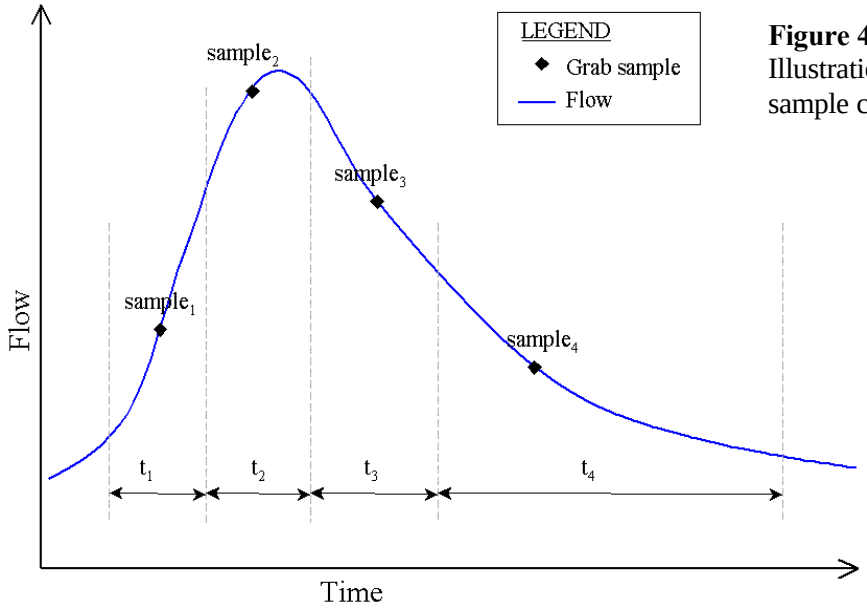


Figure 4.
Illustration of composite sample collection strategy.

Computed EMCs for each sampling site prior to treatment are as follows:

Table 3.

Location	TP EMC (mg/L)	TSS EMC (mg/L)
Site #1 *(Milham Park Runoff)*	0.47	300
Site #2 *(AquaSwirl-In)*	0.01	155
Site #4 *(Loy Norrix Outfall)*	0.3	66
Site #5 *(Maple St. Rain Garden)*	0.02	4.4
Site #6 *(Pfizer Curb Cut)*	0.04	2

Note: AquaSwirl-In (site #2) TP was non-detect at <0.01 mg/L. EMC is an estimate.

Where multiple sampling events were conducted at a particular site (e.g., Site #1 and Site #4), EMC values were averaged to obtain the final concentrations listed above.

Surface soil samples were also collected for laboratory analysis at the Milham Park location. Composite surface soils were collected at two areas in Milham Park. The first area (SS-1) is representative of heavy waterfowl traffic. The second area (SS-2) is representative of low waterfowl traffic. Three subsamples were collected at each area at a depth of zero to one half inch below the surface. These subsamples were then combined into a 100 ml composite sample in equal proportions for analysis of total phosphorus. Sample composite concentrations are presented in Table 4.

Annual Pollutant Load Estimates

Pollutant loads from stormwater runoff were calculated for each project sampling site using the EMCs listed in the previous text section. Often, EMCs are estimates of nonpoint source pollution as determined from the USEPA Nationwide Urban Runoff Program (NURP). However, since site-specific EMCs were obtained for this project, the stormwater pollutant loads are based on pollutant loading factors that vary by land use, land type, and percent imperviousness (Wayne County, 1998). Loads were computed using Equations 1 and 2 as follows:

$$M_L = EMC_L * R_L * K \qquad \textbf{(Eq. 1)}$$

Where:

M_L = Loading factor from land use L (lbs/ac/yr)

EMC_L = Event mean concentration of runoff from land use L (mg/L)

R_L = Total average annual surface runoff from land use L computed from Eq. 2

K = Unit conversion factor of 0.2266

Runoff Equation:

$$R_L = [\ C_P + (\ C_I - C_P\ )\ IMP_L\ ] * I \qquad \textbf{(Eq. 2)}$$

Where:

R_L = Total average annual surface runoff from land use L (in/yr)
IMP_L = Fractional imperviousness of land use L
I = Long term average annual precipitation (in/yr)
C_P = Pervious area runoff coefficient *(0.20)*
C_I = Impervious area runoff coefficient *(0.95)*

Equation 1 shows that the loading factor (M_L) for land use L is the product of the event mean concentration for land use L, the annual runoff for land use L, and a unit conversion factor. The runoff calculation in Equation 2 provides the R_L value used in Equation 1 through the product of the annual rainfall depth (34" from Kalamazoo rainfall records) and the percent imperviousness of land use L, with the tuning coefficients C_P and C_I. The loading factor, M_L, is multiplied by the area of land use L to obtain a total annual loading for that land use.

The above equations were utilized to calculate site-specific loading rates for each sampling site. Table 5 provides a summary of loading data for each sampling site based on existing land use and percent imperviousness. Estimated annual loads (lbs/yr) for total phosphorus and total suspended solids are as follows:

Table 6.

		Phosphorus		Suspended Solids	
Location	**Total Area** (ac)	**M_L** (lbs/ac/yr)	**Annual$_L$** (lbs/yr)	**M_L** (lbs/ac/yr)	**Annual$_L$** (lbs/yr)
Site #1 *(Milham Park Runoff)*	0.7	3.44	2.41	2,196	1,537
Site #2 *(AquaSwirl-In)*	1.91	0.04	0.07	1,134	2,167
Site #4 *(Loy Norrix Outfall)*	20.7	1.62	33.49	356	7,368
Site #5 *(Maple St. Rain Garden)*	0.73	0.15	0.11	32	24
Site #6 *(Pfizer Curb Cut)*	10.38	0.26	2.68	13	134

Results Summary

The following findings were noted based upon these Portage-Arcadia Transition Grant monitoring efforts. They relate to specific observations at the sites, and discuss their relevance to pending BMPs where applicable.

Milham Park Runoff (site #1)

- Future Milham Park bioretention BMPs (2005-2007 CMI Grant) will need to address first flush sediment loads (1,537 lbs TSS/yr) via filter strips, check dams, forebays, etc.
- Initial bioretention BMP concepts are currently in-place and have been acknowledged by the PA Steering Committee.

- Final treatment BMP design details will be finalized in early 2006.
- This sampling location is not well suited to accommodate composite sampling of surface runoff. From on-site observations, it appears that runoff is generated from the existing parking area at rainfall amounts greater than approximately 0.25 inches. Once this initial threshold is achieved, a significant portion of the parking lot runoff is directed toward the creek across the existing manicured lawn and waterfowl traffic areas. Proper timing was required to obtain first flush stormwater grab samples from this location.
- Observed EMC values for TP (0.47 mg/L) and TSS (300 mg/L) are higher than other urban runoff concentrations reported by others for parking lot studies during the past twenty years. (Refer to Attachment A.)
- Soil phosphorus concentrations for the existing bare soils in the park appear to be relatively consistent with other area streambank phosphorus levels observed throughout the Kalamazoo River Watershed. One possible explanation for these "normal range" concentrations in high traffic waterfowl areas is that most phosphorus is transported to the creek as particulate matter prior to binding onto bare site soils. (A recent CMI-funded project called the Kalamazoo River Critical Erosion Sites Mitigation Project revealed that the average soil phosphorus concentration for nine streambank sites along the Kalamazoo River was 514 mg/kg within Calhoun, Allegan and Kalamazoo Counties.) For more information, go to http://www.kalamazooriver.net/tmdl/nps_opps/cmi.htm

AquaSwirl-In/Out (sites #2/3)

- Based on limited data for a single sampling event conducted at the Aqua-Swirl™ stormwater treatment unit located at the City's Public Services Building, this BMP structure appears to capture approximately 34% of the total suspended solids load.
- This BMP structure prevents approximately 737 lbs sediment from reaching Portage Creek each year from this impervious drainage area.
- Additional sampling conducted at this location may reveal a higher removal percentage of solids.
- Furthermore, variations in sampling strategy may also allow for improved monitoring/evaluation of phosphorus and volatiles treatment that were not directly discernable during this study. For more information related to Aqua-Swirl™ systems, go to http://www.epa.gov/NE/assistance/ceitts/stormwater/techs/aquafiltersys.html

Loy Norrix Outfall (site #4)

- Future Loy Norrix stormwater BMPs (2005-2007 CMI Grant) will also need to address significant first flush sediment and phosphorus loads.
- Initial stormwater BMP concepts are currently in-place and have been acknowledged by the PA Steering Committee.
- Final treatment BMP design details will be finalized in early 2006.
- Observed EMC values for TP (0.3 mg/L) and TSS (66 mg/L) are very similar to other urban runoff concentrations reported by others for parking lot studies during the past twenty years. (Refer to Attachment A.)

Maple Street Rain Garden (site #5)

- Sampling conducted at the Maple Street Rain Garden BMP site was somewhat problematic due to a lack of significant runoff. The two storm events that were sampled at the rain garden manhole structure were relatively small in size (both <0.34 inches of rain).
- The existing, flat rooftop at the Maple Street Middle School is comprised of a tar and gravel substrate. Previous estimates for this site suggest that significant runoff does not typically occur from this rooftop unless rainfall greater than 0.35-0.5 inches has occurred (dependant upon antecedent moisture conditions). Thus, the site-specific EMCs and the calculated loads for TP and TSS are significantly under-estimated at this location.
- This sampling location is not well suited to accommodate composite sampling of surface runoff. As a result, grab samples were collected at the rain garden inlet structure during this study.
- Observed EMC values for TP (0.02 mg/L) and TSS (4.4 mg/L) are below other urban runoff concentrations reported by others for rooftop studies during the past twenty years. (Refer to Attachment A.)
- Using NURP EMC values, the rain garden is estimated to prevent 225 lbs TSS and 0.5 lbs TP from reaching Axtell Creek each year. Fore more information, go to http://www.kalamazooriver.net/pa319new/axtell/raingarden/project.htm
- Further monitoring of larger rain events (>0.5 inches) for this site is recommended to obtain more accurate EMCs associated with the Maple Street School tar and gravel rooftop runoff.

Pfizer Curb Cut (site #6)

- This sampling location is not well suited to accommodate composite sampling of surface runoff. From on-site observations, it appears that runoff is generated from the existing parking area at rainfall amounts greater than approximately 0.25 inches. Once this initial threshold is achieved, a significant portion of the parking lot runoff is directed toward the creek across an existing manicured lawn area. Proper timing is required to obtain first flush stormwater grab samples from this location. The first flush runoff of stormwater may have been missed on August 20, 2005.
- Observed EMC values for TP (0.04 mg/L) and TSS (2 mg/L) are well below other urban runoff concentrations reported by others for parking lot studies during the past twenty years. (Refer to Attachment A.)

While initial data are helpful for targeting problem loading areas, the data collected during these BMP sampling efforts are limited to three storm events (all below 0.35 inches) and should be considered initial findings. Additional sampling is recommended if more detailed evaluation of loading is desired for a particular site. Seasonal influences (i.e., spring, summer, fall) should also be identified to obtain more accurate EMCs related to each sampling site. Other considerations such as use of automated sampling equipment, first flush characterization, quantification of peak flows, rainfall intensity and storm duration should be carefully contemplated if more detailed

monitoring data is desired. Overall, it was determined that proposed BMPs for Milham Park and Loy Norrix High School will be beneficial given measured EMCs at or above national averages.

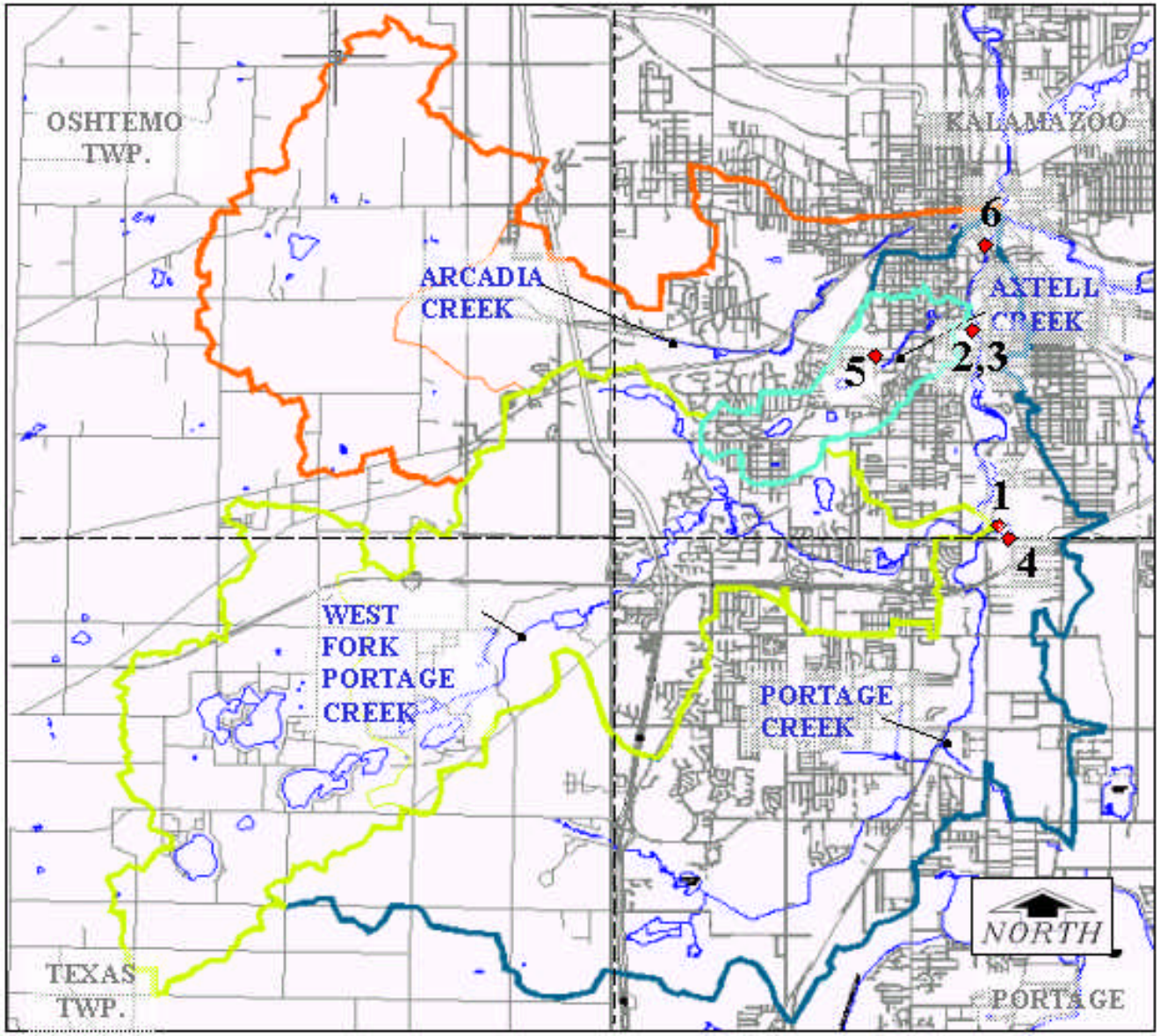
References

American Public Health Association (APHA), American Water Works Association & Water Environment Federation. 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed. APHA. Washington, D.C.

Kieser & Associates (K&A). Quality Assurance Project Plan for Monitoring and Water Quality Sampling Associated with the Portage and Arcadia Creeks Section 319 Nonpoint Source Pollution Grant. April 26, 2001.

Lucas, William C., Integrated Land Management, Inc. Green Technology: The Delaware Urban Runoff Management Approach. A Technical Manual for Designing Nonstructural BMPs to Minimize Stormwater Impacts from Land Development. January 2004. http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/New/DURMM_TechnicalManual_01-04.pdf

U.S. Environmental Protection Agency. 1983. *Final Report of the Nationwide Urban Runoff Program.* Water Planning Division, Washington, D.C.



LEGEND

BMP Sampling Location

1 = Milham Park Runoff

2 = Aqua Swirl-In
3 = Aqua Swirl-Out

4 = Loy Norrix Outfall

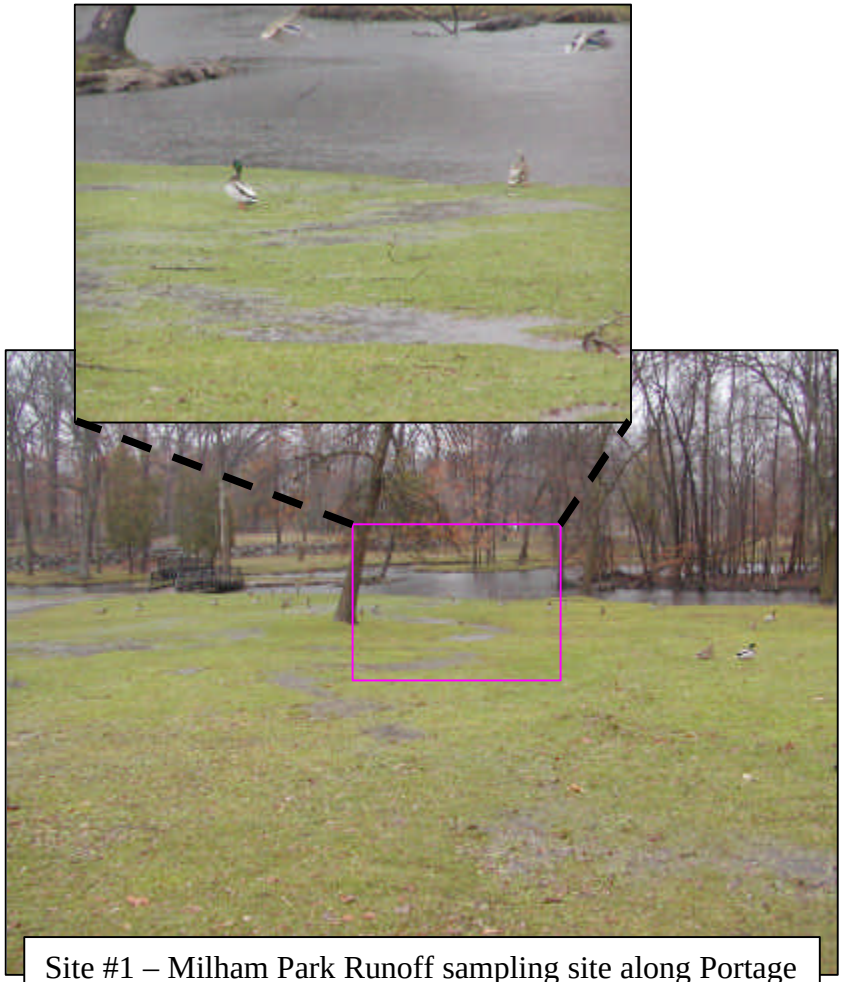
5 = Maple St. Rain Garden

6 = Pfizer Curb Cut

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E Michigan Ave, Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Approximate location of PA319 BMP Monitoring Sites, Kalamazoo, Michigan with respect to subwatersheds and nearby water features.

FIGURE 1



Site #1 – Milham Park Runoff sampling site along Portage Creek in Kalamazoo's Milham Park.

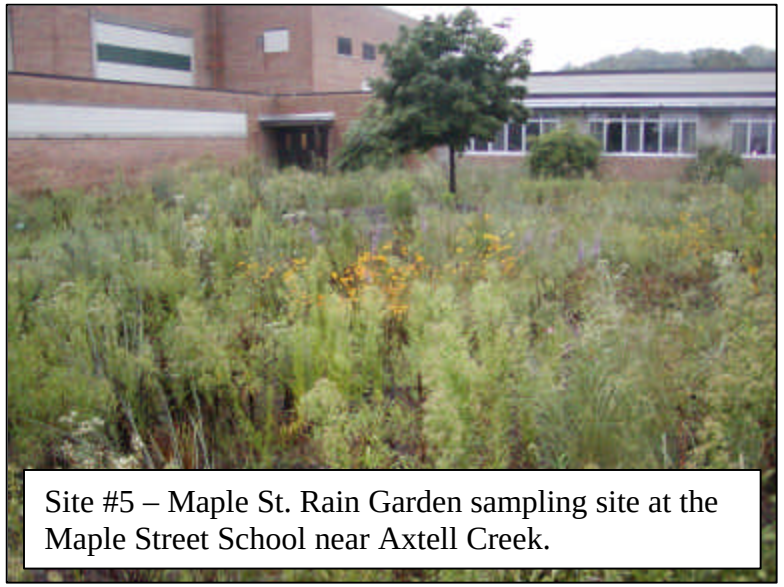
Site #2 & #3 – Aqua Swirl In and Out sampling sites along Portage Creek behind the City of Kalamazoo Public Services Building on Stockbridge St.

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

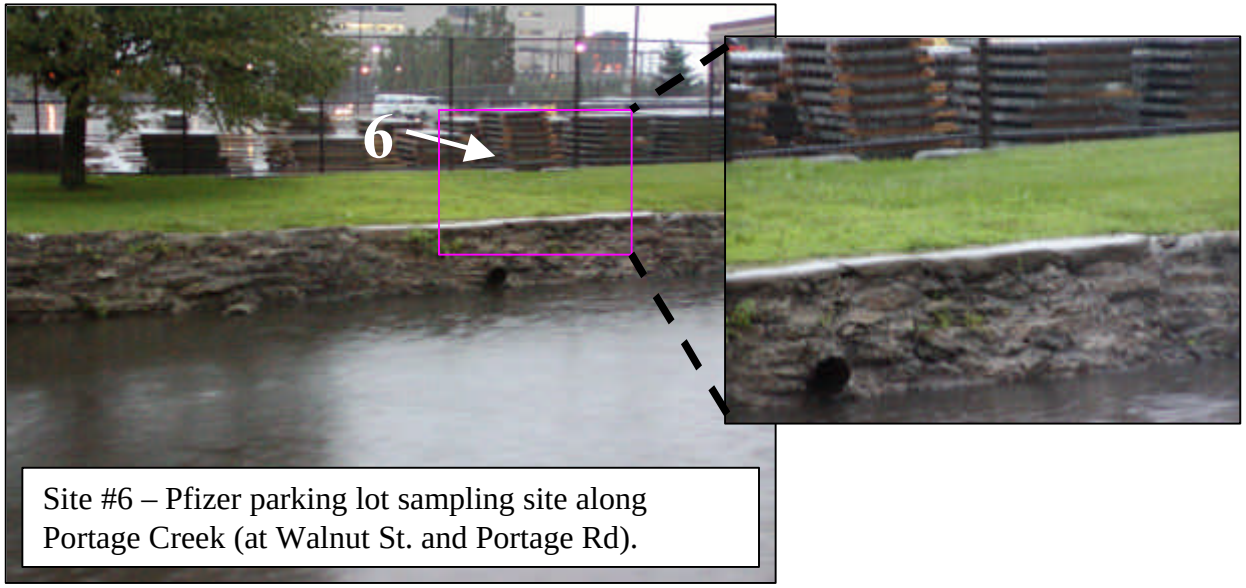
Photographs of PA319 BMP monitoring sites where sampling was conducted.

FIGURE
2

Site #4 – Loy Norrix Outfall sampling site along Portage Creek in Milham Park.



Site #5 – Maple St. Rain Garden sampling site at the Maple Street School near Axtell Creek.



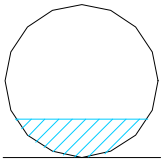
Site #6 – Pfizer parking lot sampling site along Portage Creek (at Walnut St. and Portage Rd).

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Photographs of PA319 BMP monitoring sites where sampling was conducted.

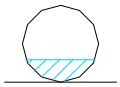
FIGURE
3

Milham Park
City/Norrix Outfall
(2 ft Diameter Corrugated PVC)



8-20-05
8:10 AM
depth = 6 in.
velocity = 5.28 ft/s
area = 0.57 ft2
flow = 3.01 cfs

Aqua Swirl Unit
City of Kalamazoo
Stockbridge Outfall
(1 ft Diameter PVC)

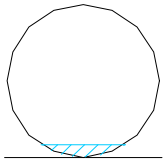


11-15-05
2:45 PM
depth = 3.5 in.
Max velocity = 7.04 ft/s
area = 0.17 ft2
flow = 0.6 cfs
this flow represents
50% pump run time

Aqua Swirl Unit
City of Kalamazoo
Stockbridge Outfall
(1 ft Diameter PVC)

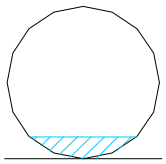
11-15-05
3:55 PM
depth = 3.5 in.
Max velocity = 6.19 ft/s
area = 0.17 ft2
flow = 0.53 cfs
this flow represents
50% pump run time

Milham Park
City/Norrix Outfall
(2 ft Diameter Corrugated PVC)



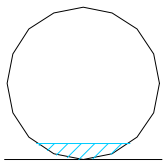
11-15-05
2:25 PM
depth = 2 in.
velocity = 1.48 ft/s
area = 0.10 ft2
flow = 0.15 cfs

Milham Park
City/Norrix Outfall
(2 ft Diameter Corrugated PVC)



11-15-05
3:30 PM
depth = 3.5 in.
velocity = 6.44 ft/s
area = 0.25 ft2
flow = 1.61 cfs

Milham Park
City/Norrix Outfall
(2 ft Diameter Corrugated PVC)



11-15-05
4:10 PM
depth = 2.5 in.
velocity = 4.25 ft/s
area = 0.16 ft2
flow = 0.68 cfs

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ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Instantaneous flow data recorded on Nov 15, 2005 during wet weather sampling at the #2, #3 and #4 BMP monitoring sites.

FIGURE
5

Table 1. Summary of BMP Sampling Events Conducted at Approved Study Sites.
(2005 Section 319 NPS Transition Grant)

Date	Rainfall *(inches)*	Sample Locations	Sample Type
August 20, 2005	0.28	Pfizer Curb Cut	Grab
		Maple St. Rain Garden	Grab
		Milham Park Runoff	Grab
		Loy Norrix Outfall	Grab
November 15, 2005	0.33	Aqua Swirl-In	Composite
		Aqua Swirl-Out	Composite
		Loy Norrix Outfall	Composite
November 28, 2005	0.34	Maple St. Rain Garden	Grab
		Milham Park Runoff	Grab

Note:
The Aug 20, 2005 rainfall data was obtained from the Kellog Biological Station near Gull Lake. All other rainfall data was obtained from the Portage Creek ISCO rain gage.

Table 2. Summary of Portage-Arcadia BMP Sampling Analytical Results.
(2005 Section 319 NPS Transition Grant)

Sample Date	Sample Time	Sample Type	Site Number	Sample ID	Analyte	Concentration	Units
8/20/05	7:15 AM	Grab	# 6	Pfizer Curb Cut	Total Suspended Solids	2.0	mg/L
(pre-QAPP)					Total Phosphorus	0.04	mg/L
					temperature	NA	^{o}C
					pH	7.08	S.U.
					Specific Conductance	36	μS/cm
					dissolved oxygen	NA	mg/L
8/20/05	7:55 AM	Grab	# 1	Milham Park Runoff	Total Suspended Solids	6.0	mg/L
(pre-QAPP)					Total Phosphorus	0.92	mg/L
					temperature	NA	^{o}C
					pH	6.43	S.U.
					Specific Conductance	270	μS/cm
					dissolved oxygen	NA	mg/L
8/20/05	8:10	Grab	# 4	Loy Norrix Outfall	Total Suspended Solids	119	mg/L
(pre-QAPP)					Total Phosphorus	0.53	mg/L
					temperature	NA	^{o}C
					pH	6.12	S.U.
					Specific Conductance	136	μS/cm
					dissolved oxygen	NA	mg/L
8/20/05	7:35 AM	Grab	# 5	Maple St. Rain Garden	Total Suspended Solids	2.8	mg/L
(pre-QAPP)					Total Phosphorus	0.02	mg/L
					temperature	NA	^{o}C
					pH	6.64	S.U.
					Specific Conductance	48	μS/cm
					dissolved oxygen	NA	mg/L
11/15/05	2:45 PM	Composite	# 2	Aqua Swirl-In	Total Suspended Solids	155	mg/L
(post-QAPP)					Total Phosphorus	<0.01	mg/L
					temperature	10.3	^{o}C
					pH	7.70	S.U.
					Specific Conductance	NA	μS/cm
					dissolved oxygen	10.00	mg/L
11/15/05	2:45 PM	Composite	# 3	Aqua Swirl-Out	Total Suspended Solids	103	mg/L
(post-QAPP)					Total Phosphorus	<0.01	mg/L
					temperature	10.2	^{o}C
					pH	7.16	S.U.
					Specific Conductance	NA	μS/cm
					dissolved oxygen	9.38	mg/L
11/15/05	2:25 PM	Composite	# 4	Loy Norrix Outfall	Total Suspended Solids	12	mg/L
(post-QAPP)					Total Phosphorus	0.062	mg/L
					temperature	10.9	^{o}C
					pH	6.94	S.U.
					Specific Conductance	NA	μS/cm
					dissolved oxygen	9.22	mg/L
11/28/05	1:05 PM	Grab	# 1	Milham Park Runoff	Total Suspended Solids	594	mg/L
(post-QAPP)					Total Phosphorus	0.017	mg/L
					temperature	13.7	^{o}C
					pH	7.51	S.U.
					Specific Conductance	NA	μS/cm
					dissolved oxygen	8.28	mg/L
11/28/05	1:20 PM	Grab	# 5	Maple St. Rain Garden	Total Suspended Solids	6	mg/L
(post-QAPP)					Total Phosphorus	0.021	mg/L
					temperature	15.7	^{o}C
					pH	7.31	S.U.
					Specific Conductance	NA	μS/cm
					dissolved oxygen	9.39	mg/L

ND = Non-Detect
NA = Not Available/Not Measured
All sampling prior to Nov 1, 2005 was conducted prior to the new 2005 QAPP.
All VOCs and TPH analytes were reported ND.

Table 4. Summary of Portage-Arcadia BMP Soil Sampling Analytical Results
(2005 Section 319 NPS Transition Grant)

Sample Date	Sample Time	Sample Type	Site Number	Sample ID	Analyte	Concentration	Units
12/7/05	1:45 PM	Soil Composite	# 1 *(Milham)*	SS-1 *(high-traffic area)*	Total Phosphorus	505	mg/kg
12/7/05	1:35 PM	Soil Composite	# 1 *(Milham)*	SS-2 *(low-traffic area)*	Total Phosphorus	432	mg/kg

Notes:
ND = Non-Detect
NA = Not Available/Not Measured

Table 5. Portage-Arcadia Site Specific Annual Loading Rate Estimates
(2005 Section 319 NPS Transition Grant)

						Phosphorus		Suspended Solids	
Location	**Total Area** (ac)	**Imp Area** (ac)	**Perv Area** (ac)	**Imp fraction**	**R_L** (in/yr)	**TP EMC** (mg/L)	**M_L** (lbs/ac/yr)	**TSS EMC** (mg/L)	**M_L** (lbs/ac/yr)
Site #1 *(Milham Park Runoff)*	0.7	0.7	0	1.00	32.30	0.47	3.44	300	2,195.75
Site #2 *(AquaSwirl-In)*	1.91	1.91	0	1.00	32.30	0.01	0.07	155	1,134.47
Site #4 *(Loy Norrix Outfall)*	20.7	13.8	6.9	0.67	23.80	0.3	1.62	66	355.94
Site #5 *(Maple St. Rain Garden)*	0.73	0.73	0	1.00	32.30	0.02	0.15	4.4	32.20
Site #6 *(Pfizer Curb Cut)*	10.38	8.83	1.55	0.85	28.49	0.04	0.26	2	12.91

Note:
Site #3 (AquaSwirl-Out) has demonstrated reduction of 34% Total Suspended Solids, based on initial sampling results.
Total Phosphorus concentrations were reported as non-detect for AquaSwirl-in/out (<0.01 mg/L). Therefore, no TP reduction could be obtained.

ATTACHMENT A

Excerpt from The Delaware Urban Runoff Management Approach. A Technical Manual for Designing Nonstructural BMPs to Minimize Stormwater Impacts from Land Development. January 2004. Table 3-1.

To review the entire document, go to:
http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/New/DURMM_TechnicalManual_01-04.pdf

Table 3-1: Mean TSS and Total Phosphorus EMCs in Urban and Agricultural Runoff (mg/l)

	TOTAL SUSPENDED SOLIDS												TOTAL PHOSPHORUS											
SOURCE	FLAT ROOFS	PITCHED ROOFS	PARKING LOTS	MEDIUM STREETS	DRIVE-WAYS	LAWNS	LAND-SCAPE	WOODS	CONV. TILL	CHISEL PLOW	NO- TILL	PAS-TURE	FLAT ROOFS	PITCHED ROOFS	PARKING LOTS	MEDIUM STREETS	DRIVE-WAYS	LAWNS	LAND-SCAPE	WOODS	CONV. TILL	CHISEL PLOW	NO- TILL	PAS-TURE
Owens et al, 1983												160												
Polls and Lanyon, 1976				266				34																
Peterjohn and Correll, 1984									6480												5.03			
Laflen and Tabatabai, 1984									18940	9710	4940													
Langdale et al, 1985									2310	970											0.08	0.17		
Correl et al, 1984																				0.81	0.16			0.56
Gilliam et al, 1993a									4111												1.70			
Gilliam et al, 1993b									4103												2.14			
Correl et al 1994																				0.35		2.32		0.81
Mendez et al, 1999									7890															
Linde and Watschke, 1997						15																		
Gross et al, 1991						231																		
Gross et al, 1990						25																		
Gross et al, 1990						8																		
Horner et al, 1994			45					1							0.08					0.10				
Garn, 2002																		2.06	3.52					
Schueler & Shepp 1993			11	3											0.50	0.06								
Pitt et al 1996a				450	310	118										0.30	0.63	0.29						
Pitt et al 1996b		0		136	687	807								0.04		0.49	0.62	0.20						
Pitt, et al, 1996	3	27	16	15			38																	
DSWF, 1996	9	19	27	172	173	602	37						0.20	0.09	0.45	0.63	1.16	1.67						
Wisconsin, 1992	19	36	474	241	193	457							0.24	0.19	0.48	0.53	1.50	3.47						
Bannerman et al, 1993	15	27	58	326	173	397							0.20	0.15	0.19	1.07	1.16	2.67						
Steuer et al, 1997	24	36	138	305	157	262							0.09	0.06	0.20	0.23	0.35	2.33						
Waschbusch et al, 1999a	18	16	51	69	34	91							0.07	0.11	0.05	0.32	0.18	1.20						
Waschbusch et al, 1999b		20		211	68	128								0.16		0.76	0.24	1.54						
Waschbusch et al, 1999c	21	18	75	94	266	77							0.13	0.07	0.11	0.38	0.50	1.05						
Waschbusch et al, 1999d	21	20	75	94	255	88							0.13	0.12	0.11	0.38	0.47	1.13						
Arithmetic Mean	16	22	97	183	232	236	37	18	7306	5340	4940	160	0.15	0.11	0.24	0.47	0.68	1.60	3.52	0.42	1.82	1.24		0.68
Geometric Mean	14	14	54	111	177	121	37	6	5791	3069	4940	160	0.14	0.10	0.18	0.38	0.55	1.23	3.52	0.30	0.74	0.63		0.67
MODEL VALUE	15	20	60	110	180	125	50	30	6000	3000	1000	160	0.15	0.11	0.25	0.38	0.49	1.30	3.60	0.30	2.30	1.70	1.10	1.30