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2009 Biological and Water Quality Study of the West Branch DuPage River

DuPage, Cook and Will Counties, Illinois

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Final Report

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FOREWORD

What is a Biological and Water Quality Survey?
A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. The latter is the case with the West Branch DuPage River biological and water quality study in that the West Branch represents a defined watershed of approximately 150 square miles in drainage area that has a complex mix of overlapping stressors and sources in a highly developed landscape. This assessment is a follow-up to a similarly intensive survey of the West Branch done in 2006 that was the first effort of comprehensive reach and scope accomplished for this watershed. Previous surveys and assessments by Illinois EPA and DNR were done at a less intense spatial scale. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, can also be addressed.

Scope of the West Branch DuPage River Biological and Water Quality Assessment
Biological, chemical, and physical monitoring and assessment techniques were employed to meet two major objectives: 1) determine the extent to which biological assemblages are impaired (using current Illinois EPA guidelines; IEPA 2008), and 2) determine the categorical stressors and sources that are associated with those impairments. The data gathered here were processed, evaluated, and synthesized as a biological and water quality assessment of aquatic life support. The assessment made here is directly comparable to that made in 2006, such that trends in support status can be examined, and causes and sources of impairment can be confirmed or appended as needed. This study contains a summary of major findings and recommendations for future monitoring, follow-up investigations, and any immediate actions that may be needed to resolve readily diagnosed impairments. It was not the role of this study to identify specific remedial actions on a site specific or watershed basis. However, the baseline data established by this study should provide a firmer basis for developing these types of remedial projects in the future.

Biological and Water Quality Study of the West Branch of the DuPage River 2009

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INTRODUCTION

A biological and water quality study of the West Branch DuPage River and its tributaries was conducted in 2009 to assess current condition status, identify proximate stressors, examine water quality and biological condition relative to publicly owned treatment works, and monitor for trends relative to the baseline survey conducted in 2006. Results from the 2006 survey were published in Biological and Water Quality Study of the East and West Branches of the DuPage River and the Salt Creek Watersheds (2008). That report is hereafter referred to as the Bioassessment Report. Subsequent to the 2006 survey, significant habitat restoration in the West Branch DuPage River mainstem from river mile (RM) 15 to 9, and the lower 1.5 miles of Kress Creek was part of an on-going remediation of contaminated sediments (see http://www.epa.gov/R5Super/npl/illinois/ILD980823991.htm) . The remediation effort included channel restoration of the West Branch mainstem and Kress Creek, and initiated removal of low-head dams at McDowell Grove and Warrenville.

Executive Summary

The effluent quality of publicly owned wastewater facilities was within limits specified in National Pollution Discharge Elimination System (NPDES) permits for all of the plants evaluated, and loadings from five of the seven evaluated majors showed no trend over the last decade. For the two where an increasing trend was noted, the Carol Stream Water Reclamation Center had 43 percent higher effluent concentrations of biological oxygen demand in 2008 and 2009, and flows at the Wheaton plant increased 28 percent in 2008 and 2009 relative to the 1998-2007.

Chloride and total Kjeldahl nitrogen (TKN) concentrations were higher in 2009 compared to 2006, especially in small streams. The increase in chloride concentrations likely reflected higher snowfall in 2008/09 compared to 2005/06. The increase in TKN concentrations was explained, in part, by Julian day[1] and flow, suggesting the wetter winter in 2008-9 resulted in either more humic compounds carried by groundwater, or more algae from increased stormwater pond overflows.

[1] Julian day is the day number starting with January 1 as day 1 and subsequently through December 31 as day 365.

Dissolved oxygen (D.O.) concentrations measured by continuous monitors in 2008 and 2009 showed fewer and shorter duration episodes of critically low concentrations compared to 2006. The improved D.O. regime was likely due to higher flows in 2009 (geometric mean flow for the summer period of June 15 – September 15 was 22 cfs in 2006 compared to 27 cfs in 2009). Nevertheless, some critically low D.O. concentrations were recorded in 2009. Furthermore, analysis of nitrate, nitrite, ammonia and D.O. concentrations from daytime grab samples revealed a positive association between D.O. and nitrate, and a negative association between D.O. and both nitrite and ammonia, suggesting that the effect of organic enrichment on D.O. could be influencing nitrification-denitrification processes. Geometric mean ammonia and nitrite concentrations were elevated above concentrations typical for unpolluted streams at approximately one-half the sites.

A trend toward improving macroinvertebrate communities in the West Branch mainstem was detected in the reach downstream from Kress Creek relative to that found in 2006. Given that the habitat restoration had only recently been completed prior to the 2009 survey, the trend suggests that further improvement within the reach can reasonably be expected. Macroinvertebrate communities in small headwaters (those $\leq$5 mi^2), scored lower in 2009 compared to 2006. The difference may have been caused by the increased use of chloride-bearing road deicing chemicals, as snowfall during the antecedent winter was nearly double that for the winter prior to the 2006 survey. No change in the quality of fish communities was detected in either the mainstem or tributaries relative to 2006 (Table 1).

For the watershed as a whole, only the lower eight-mile reach of the West Branch downstream from the Fawell Dam is considered in full attainment of IEPA guidelines for the aquatic life use (Figure 1, Table 1). All other mainstem reaches and tributaries failed to meet the aquatic life use guidelines due to varying combinations of poor habitat, organic enrichment, and urban stormwater. Partial support of the aquatic life use was noted in mainstem reach between river mile 16 and 19, and near the mouth of Klein Creek. Urban stormwater is an overarching source of stress to the system, whereas organic enrichment and habitat tend to be more localized (Table 1).

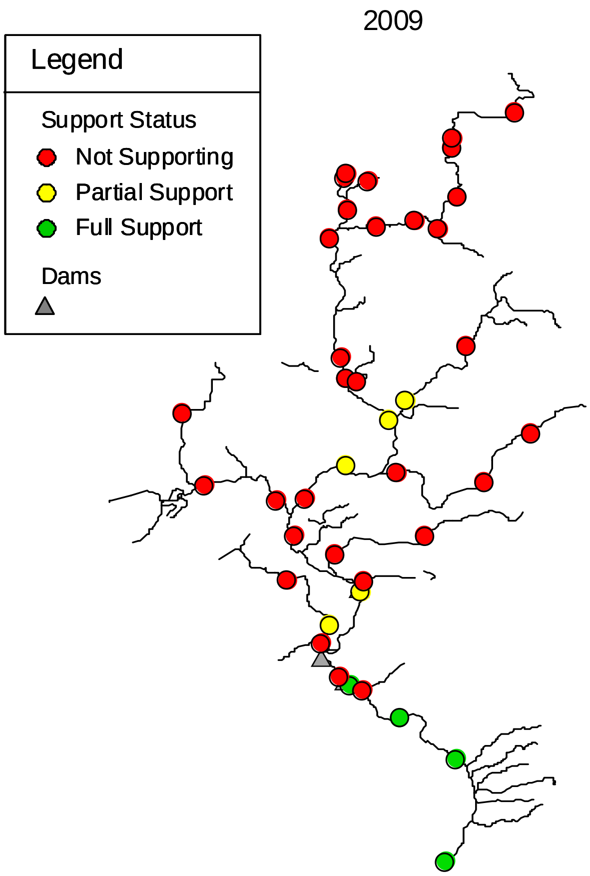

Figure 1. Support of aquatic life for sites sampled in the West Branch DuPage River basin, 2009 and 2006.

Table 1. Status of aquatic life use support for stream segments sampled in the West Branch DuPage River basin, 2009.

Site ID	River Mile	QHEI	mIBI	fIBI	ALU[1] Support Status	MBI Assessed Cause[2]	IEPA 303d Listing[3]	2006 mIBI	2006 fIBI
West Branch DuPage River (95-900)									
IL_GBK-14									
WB25	34.0	36.0	18.0	8.5	Not (Poor)	BOD, TKN, Habitat, TP	Not assessed	26.5	13.5
WB31	31.9	56.0	32.1	13.5	Not (Poor)			30.4	13.0
IL_GBK- 09									
WB24	31.6	54.5	17.9	9.5	Not (Poor)	BOD, TKN, Habitat, TP,	Sediment, Zn, pH, TP	20.5	11.5
WB32	30.1	70.5	18.7	20.0	Not (Poor)	NH3		29.1	19.5
WB27	28.7	72.0	27.3	18.5	Not (Poor)			35.1	22.0
WB28	27.4	73.0	24.2	18.5	Not (Poor)			10.2	18.0
WB20	25.6	76.0	41.3	20.0	Not (Poor)			37.7	21.5
WB39	21.7	58.0	46.2	19.5	Not (Poor)			47.4	17.0
IL_GBK- 05									
WB33	21.3	70.5	41.0	19.0	Not (Poor)	Flow alteration[4],NH3	Sediment, TSS, TP		19.0
WB17	19.2	65.0	64.9	22.0	Not (Fair)			72.4	19.5
WB38	16.0	75.0	58.7	21.5	Not (Fair)				21.0
WB34	15.1	83.0	52.7	17.0	Not (Poor)				
WB12	13.6	75.0	54.4	18.5	Not (Poor)			46.6	18.5
WB40	11.7	77.5	51.2	22.0	Not (Fair)			46.7	18.5
WB36	8.6	70.0	48.9	16.5	Not (Poor)			44.9	17.5
IL_GB-02									
WB41	8.0	84.0	66.6	28.0	Full		Sediment, As, TP, Methoxychlor	38.3	27.0
WB37	6.3	86.5	59.9	31.5	Full			65.6	33.5
WB35	4.2	75.8	60.9	31.5	Full			53.6	31.5
WB08	0.9	72.0	75.8	33.5	Full			65.0	

Table 1. Attainment table

Site ID	River Mile	QHEI	mIBI	fIBI	ALU[1] Support Status	Cause[2]	303d Listing[3]	2006 mIBI	2006 fIBI
Unnamed Tributary (95-902) - IL_GBK-36									
WB18	0.3	51.5	38.6	15.0	Not (Poor)	Habitat	Not listed	39.2	14.0
Unnamed Tributary (95-904) - IL_GBK-40									
WB22	0.2	18.0	11.3	18.0	Not (Poor)	BOD, TKN, Habitat	Not listed	35.8	12.0
Unnamed Tributary (95-905) - IL_GBK-41									
WB23	0.2	42.5	24.0	17.0	Not (Poor)	TKN, Habitat	Not listed	31.8	14.0
Unnamed Tributary (95-906) - IL_GBK-39									
WB29	2.2	40.0	25.7	4.5	Not (Poor)	TKN, Habitat	Not listed	20.7	6.5
WB30	1.9	42.0	18.6	7.5	Not (Poor)			27.9	6.0
WB21	0.9	64.8	19.1	18.0	Not (Poor)			32.9	19.0
Kress Creek (95-910) - IL_GBK-B01									
WB02	5.1	47.0	24.4	13.5	Not (Poor)	Nitrite, Habitat	Not assessed	32.7	11.0
WB01	2.7	53.0	44.2	19.0	Not (Poor)			44.5	18.0
WB03	0.5	81.5	31.2	18.5	Not (Poor)			37.0	17.5
Ferry Creek (95-920) - IL_GBK- 21									
WB04	2.8	62.5	17.7	16.0	Not (Poor)	NH3, BOD, TKN,	Not listed	15.0	16.5
WB06	0.7	57.0	32.8	22.5	Not (Fair)	Habitat, D.O.		43.0	
West Branch Ferry Creek (95-925) - IL_GBK- 22									
WB05	0.3	72.0	21.8	18.0	Not (Poor)		Not listed	32.7	15.0

Table 1. Attainment table

Site ID	River Mile	QHEI	mIBI	fIBI	ALU[1] Support Status	Cause[2]	303d Listing[3]	2006 mIBI	2006 fIBI
Cress Creek (95-930) - IL_GBK- 20									
WB07	0.2	69.0	27.4	27.5	Not (Poor)	BOD	Not listed	24.0	26.5
Bremme Creek (95-940) - IL_GBK- 24									
WB09	0.3	56.0	28.2	5.5	Not (Poor)	Habitat			
Spring Brook (95-950) - IL_GBK-A01									
WB11	3.3	49.5	12.3	16.5	Not (Poor)	Nitrite, TKN, Habitat	Cu, TP	14.3	19.0
WB26	3.0	59.5	21.9	15.5	Not (Poor)				16.5
WB10	0.8	64.0	30.1	21.5	Not (Poor)				19.5
Winfield Creek (95-960) - IL_GBK-31									
WB15	5.4	50.0	23.6	18.5	Not (Poor)	D.O., NH3, BOD,	Not listed	31.3	16.5
WB14	3.5	50.5	19.0	13.0	Not (Poor)	TKN, Chloride, Habitat		23.4	15.5
WB13	0.4	50.5	38.0	20.0	Not (Poor)				18.0
Klein Creek (95-970) - IL_GBK-32									
WB19	3.6	52.3	29.0	18.0	Not (Poor)	TKN, Habitat	Not listed	39.3	21.0
WB16	1.0	87.0	38.7	21.5	Not (Fair)			51.3	18.5

[1]Aquatic Life Use
[2]The most proximate or highest magnitude stressor causing impairment is listed.
[3]As listed in the 2008 IEPA Integrated Water Quality Report (IEPA/BOW/08-016)
[4]Flow alteration due to Fawell Dam

STUDY AREA

The 2009 study area included the West Branch DuPage River and its perennial tributaries (Plate 5). A detailed description of the catchment was given in the Bioassessment Report, and will not be reproduced here, save for an update on the status of three dams on the mainstem of the West Branch. Sampling locations duplicated those of 2006, and were selected to systematically cover the watershed down to a drainage area size of approximately 2 mi^2 (Figure 2), bracket point sources, and target specific segments of interest (Table 2).

Warrenville Grove Dam: The Warrenville Grove Dam is located on the West Branch of the DuPage River within the Warrenville Grove Forest Preserve in the City of Warrenville. The dam is one third of a mile upstream of Warrenville Road and 0.4 miles downstream of Butterfield Road (IL Route 56). The low head dam is owned by the Forest Preserve District of DuPage County (FPDDC) and is approximately 75 years old. Access to the dam is best gained via the Forest Preserve parking lot on the east side of Batavia Road.

The dam was constructed of limestone facing placed in a stair step configuration with a concrete foundation and headwall on the upstream face of the spillway. The dam is 107 feet across with a curving spillway face that has a total crest length of about 125 feet. The dam has a total height of 8.5 feet above the downstream river channel bottom and a total hydraulic height of 5.7 feet (from spillway crest to tailwater elevation under average flow conditions). The dam also features a mill race that was partially retrofitted in 1995 to function as a fish ladder and canoe chute. The impoundment created by the Warrenville Grove Dam is approximately 1.2 miles in length and covers about 16.9 acres.

Plate 1. The Warrenville Dam, looking upstream.

The dam was constructed by the Civilian Conservation Corps between 1936 and 1938. The dam was designed by the National Park Service and was part of a dam building program in the region that was conveyed as a way to "reduce bank erosion". The site for the dam was chosen due to the presence of an older abandoned dam in the same location that provided a power source to mills between 1847 and 1897. The FPDDC and DuPage County Division of Stormwater Management are planning to remove the dam during 2010 to 2011.

McDowell Grove Dam: The McDowell Grove Dam was removed in mid 2008 in a cooperative project administered by the FPDDC and DuPage County Division of Stormwater Management.

The dam was located on the West Branch of the DuPage River within the McDowell Grove Forest Preserve in unincorporated DuPage County and was approximately 75 years old.

Plate 2. Remnants of the McDowell Grove dam used to form a riffle.

Plate 3. Temporary coffer dam upstream of McDowell Grove Dam, dissolved oxygen monitoring site WBMG can be seen in the background.

The site is best accessed from the signalized intersection of McDowell Road and Raymond Drive, which provides an entrance to the parking lot within McDowell Grove Forest Preserve. The majority of the impoundment still exists due to the construction of a temporary steel sheet piling coffer dam (see Plate 3) 0.8 miles upstream of the original dam location. This coffer dam needs to remain in place until the ongoing thorium removal project is completed within the West Branch of the DuPage River, perhaps as soon as 2011 depending on federal funding. As Plate 2 shows the foundation of the original dam was left in place to form a riffle feature.

Plate 4. Aerial photo of Fawell Dam.

Fawell Dam: Located one mile downstream of the former McDowell Grove dam in McDowell Grove Forest Preserve. It is a flood control structure consisting of a large earthen berm with three automatically controlled floodgates. The stormwater control facility run by DuPage County Division of Stormwater Management.

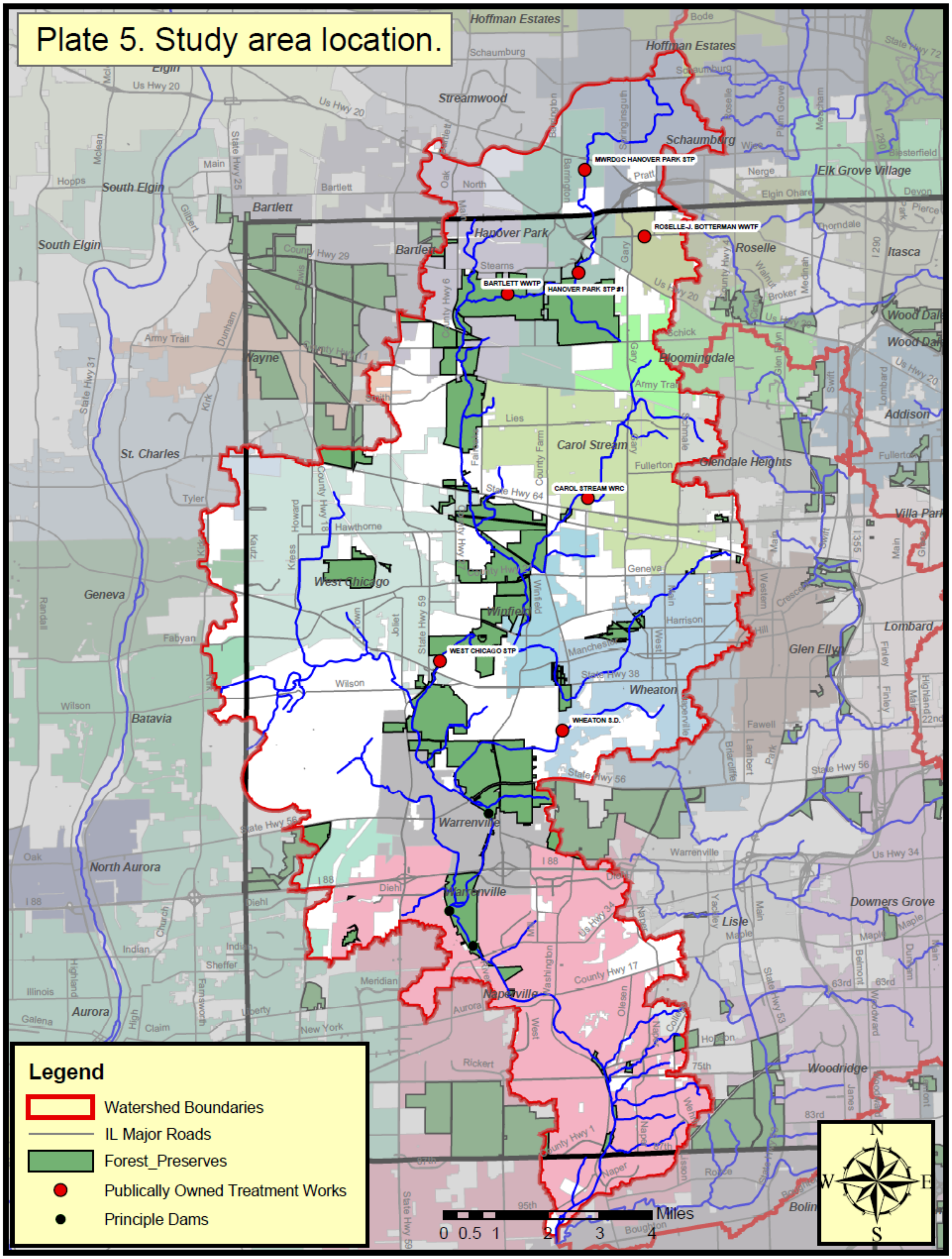

Plate 5. West Branch DuPage River study area location.

METHODS

Sites sampled (Figure 2) were selected systematically using a geometric approach by starting at the downstream terminus of the watershed as the first site, and selecting subsequent sites at fixed intervals of one-half the drainage area of the preceding site. Thus, the upstream drainage area of each succeeding point, as one moves upstream, decreases by 50%. This resulted in seven levels of drainage area, starting from 150 mi.^{2}, through drainage sizes of 75, 38, 19, 9, 5 and finally 2 mi^2. Each level was then supplemented with sites that targeted stream segments of particular interest such as those that have outfalls of publicly owned treatment works (POTW), major stormwater sources, and dams.

Each site was sampled for habitat quality, macroinvertebrates, and fish. All sites except for RM 13.6 (Site WB12) were sampled for water quality. Water quality parameters at all sites (except WB12) included nutrients (nitrogen and phosphorus), indicators of organic enrichment (5-day biochemical oxygen demand, ammonia-nitrogen, total Kjeldahl nitrogen), indicators of ionic strength (chloride, conductivity, total dissolved solids), total suspended solids, dissolved oxygen, and water temperature. Water column metals (Ca, Cd, Cu, Fe, Mg, Pb, and Zn and hardness) were included at 29 locations. Additionally, sediment quality was sampled at 23 locations, and continuous dissolved oxygen monitoring was conducted at 4 locations. Sediments were analyzed for metals, polycyclic aromatic hydrocarbons, and pesticides.

The macroinvertebrate assemblage was sampled using the Illinois EPA multihabitat method at all sites. This method involves the selection of a sampling reach that has instream and riparian habitat conditions typical of the assessment reach, has flow conditions that approximate typical summer base flow, has no highly influential tributary streams, contains one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present, and is at least 300 feet in length. This method is applicable if conditions allow the sampler to collect macroinvertebrates (i.e., to take samples with a dip net) in all bottom-zone and bank-zone habitat types that occur in a sampling reach. The habitat types are defined explicitly in Appendix E of the project QAPP (MBI 2006b). Conditions must also allow the sampler to apply the 11-transect habitat-sampling method, as described Appendix E of the Quality Assurance Project Plan[2] or to estimate with reasonable accuracy--via visual or tactile cues the amount of each of several bottom-zone and bank-zone habitat types. If conditions (e.g., inaccessibility, water turbidity, or excessive water depths) prohibit the sampler from estimating with reasonable accuracy the composition of the bottom zone or bank zone throughout the entire sampling reach, then the multi-habitat method is not applicable. In most cases, if more than one-half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of the bottom-zone and bank-zone habitat types are attainable; thus, the multi-habitat method is not applicable. The resulting samples were preserved in 10% formalin.

[2] http://www.drscw.org/reports/DuPage.QAPP_AppendixE.07.03.2006.pdf

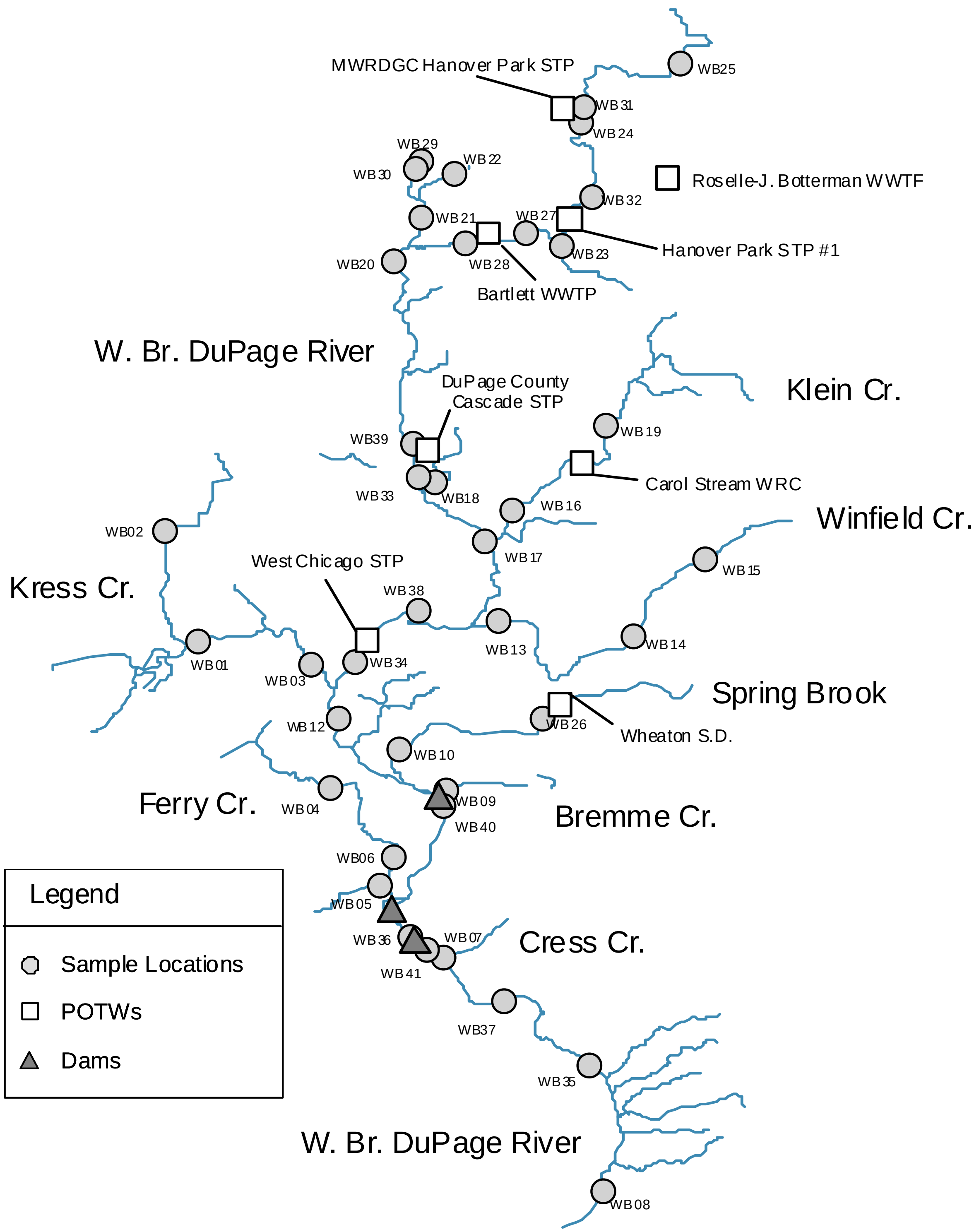

Figure 2. Locations sampled during the 2009 West Branch DuPage bio-survey.

Table 2. Location descriptions, geographic coordinates, stream size and site identifiers used for sites sampled during the 2009 biological and water quality survey of the West Branch DuPage River and its tributaries. Site identifiers used in the 2006 are cross-referenced.

Site ID	River Mile	Latitude	Longitude	Drain Area	Wetted Width	Location	Samples
West Branch DuPage River (95-900)							
WB25	34.00	42.01123	-88.11092	2	8.7	UST Braintree Drive, Schaumburg	C, F, M
WB31	31.90	42.00065	-88.13599	5	20.7	UST Longmeadow Ln. & MWRDGC WWTP	C, F, M, S
WB24	31.60	41.99676	-88.13637	5	23.2	UST Walnut Ave., MWRDGC Hanover Park	C, F, M, S
WB32	30.10	41.97719	-88.13406	5	33.4	DST SR 20, Hanover Park	C, F, M
WBAD	29.90	41.9750	-88.1386	5	NA	Arlington Drive	D
WB27	28.70	41.96771	-88.15060	9	25.2	UST County Farm Road, Hanover Park	C, F, M, S
WB28	27.40	41.96565	-88.16631	9	21.9	DST Bartlett WWTP, Bartlett	C, F, M, S
WB20	25.60	41.96095	-88.18444	9	31.8	DST Struckman Blvd., Bartlett	C, F, M, S
WB39	21.70	41.91364	-88.17987	19	35.0	UST St. Charles Rd, W. Chicago	C, F, M, S
WB33	21.30	41.90527	-88.17825	19	32.2	UST Great Western Trail, Timber Ridge FP	C, F, M, S
WB17	19.20	41.88889	-88.16104	19	44.5	UST Geneva Rd. West Chicago	C, F, M, S
WB38	16.00	41.87088	-88.17831	25	47.1	UST Barnes Rd, UST W. Chicago WWTP	C, F, M, S
WB34	15.10	41.85730	-88.19427	58	0.0	DST Gary's Mills Rd.	C, F, M, S
WB12	13.60	41.84301	-88.19867	40	91.1	UST Mack Rd at dog park, Warrenville	F, M, S
WBBR	12.10	41.82761	-88.17905	50	NA	Butterfield	D
WB40	11.70	41.82027	-88.17212	50	95.1	DST Butterfield Road & Warrenville dam	C, F, M, S, D
WBMG	9.10	41.7959	-88.1873	70	NA	McDowell Grove	D
WB36	8.60	41.78688	-88.18070	70	112.5	Adj Raymond Dr/Redfield Rd, ust Fawell dam	C, F, M, S
WB41	8.00	41.78329	-88.17648	76	60.0	DST Fawell dam, UST Ogden Ave. Naperville	C, F, M, S
WB37	6.30	41.77050	-88.15664	96	98.8	Adj. Centennial Park/ Jackson Ave., Naperville	C, F, M, S
WB35	4.20	41.75396	-88.13423	116	118.2	Adj. Washington St. in Pioneer Park	C, F, M, S
WB08	0.85	41.78187	-88.17113	150	90.0	Knoch Knolls Park, Naperville	C, F, M, S
Unnamed Tributary (95-902)							
WB18	0.30	41.90387	-88.17410	2	3.4	Prairie Path trib, W. Chicago	C, F, M
Unnamed Tributary (95-904)							
WB22	0.15	41.98356	-88.16914	2	0.0	UST Coral Ave. , Bartlett Village, Bartlett	C, F, M
Unnamed Tributary (95-905)							
WB23	0.15	41.96480	-88.14138	2	5.7	DST Schick Rd, Mallard Lake FP, Hanover	C, F, M
Unnamed Tributary (95-906)							
WB29	2.20	41.98669	-88.17798	2	24.3	DST Devon Ave. adj. to Leiseburg Park	C, F, M, S
WB30	1.90	41.98468	-88.17884	2	7.1	DST Amherst Drive/DST Bartlett WWTP	C, F, M, S
WB21	0.90	41.97220	-88.17770	1	0.0	DST Stearns Road	C, F, M
Kress Creek (95-910)							
WB02	5.10	41.89163	-88.24309	5	5.4	DST Prairie Path Crossing, adj. Kress Rd.	C, F, M
WB01	2.70	41.86271	-88.23458	9	19.9	UST Road A, Fermi Lab Compound	C, F, M, S
WB03	0.50	41.85701	-88.20567	19	29.8	UST intersection Joliet St./Wilson St. bridge	C, F, M, S

Table 2. continued.

Site ID	River Mile	Latitude	Longitude	Drain Area	Wetted Width	Location	Samples
Ferry Creek (95-920)							
WB04	2.80	41.82527	-88.20142	2	22.7	DST SR 59 bridge adj. parking lot	C, F, M
WB06	0.70	41.80735	-88.18452	2	14.0	UST Ferry Rd bridge, Warrenville	C, F, M
West Branch Ferry Creek (95-925)							
WB05	0.25	41.79998	-88.18789	5	8.1	DST Raymond Ave, Naperville McDowell FP	C, F, M
Cress Creek (95-930)							
WB07	0.20	41.78158	-88.17168	2	27.8	DST 5th Ave. bridge; South of Ogden Ave.	C, F, M
Bremme Creek (95-940)							
WB09	0.25	41.82457	-88.17131	2	6.3	DST Winfield Dr; ust bridge on W. Br. bike trail	C, F, M
Spring Brook (95-950)							
WB11	3.30	41.04597	-88.14260	2	20.7	UST Wheaton WWTP Sanitary discharge	C, F, M, S
WB26	3.00	41.84299	-88.14684	2	20.5	DST Mack Rd, WWTP at Allen Park, Wheaton	C, F, M, S
WB10	0.75	41.83518	-88.18279	5	27.3	Behind Maintenance Bldg, Blackwell FP	C, F, M
Winfield Creek (95-960)							
WB15	5.40	41.88385	-88.10467	2	3.6	At St Mark's Catholic Church	C, F, M
WB14	3.50	41.86397	-88.12344	5	17.7	End of Liberty St. Winfield	C, F, M
WB13	0.40	41.86816	-88.15784	9	11.7	UST Winfield Rd. in Creekside Park, Winfield	C, F, M
Klein Creek (95-970)Klein Creek (95-970)							
WB19	3.60	41.91849	-88.13046	5	19.3	UST Illini Drive, Armstrong Park, Carol Stream	C, F, M
WB16	1.00	41.89676	-88.15449	9	25.9	Klein Creek Farm, W. Chicago	C, F, M

Laboratory procedures generally followed Illinois EPA methods. For the multi-habitat method this required the production of a 300 organism subsample with a scan and pre-pick of large and/or rare taxa from a gridded tray. Taxonomic resolution was performed at the lowest practicable resolution for the common macroinvertebrate assemblage groups such as mayflies, stoneflies, caddisflies, midges, and crustaceans. This goes beyond the genus level requirement of Illinois EPA; however, calculation of the macroinvertebrate IBI followed Illinois EPA methods in using genera as the lowest level of taxonomy for mIBI scoring.

Methods for the collection of fish at wadeable sites was performed using a tow-barge or long-line pulsed D.C. electrofishing equipment based on a T&J 1736 DCV electrofishing unit described by Ohio EPA (1989). A Wisconsin DNR battery powered backpack electrofishing unit was used as an alternative to the long line in the smallest streams and in accordance with the restrictions described by Ohio EPA (1989). A three person crew carried out the sampling protocol for each type of wading equipment. Sampling effort was indexed to lineal distance and ranged from 150-200 meters in length. Non-wadeable sites were sampled with a boat-mounted pulsed D.C.

electrofishing device. A Smith-Root 5.0 GPP unit was mounted on a 12' john boat following the design of Ohio EPA (1989). Sampling effort for this method was 500 meters. A summary of the key aspects of each method appears the project QAPP (MBI 2006b). Sampling distance was measured with a GPS unit or laser range finder. Sampling locations were delineated using the GPS mechanism and indexed to latitude/longitude and UTM coordinates at the beginning, end, and mid-point of each site. The location of each sampling site was indexed by river mile (using river mile zero as the mouth of the river). Sampling was conducted during a June 15-October 15 seasonal index period.

Samples from each site were processed by enumerating and recording weights by species and in some cases by life stage (y-o-y, juvenile, adult). All captured fish were immediately placed in a live well, bucket, or live net for processing. Water was replaced and/or aerated regularly to maintain adequate dissolved oxygen levels in the water and to minimize mortality. Fish not retained for voucher or other purposes were released back into the water after they had been identified to species, examined for external anomalies, and weighed. Weights were recorded at level 1-5 sites only. Larval fish were not included in the data and fish measuring less than 15-20 mm in length were generally not included in the data as a matter of practice. The incidence of external anomalies was recorded following procedures outlined by Ohio EPA (1989) and refinements made by Sanders et al. (1999). While the majority of captured fish were identified to species in the field, any uncertainty about the field identification of individual fish required their preservation for later laboratory identification. Fish were preserved for future identification in borax buffered 10% formalin and labeled by date, river or stream, and geographic identifier (e.g., river mile). Identification was made to the species level at a minimum and to the sub-specific level if necessary. A number of regional ichthyology keys were used and included the Fishes of Illinois (Smith 1979) and updates available through the Illinois Natural History Survey (INHS). Vouchers were deposited and verified at The Ohio State University Museum of Biodiversity (OSUMB).

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with baseline Clean Water Act goal expectations (e.g., the General Use in the Illinois WQS). Scores greater than 75 frequently typify habitat conditions which have the ability to support an exceptional warmwater fish assemblage.

Data Management and Analysis
MBI employed the data storage, retrieval, and calculation routines available in the Ohio ECOS system as described in the project QAPP (MBI 2006b). Fish and macroinvertebrate data were reduced to standard relative abundance and species/taxa richness and composition metrics. The Illinois Index of Biotic Integrity (IBI) was calculated with the fish data. The macroinvertebrate data were analyzed using the Illinois Macroinvertebrate Index of Biotic Integrity (mIBI).

Determination of Causal Associations
Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine biological status (i.e., unimpaired or impaired, narrative ratings of quality) and assigning associated causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological indices are the principal arbiter of aquatic life use attainment and impairment following the guidelines of Illinois EPA. The rationale for using the biological results in the role of principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995).

Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures (Yoder and Rankin 1995; Yoder and DeShon 2003). Thus the assignment of principally associated causes and sources of biological impairment in this report represents the association of impairments (based on response indicators) with stressor and exposure indicators using linkages to the biosurvey data based on previous experiences within the strata of analogous situations and impacts. The reliability of the identification of associated causes and sources is increased where many such prior associations have been observed. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research which experimentally or statistically links symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experiences in interpreting symptoms (*i.e.,* multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and well-being of the patient, the ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including assemblage structure and function. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports can then provide the foundation for aggregated assessments such as the Illinois Water Resource Inventory (305[b] report), the 303[d] listing process, and the Illinois Nonpoint Source Assessment, and other technical products.

Hierarchy of Water Indicators
A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. A tiered approach that links the results of administrative actions with true environmental measures was employed by our analyses. This

integrated approach is outlined in Figure 3 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include:

1) actions taken by regulatory agencies (permitting, enforcement, grants);
2) responses by the regulated community (treatment works, pollution prevention);
3) changes in discharged quantities (pollutant loadings);
4) changes in ambient conditions (water quality, habitat);
5) changes in uptake and/or assimilation (tissue contamination, biomarkers, assimilative capacity); and,
6) changes in health, ecology, or other effects (ecological condition, pathogens).

In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). An example is the aggregate effect of billions of dollars spent on water pollution control since the early 1970s that have been determined with quantifiable measures of environmental condition (Yoder et al. 2005). Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise the Illinois EPA biological endpoints. Other response indicators can include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels that serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each (Yoder and Rankin 1998).

Illinois Water Quality Standards: Designated Aquatic Life Uses

The Illinois Water Quality Standards (WQS; 303.204-206) consist of designated uses and chemical criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic

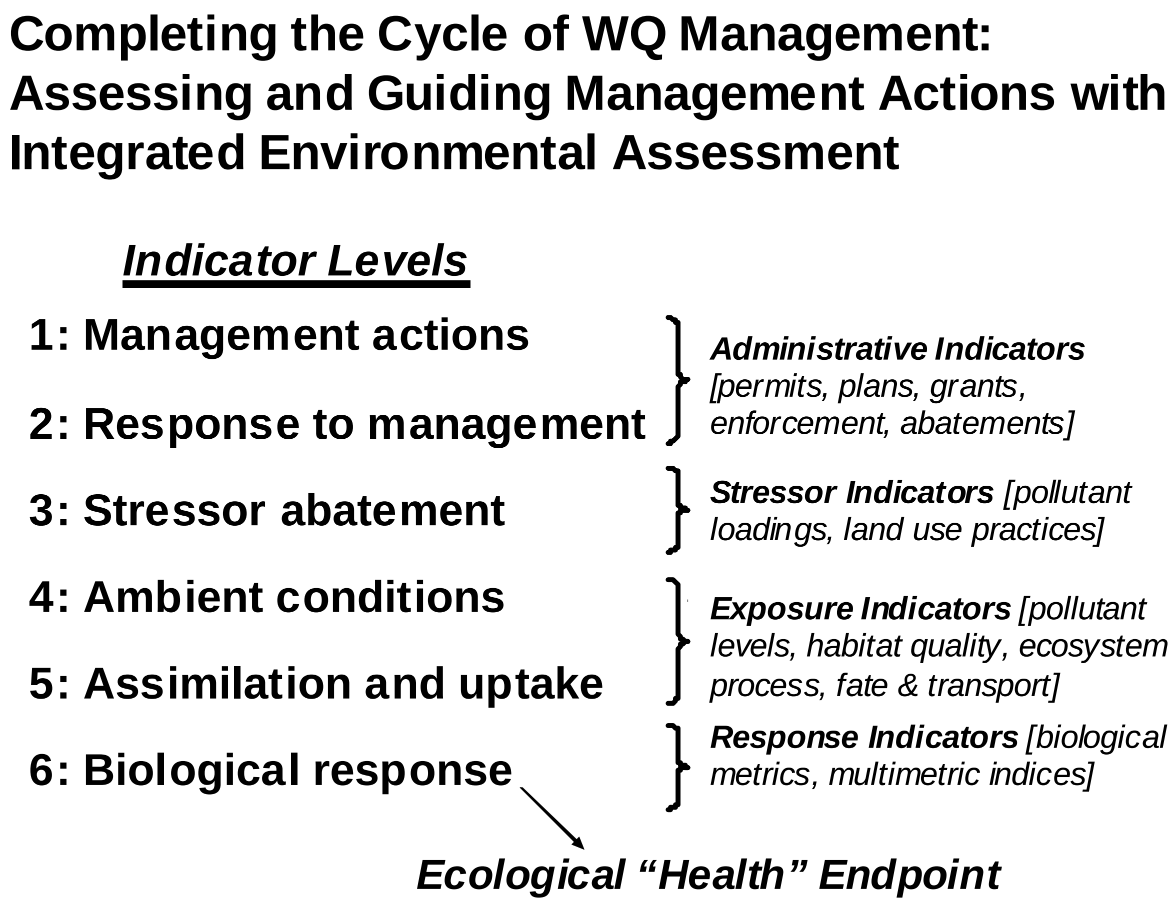

Figure 3. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995) and further enhanced by Karr and Yoder (2004).

life and non-aquatic life uses. Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. The system of use of protection are provided and extended to all water bodies regardless of size or position in the landscape. In applications of state WQS to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses.

Aquatic life use support for a water body is determined by examining all available biological and water quality information. Where information exists for both fish and macroinvertebrate indicators, and both indicators demonstrate full support, the water body is considered in full support independent of water chemistry results. Where information for both biological indicators exists, and one indicator suggests full support while the other shows moderate impairment, a use decision of full support can be made if the water chemistry data show no indication of impairment. Where one biological indicator is severely impaired, non-support is demonstrated.

If information for only one biological indicator exists, water chemistry information is used to inform the use support decision in that a biological result of full support can be overridden if the water chemistry results clearly demonstrate impairment.

RESULTS AND DISCUSSION

Pollutant Loadings by Publicly Owned Treatment Works

The West Branch DuPage River is typically effluent dominated during the summer base-flow period of July through October. For example, effluent composed over 90 percent of the stream flow during the first week of August 2009. Effluent quality data from major dischargers in the West Branch watershed (Table 3) were evaluated against permit limits to gauge the relative performance of each plant, especially with respect to plant flows (the amount of effluent leaving the plant) relative to treatment capacity, and concentrations of several key effluent constituents: fecal coliform colonies, 5-day bio-chemical oxygen demand (BOD[3]), total suspended solids (TSS) and ammonia nitrogen (NH3-N). Detailed descriptions of each plant and effluent quality were given in the Bioassessment Report; therefore, the discussion for each plant will be limited to effluent quality for 2008 and 2009 data, and trends in effluent quality over the last decade.

HANOVER PARK MWRDGC [IL0036137] No discernable trends in plant flows were detected for data reported for 2008 and 2009 relative to the preceding 7 years. Flows exceeded design capacity twice during 2008 (Figure 5). However, effluent quality for fecal coliforms, TSS, cBOD, and NH_3-N was within permit limits for 2008 and 2009 (Figures 3 and 4)., and BOD trended down for 2008 & 2009 relative to the previous time period.

ROSELLE-J. BOTTERMAN WWTF [IL0048721] The design average flow (DAF) for the treatment facility is 1.22 million gallons per day (MGD) and the design maximum flow (DMF) for the facility is 4.60 MGD. Data for this facility were not reported for the 2006 Bioassessment Report, consequently, an assessment of trends is not possible. Data for 2008 and 2009 (Figures 6 and 7) indicate that the plant is operating within permit limits, and is not hydraulically over-loaded. Fecal counts were higher during the 3rd quarter in 2009 compared to 2008.

VILLAGE OF HANOVER PARK STP #1[IL0034479] Plant flows relative to design capacity showed no discernable trends over the 2002 – 2009 time period (Figure 9). One flow in excess of design capacity was noted in 2008; however, nearly all other flows for 2008 were less than the daily designed flow of 2.42 MGD. Effluent quality was consistent through the measured time period, with values for fecal colonies (Figure 9), TSS, BOD, and NH_3-N (Figure 10) within permit limits.

BARTLETT WWTP [IL0027618] Annual and third quarter effluent flows from the Bartlett WWTP were of consistent magnitude and variation between 2000 and 2009, and were less than the daily design average (Figure 11). Similarly, fecal colonies measured in effluent samples did not

[3] Biochemical oxygen demand results were synonymously reported as BOD, cBOD and BOD_5. Labels in the loadings plots follow what was reported.

Table 3. Publicly owned sewage treatment plants that discharge to the West Branch DuPage watershed. DAF is design average flow, DMF is design maximum flow. The accompanying figure shows the relative contribution of each plant as a percentage of the average effluent volume for the first week of August, 2009. The DuPage County-Cascade STP and the Pleasant Ridge MHP are included in the table to show their relative, minor contribution to the whole, but are not discussed in the text. Facility location coordinates are listed for reference.

NPDES #	Facility Name	DAF MGD	DMF MGD	Receiving Stream	Longitude	Latitude
IL0036137	MWRDGC Hanover Park STP	12	22	West Branch	-88.1361	42.0008
IL0048721	Roselle-J. Botterman WWTF	1.22	4.6	West Branch	-88.1139	41.9822
IL0034479	Hanover Park STP #1	2.42	8.68	West Branch	-88.1386	41.9722
IL0027618	Bartlett WWTP	3.68	5.15	West Branch	-88.1650	41.9664
IL0026352	Carol Stream WRC	6.5	13	Klein Creek	-88.1353	41.9094
IL0028428	DuPage County-Cascade STP	.0058	.0234	West Branch	-88.1783	41.9011
IL0037028	Pleasant Ridge MHP	.027	0.068	Klein Creek	-88.1542	41.8889
IL0023469	West Chicago STP	7.64	20.3	West Branch	-88.1906	41.8642
IL0031739	Wheaton S.D.	8.9	19.1	Spring Brook	-88.1450	41.8447

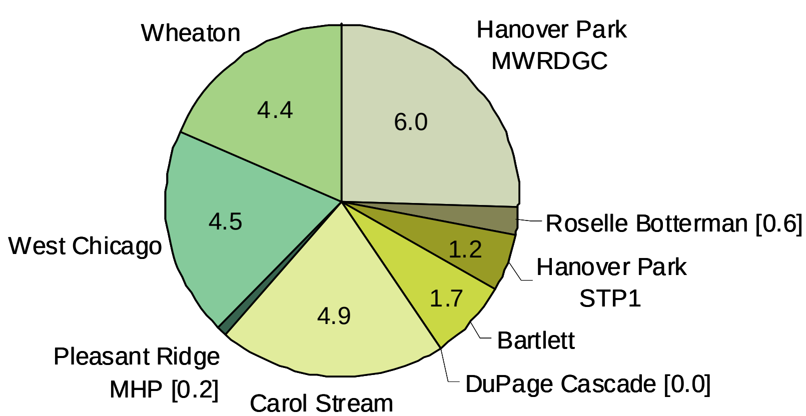

Figure 4. WWTP flows in MGD for first week of August 2009; effluent made up over 90% of stream flow.

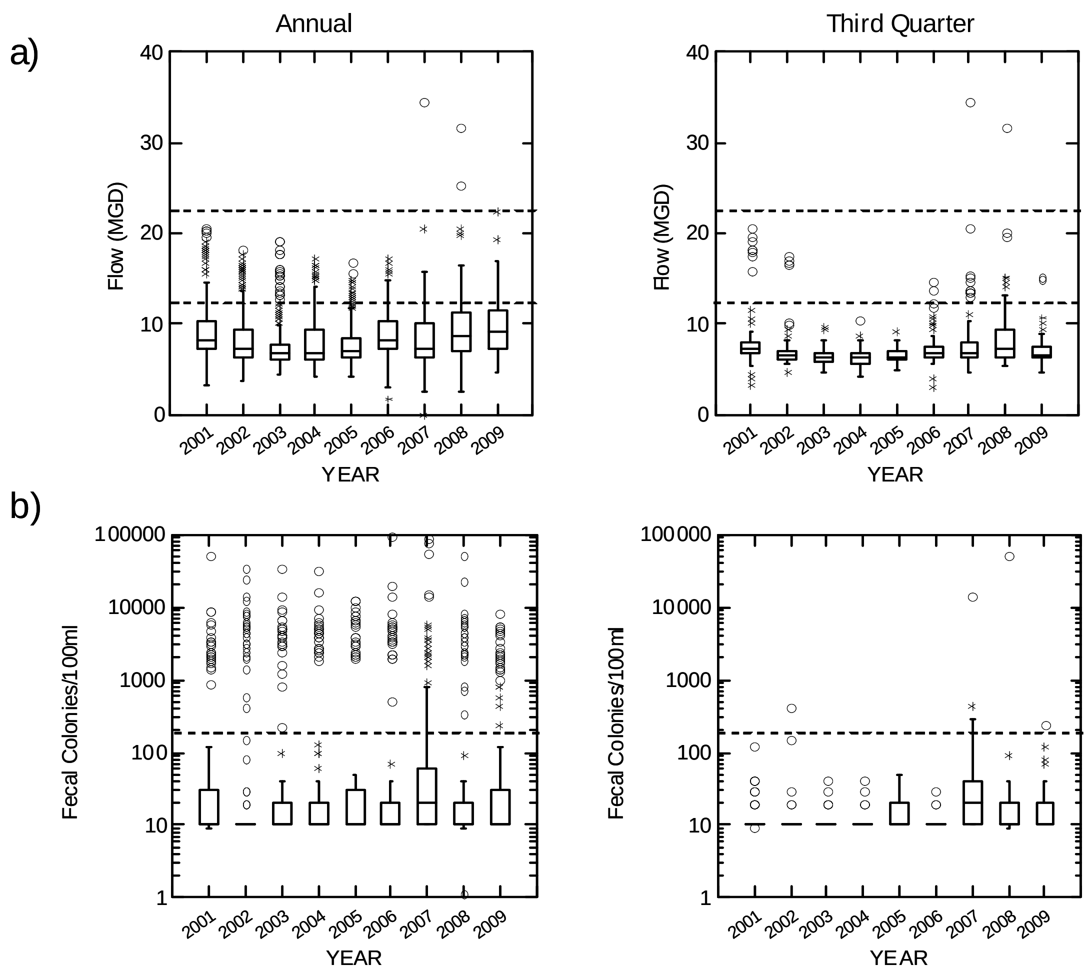

Figure 5. a) Distributions of annual and third quarter effluent flows for the MWRDGC Hanover Park WWTP, 2001 – 2009, in relation to the design maximum and design daily average (dashed lines). b) Distributions of annual and third quarter fecal coliform concentrations in plant effluent in relation to permitted monthly geometric mean (applies May through October).

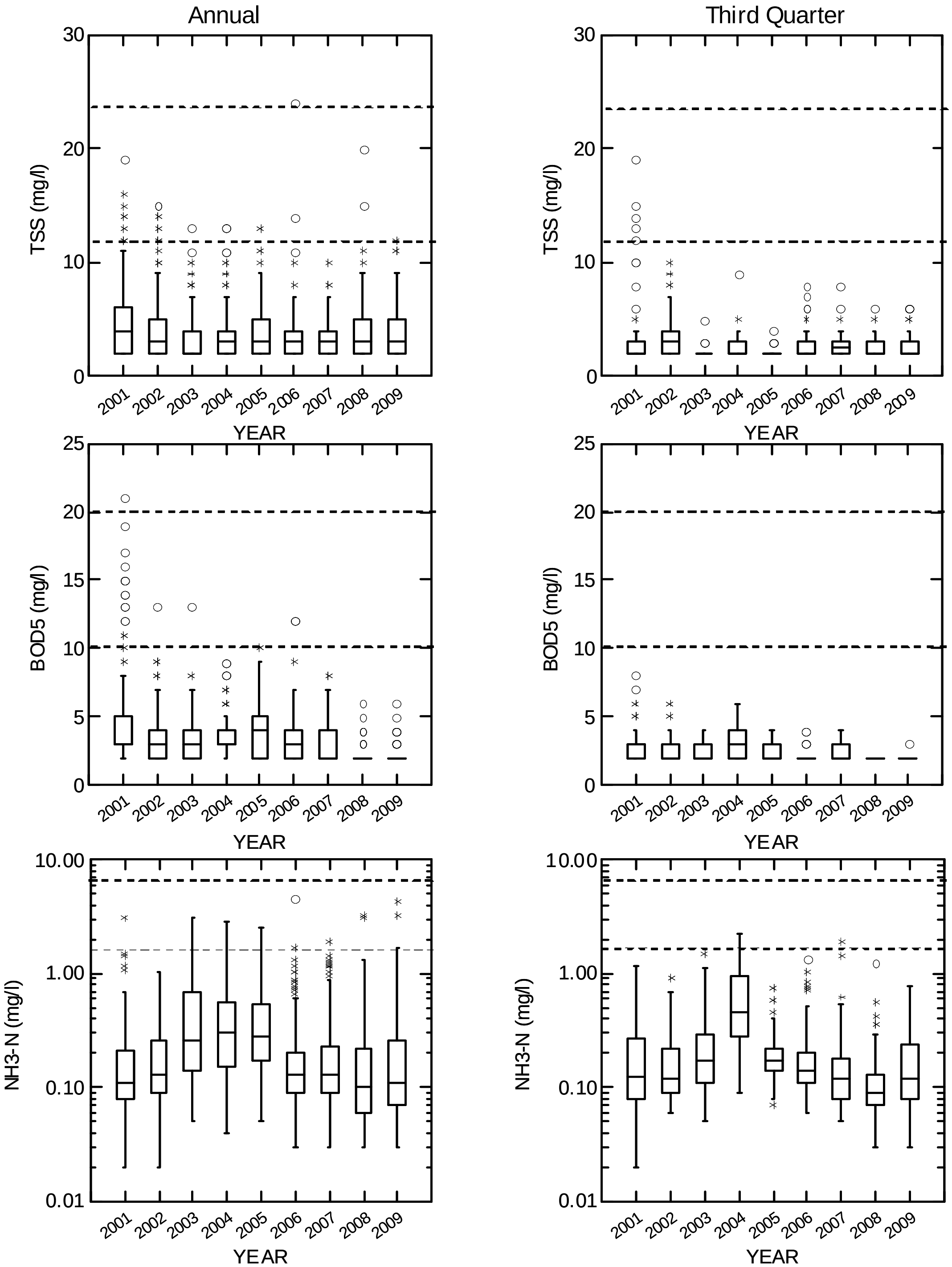

Figure 6. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the MWRDGC Hanover Park WWTP, 2001 – 2009. Effluent limits for respective monthly averages and daily maximums are denoted by dashed lines. The April through October limits are shown for ammonia.

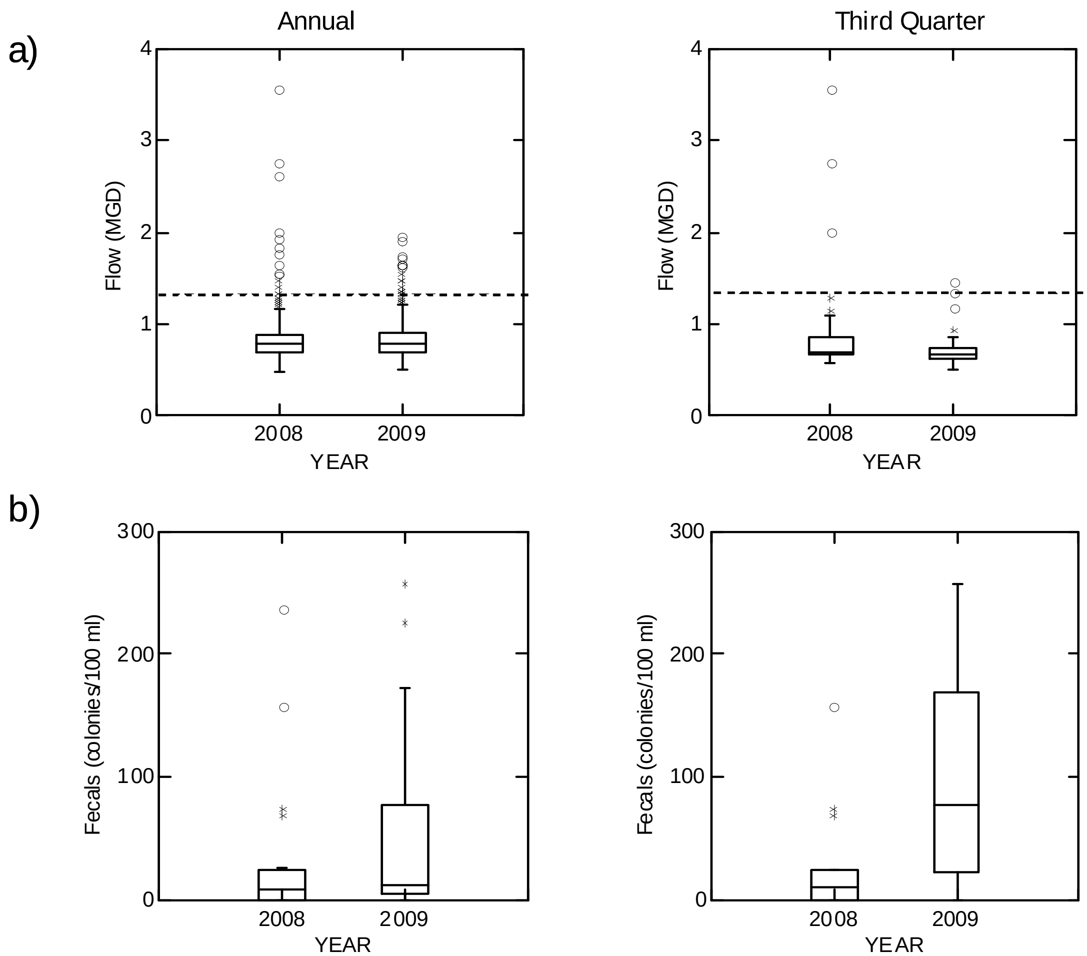

Figure 7. a) Distributions of annual and third quarter effluent flows for the Roselle-J. Botterman WWTF, 2008 and 2009, in relation to the design daily average (dashed line). b) Distributions of annual and third quarter fecal coliform concentrations in plant effluent. The permitted monthly geometric mean is 400 fecals/100 ml (applies May through October).

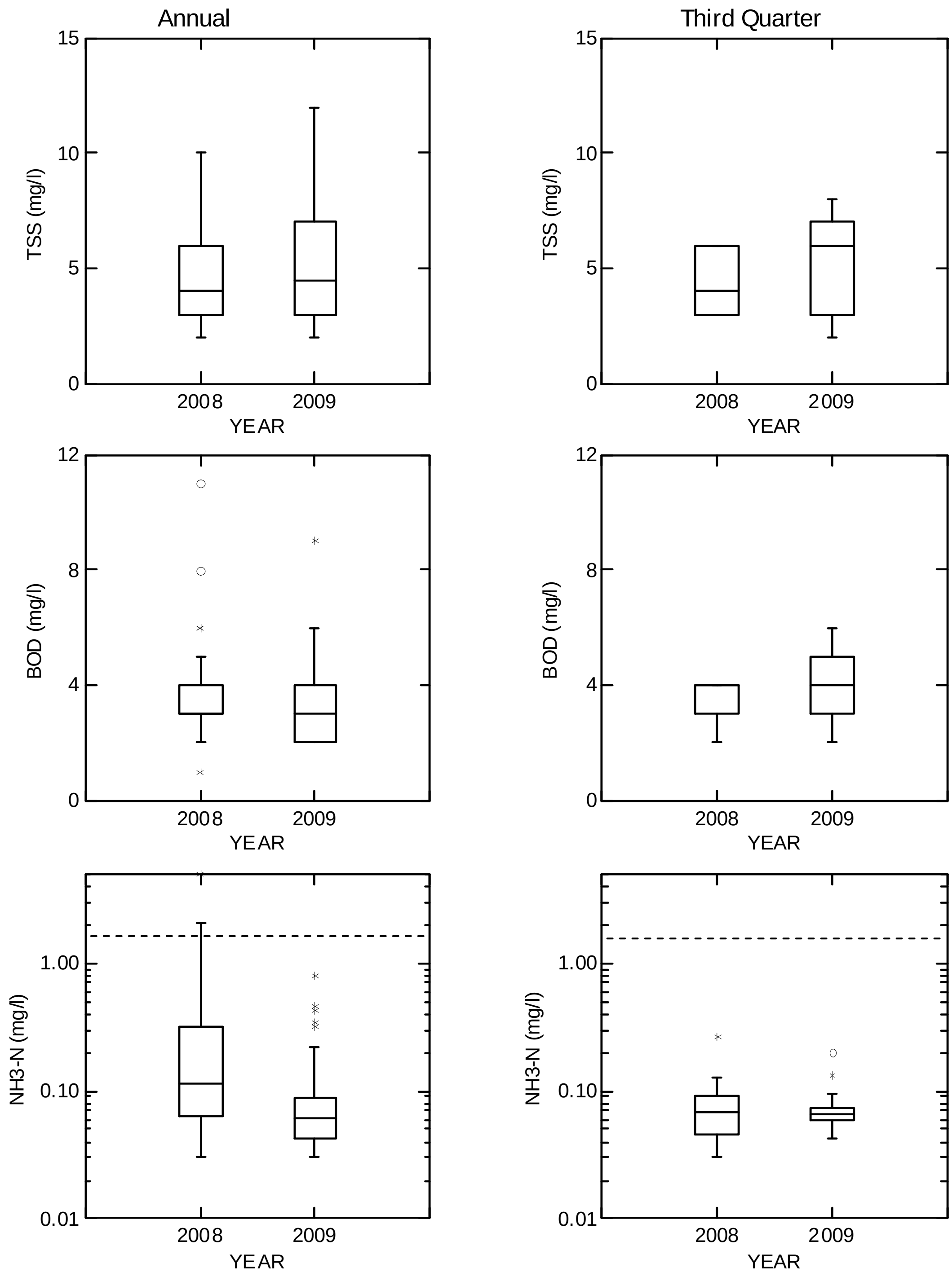

Figure 8. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the Roselle-J. Botterman WWTF, 2008 and 2009. Effluent concentrations of TSS and BOD were less than permitted limits for respective monthly averages and daily maximums. For NH3-N, the April through October monthly average ammonia limit is shown.

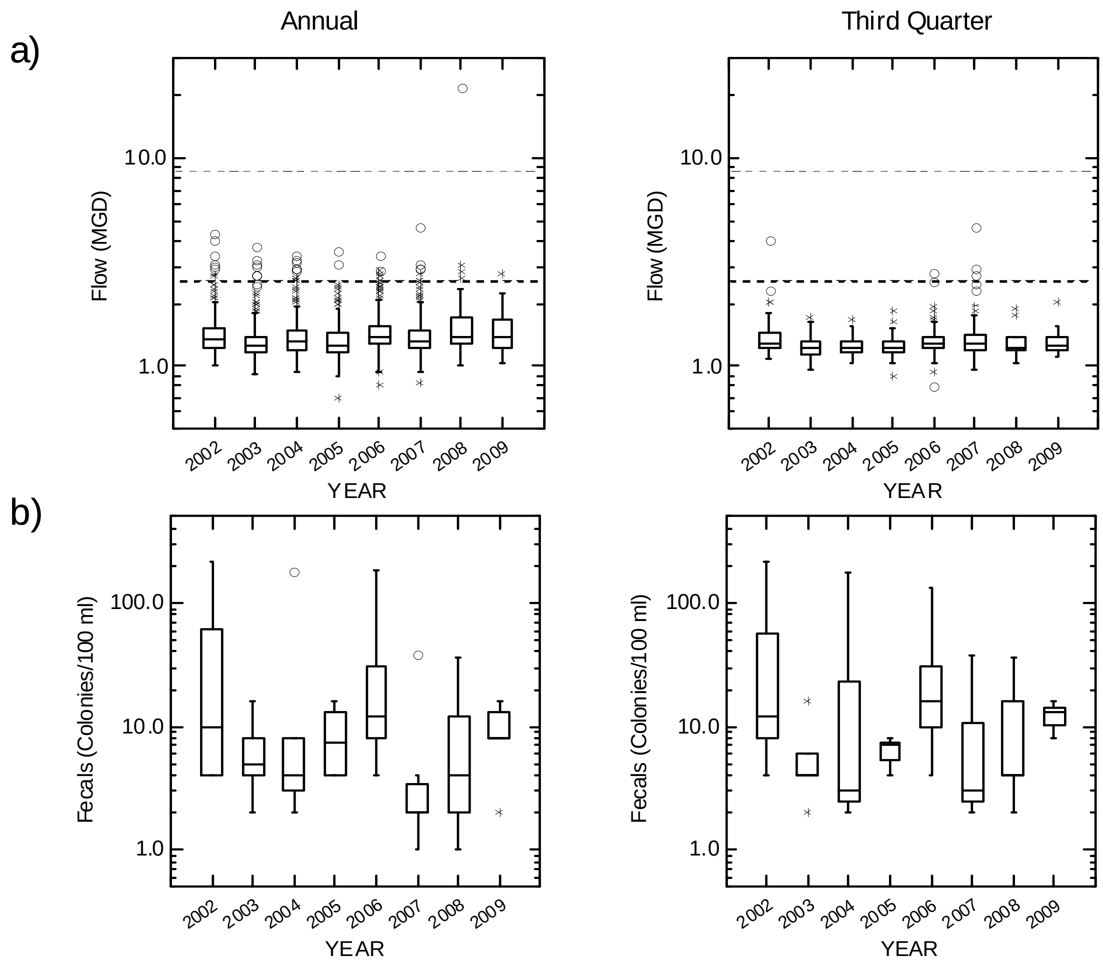

Figure 9. a) Distributions of annual and third quarter effluent flows for the Hanover Park STP, 2002 – 2009, in relation to the design maximum and design daily average (dashed lines). b) Distributions of annual and third quarter fecal coliform concentrations in plant effluent. The permitted monthly geometric mean for May through October is 400 fecal colonies/100 ml.

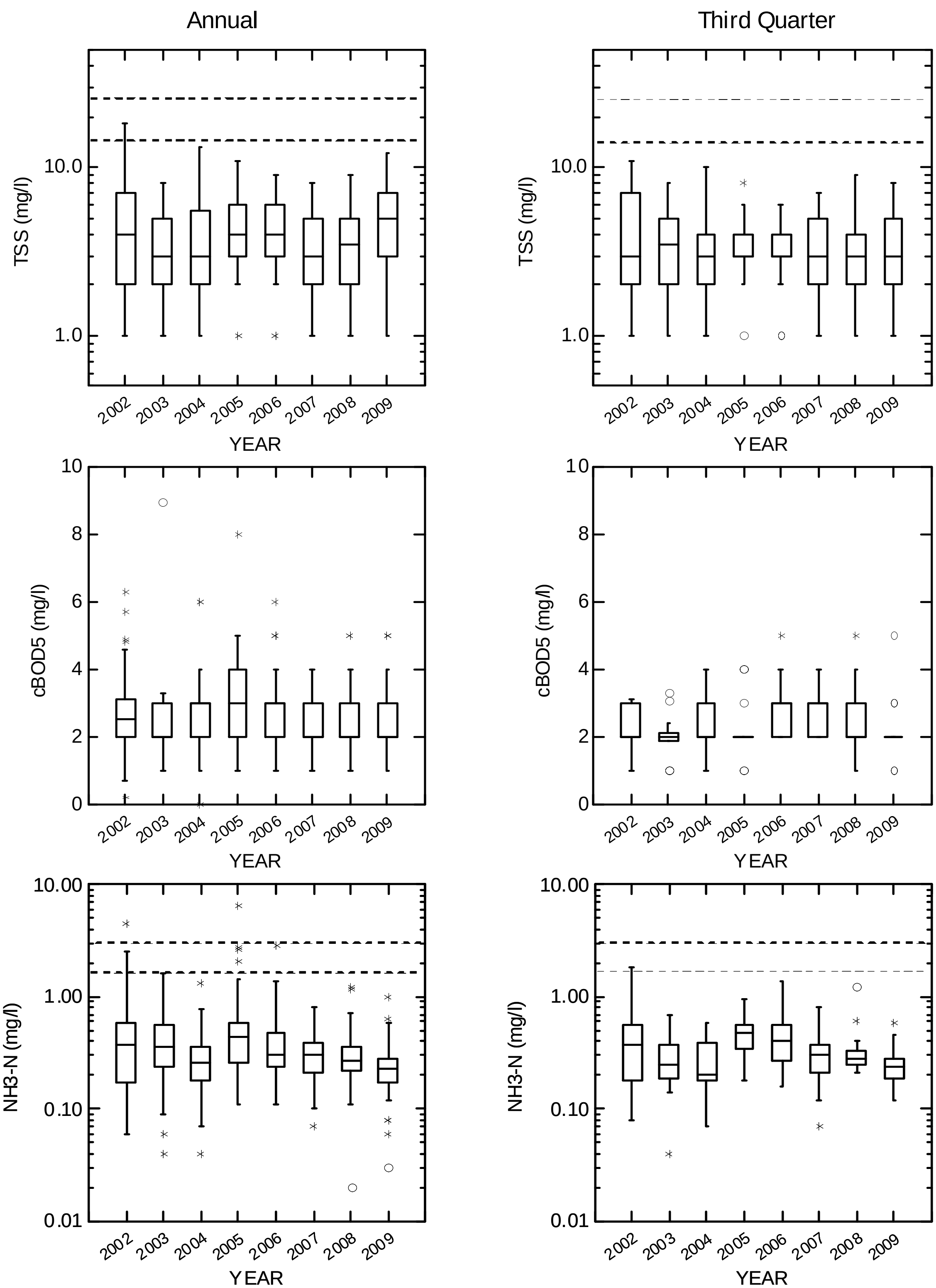

Figure 10. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the Hanover Park STP, 2002 – 2009. Effluent limits for respective monthly averages and daily maximums are denoted by dashed lines for TSS and NH3-N. The April through October limits are shown for ammonia. The monthly average limit for BOD is 10 mg/l.

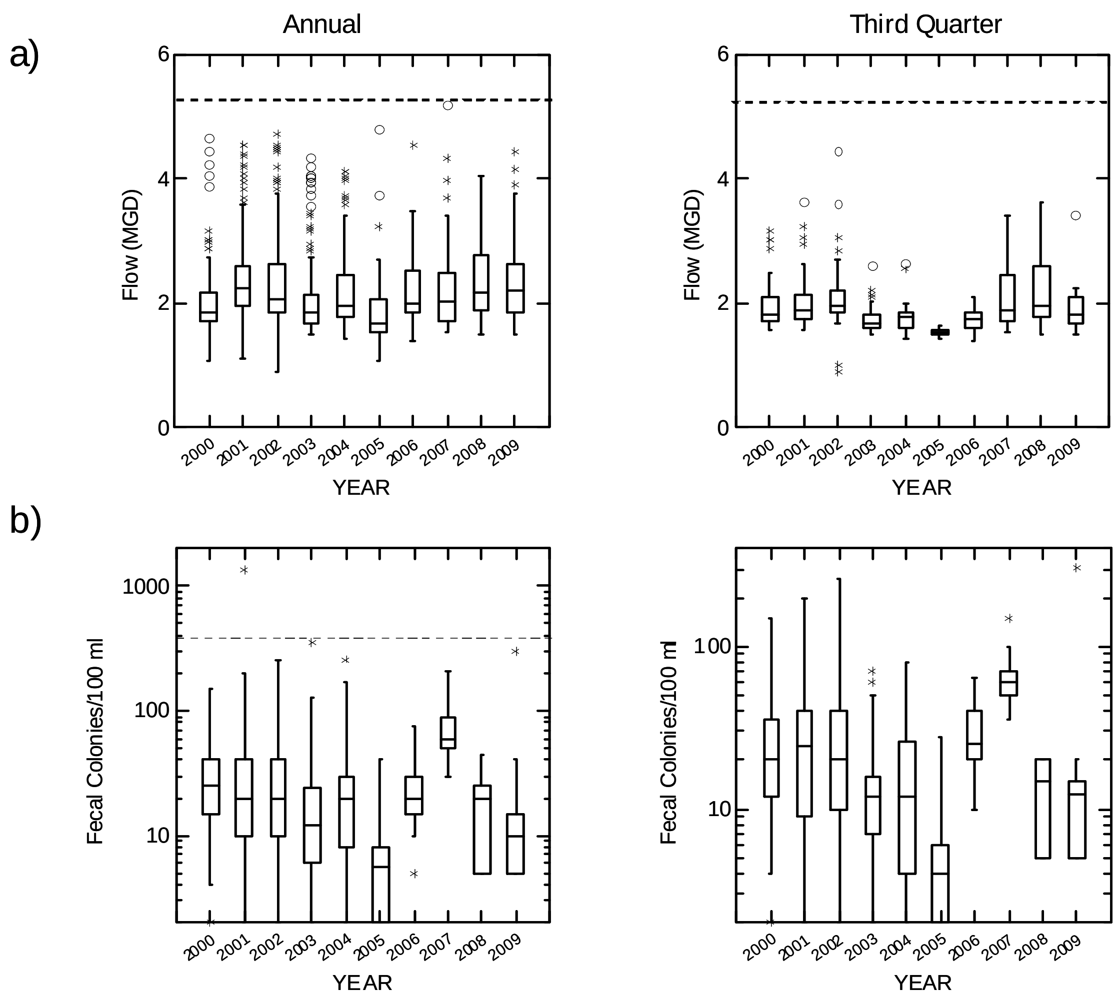

Figure 11. a) Distributions of annual and third quarter effluent flows for the Bartlett WWTP, 2000 – 2009, in relation to the design daily average (dashed line). b) Distributions of annual and third quarter fecal coliform concentrations in plant effluent. The permitted monthly geometric mean for May through October is 400 fecal colonies/100 ml.

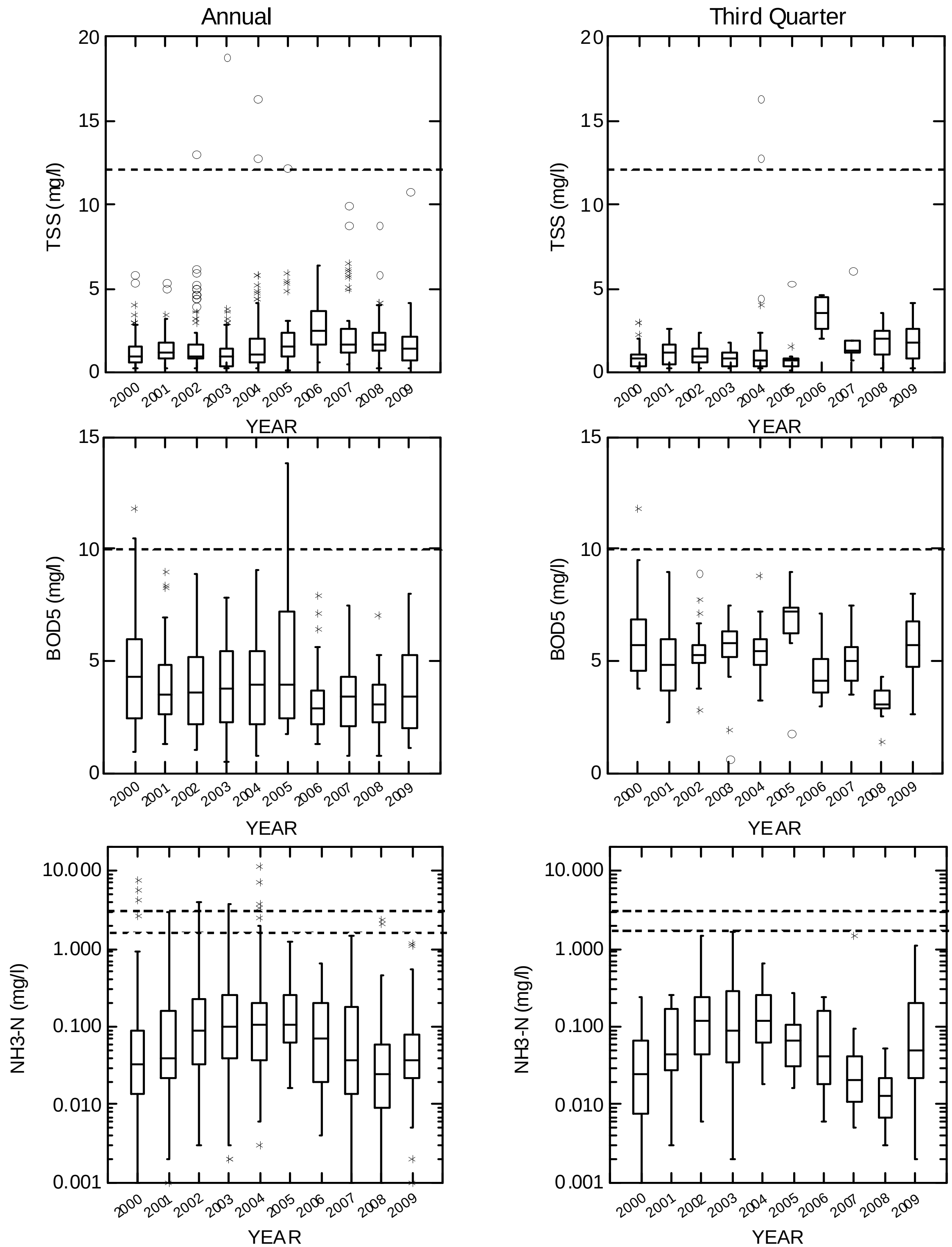

Figure 12. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the Bartlett WWTP, 2000 – 2009. Effluent limits for respective monthly averages are denoted by dashed lines for TSS and BOD. The April through October monthly average and daily maximum limits are shown for ammonia.

vary across the measured time period (Figure 11). Effluent quality as inferred by TSS, BOD and NH_3-N concentrations was within permit limits and showed no trend (Figure 12).

CAROL STREAM WATER RECLAMATION CENTER [IL0026352] A trend of increasing flows from the Carol Stream WRC was detected for the period 2000 – 2009 (Figure 13). Annual flows from 2006 to 2009 were higher than those from the preceding time period (linear contrast, $p < 0.0001$). Third quarter flows were marginally higher for the same contrast. Effluent concentrations of TSS and BOD paralleled the trend in flows, and also showed a significant increase between 2006 – 2009 compared to 2000 – 2005 for both annual and third quarter measures (Figure 13). Annual effluent concentrations of NH3-N showed no trend, but third quarter concentrations trended higher ($p<0.05$) for the period 2006 – 2009 relative to 2000 – 2005 (Figure 14). Despite the increasing trend in flows and effluent concentrations of TSS, BOD and third quarter NH3-N, the plant operated within design specifications, and effluent quality remained within permit limits.

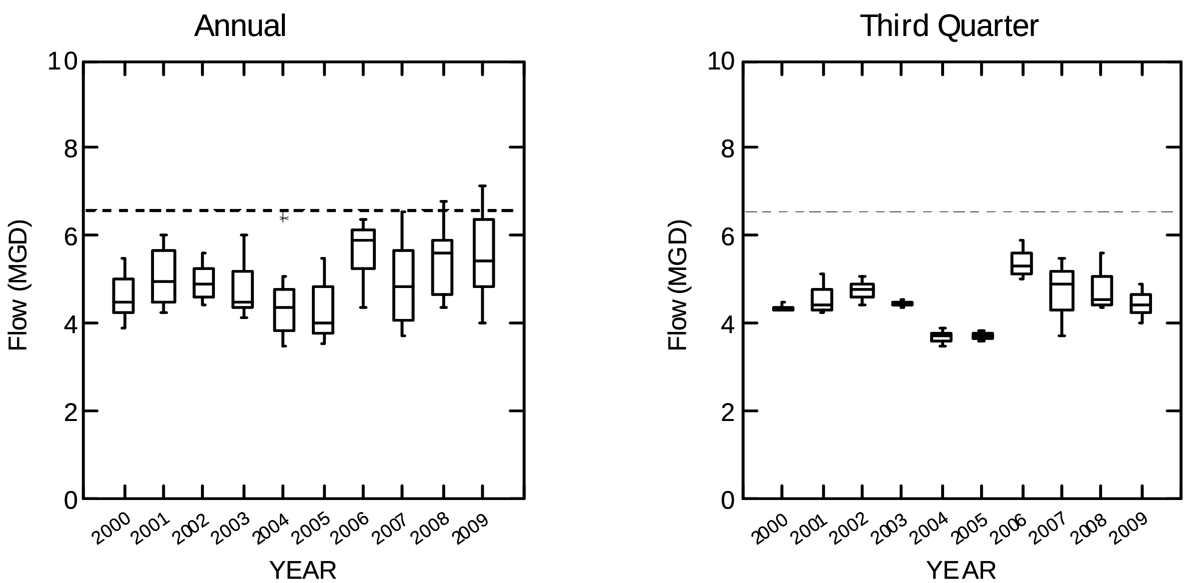

Figure 13. Distributions of annual and third quarter effluent flows for the Carol Stream WRC, 2000 – 2009, in relation to the design daily average (dashed line).

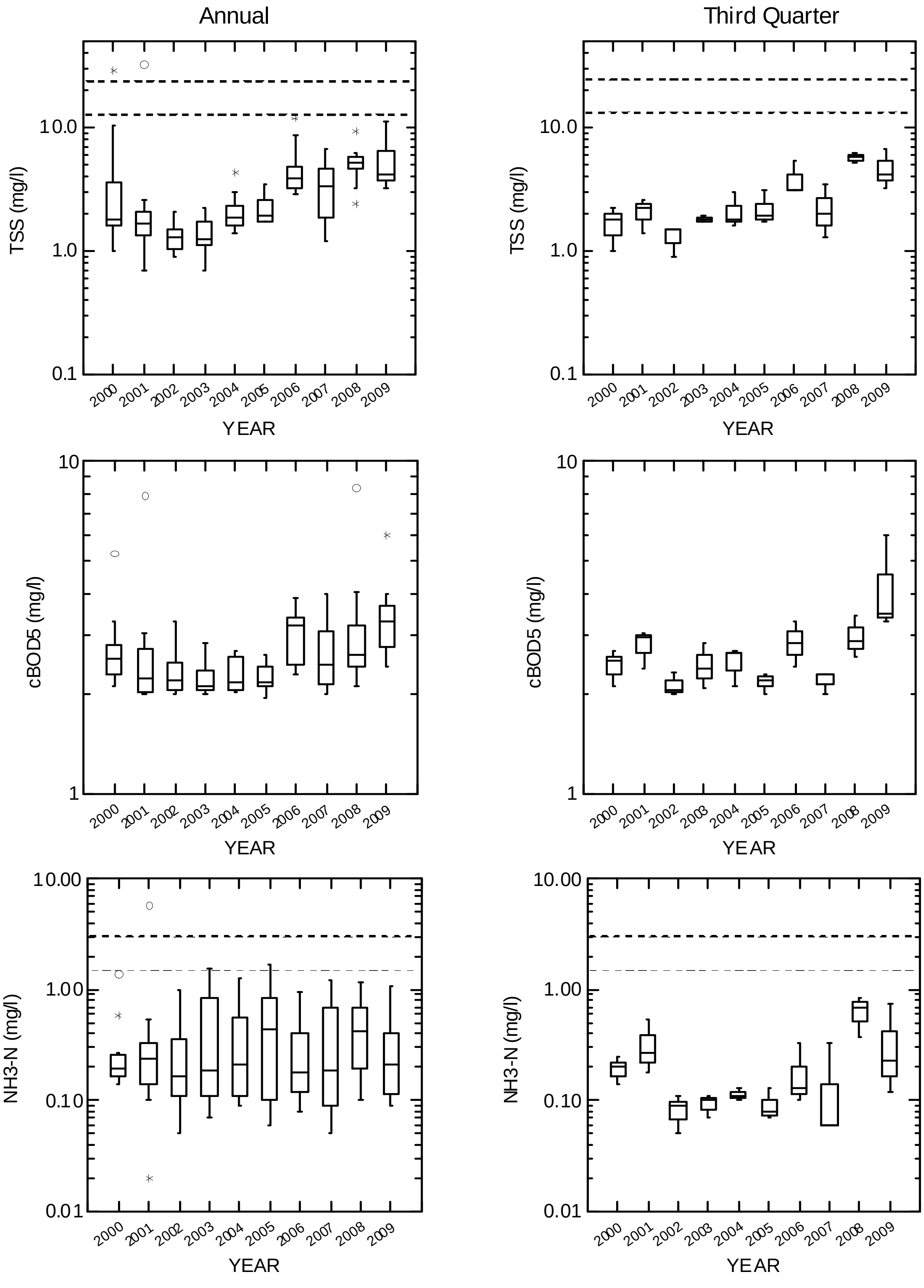

Figure 14. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the Carol Stream WRC, 2000 – 2009. Effluent limits for respective monthly averages and daily maximums are denoted by dashed lines for TSS and NH3-N. The April through October limits are shown for ammonia. The monthly average limit for BOD is 10 mg/l.

WHEATON SANITARY DISTRICT WWTF [IL0031739] Annual and third quarter effluent flows for the Wheaton WWTF trended higher in 2007, 2008 and 2009 relative to 1998 – 2006 (Figure 15). Concentrations of TSS and BOD also trended higher (Figure 16) when contrasting the same two time periods. Mean annual effluent flows were correlated with the mean annual discharge of the West Branch DuPage River recorded at West Chicago (Figure 17), suggesting inflow and infiltration of stormwater was reflected in the effluent volume. Coincidentally, effluent flows exceeding design capacity were more frequent between 2007 and 2009 (4, 11 and 15,) compared to 1998 – 2006 (once in 2001 and once in 2006). Third quarter effluent concentrations of TSS, BOD, and NH3-N were always less than permitted daily maximum limits; however, it should be noted that the June – August daily maximum limit for NH3-N is 15.0 mg/l.

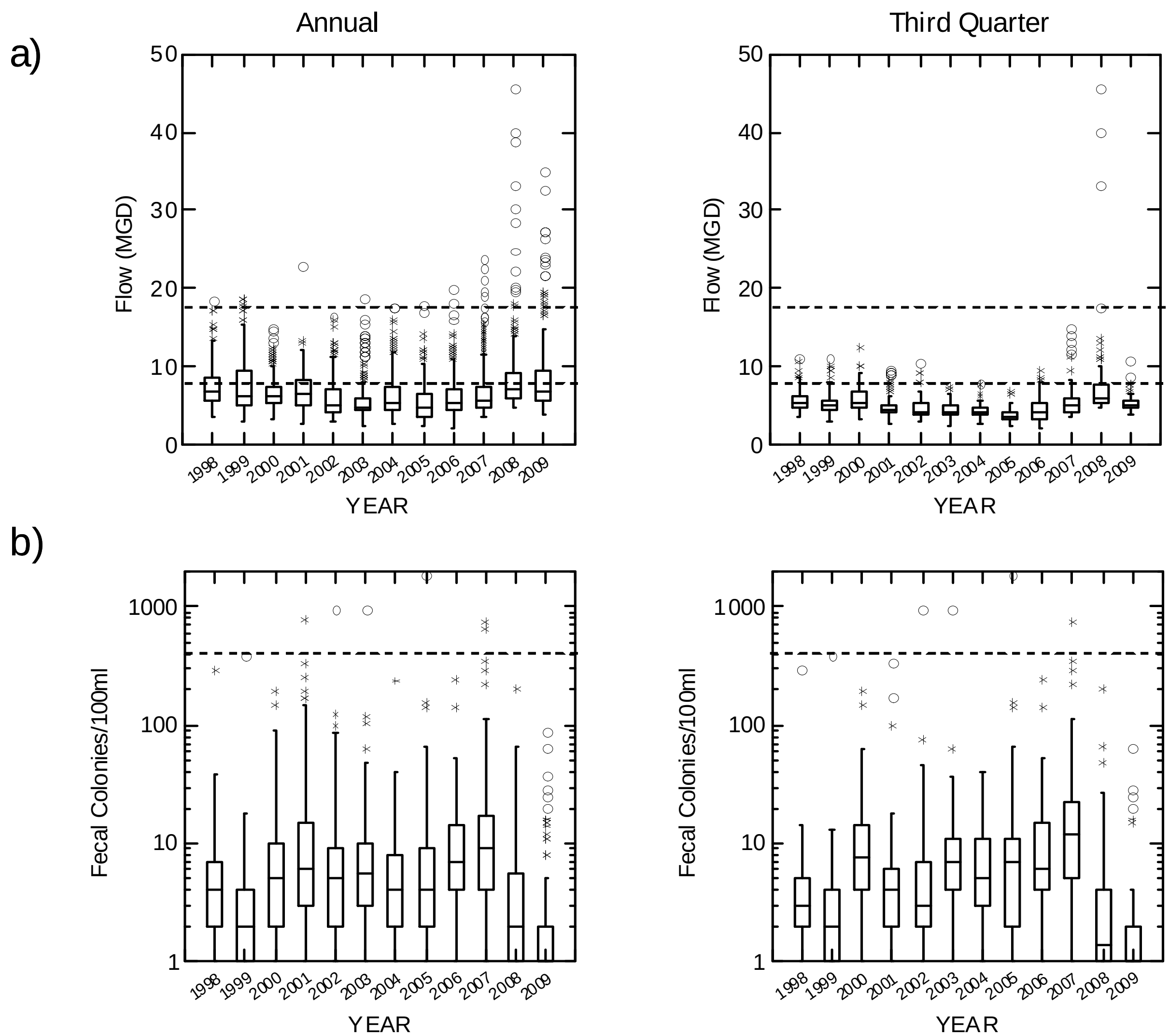

Figure 15. a) Distributions of annual and third quarter effluent flows for the Wheaton WWTF, 1998 – 2009, in relation to the design maximum and design daily average (dashed lines). b) Distributions of annual and third quarter fecal coliform concentrations in plant effluent in relation to permitted monthly geometric mean (applies May through October).

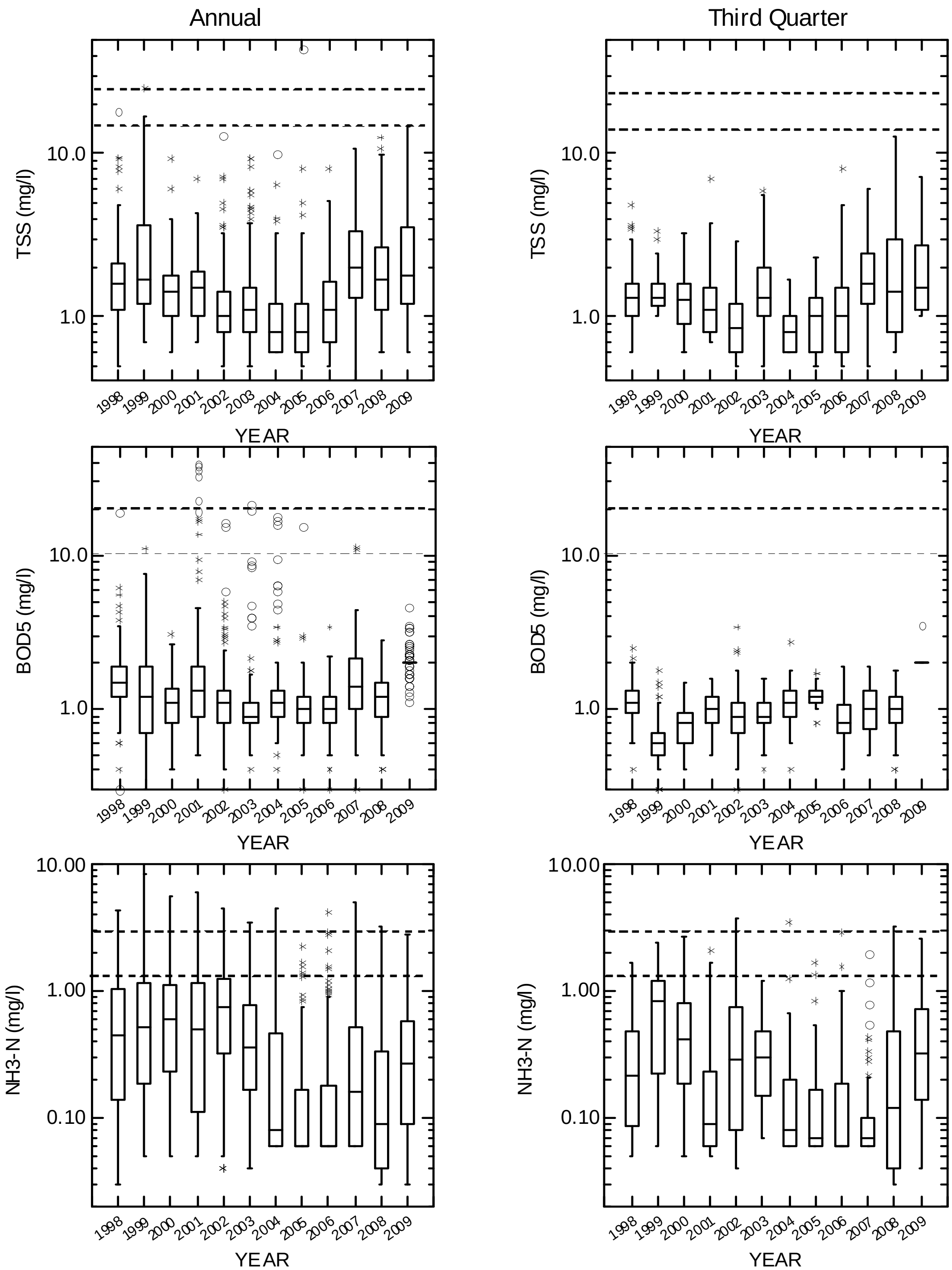

Figure 16. Annual and third quarter effluent concentrations for TSS, BOD and NH3-N reported by the Wheaton WWTF, 1998 – 2009. Effluent limits for respective monthly averages and daily maximums are denoted by dashed lines. The April through October limits are shown for ammonia.

WEST CHICAGO STP [IL0023469] Monthly summary statistics for the period of January 2008 through December 2009 were reported by the West Chicago STP. Monthly average effluent concentrations for BOD, TSS and NH3-N met applicable permit limits for all months reported (Figure 18). Daily maximum concentrations for these same measures did not exceed permit limits except for TSS during December 2008, coincidental with a reported excess flow. Excess flows were reported for five of the twelve months. Although daily maximum NH3-N concentrations did not exceed applicable limits, maximum concentrations greater than 1.0 mg/l occurred during September and October of 2008. Ammonia concentrations greater than 1.0 mg/l are stressful to aquatic life.

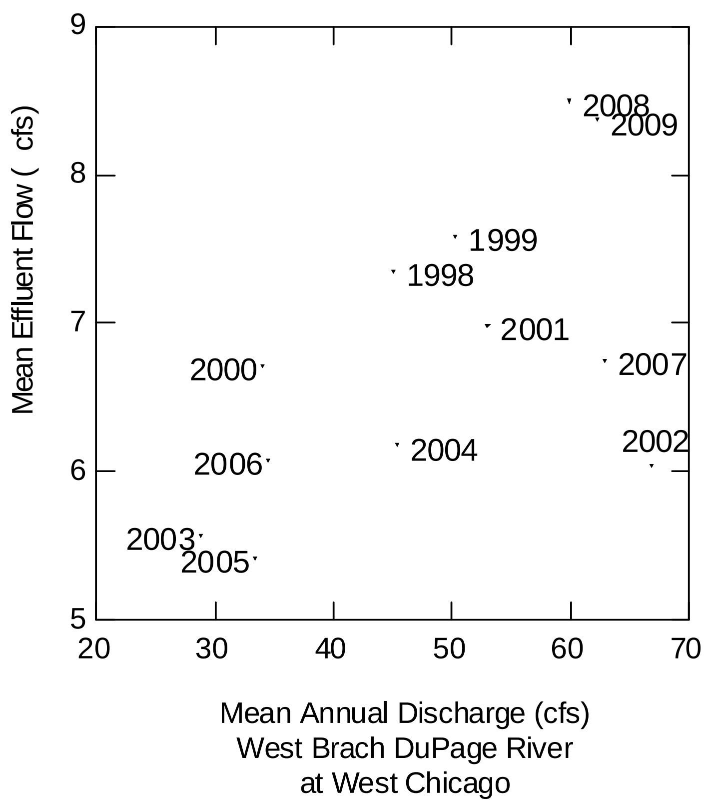

Figure 17. Mean annual effluent flow for the Wheaton WWTF plotted against mean discharge for the West Branch DuPage River at West Chicago. The gauging station at West Chicago is upstream from where the Wheaton WWTF ultimately discharges to the West Branch via Spring Brook.

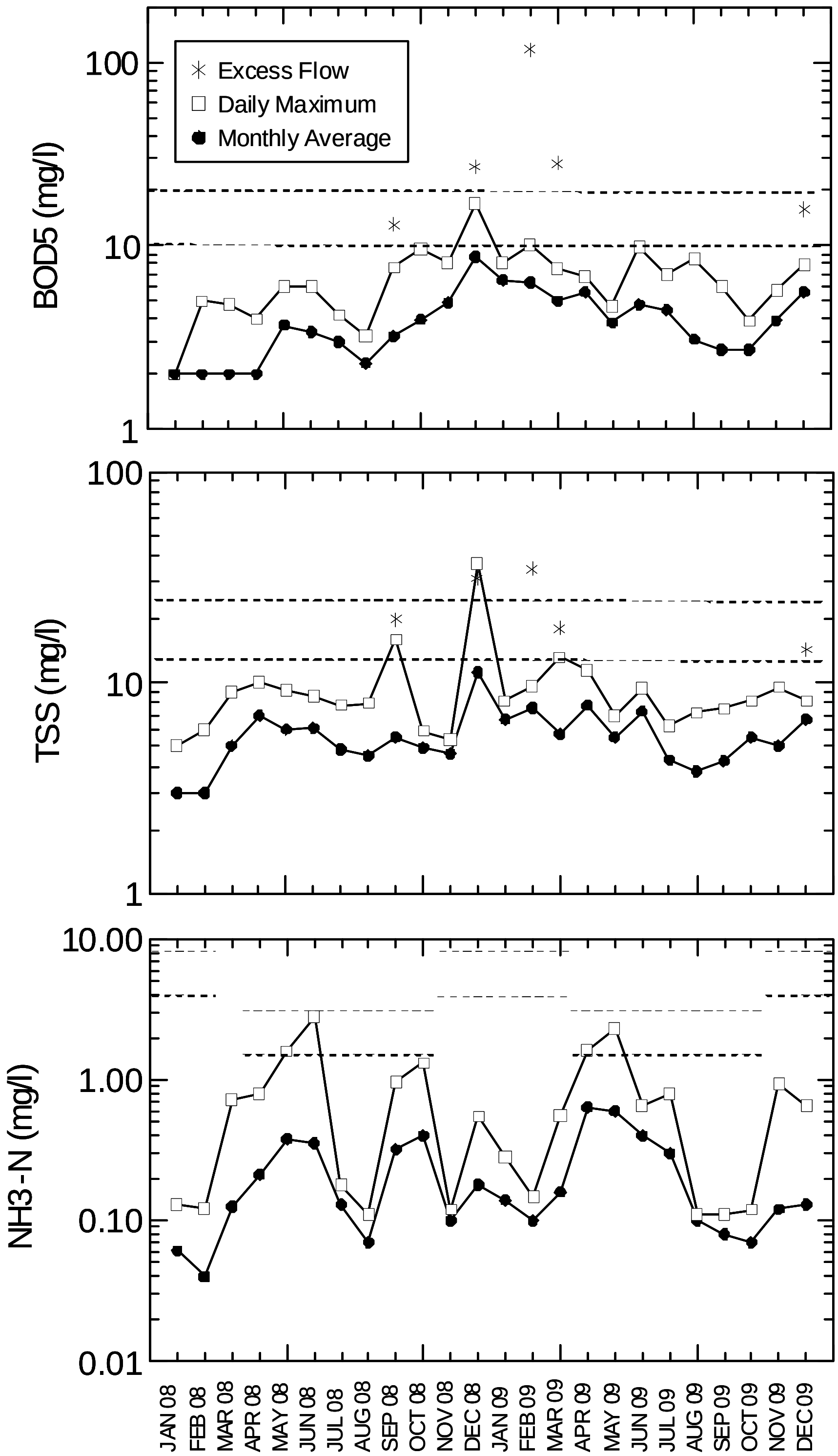

Figure 18. Effluent concentrations of 5-day biological oxygen demand (BOD5), total suspended solids (TSS) and ammonia-nitrogen (NH3-N) in relation to permit limits for daily maximums and monthly averages (represented by dashed lines) for the West Chicago STP.

Water Chemistry
Water quality in the West Branch DuPage mainstem is influenced by treated wastewater and urban land use. The influence of effluent is most apparent in concentrations of total phosphorus (TP) and nitrate-nitrite nitrogen (NOx) where median concentrations for both parameters sampled downstream from the most upstream treatment facility are an order of magnitude higher than the upstream control (Figure 19). In contrast, concentrations of NH3-N, TKN, and BOD at the upstream control were generally higher than at sites sampled downstream from treatment facilities (Figure 20) reflecting diffuse organic enrichment from the urban landscape.

Phosphorus and BOD concentrations were similar between years, whereas NOx and TKN concentrations were higher. The consistency in BOD and TP concentrations likely reflects stability in wastewater loadings. The difference in TKN concentrations is explained, in part, by flow and sampling window. Water quality samples were collected earlier in the summer in 2009 compared to 2006 when flows were higher, and therefore, presumably carrying more humic compounds from groundwater. The higher NOx concentrations could not be explained by flow. Interestingly, NH3-N concentrations were lower in 2009 compared to 2006. Dissolved oxygen regimes measured by continuous data loggers were better in 2009 relative to 2006, at least in terms of minimum concentrations (Figure 21), suggesting that the difference in NOx concentrations may be explained, in part, by nitrification and denitrification. A line of evidence in support of this hypothesis is given by the relationship between nitrite, nitrate and dissolved oxygen in 2009 (Figure 22), wherein 36 percent of the variance in nitrite concentrations are explained by a linear combination of nitrate and dissolved oxygen.

Dissolved oxygen concentrations were measured by continuous data loggers at three locations (Figure 23) along the West Branch mainstem : Arlington Drive (RM 29.90), Butterfield Road (RM 12.10), and McDowell Grove (RM 9.10). Dissolved oxygen concentrations were maintained above levels suitable for aquatic life, as judged by water quality standards established by the State of Illinois (35 Ill. Adm. Code 302.206), throughout most of the critical summer period at each station except for short duration events at Arlington Road and Butterfield Road (Table 4) where the 7 day moving average was exceeded at both sites. Perhaps of greater or equal consequence to aquatic life, large 24 hour swings in concentrations between day and night were noted at all sites (Figure 24), especially in June of 2008 during a period of stable, low flow. These large swings are symptomatic of nutrient enrichment, and coincided with a fluctuations in pH spanning 1.2 units at Arlington Drive (Figure 25). The upper bounds for pH in the Illinois water quality standards is 9.0, unless caused by natural conditions; IEPA gives no guidance as to what constitutes a "natural cause." The high pH alone clearly represents a source of stress, but the wide swings may also be stressful, as an association between wide swings and impaired aquatic life has been documented by Heiskary and Markus (2003) and Miltner (2010).

Chloride concentrations were higher in 2009 compared to 2006 (Figure 20). The snowfall total during the winter of 2005-2006 for Chicago was 26.0 inches, compared to 52.7 inches for the 2008-2009 winter. Presumably, more de-icing compounds were used during the snowier winter. Although chloride concentrations were higher in 2009 compared to 2006 across stream size, the difference was most pronounced in headwaters less than 5 square miles in drainage area (Figure

26). DSCRW is currently studying the relationship between application rates of deicing compounds and chloride concentrations in the study area; a report is forthcoming. The connection to shallow groundwater parallels what was suspected for TKN where the difference in concentrations between time periods was also most pronounced in small headwaters. Concentrations of NH3-N and BOD were similar or lower in 2009 compared to 2006 across stream size classes. Dissolved oxygen concentrations measured during spot sampling were lowest in small headwaters (Figure 27).

Table 4. Water quality standards exceedences noted in water quality samples collected from the West Branch DuPage River and its tributaries, 2008-2009.

Water Body	Location	Date	Constituent	Concentration	Standard
Sonde Deployments					
West Branch	Arlington Drive	06/24-27/09	D.O.	<6.0 mg/l	7-day MAVG
West Branch	Butterfield Road	07/22-23/08	D.O.	<6.0 mg/l	7-day MAVG
Grab Samples					
Kress Creek	Prairie Path	06/22/09	D.O.	<5.0 mg/l	Not to exceed
Winfield Creek	Winfield Rd.	06/24/09	D.O.	<5.0 mg/l	Not to exceed
W. Br. Ferry Cr.	Raymond Ave.	06/26/09	D.O.	<5.0 mg/l	Not to exceed
West Brach trib.	Sterns Rd.	07/13/09	D.O.	<5.0 mg/l	Not to exceed
Winfield Creek	Liberty St.	08/05/09	D.O.	<3.5 mg/l	Not to exceed

Water Column Organics

Organic compounds were detected at 7 of 16 sites sampled for water column organics (Table 5). Chloroform, a disinfection byproduct of chlorination, was detected at 4 of 6 sites sampled downstream from wastewater treatment plants. Trichloroethene, a common industrial solvent, was detected at two locations sampled in an unnamed tributary to the West Branch (95-906; near Amherst Drive). Polycyclic aromatic hydrocarbons (PAHs) were detected at 2 sites.

Sediment Chemistry

Sediments were sampled at twenty-three locations in 2009, mostly from the mainstem (Table 6). Concentrations of heavy metals were below levels likely to impact aquatic life (i.e., the probable effect level [PEL]) at all but one location where arsenic exceeded the PEL. Metals were detected, however, at 19 of the sampling locations (Figure 27) in concentrations that exceed threshold effect levels (TEL). No spatial pattern to the detections was evident in terms of geographic location or stream size.

PAHs exceeding threshold effects levels were detected at twenty-two of the sites, and concentrations exceeding the probable effects levels were detected at eleven sites. As with metal concentrations, no spatial pattern was evident, likely reflecting the ubiquitously high road density of the basin. A common source of PAHs is the incomplete combustion of gasoline. No trend in the number of detections of either PAHs or metals was detected between 2006 and 2009.

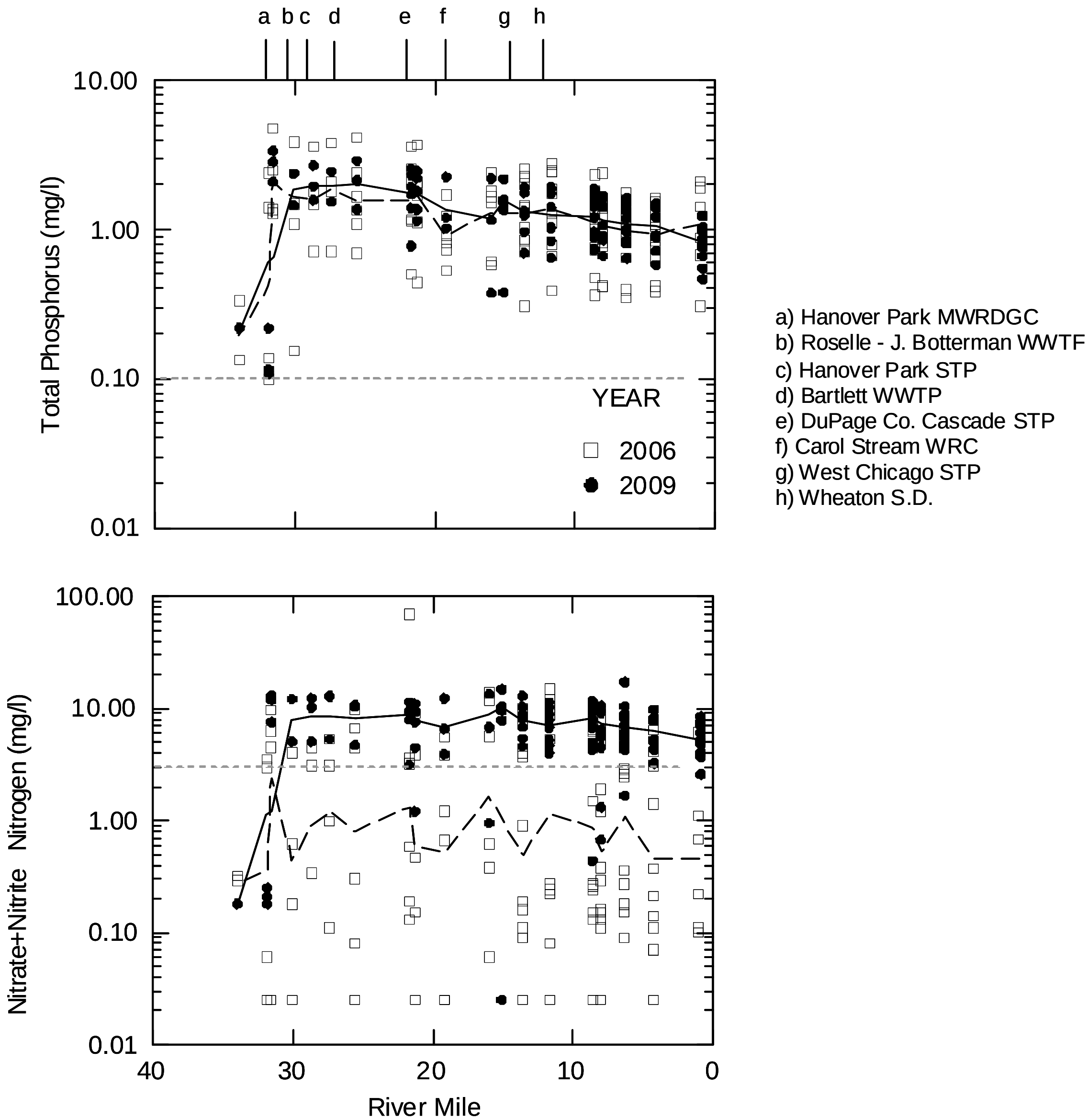

Figure 19. Concentrations of total phosphorus and nitrate+nitrite nitrogen plotted by river mile for the West Branch DuPage River, 2006 and 2009. Lines running through the data points show the median concentration by river mile for the respective years. The dashed horizontal line in each plot depicts the upper end of concentrations typical for unpolluted waters.

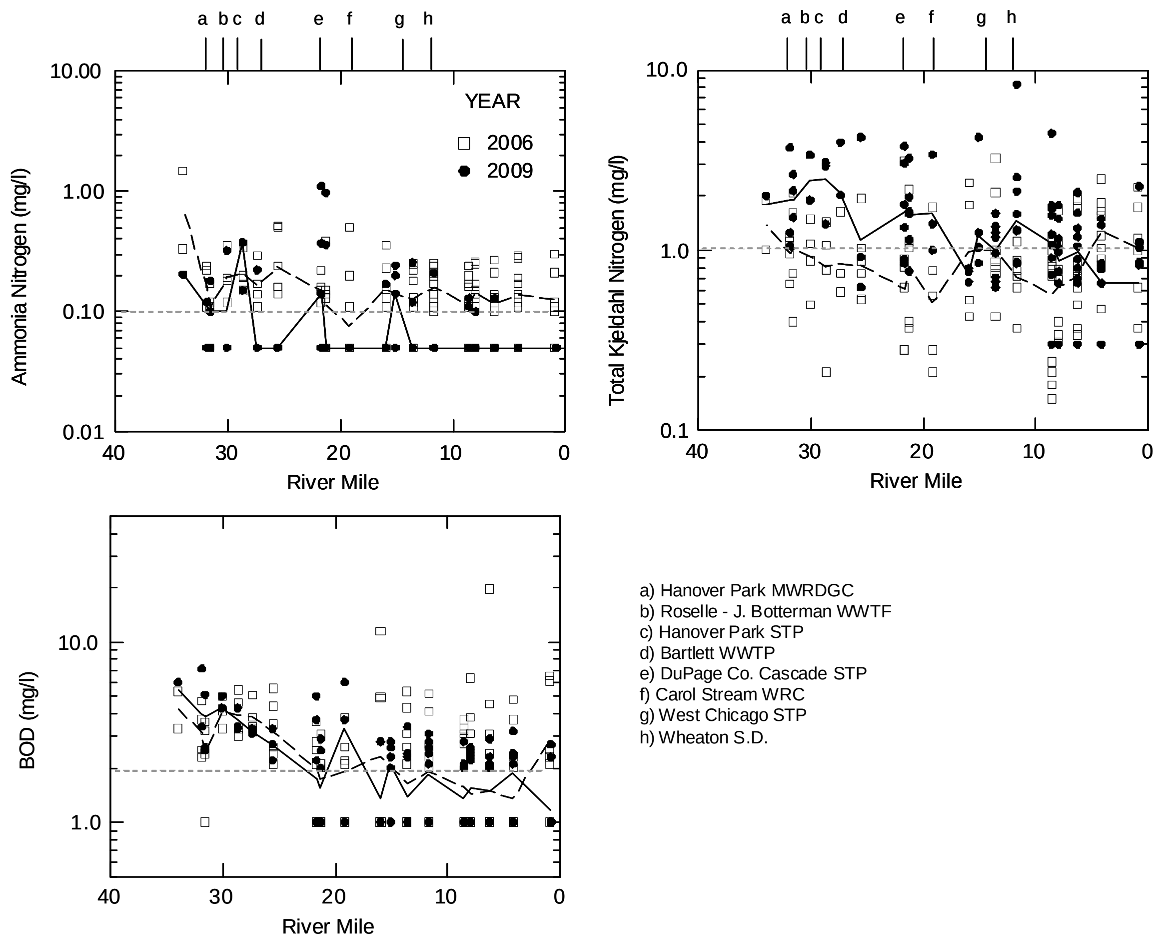

Figure 20. Concentrations of ammonia nitrogen, total Kjeldahl nitrogen and 5-day biochemical oxygen demand in plotted by river mile for the West Branch DuPage River, 2006 and 2009. The approximate locations of dischargers discussed in the text are noted along the top margin as an alphabetical key. Dashed horizontal lines in each plot depict the upper bounds of concentrations typical of unpolluted waters.

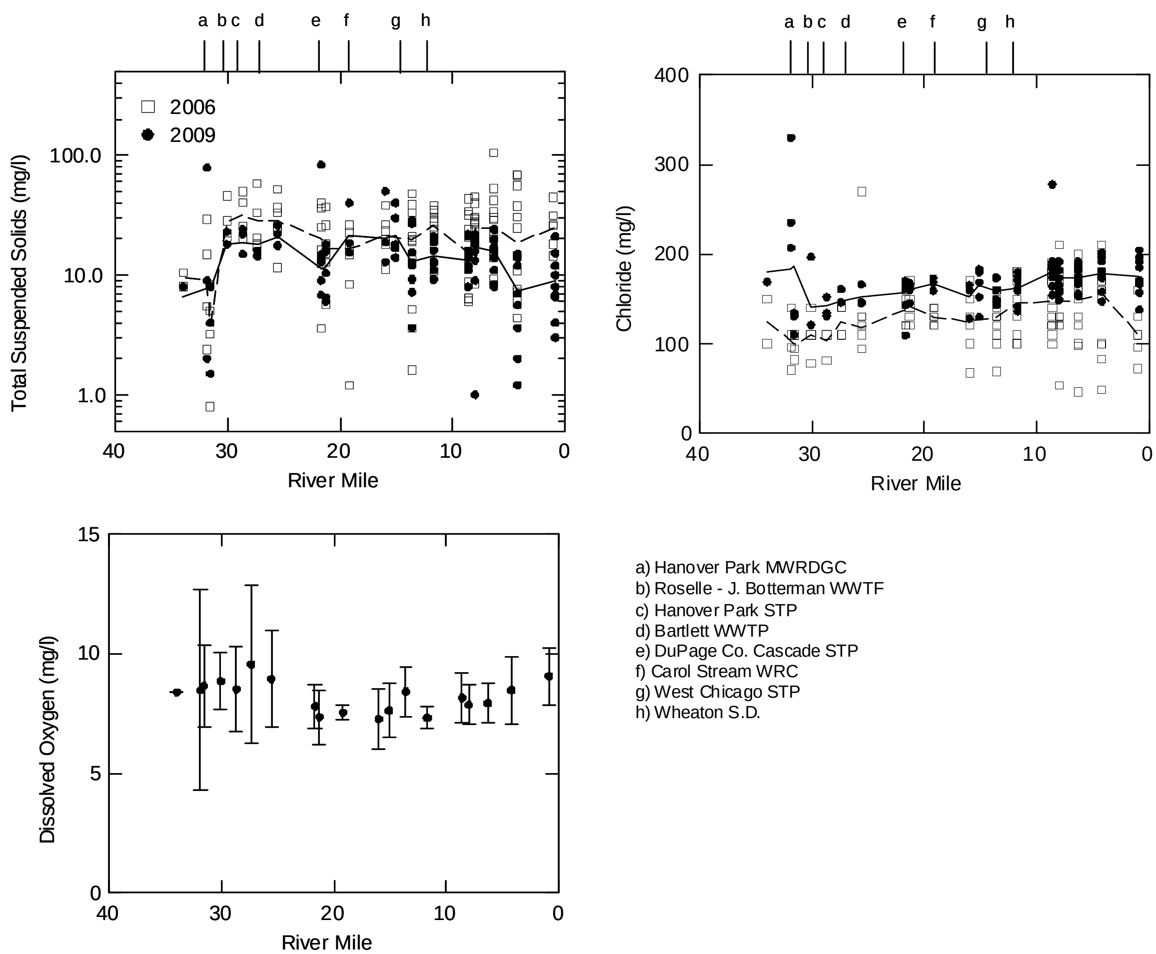

Figure 21. Concentrations of total suspended solids, chloride and dissolved oxygen plotted by river mile for the West Branch DuPage River, 2006 and 2009. The dissolved oxygen plot is for 2009 data, and shows the mean +/- 1SD. The approximate locations of dischargers discussed in the text are noted along the top margin as an alphabetical key.

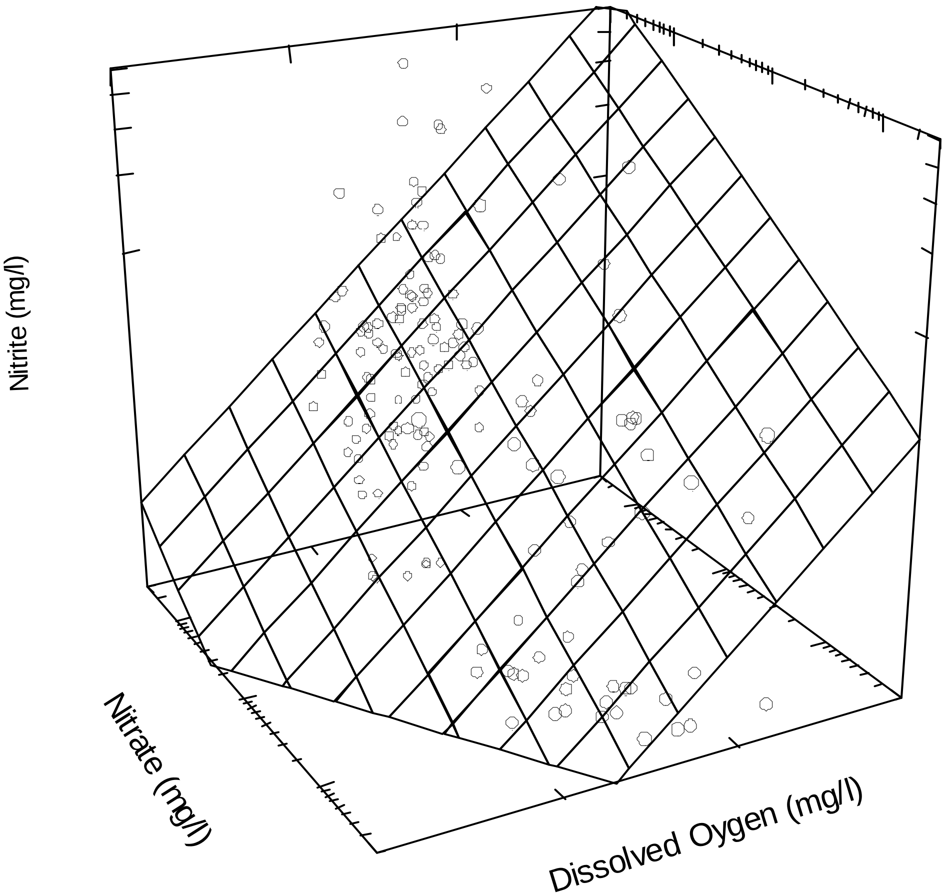

Figure 22. Nitrite concentrations as a function of nitrate and dissolved oxygen concentrations in the West Branch DuPage River basin, 2009.

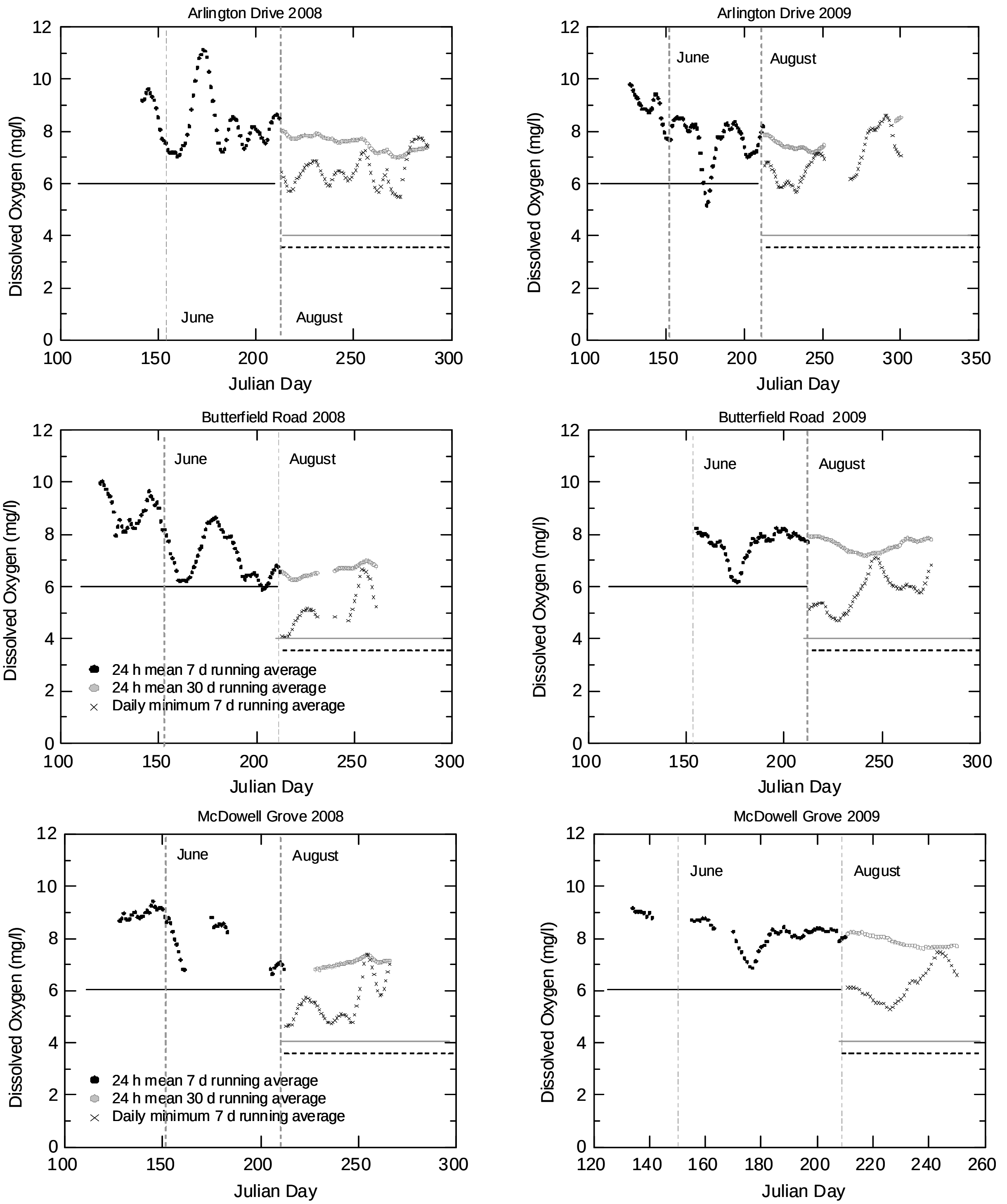

Figure 23. Statistical measures of dissolved oxygen recorded by continuous monitors deployed in the West Branch DuPage River, 2008 and 2009. The reported values follow Illinois water quality standards (35 Ill. Adm. Code 302.206). Horizontal lines in the plots depict applicable water quality standards (24 h mean 7 day running average, solid black; 24 h mean 30 day running average, solid gray; daily minimum 7 day running average, dashed black). Note that the 30-day running average and daily minimum 7-day running average applies only during August through February. Julian Day, as used here, is the ordinal day in the calendar year.

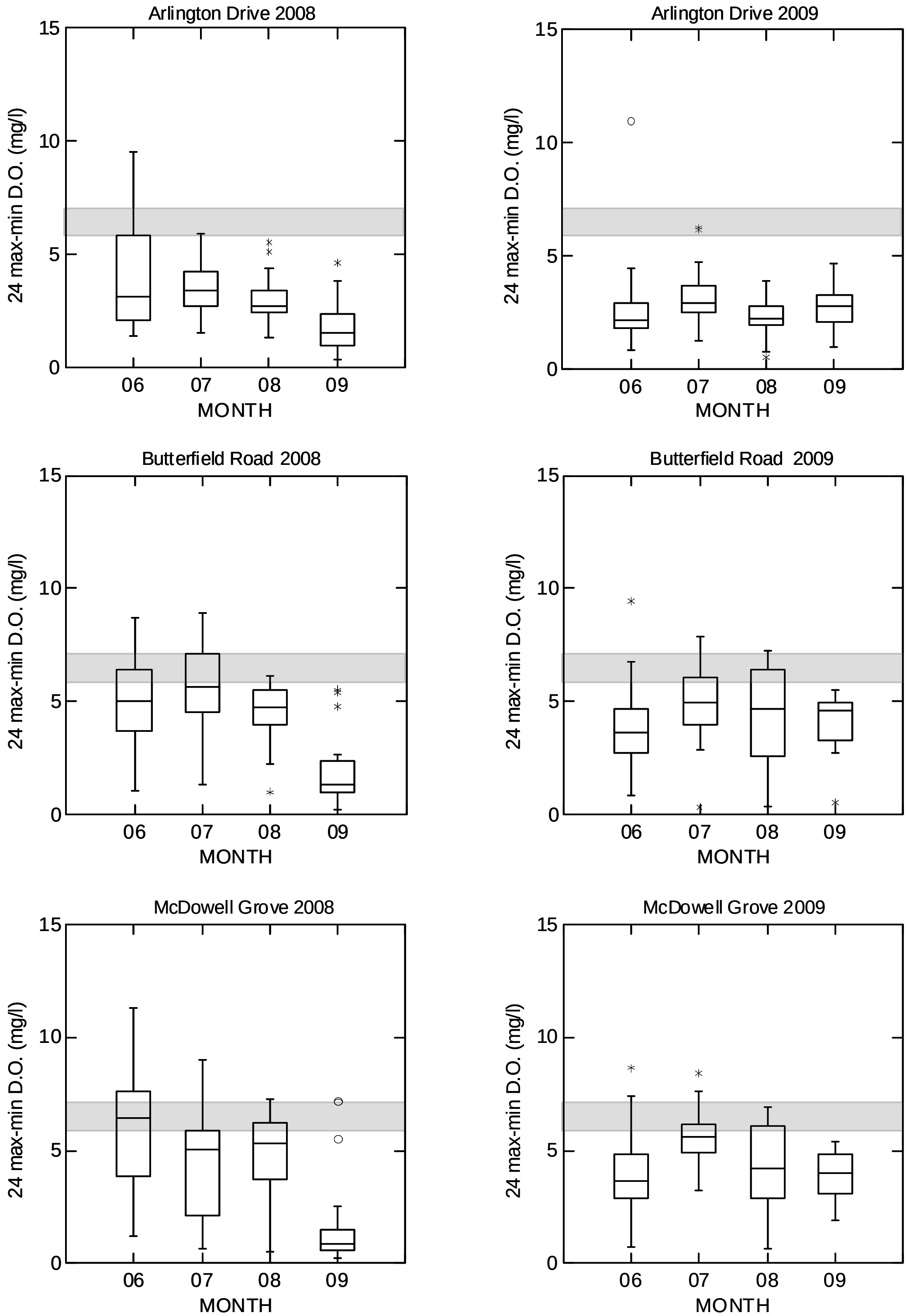

Figure 24. Distributions of daily range in dissolved oxygen (24 hour maximum minus 24 hour minimum) by month recorded by continuous monitors deployed in the West Branch DuPage River, 2008 and 2009. The shaded region in each plot depicts the range magnitude that is associated with stress to aquatic communities.

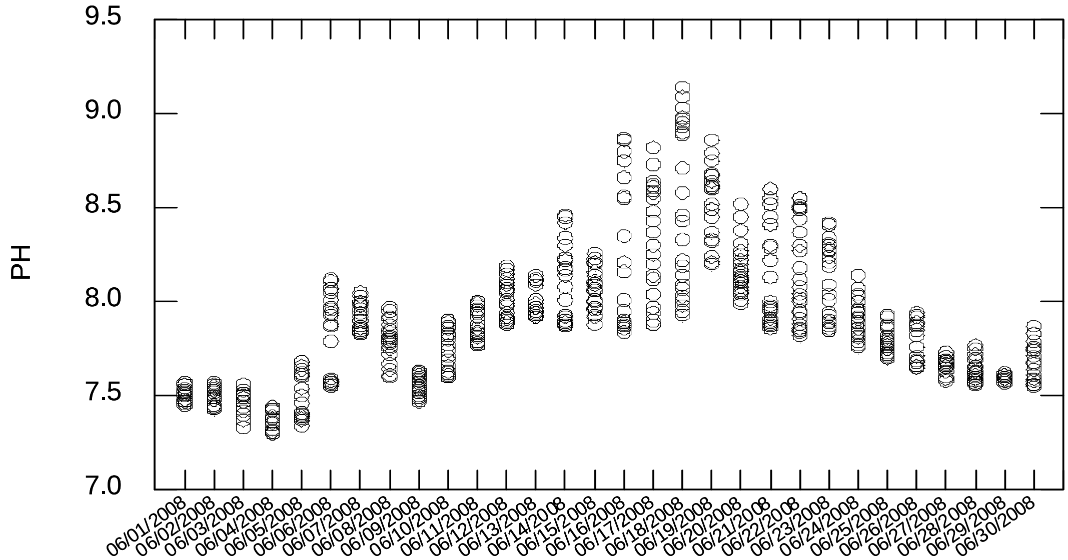

Figure 25. Hourly pH measured by a continuous data logger at Arlington Drive, June 2008.

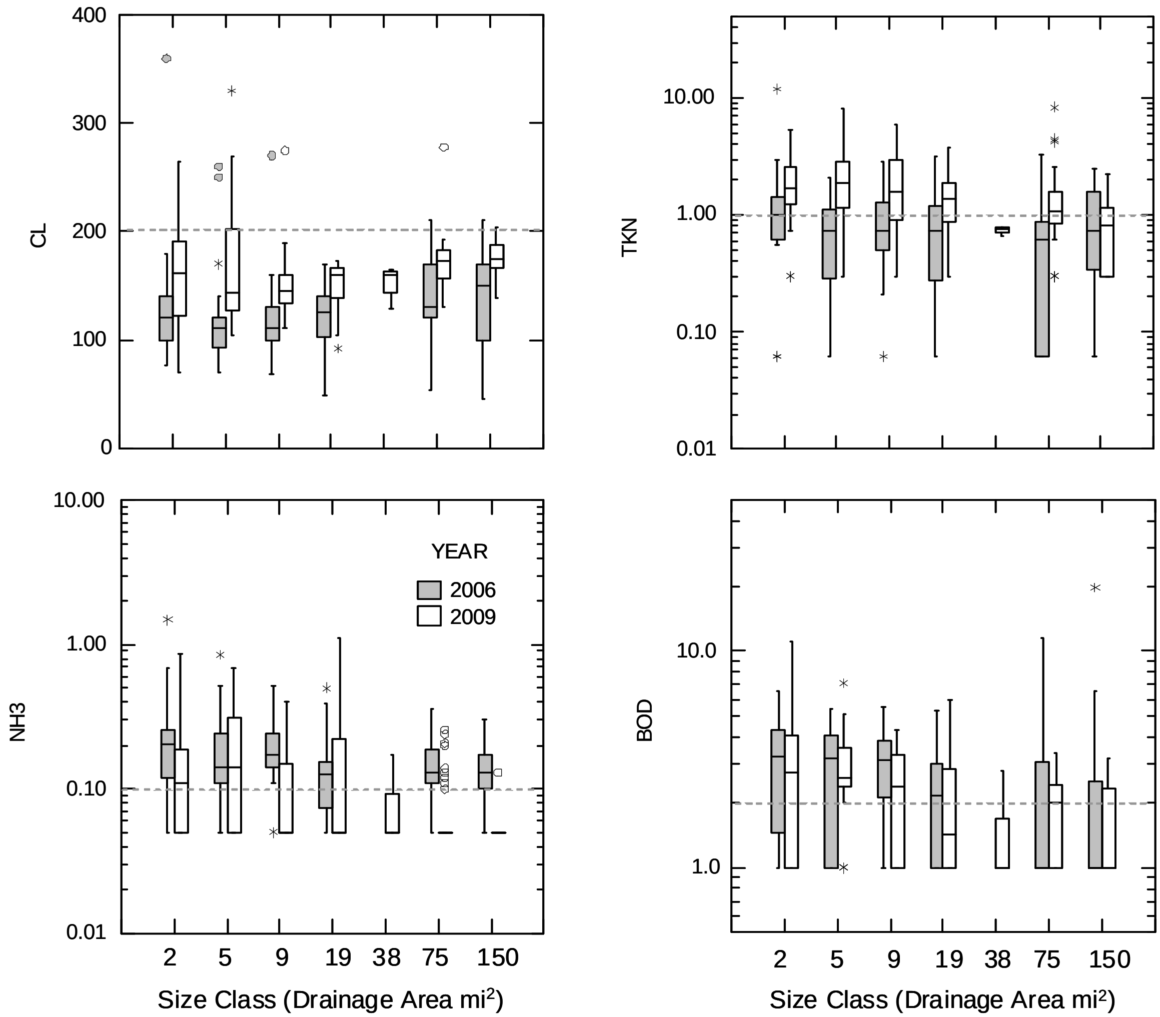

Figure 26. Distributions of chloride (CL), total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH3) and 5 day biological oxygen demand (BOD) measured in water quality samples collected from the West Branch DuPage River basin, 2006 and 2009. Distributions are plotted by stream size class.

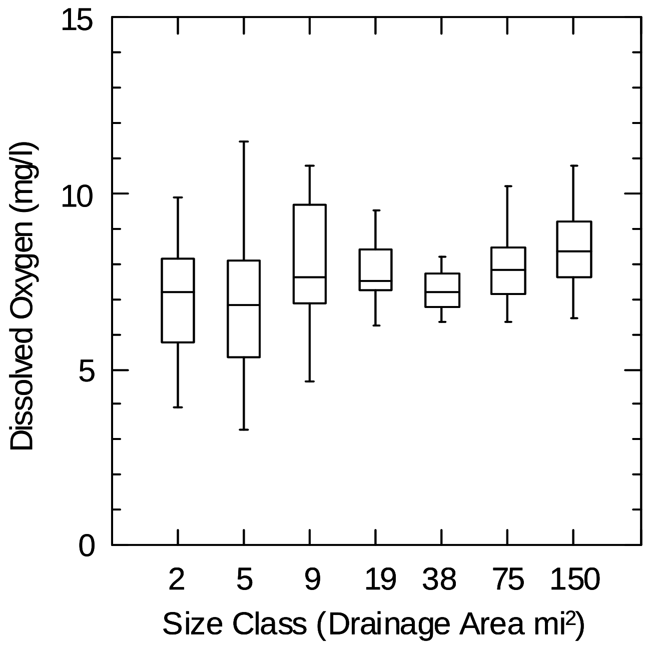

Figure 27. Distributions of dissolved oxygen concentrations measured in water quality samples collected from the West Branch DuPage River basin, 2009. Distributions are plotted by stream size class.

Table 5. Locations sampled for water column organic compounds, detections and concentration detected, West Branch DuPage River and tributaries, 2009.

Site ID	RM	Detections	Concentration (µg/l)
West Branch DuPage River			
WB31	31.90	ND	
WB24	31.60	Chloroform	3.790
WB27	28.70	Benzo(b)fluoranthene	0.150
		Chloroform	2.600
		Fluoranthene	0.145
WB28	27.40	Chloroform	2.320
WB39	21.70	Phenanthrene	1.460
WB33	21.30	ND	
WB38	16.00	ND	
WB34	15.10	ND	
WB12	13.60	ND	
WB37	6.30	ND	
WB08	0.85	ND	
Unnamed Tributary (95-906; IL_GBK05-GBK39)			
WB29	2.20	Trichloroethene	1.800
WB30	1.90	Trichloroethene	1.840
Kress Creek			
WB01	2.70	ND	
Spring Brook			
WB11	3.30	ND	
WB26	3.00	Bromodichloromethane	1.620
		Chloroform	3.370

Table 6. Detections of organic compounds exceeding threshold effect levels (TEL) and probable effect levels (PEL) in sediment samples collected from the West Branch DuPage River and tributaries, 2009.

Site ID	River Mile	Metals TEL	Metals PEL	PAHs TEL	PAHs PEL	Pesticides TEL	Pesticides PEL
West Branch DuPage River							
WB31	31.90	4	0	12	6	0	0
WB24	31.60	2	0	6	0	1	0
WB27	28.70	2	0	8	0	0	0
WB28	27.40	2	0	10	2	3	2
WB20	25.60	0	0	11	5	0	0
WB39	21.70	2	0	6	0	0	0
WB33	21.30	1	0	9	0	0	0
WB17	19.20	1	0	11	6	0	0
WB38	16.00	5	1	4	0	0	0
WB34	15.10	4	0	9	1	0	0
WB12	13.60	0	0	9	1	0	0
WB40	11.70	4	0	9	3	0	0
WB36	8.60	2	0	10	2	0	0
WB41	8.00	0	0	0	0	0	0
WB37	6.30	4	0	8	0	0	0
WB35	4.20	2	0	11	6	0	0
WB08	0.85	2	0	12	6	0	0
Unnamed Tributary (95-906)							
WB29	2.20	1	0	9	0	0	0
WB30	1.90	4	0	12	6	0	0
Kress Creek							
WB01	2.70	0	0	9	0	0	0
WB03	0.50	2	0	9	0	0	0
Spring Brook							
WB11	3.30	5	0	5	0	0	0
WB26	3.00	4	0	0	0	0	0

Physical Habitat for Aquatic Life

Habitat quality in the West Branch DuPage mainstem improved markedly in 2009 compared to 2006 owing to the restoration project associated with the removal of thorium contaminated sediments in reach near Warrenville (RM ~ 9 – 14; see Figures 27 and 28). The effectiveness of the restoration project in improving habitat is especially evident in the ratio of modified to warmwater habitat attributes (Figure 29). In 2006, modified attributes dominated the reach, whereas in 2009 no modified attributes were recorded save for sparse cover at RM 13.6 (Table 7). With the exception of the headwater reach upstream from County Farm Road, the habitat quality in the mainstem is now of sufficient quality so as to not be a limiting factor to aquatic life.

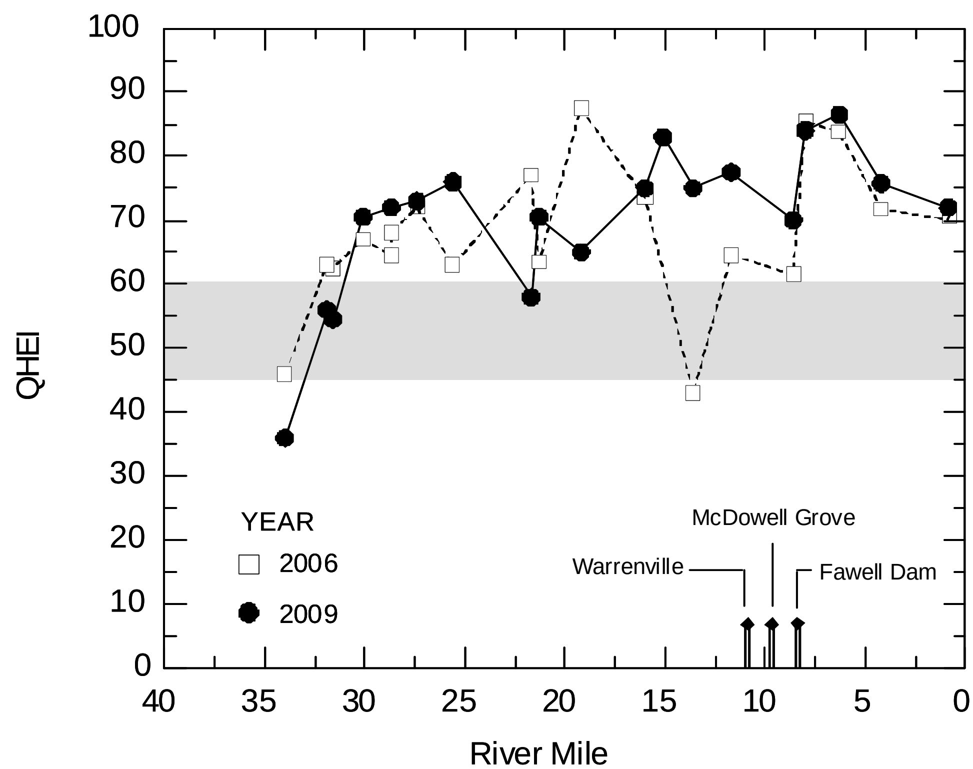

Figure 28. QHEI scores recorded for the West Branch DuPage River, 2006 and 2009, plotted by river mile. The shaded region of the graph shows the range of QHEI scores where habitat quality becomes limiting to aquatic life. Streams with QHEI scores less than 45 are devoid of functional habitat, and rarely support aquatic assemblages consistent with Clean Water Act (CWA) goals. Scores greater than 60 generally indicate that stream habitat is of sufficient quality to support aquatic life. Scores between 45 and 60 (the gray shaded region in the plot) are generally not conducive to supporting fully-functional aquatic assemblages, but must be interpreted in light of site-specific information and in the context of information from adjacent sites.

Habitat quality surveyed in tributaries to the West Branch remained static in 2009 relative to 2006 (Figure 28). The median QHEI score for the tributaries was 53, and modified attributes were more prevalent than warmwater attributes at most sites. Collectively, habitat quality is an obvious limiting factor to aquatic life in the tributaries; however, two tributaries, Klein Creek and Ferry Creek (Table 7), are exceptions, and should be capable of supporting aquatic assemblages meeting CWA goals.

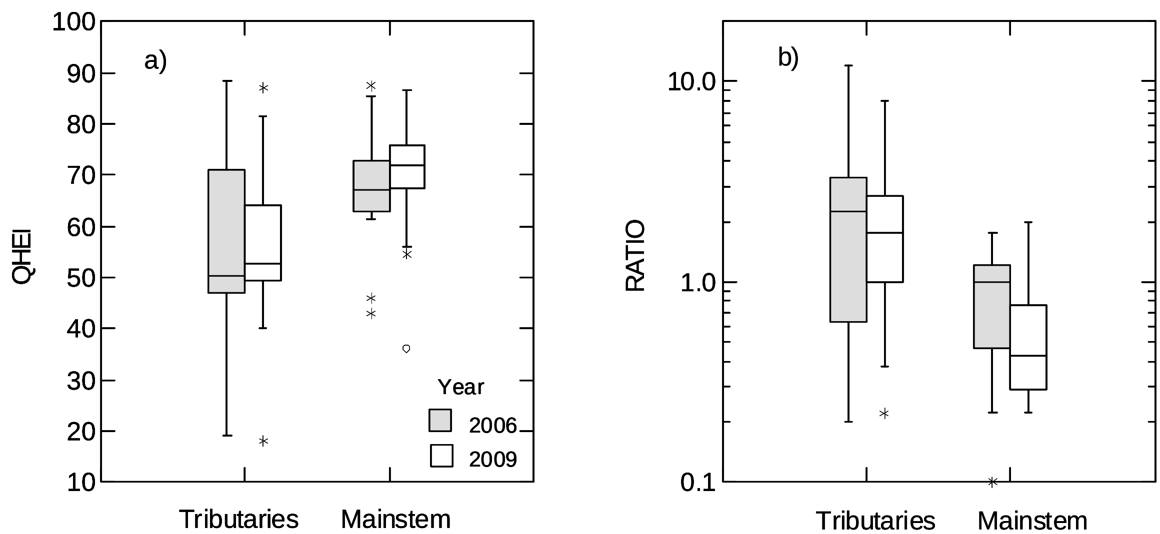

Figure 29. a) Distributions of QHEI scores in West Branch tributaries and the West Branch mainstem, 2006 and 2009. b) Distributions of the ratio of modified to warmwater habitat attributes for tributaries and the mainstem, 2006 and 2009.

Table 7. QHEI scores and matrix of good and modified attributes in the W. Br. DuPage study area (2009).

Key: QHEI Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(95900) W. Br. DuPage River																																		
Year: 2009																																		
42.0	75.75	6.24		■		■	■	■	■	■	■	■	8	◆					1		■											1	0.22	0.33
34.0	36.00	8.55		■			■	■					3	◆	◆			◆	3		■			■				■	■	■	■	6	1.00	2.50
31.9	56.00	5.15		■				■			■		3	◆		◆			2		■			■	■			■	■	■		6	0.75	2.25
31.6	54.50	5.15		■				■		■	■	■	5	◆		◆			2					■	■			■				3	0.50	1.00
30.1	70.50	4.20		■		■	■	■		■	■	■	7						0	■								■				2	0.13	0.38
28.7	72.00	17.10	■	■		■	■	■			■		6						0		■							■	■	■		4	0.14	0.71
27.4	73.00	6.80		■		■	■	■		■	■		6						0	■								■		■		3	0.14	0.57
25.6	76.00	6.80		■		■	■	■		■	■	■	7						0	■								■				2	0.13	0.38
21.7	58.00	3.42		■			■	■			■		4				◆		1	■	■			■				■	■	■		6	0.40	1.60
21.3	70.50	3.42	■	■					■	■	■	■	6				◆		1					■	■							2	0.29	0.57
19.2	65.00	4.50		■				■			■		3						0	■	■			■	■			■	■	■		7	0.25	2.00
16.0	75.00	2.90	■	■		■	■	■		■	■		7						0									■		■		2	0.13	0.38
15.1	83.00	2.90		■		■	■	■		■	■	■	7						0	■								■				2	0.13	0.38
13.6	75.00	3.43	■	■		■		■	■	■	■	■	8				◆		1						■							1	0.22	0.33
11.7	77.50	2.18		■		■	■	■	■	■	■	■	8						0	■												1	0.11	0.22
8.6	70.00	4.80		■			■	■			■	■	5						0		■			■				■	■			4	0.17	0.83
8.0	84.00	4.80		■		■	■	■	■	■	■	■	8						0	■												1	0.11	0.22
6.3	86.50	5.73		■		■	■	■	■	■	■		8						0	■												1	0.11	0.22
0.8	72.00	6.81		■				■	■	■	■	■	6						0	■				■	■							3	0.14	0.57
(95902) Trib to W. Br. DuPage Riv																																		
Year: 2009																																		
0.5	51.50	12.21	■	■							■		3			◆	◆		2		■			■	■			■	■	■		6	0.75	2.25
(95904) Trib to W. Br. DuPage Riv																																		
Year: 2009																																		
0.1	18.00	9.68									■		1	◆	◆	◆	◆		4		■			■	■	■		■	■		■	7	2.50	6.00
(95905) Trib to W. Br. DuPage Riv																																		
Year: 2009																																		
0.1	42.50	12.20						■			■		2	◆	◆	◆			3		■			■	■			■	■	■	■	7	1.33	3.67

Table 7. continued.

Key: ■ QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(95906) Trib to W. Br. DuPage Riv																																		
Year: 2009																																		
2.2	40.00	17.05											0	◆		◆	◆	◆	4		■			■	■			■	■	■	■	7	5.00	12.00
1.9	42.00	17.05		■							■		2	◆		◆	◆		3		■			■	■			■	■	■	■	7	1.33	3.67
0.9	64.75	21.70	■				■	■			■		4						0		■		■	■				■	■	■		6	0.20	1.40
(95910) Kress Creek																																		
Year: 2009																																		
5.1	47.00	5.13						■			■		2		◆	◆			2	■	■			■	■			■	■	■	■	8	1.00	3.67
2.7	53.00	6.81		■							■		2	◆		◆	◆		3		■			■	■			■	■		■	6	1.33	3.33
0.5	81.50	6.81		■		■	■	■		■	■	■	7						0	■								■				2	0.13	0.38
(95920) Ferry Creek																																		
Year: 2009																																		
2.8	62.50	15.82		■				■			■		3		◆	◆			2	■	■			■	■			■	■		■	7	0.75	2.50
0.7	57.00	12.50		■				■			■		3			◆			1	■	■			■	■			■	■	■		7	0.50	2.25
(95925) W. Br. Ferry Creek																																		
Year: 2009																																		
0.2	72.00	22.39		■		■	■	■			■		5						0	■	■							■	■	■		5	0.17	1.00
(95930) W. Br. Cress Creek																																		
Year: 2009																																		
0.2	69.00	27.80		■			■	■		■	■	■	6				◆		1	■	■			■				■				4	0.29	0.86
(95940) Trib to W. Br. DuPage Riv																																		
Year: 2009																																		
0.2	56.00	50.80				■	■	■		■			4		◆			◆	2	■				■				■			■	4	0.60	1.40
(95950) Spring Brook																																		
Year: 2009																																		
3.3	49.50	6.38		■				■			■		3	◆		◆			2		■			■	■			■	■	■		6	0.75	2.25
3.0	59.50	6.38		■						■	■	■	4	◆		◆	◆		3		■			■	■			■				4	0.80	1.60
0.7	64.00	8.33		■		■				■	■	■	5			◆	◆		2	■	■				■			■	■			5	0.50	1.33

Table 7. continued.

Key: QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes – High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes – Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(95960) Winfield Creek																																		
Year: 2009																																		
5.4	50.00	16.59		■									1	◆		◆	◆	◆	4		■			■	■			■	■	■		6	2.50	5.50
3.5	50.50	7.45		■							■		2	◆		◆	◆		3		■			■	■			■	■	■		6	1.33	3.33
0.4	50.50	5.60		■				■			■	■	4	◆		◆	◆		3		■			■	■			■	■			5	0.80	1.80
(95970) Klein Creek																																		
Year: 2009																																		
3.6	52.25	3.70		■				■		■	■		4	◆		◆			2					■	■			■	■	■		5	0.60	1.60
1.0	87.00	12.98		■		■	■	■	■	■	■	■	8						0	■												1	0.11	0.22
(95982) Big Rock Creek																																		
Year: 2009																																		
11.0	92.00	8.90	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
3.4	84.50	19.20	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(95985) Forked Creek																																		
Year: 2009																																		
4.4	92.00	4.38	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10

Fish Assemblage
Fish were sampled at nineteen locations along the West Branch DuPage river mainstem. None of the fIBI scores derived from the fish samples met the benchmark score of 41. The best scores were observed downstream from the Fawell dam in the lower eight mile reach of the river. The longitudinal pattern of fIBI scores was nearly identical that found in 2006, and showed no relation to the locations of wastewater plants (Figure 30). Also, no improvement within the restored reach was detected, though that result was not unanticipated given that restoration was completed just prior to the 2009 survey. Several years may be needed for recovery of the fish community to be fully realized.

Compared to a limited survey done in 1983 (Ludwig et al. 1987), fIBI scores were higher in 2006 and 2009 (Figure 30), likely reflecting the investment in improved wastewater infrastructure that occurred throughout the 1980s. Fish communities sampled in 1983 contained a higher percentage of tolerant species compared to 2006 and 2009, and moderately intolerant species like stonecat, smallmouth bass and hornyhead chub were rare or absent in 1983, whereas in 2009 those species were relatively common and abundant.

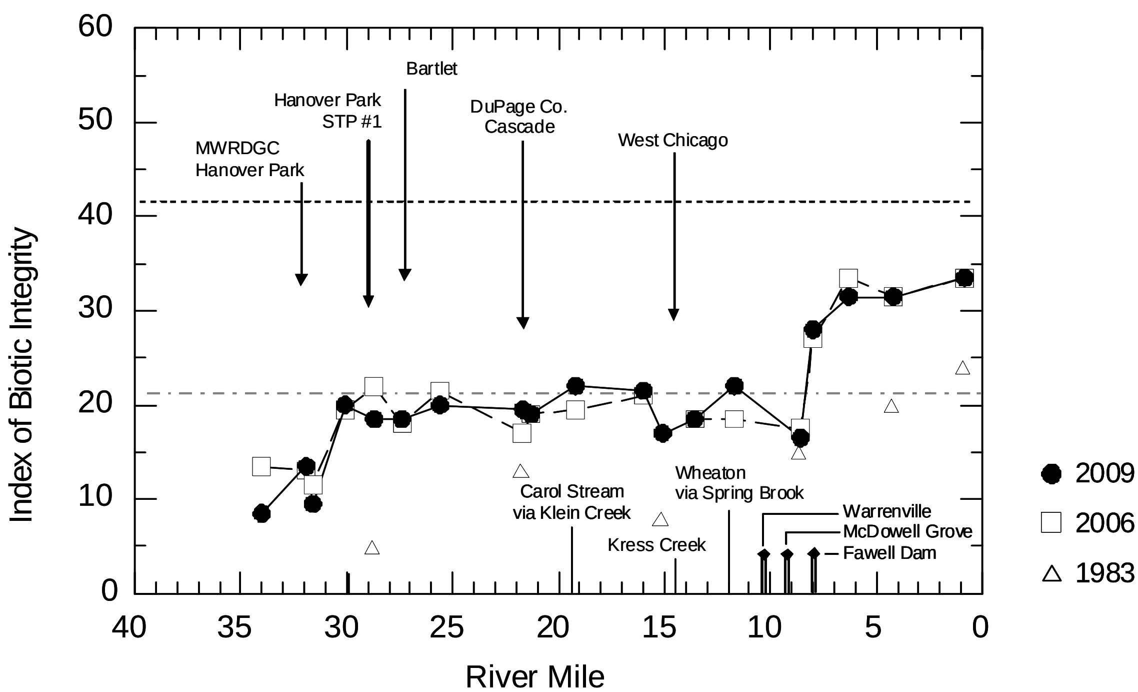

Figure 30. Fish Index of Biotic Integrity scores plotted by river mile for the West Branch DuPage River, 1983, 2006 and 2009. The approximate discharge locations of publicly owned treatment plants are shown for reference. The dashed horizontal line at a score of 41 corresponds to the benchmark goal for unimpaired waters. Scores less than 21 are considered severely impaired.

Fish IBI scores for samples collected from tributaries to the West Branch in 2009 were essentially identical to those reported in 2006 (Figure 31). No scores met the benchmark of 41. No trend was detected in fIBI scores for Kress Creek in the restored reach.

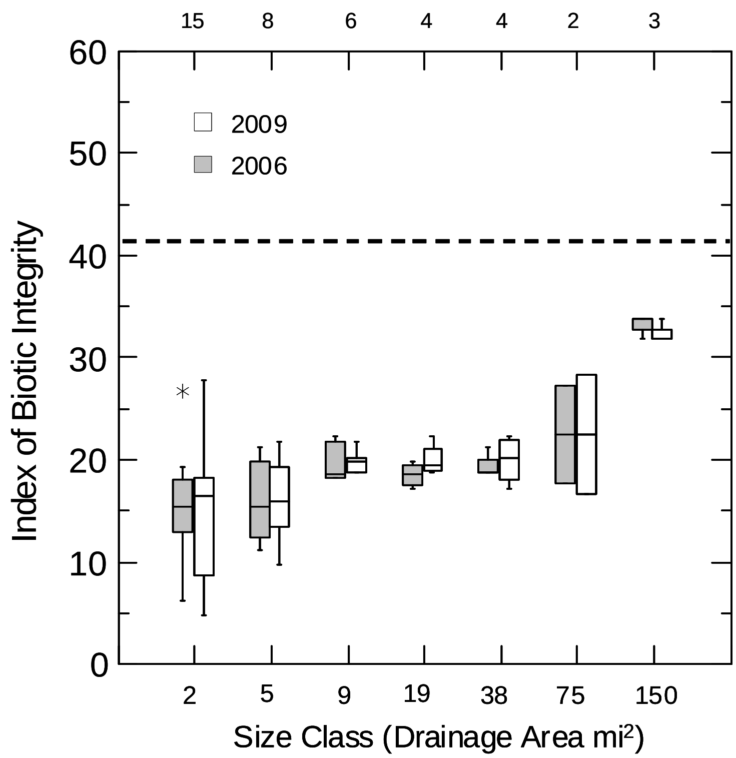

Figure 31. Distributions of fish Index of Biotic Integrity scores plotted by stream size class for sites sampled in the West Branch DuPage River basin, 2006 and 2009. The dashed line corresponds to the benchmark score of 41 for unimpaired waters.

Habitat quality and drainage area best explained variation in fIBI scores (Figure 32). Drainage area is likely serving as a proxy for other variables, most probably as surrogate for stormwater given that the relationship between fIBI scores and drainage is in a positive direction, and it is reasonable to suspect that most of the stormwater impact will be manifest in small streams.

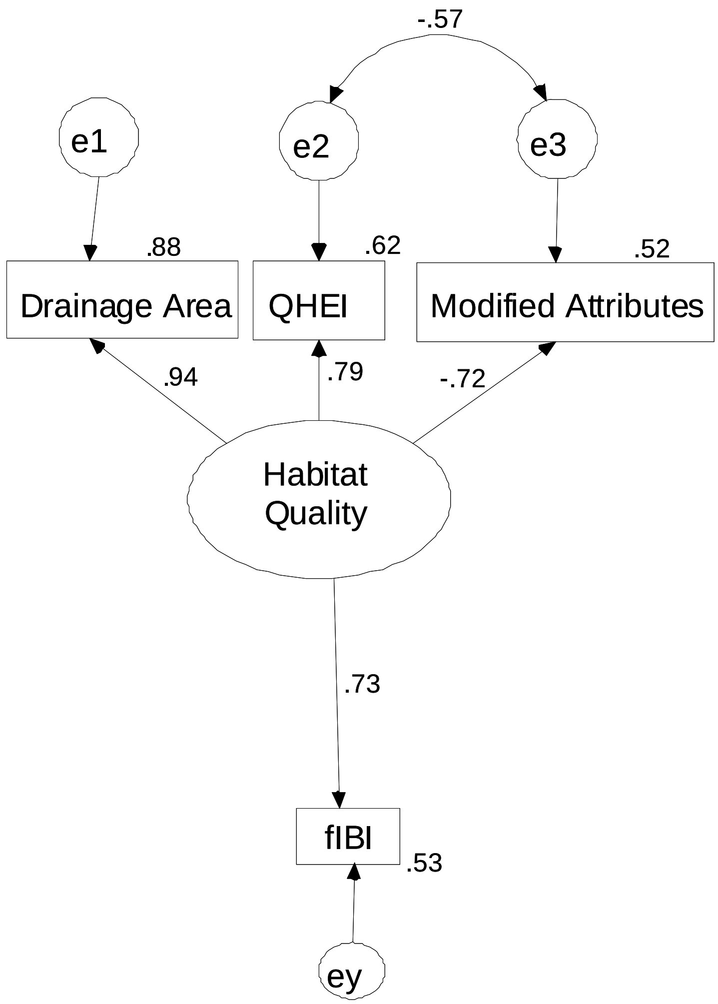

Figure 32. A structural equation model linking environmental variables to fish Index of Biotic Integrity scores for the West Branch DuPage River and tributaries, 2009. The model explains 53 percent of the variance in fIBI scores. Numbers above the variables bounded by rectangles show the strength of correlation of the variable to the latent variable (Habitat Quality). The number adjacent the arrow pointing from Habitat Quality to fIBI suggests that a unit change in habitat quality will result in an increase in fIBI score of 0.73.

Macroinvertebrate Assemblage

For the West Branch mainstem as a whole, macroinvertebrate communities sampled in 2009 (45.3 +/- 17.9 SD) were similar to 2006 (41.9 +/- 17.0 SD) . However, for the reach downstream from Kress Creek a trend (paired t-test, p=0.08) of improvement was detected with mean index scores increasing from 51.5 in 2006 to 59.7 in 2009. Given the recent completion of the restoration work within the reach, a non-significant trend toward improvement may functionally be considered significant.

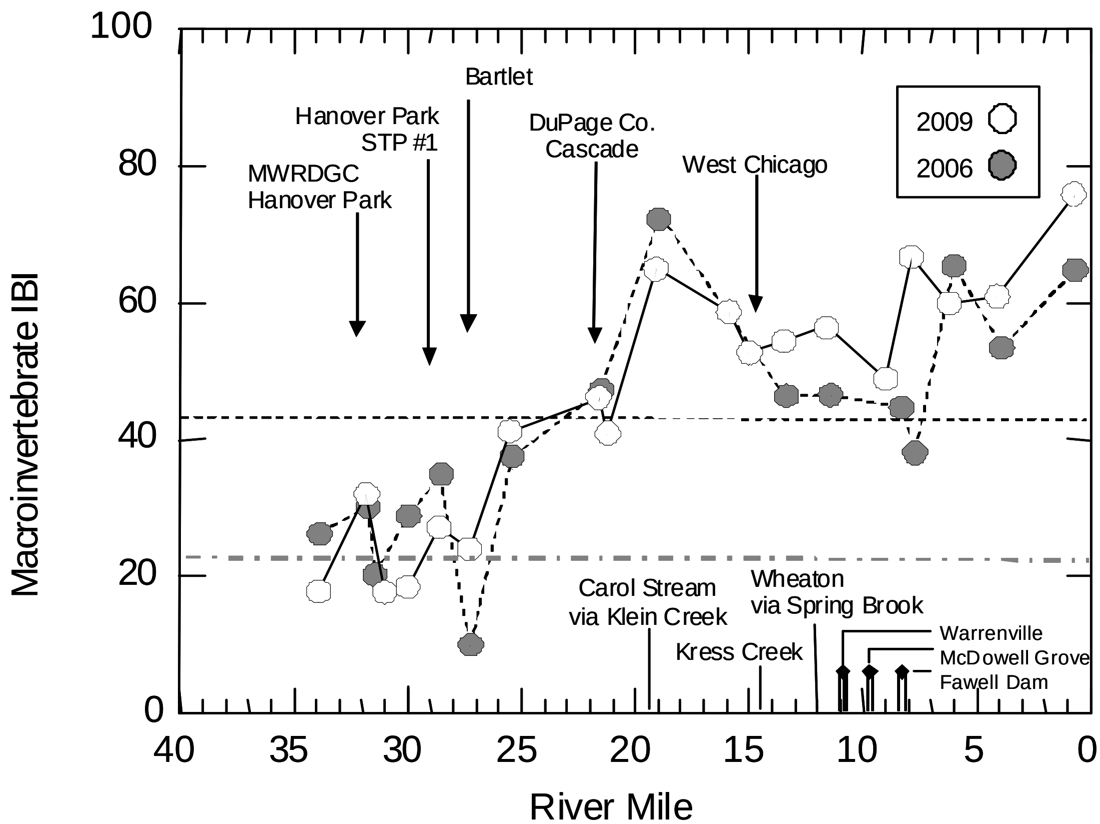

Figure 33. Macroinvertebrate Index of Biotic Integrity Scores for the West Branch DuPage River mainstem, 2006 and 2009 in relation to publicly owned sewage treatment plants and the Fawell Dam. The dashed horizontal line corresponds to the benchmark score for unimpaired streams. The stippled gray line shows the boundary for scores classed as severely impaired.

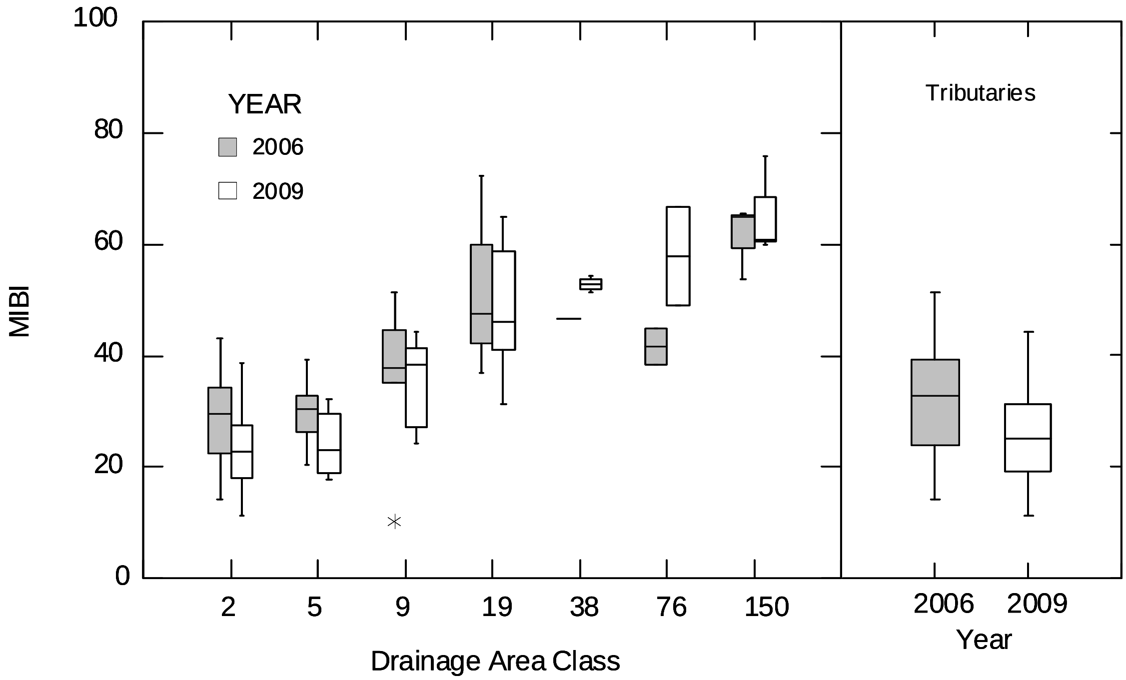

Figure 34. Distributions of macroinvertebrate Index of Biotic Integrity scores plotted by stream size class, 2006 and 2009. The right panel shows distributions for tributaries only.

Macroinvertebrate IBI scores in tributaries to the West Branch DuPage River decreased on average in 2009 compared to 2006 (Figure 34). One possible cause for the decrease was the increased snowfall antecedent to the 2009 sampling relative to that for 2006, and the likely attendant increase in deicing chemicals used during the winter of 2008 and 2009. An alternate hypothesis is that the increased runoff resulted in more exposure, in general, to all contaminants associated with stormwater. Be that as it may, most of the variation in mIBI scores was explained by a combination of measured water quality, specifically BOD, TKN and NH3-N (all indicators of organic enrichment), and drainage area (Figure 35). This result comports well with the results for the DuPage-Salt Creek basin as whole (MBI 2008), and suggests that organic enrichment is an important proximate stressor limiting aquatic life.

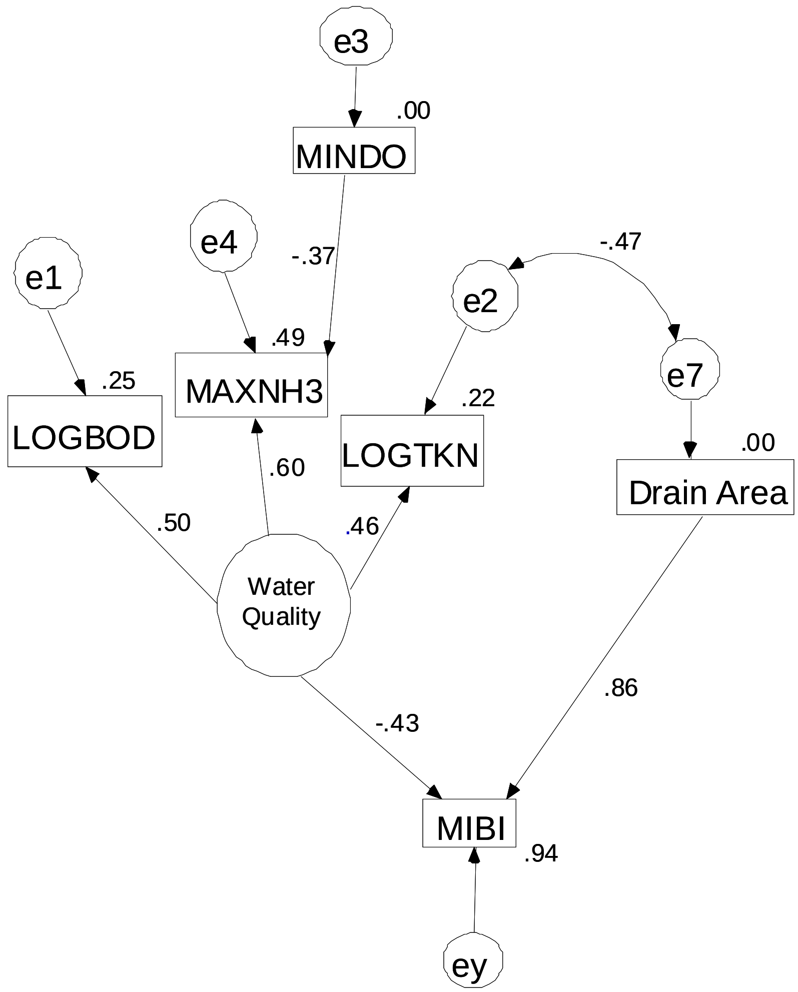

Figure 35. A structural equation model linking environmental variables to macroinvertebrate Index of Biotic Integrity scores for the West Branch DuPage River and tributaries, 2009. The model explains 94 percent of the variance in mIBI scores. Numbers above the variables bounded by rectangles show the strength of correlation of the variable to the latent variable (Water Quality). The number adjacent the arrow pointing from Water Quality to mIBI suggests that a unit change in water quality (toward worse water quality) will result in a decrease in mIBI score of 0.43.

Drainage area as a significant explanatory variable raises both the issue of whether the mIBI is calibrated for very small streams, and if drainage area is serving as a proxy for unmeasured (or partially measured) stressor variables. Examining mIBI scores and environmental variables in relation to drainage area for sites sampled in the DuPage River-Salt Creek study area yields a partial explanation (Figure 36). mIBI scores do show a strong positive relationship with drainage area; however, several (actually more, but for the sake of convenience, the ones discussed here will suffice) environmental variables are also associated with drainage area. For ammonia-nitrogen, road density, and percent urban land use, the direction of increasing environmental stress is toward smaller streams. Conversely, better habitat and wider buffers tend to occur at larger drainage areas. Residuals from a regression of mIBI scores on drainage show a weak trend of under-prediction the small streams; a result consistent with poor calibration. However, when the mIBI is regressed against environmental variables associated with drainage area, the trend is not apparent, suggesting that the mIBI is tracking the stressor gradient. This does not necessarily answer the question of whether the mIBI is fully calibrated to small streams, but it does show that the small streams in the watershed are proportionately more stressed than the larger streams, given their closer proximity to stressors associated with urban land uses.

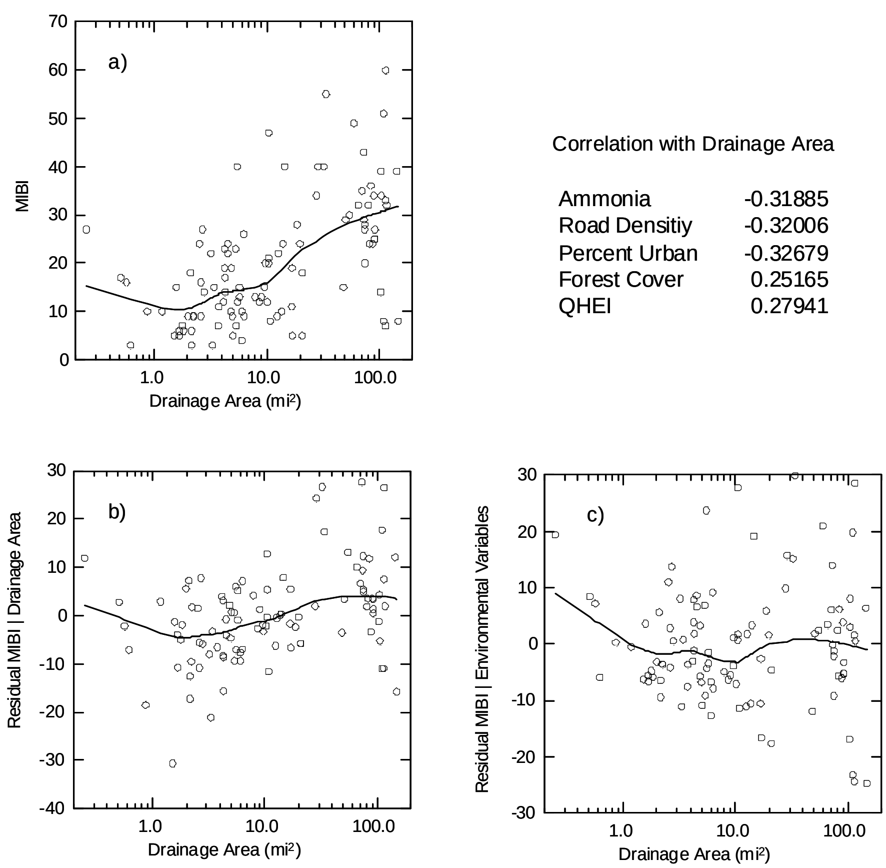

Figure 36. a) MIBI scores plotted against drainage area for sites sampled in the DuPage River-Salt Creek watersheds (2006-2007). b) Residuals from the regression of mIBI on drainage area plotted against drainage area, and c) residuals from the regression of mIBI against environmental variables correlated with drainage area plot against drainage area.

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