Phosphorus and Sediment Loss from Plum Creek Watershed

Marty Jacobson, Kevin Fermanich, Paul Baumgart
Department of Natural and Applied Sciences
University of Wisconsin-Green Bay

October 14, 2011

Project Overview

Modeling suggests that Plum Creek contributes significant phosphorus (P) and sediment loads to the Lower Fox River and that agriculture is the largest source of these pollutants (Table 1). To meet water quality goals outlined in the pending Lower Fox River Basin and Lower Green Bay Total Maximum Daily Load (TMDL) and Watershed Management Plan, major reductions (>70%) of both P and sediment are needed (Table 1). The major goals of this project are to estimate Plum Creek P and sediment load contributions to the Lower Fox River and to examine the effect of land use characteristics (soil test P, tillage, nutrient management) on P and sediment loss within the watershed.

Table 1. Modeled Plum Creek watershed TSS (A) and TP (B) sources, baseline contributions, TMDL allocations, and % reductions from baseline to meet TMDL allocations (WDNR 2010).

A	Sources	Total Suspended Solids Load (lbs/yr)			%
		Baseline	Allocated	Reduction	Reduction
	Agriculture	11,171,743	2,835,478	8,336,265	74.6%
	Urban (non-regulated)	447,810	447,810	-	-
	Natural Background	148,577	148,577	-	-
	LOAD ALLOCATION	11,768,130	3,431,865	8,336,265	**70.8%**
	Urban (MS4)	24,329	14,597	9,732	40.0%
	Construction	168,238	33,648	134,590	80.0%
	General Permits	47,269	47,269	-	-
	WWTF-Industrial	682	682	-	-
	WWTF-Municipal	30,257	30,257	-	-
	WASTELOAD ALLOCATION	270,775	126,453	144,322	**53.3%**
	TOTAL (WLA + LA)	12,038,905	3,558,318	8,480,587	**70.4%**

B	Sources	Total Phosphorus Load (lbs/yr)			%
		Baseline	Allocated	Reduction	Reduction
	Agriculture	27,660	3,861	23,799	86.0%
	Urban (non-regulated)	1,316	1,316	-	-
	Natural Background	359	359	-	-
	LOAD ALLOCATION	29,335	5,536	23,799	**81.1%**
	Urban (MS4)	76	53	23	30.0%
	Construction	164	164	-	-
	General Permits	168	168	-	-
	WWTF-Industrial	546	341	205	37.5%
	WWTF-Municipal	1,280	931	349	27.3%
	WASTELOAD ALLOCATION	2,234	1,657	577	**25.8%**
	TOTAL (WLA + LA)	31,569	7,193	24,376	**77.2%**

Figure 1. Multi-field catchment sampling sites 2 (left) and 11 (right).

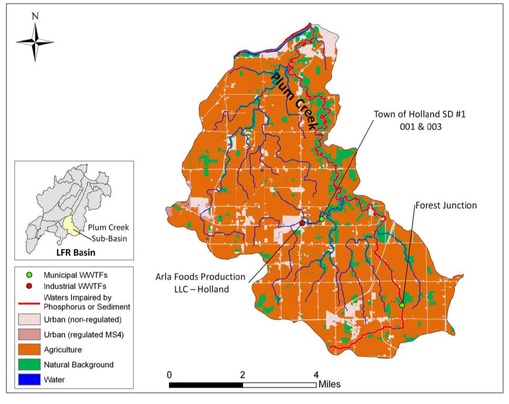

Figure 1. Plum Creek watershed land uses and point sources (WDNR 2010).

Plum Creek Watershed

- Area: 92.3 km^2 (35.6 mi^2)
  - Main branch: 63.5%; West branch: 36.5%
  - Brown County (38%); Calumet County (37%); Outagamie County (25%)
- Land Use:
  - Agriculture is dominate (76.2%)
  - Urban (11%)
  - Natural (12%)
- Mean Slope: 2.34%; Range: 0%-32.1%

Goals

1. Estimate Plum Creek P and sediment export to the Lower Fox River
2. Examine the effect of land use characteristics (soil test P, tillage, nutrient management, point sources) on P and sediment loss within the watershed
3. Evaluate SNAP-Plus and the Wisconsin P-Index in respect to water quality objectives.

Study Design and Approach (in progress)

Goal 1

- Analyze low flow samples from the main and west branches of Plum Creek for total P (TP), total dissolved P (DP) and total suspended solids (TSS)
- Analyze event flow sampling of main and west branches of Plum Creek for TP, DP and TSS
- Measure discharge at the main and west branches to develop a rating curve

Goal 2

- Analyze event peak flow samples from multi-field catchments for TP, DP and suspended sediment concentration (SSC)
- Determine relationship between P and sediment loss and land use practices and characteristics
- Analyze low flow samples upstream and downstream from a cheese factory.

- Goal 3
- Analyze event peak flow samples of multi-field catchments for TP, DP and suspended sediment concentration (SSC)
- Gather nutrient management plan data and enter into SNAP-Plus
- Compare SNAP-Plus P-Index and RUSLE2 values to measured P and sediment loss

Methods

- Plum Creek cooperative USGS automated flow and sampling station on County D south of Wrightstown (Figure 7).
- Continuous stage measurements and grab sampling of Plum West Branch at New Road (Figure 7).
- Bi-weekly low flow sampling.
- Low flow sampling upstream and downstream of cheese factory discharge in Holland (Figure 1).
- Peak flow sampling at culverts downstream of 17 multi-field catchments (37-524 ac) following uniform runoff events (Figure 7). The goal is to sample a minimum of five events.
- Samples analyzed for SSC or TSS, TP and total DP at GBMSD or UWGB labs.
- Plum data is compared to ongoing sampling at Baird and Mahon Watersheds.
- Data were statistically analyzed in SAS.

Watershed Scale Water Quality Results

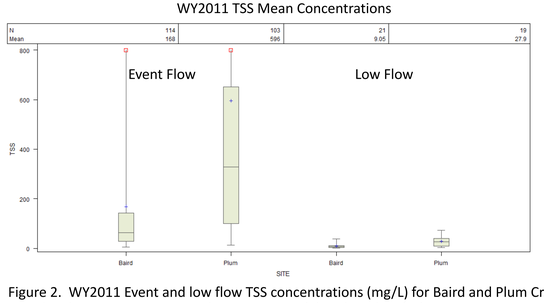

Figure 2. WY2011 Event and low flow TSS concentrations (mg/L) for Baird and Plum Creeks. Box plot show range, interquartile range, mean (+) and median (—) concentrations.

- Higher sediment loss in Plum likely a result of agricultural intensity and greater slopes (2.34% - 1.67%).
- Event and low flow mean concentrations for Plum were significantly greater than Baird ($p \leq 0.05$).

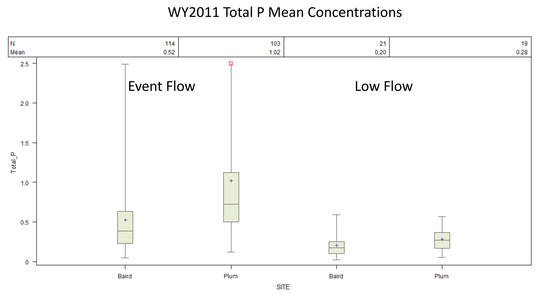

Figure 3. WY2011 Event and low flow TP concentrations (mg/L) for Baird and Plum Creeks. Box plot show range, interquartile range, mean (+) and median (—) concentrations.

- Higher P loss in Plum likely a result of agricultural intensity (Figure 1).
- Event flow TP mean concentrations for Plum Creek were significantly greater than Baird Creek($p \leq 0.05$).
- All mean and median concentrations are well above target of 0.075 mg/L TP.

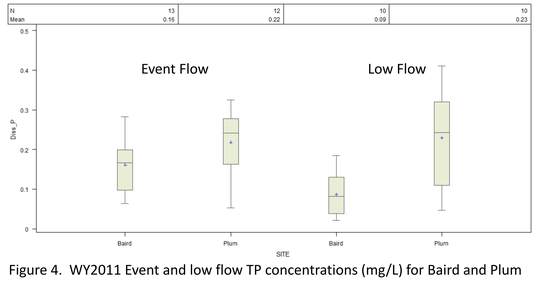

Figure 4. WY2011 Event and low flow TP concentrations (mg/L) for Baird and Plum Creeks. Box plot show range, interquartile range, mean (+) and median (—) concentrations.

- Higher P loss in Plum likely a result of agricultural intensity (Figure 1).
- Low flow DP mean concentrations for Plum Creek were significantly greater than Baird Creek($p \leq 0.05$).

Point Source Inputs

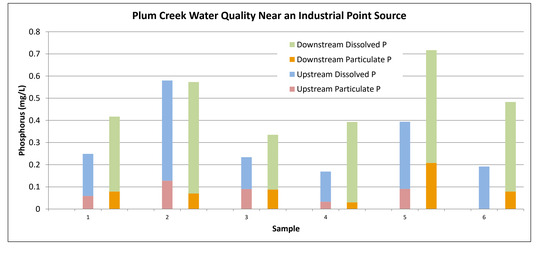

Figure 5. Low flow TP and DP concentrations upstream and downstream of cheese factory. Samples taken May-September 2011.

- Upstream and downstream TP and DP concentrations are statistically significant different ($p \leq 0.05$).
- Loads from this source are estimated to be <2% of total watershed load and less than the one WWTP (Table 1).

Multi-Field Catchment Water Quality

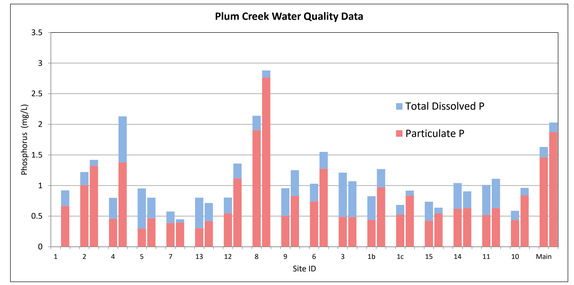

Figure 6. Phosphorus concentrations for 17 multi-field catchments and the main branch of Plum Creek from April 16 and April 26, 2011 events.

- There is a range of P concentration in runoff among sites.
- The differences appear to be related to STP, cover and slope. More data is needed to explore these relationships (Figure 7).

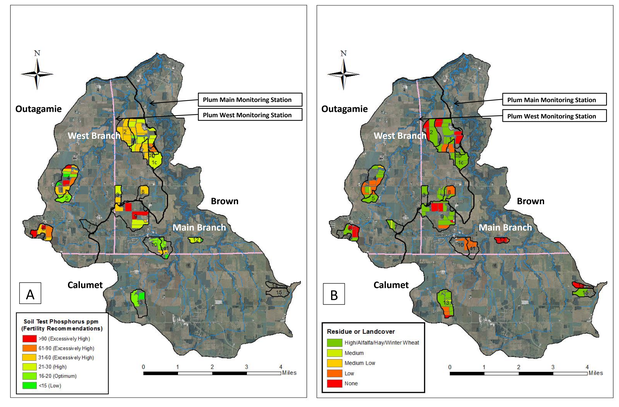

Figure 7. Soil test P ppm/fertility recommendations (A) and residue/land cover (B) of17 multi-field catchments in Plum Creek watershed. Also shown are streams, west and main branch sub-watershed boundaries, and county boundaries.

Discussion of ongoing study

Preliminary data suggests TSS and P concentrations at the multi-field catchment and watershed scales exceed TMDL water quality goals (WDNR 2010) but further data collection is needed. Future data from the multi-field scale aspect of this study may inform us as to how the current P-Index standard of 6 (NR 151) relates to water quality in Plum Creek and similar watersheds across Wisconsin. Consistent with previous monitoring and modeling efforts P and sediment loss from Plum Creek is significantly greater than other watersheds in the basin.

Acknowledgements

- USGS
- UWGB Foundation: Arjo Wiggins
- Brown County Land Conservatin Department
- Calumet County Land Conservation Department
- Outagamie County Land Conservation Department
- Matt Abrahamzon, Dave Dolan - UWGB

Literature Cited

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- Wisconsin Adminstrative Code, Chapter NR 151. 2010 Runoff Management.