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2012 Biological and Water Quality Study of the West Branch DuPage River Watershed

Cook and DuPage Counties, Illinois

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Cover photo: West Branch DuPage River (Station WB08) at Knoch Knolls Park, near Naperville (RM 0.85).

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DuPage, Cook and Will Counties, Illinois

Technical Report MBI/2014-6-9

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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 suburban landscape. This assessment is a follow-up to similarly intensive surveys of the West Branch done in 2009 and 2006, 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 Watershed Biological and Water Quality Assessment

Standardized biological, chemical, and physical monitoring and assessment techniques were employed to meet three major objectives: 1) determine the extent to which biological assemblages are impaired (using Illinois EPA guidelines); 2) determine the categorical stressors and sources that are associated with those impairments; 3) compare 2012 results to previous assessments of the West Branch DuPage River watershed to evaluate trends. Data presented herein were processed, evaluated, and synthesized as a biological and water quality assessment of aquatic life use support status. The assessments are directly comparable to those accomplished in previous surveys of the watershed in 2006 and 2009, such that trends in status can be examined, and causes and sources of impairment can be confirmed, appended, or removed. 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 contributes to a process termed the Integrated Priority System (IPS; MBI 2010a) that was developed for the upper DuPage watersheds to help determine and prioritize restoration projects.

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INTRODUCTION

A biological and water quality study of the West Branch DuPage River and selected tributaries was conducted in 2012 to assess aquatic life condition status, identify proximate stressors, and examine chemical/ physical water quality and biological condition relative to publicly owned treatment works and other potential sources of stress and impact. The 2012 survey data were also used to assess trends relative to baseline and follow up surveys conducted in 2006 and 2009. Results from the 2006 survey were first published in *Biological and Water Quality Study of the East and West Branches of the DuPage River and the Salt Creek Watersheds* (2008a) and in a subsequent errata report (2008b). Results from 2009 were presented in *Biological and Water Quality Study of the West Branch of the DuPage River* (2010b); the 2010b report is hereafter referred to as the Bioassessment Report.

Data analyses and site selection for the 150 sq. mi. West Branch DuPage watershed was organized by geometric survey design. The chemical and biological results were displayed by drainage area categories within 5, 10, 19, 38, 75, and 150 sq. mi. geometric panels. Additional sites that targeted discharges of specific interest or that filled gaps in the geometric design were also included. MBI has employed a similar survey design in the East and West Branch DuPage Rivers, Lower DuPage River, and Salt Creek between 2006 and 2012 (MBI 2008a, 2010b, 2012, 2013).

Following the 2006 survey, a significant habitat restoration project was conducted in the West Branch mainstem from river mile (RM) 15 to 9, and within the lower 1.5 miles of Kress Creek (http://www.epa.gov/R5Super/npl/illinois/ILD980823991.htm). The restoration was part of an on-going remediation of contaminated sediments that initiated removal of low-head dams at McDowell and Warrenville Grove.

SUMMARY

The entirety of the West Branch DuPage River watershed remains impaired based on biological assemblages surveyed in 2012 (Figure 1; Table 2). As in other DuPage River drainages, the most severe and consistent impairments were manifest in the smallest tributary drainages which are proportionately more impacted than the larger streams given their close proximity to urban land use related stressors. In fact, since the initial bioassessment in 2006, no stream site draining less than 20 sq. mi. has fully attained the Illinois biological thresholds within the

DuPage River or adjacent Salt Creek basins (see Figure 24). These results reflect a consistent inability of small drainages to support warmwater assemblages. Impairments appear primarily related to urban land use and likely include a combination of chemical and physical factors such as flashy flows, impoundment, habitat alteration, and chemical contaminants delivered by runoff events.

The 2009 assessment report attributed much of the tributary impairment to organic enrichment influences, as evidenced by elevated BOD, TKN, and ammonia levels. Stormwater impoundments, ponds, and humic substances from groundwater were considered the most likely sources. The 2012 results generally confirmed these observations as elevated levels of BOD5, TKN, and TSS were often encountered in the small, densely urban drainages or at sites located just downstream from impoundments and retention ponds. Background phosphorus levels in tributaries were consistently elevated above target levels while nitrate levels were consistently low. However, a near order of magnitude increase in these nutrients was observed downstream from the Wheaton and Carol Stream WWTP discharges on Klein Creek and Spring Brook, respectively.

Throughout the West Branch watershed, the 2012 chemical results displayed a pattern of elevated chloride levels and chronic increases during each successive survey (see Figure 12 and Figure 15). This phenomenon mirrors trends observed in other northern drainages (and other DuPage and Salt Creek assessment surveys) and is largely attributed to road salt applications and the resultant build-up of chlorides in urban soils and near surface groundwater (CH_2M Hill 2004, Kelly et al. 2012). Kelly et al. (2012) also considered WWTP discharges to be a significant chloride source although recent monitoring of West Branch WWTPs by the Conservation Foundation found minimal change from upstream to downstream (see Table 6). The highest chloride concentrations (and resultant WQS exceedances) in the 2012 and 2009 West Branch surveys were detected in Winfield Creek, about 0.6 miles downstream from a salt storage facility.

West Branch mainstem nutrient levels were highly elevated, particularly downstream from a succession of major municipal wastewater treatment plants[1,2]. Under the extended low-flow conditions of 2012, severe daytime D.O. swings or diurnal D.O. violations were also registered at several locations along the mainstem length. Elevated nutrient levels in the West Branch tend to mirror the enriched condition of the adjacent and effluent dominated East Branch DuPage River, documented in 2011, and in portions of the lower DuPage in 2012.

While the mainstem chemical quality is variable, outside of the extreme upper reaches West Branch, habitats were more than adequate to support good quality biological assemblages.

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[1] Major mainstem WWTPs include the MWRDGC Hanover Park, Roselle-J. Botterman, Hanover Park #1, Bartlett, and West Chicago facilities. Tributary plants include Carol Stream on Klein Creek and Wheaton on Spring Brook; the Bartlett WWTP “overflow” plant intermittently discharges to an unnamed West Br. tributary (95-906).

[2] Elevated mainstem nutrients were most often associated with point source discharges. However, sharp increases in nitrate and phosphorus at WB31 (upstream MWRDGC and all point sources) and ammonia at WB25 (RM 34.1) suggest additional, unknown sources.

Despite these positive attributes, biological performance is consistently impaired, particularly among the fish. Since 2006, fish assemblage quality has remained virtually unchanged and barely surpasses the poor range upstream from the Fawell Dam (RM 8.1), the last remaining impediment to fish migration[3]. Since 2006, the most consistent improvement in fish has been observed in the eight-mile reach downstream from the dam, further illustrating the contrast in quality from upstream to downstream.

Mainstem macroinvertebrate assemblage performance, while showing some improvements has been erratic between the 2006, 2009, and 2012 surveys. In contrast to fish, improvements were manifest over the lower 20 miles and were not restricted to the reach downstream from the Fawell Dam. Variability in quality between surveys *(i.e.,* collections improved substantially between 2006 and 2009 but returned to near-2006 levels in 2012), was considered primarily related to low flows and subsequent increases in nutrients, dissolved solids (including chlorides), and depressed dissolved oxygen levels. Variation in sampling locations or habitat quality between surveys at a few sites may explain some lower scores, but that alone does not negate the overall trend of decline in 2012.

Contrasting biological results and sharp differences in fish assemblage quality above and below the Fawell dam suggests that the physical barrier to fish movement contributes to the impairment observed upstream. At the same time, under the effluent dominated conditions encountered in 2012, biological and water quality impairment related to point and nonpoint sources remain a significant issue. In the future, additional improvement in biological condition will likely hinge on removal or modification of Fawell Dam to improve connectivity to downstream reaches. However, it seems unlikely that this recovery will be fully realized without additional water quality improvements upstream.

The pattern of decline in 2012 West Branch biological performance tends to mirror declines in other branches of the DuPage River basin (Table 1). To varying degrees, both fish and macroinvertebrate index scores from the West Branch, East Branch, and DuPage River mainstems have declined over time. Concurrently, these same reaches were impacted in 2012 by increased concentrations of nutrients, chlorides, and dissolved solids. The increases appear primarily related to lower ambient flows relative to constant nutrient inputs from point sources in the effluent dominated reaches and increasing levels of road salt residue leaching into watershed streams from groundwater. As discussed above, the smallest change in quality was among the fish assemblages from the most severely impaired section of the West Branch upstream from the Fawell Dam. Again, while the persistently poor quality of the fish assemblage may be related to a loss of connectivity, water quality impairments are also considered a factor. Persistent macroinvertebrate declines in both the West Branch and other DuPage River branches also suggest pervasive water quality influences.

[3] Although the McDowell Grove Dam was removed in 2008, a temporary cofferdam was installed immediately upstream (to contain potentially contaminated sediments) and continued to obstruct the channel until its removal in the fall of 2012.

Table 1. Trends in average fIBI and mIBI scores from selected reaches of the DuPage River and its branches surveyed by MBI since 2007. River sections were restricted to non-headwater mainstem sites with drainage areas > 20 square miles.

DuPage River Basin Surveys Mainstem River Reaches >20 sq. mi. DA	**Mean fIBI Scores**				**fIBI Change**	**Mean mIBI Scores**				**mIBI Change**
	2007	**2009**	**2011**	**2012**		**2007**	**2009**	**2011**	**2012***	
West Branch DuPage River – Ust Fawell Dam		19.6		19.4	-0.2		51.0		42.0	-9.0
West Branch DuPage River – Dst. Fawell Dam		31.1		27.1	-4.0		65.8		47.8	-18.0
East Branch DuPage River	30.5		24.9		-5.6	42.2		33.0		-9.2
DuPage River – Source to Hammel Woods Dam		32.3		29.9	-2.4		NA		40.3	NA
Average Total					-3.1					-12.1

* 2012 mIBI scores from two West Branch sites upstream from the Fawell Dam and one site down-stream were not included due to differences in sample location.

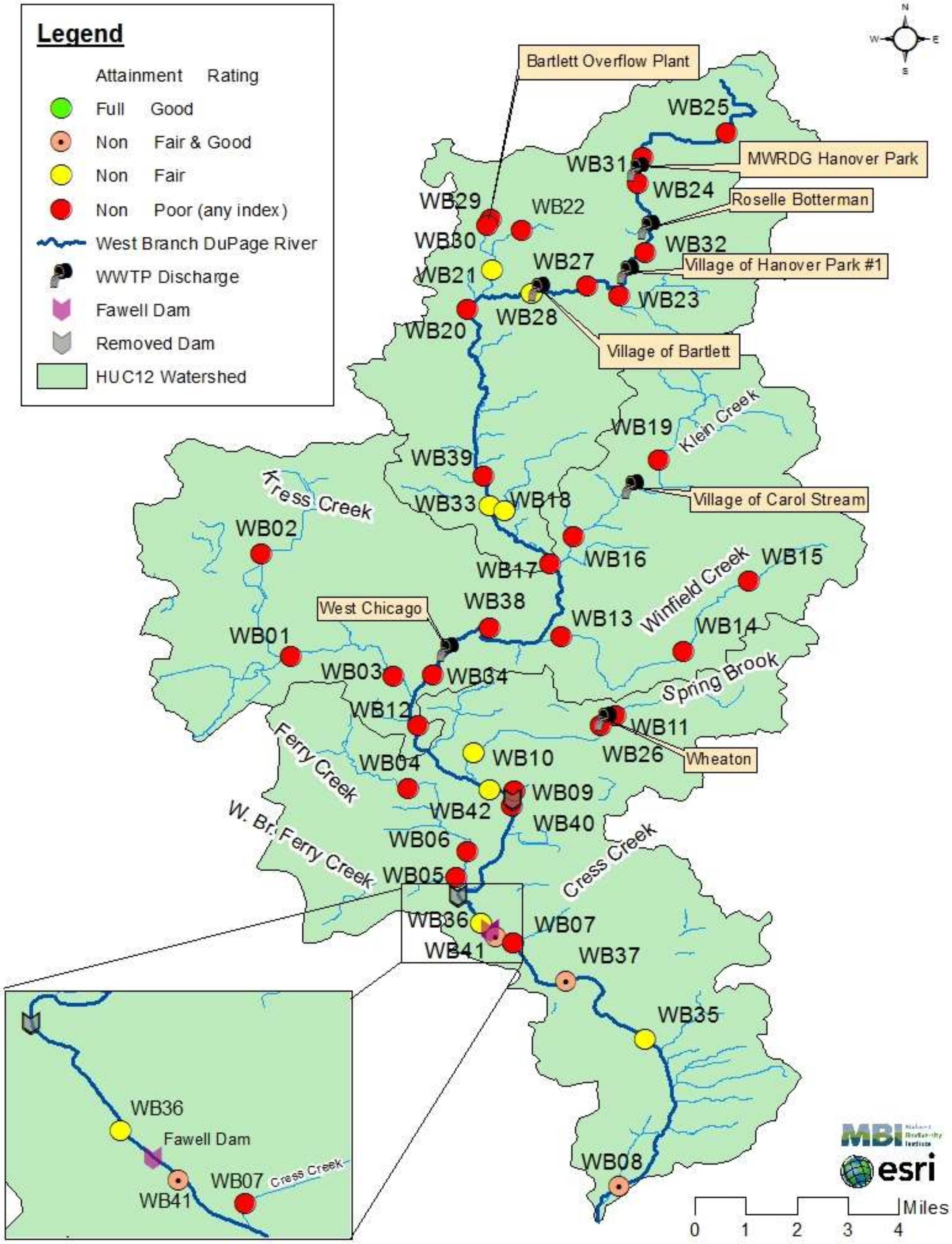


Figure 1. *Aquatic life use attainment status at West Branch DuPage River watershed biological sampling sites in 2012. Non-attainment based on biological performance is noted with orange circles (fair and good range), yellow circles (fair range) and red circles (poor). No sites were in Full attainment. Note: A low-head dam on Spring Brook, immediately upstream from WB10, is not shown.*

Table 2. Status of aquatic life use support for stream segments sampled in the West Branch DuPage River watershed study area in 2012. All sites with one or more fair or poor index scores are in Non-attainment and categorized as follows: 1) sites with <u>any index in the poor range</u> [i.e., Non (Poor)] are shaded in red and poor scores are underlined; 2) fair quality sites [i.e., Non (Fair)] are shaded in yellow; 3) fair to good quality sites [i.e., Non (Fair/Good)] are shaded in orange and the "good" scores are bold.

River (95-Code #) Site ID[a]	River Mile	DA (sq. mi)	IL fIBI	MIwb	IL mIBI	QHEI	Attainment Status	MBI Associated Causes [d]	fIBI 2009	mIBI 2009
W. Br. DuPage River (95-900)										
WB25 (WB30)	34.0	2.1	<u>2.0</u>	--	26.3	49.0	Non (Poor)	Chloride, D.O., T. Ammonia, nutrients (TKN, P), habitat alt.	<u>8.5</u>	<u>18.0</u>
WB31 (WB95)	31.3	4.9	<u>11.0</u>	--	26.1	52.3	Non (Poor)	Chloride/TDS, <u>nutrients (P</u>, N), D.O., habitat alt.	<u>13.5</u>	32.1
WB24 (WB29)	31.1	5.4	<u>15.5</u>	--	<u>20.7</u>	53.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>,TKN), habitat alt.	<u>9.5</u>	<u>17.9</u>
WB32 (WB112)	29.3	7.4	21.0	--	<u>15.6</u>	65.3	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>, NH_3),	<u>20.0</u>	<u>18.7</u>
WB27 (WB91)	27.8	12.9	<u>18.5</u>	--	<u>20.0</u>	73.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>),	<u>18.5</u>	27.3
WB28 (WB92)	27.4	14.0	22.0	--	27.2	81.0	Non (Fair)	Chloride/TDS, <u>nutrients (N, P</u>),	<u>18.5</u>	24.2
WB20 (WB25)	25.6	19.7	<u>19.0</u>	--	37.9	81.5	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier	<u>20.0</u>	41.3
WB39 (WB128)	21.7	27.8	<u>20.0</u>	6.15	40.4	78.5	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier	<u>19.5</u>	**46.2**
WB33 (WB115)	21.3	28.1	21.0	5.67	39.0	69.0	Non (Fair)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier	<u>19.0</u>	41.0
WB17 (WB21)	19.2	33.8	<u>20.0</u>	6.24	**45.9**	79.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier, metals	22.0	**64.9**
WB38 (WB127)	16.0	58.4	<u>18.5</u>	5.84	32. 5	74.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier	21.5	**58.7**
WB34 (WB116)	15.1	59.9	<u>18.5</u>	6.77	38.2	78.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier	17.0	**52.7**
WB12 (WB16)	13.6	80.5	<u>16.5</u>	5.37	39.6	72.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), fish barrier, metals	18.5	**54.4**
WB42	11.6	90.0	21.0	5.82	36.3	69.5	Non (Fair)	Chloride/TDS, <u>nutrients (N, P</u>), D.O, fish barrier	--	--
WB40 (WB130)	11.1	91.3	<u>18.0</u>	5.93	**56.5**	66.0	Non (Poor)	Chloride/TDS, <u>nutrients (N, P</u>), D.O, fish barrier	22.0	**51.2**
WB36 (WB125)	8.3	105	21.0	5.64	24.8	42.0	Non (Fair)	Chloride/TDS, <u>nutrients (N, P</u>), D.O, fish barrier	16.5	**48.9***
WB41 (WB131)	8.0	105	27.0	7.62	**42.9**	75.5	Non (F/G)	Chloride/TDS, <u>nutrients (N, P</u>)	28.0	**66.6**

River (95-Code #) Site ID[a]	River Mile	DA (sq. mi)	IL fIBI	MIwb	IL mIBI	QHEI	Attainment Status	MBI Associated Causes [d]	fIBI 2009	mIBI 2009
WB37 (WB126)	6.3	110	30.0	7.36	**50.6**	86.0	Non (F/G)	Chloride/TDS, nutrients (N, P)	31.5	**59.9**
WB35 (WB124)	4.2	115	26.0	6.69	30.7	63.0	Non (F/G)	Chloride/TDS, nutrients (P, N)	31.5	**60.9**
WB08 (WB12)	0.85	125	25.5	6.70	**50.0**	78.5	Non (F/G)	Chloride/TDS, nutrients (P, N)	33.5	**75.8**
West Branch Trib (95-902)										
WB18 (WB22)	0.5	2.7	23.0	--	31.0	55.5	Non (Fair)	Chloride/TDS, nutrients (NH_3, TKN, P), BOD, habitat alt.	15.0	38.6
West Branch Trib (95-904)										
WB22 (WB27)	0.15	0.7	17.0	--	25.8	24.0	Non (Poor)	Habitat alt., D.O.	18.0	11.3
West Branch Trib (95-905)										
WB23 (WB28)	0.15	2.5	13.5	--	33.2	33.0	Non (Poor)	Habitat alt.	17.0	24.0
West Branch Trib (95-906)										
WB29 (WB93)	2.2	2.2	9.5	--	20.6	61.0	Non (Poor)	Chloride, nutrients (NH_3, TKN, P)	4.5	25.7
WB30 (WB94)	1.9	2.6	11.0	--	--	54.0	(Non)[b] (Poor)	Chloride, nutrients (NH_3, TKN, P), pH, habitat alt.	7.5	18.6
WB21 (WB26)	0.9	4.2	29.0	--	25.7	61.3	Non (Fair)	Chloride/TDS, nutrients (NH_3, P), D.O.	18.0	19.1
Kress Creek (95-910)										
WB02 (WB05)	5.1	4.2	18.0	--	13.5	52.0	Non (Poor)	Chloride/TDS, T. Ammonia, nutrients (TKN, P), BOD, habitat alt.	13.5	24.4
WB01 (WB04)	2.7	14.5	12.0	--	32.8	61.0	Non (Poor)	Chloride/TDS, nutrients (P), BOD	19.0	44.2
WB03 (WB06)	0.5	18.6	18.0	--	24.4	89.0	Non (Poor)	Chloride/TDS, nutrients (P), BOD, D.O.	18.5	31.2
Ferry Creek (95-920)										
WB04 (WB08)	2.8	3.3	14.5	--	15.9	30.5	Non (Poor)	Nutrients (TKN, P), BOD, habitat alt., D.O.	16.0	17.7
WB06 (WB10)	0.7	5.5	19.0	--	30.5	51.5	Non (Poor)	Chloride/TDS, nutrients (P), habitat alt.	22.5	32.8
W. Br. Ferry Creek (95-925)										
WB05 (WB09)	0.25	4.3	19.5	--	17.5	65.5	Non (Poor)	Chloride/TDS, nutrients (NH_3, TKN, P), D.O.	18.0	21.8

River (95-Code #) Site ID[a]	River Mile	DA (sq. mi)	IL fIBI	MIwb	IL mIBI	QHEI	Attainment Status	MBI Associated Causes [d]	fIBI 2009	mIBI 2009
Cress Creek (95-930)										
WB07 (WB11)	0.2	3.8	28.5	--	14.0	66	Non (Poor)	Chloride, nutrients (P), BOD	27.5	27.4
Bremme Creek (95-940)										
WB09 (WB13)	0.25	0.8	16.5	--	24.7	50.5	Non (Poor)	Habitat alt.	5.5	28.2
Spring Brook (95-950)										
WB11 (WB15)	3.3	3.7	15.0	--	20.7	39.5	Non (Poor)	Chloride/TDS, Habitat Alt., nutrients (NH_3, TKN, P), BOD., D.O. pH, metals	16.5	12.3
WB26 (WB90)	3.0	3.9	11.0	--	20.1	63.5	Non (Poor)	Chloride/TDS, nutrients (N, P)	15.5	21.9
WB10 (WB14)	0.75	6.8	21.5	--	36.6	76.0	Non (Fair)	Chloride/TDS, nutrients (N, P)	21.5	30.1
Winfield Creek (95-960)										
WB15 (WB19)	5.4	2.0	25.5	--	17.0	68.0	Non (Poor)	Chloride/TDS, nutrients (P)	18.5	23.6
WB14 (WB18)	3.5	5.0	13.0	--	11.1	53.0	Non (Poor)	Chloride/TDS, nutrients (NH_3,TKN,P), hab. alt., D.O.	13.0	19.0
WB13 (WB17)	0.4	9.0	15.5	--	16.4	56.5	Non (Poor)	Chloride (dst. Salt Storage facility), nutrients (TKN,P), BOD, hab. alt.	20.0	38.0
Klein Creek (95-970)										
WB19 (WB23)	3.6	5.0	14.0	--	32.8	50.8	Non (Poor)	Chloride/TDS, nutrients (P), BOD, habitat alt.	18.0	29.0
WB16 (WB20)	1.0	9.0	15.0	--	35.3	86.0	Non (Poor)	Chloride/TDS, nutrients (N, P), metals	21.5	38.7

a Site codes in (parentheses) correspond to former 2006 survey codes that have been replaced by updated site codes.
b [Attainment status] based on one organism group is displayed in brackets.
* 2009 sample collected upstream at RM 8.6 (lotic habitat).
d Underlined nutrient parameters refer to "severe" exceedances of the least stringent target criteria (i.e., red shaded values in Table 9). Listings of metals, pH, D.O., and Total Ammonia as "Causes" reflect WQS violations.

Narrative Ranges for Illinois fIBI and mIBI scores (IEPA 2013)

	fIBI		mIBI
Poor	0 - 20	Poor	0.0 - 20.9
Fair	>20 - <41	Fair	>20.9 - <41.8
Good	≥41	Good	≥41.8

METHODS

Sites sampled (Figure 2) were selected systematically using a geometric approach by starting with the first site at the downstream terminus of the watershed. The selection process continued by choosing additional stream "panels" at intervals of one-half the drainage area of the preceding level. Thus, the upstream drainage area of each successive level, as one moves upstream, decreases geometrically. This resulted in seven levels of drainage area, starting at 150 mi.^{2}, and extending through drainage sizes of 75, 38, 19, 9, 5 and 2 mi^2. Supplemental sites targeting stream reaches of particular interest, such as those influenced by wastewater treatment plants (WWTPs) or dams, or to fill gaps left by the geometric design were added for 42 total sampling sites.

Sampling for fish, stream habitat, macroinvertebrates and water quality were attempted at each site although macroinvertebrates were not collected from WB30 and a few tributary sites were not sampled chemically due to lack of access or stream desiccation. Sampling at WB42, in the former Warrenville Grove dam pool was limited to biological sampling and continuous dissolved oxygen (D.O.) monitoring. Water quality parameters at all sites 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 21 locations and analyzed for metals, polycyclic aromatic hydrocarbons, and pesticides. Continuous D.O. monitoring was conducted at three mainstem locations.

Macroinvertebrate Assemblage

The macroinvertebrate assemblage was sampled using the Illinois EPA (IEPA) multi-habitat method (IEPA 2005) at all sites. The IEPA multi-habitat method involves the selection of a sampling reach that has instream and riparian habitat conditions typical of the assessment reach. Sampling reach requirements include flow conditions that approximate typical summer base flows, the absence of highly influential tributary streams, the presence of one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present, and a length of at least 300 feet. This method is applicable if conditions allow the collection of 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. 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[4] 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 the composition of the bottom or bank zone with reasonable accuracy throughout the sampling reach, the multi-habitat method is not applicable. In most cases, if more than one-half of the wetted stream

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

channel cannot be seen, touched, or otherwise reliably characterized by the sampler, reasonably accurate estimates of the bottom-zone and bank-zone habitat types are unlikely; thus, the multi-habitat method is not applicable.

Multi-habitat samples were field preserved in 10% formalin. Upon delivery to the MBI lab in Hilliard, OH, the preserved samples were then transferred to 70% ethyl alcohol. Laboratory procedures generally followed the IEPA (2005) methodology. For the multi-habitat method, this requires the production of a 300-organism subsample from a gridded tray following a scan and pre-pick of large and/or rare taxa. 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 IEPA (2005); however, calculation of the macroinvertebrate IBI followed IEPA methods in using genera as the lowest level of taxonomy for mIBI scoring.

Fish Assemblage

Methods for the collection of fish at wadeable sites was performed using a tow-barge or long-line pulsed D.C. electrofishing apparatus utilizing a T&J 1736 DCV electrofishing unit described by MBI (2006b). 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 raft-mounted pulsed D.C. electrofishing device. A Smith-Root 2.5 GPP unit was mounted on a 14' raft following the design of MBI (2007). Sampling effort was indexed to lineal distance and was 500 meters in length. 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 each stream). 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 by life stage (young-of-the-year, juvenile, and 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 D.O. 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 either individually or in batches. 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 excluded from the data as a matter of practice. The incidence of external anomalies was recorded following procedures outlined by Ohio EPA (1989, 2006a) 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 required their preservation for later laboratory identification. Fish were preserved

Table 3. Biological sampling sites in the West Branch DuPage River watershed study area, 2012. Chemical sampling was also conducted at each site but may have been from slightly different river miles.

Site ID	Mile	Latitude	Longitude	DA[5]	Width (ft.)	Location	Samples
West Branch DuPage River (95-900)							
WB25	34.00	42.01123	-88.11092	2.0	8.7	UST Braintree Drive, Schaumburg	C, F, M
WB31	31.3	42.00065	-88.13599	5.0	20.7	UST Longmeadow Ln. & MWRDGC WWTP	C, F, M, S
WB24	~~31.60~~ 31.1	41.99676	-88.13637	5.0	23.2	Walnut Ave., Dst. MWRDGC WWTP	C, F, M, S
WB32	29.3	41.97719	-88.13406	7.0	33.4	DST SR 20, Hanover Park	C, F, M, S
WBAD	29.~~9~~0	41.9750	-88.1386	--	NA	Arlington Drive	D
WB27	27.8	41.96771	-88.15060	13.0	25.2	UST County Farm Road, Hanover Park	C, F, M, S
WB28	27.40	41.96565	-88.16631	14.0	21.9	DST Bartlett WWTP, Bartlett	C, F, M, S
WB20	25.60	41.96095	-88.18444	20.0	31.8	DST Struckman Blvd., Bartlett	C, F, M, S
WB39	21.70	41.91364	-88.17987	28.0	35.0	UST St. Charles Rd, W. Chicago	C, F, M
WB33	21.30	41.90527	-88.17825	28.0	32.2	UST Great Western Trail, Timber Ridge FP	C, F, M, S
WB17	19.20	41.88889	-88.16104	34.0	44.5	UST Geneva Rd. West Chicago	C, F, M, S
WB38	16.00	41.87088	-88.17831	58.0	47.1	UST Barnes Rd, UST W. Chicago WWTP	C, F, M, S
WB34	15.10	41.85730	-88.19427	60.0	0.0	DST Gary's Mills Rd.	C, F, M, S
WB12	13.60	41.84301	-88.19867	80.5	91.1	UST Mack Rd at dog park, Warrenville	C, F, M, S
WB42 / WBBR	11.6	41.82475	-88.17830	90.0		Butterfield Road (former dam pool)	~~C,~~F,M,D
WB40 / WBWD	11.1	41.82027	-88.17212	91.0	91.3	DST Warrenville Grove dam	C, F, M, S, D
WB36B	8.6	41.78688	-88.18070	105	NA	Dst. McDowell Grove dam, ust Fawell Dam	M
WB36	8.3	41.78688	-88.18070	105	112.5	Adj Raymond Dr/Redfield Rd, ust Fawell dam	C, F
WB41	8.00	41.78329	-88.17648	105	60.0	DST Fawell Dam, UST Ogden Ave. Naperville	C, F, M, S
WB37	6.30	41.77050	-88.15664	110	98.8	Adj. Centennial Park/ Jackson Ave., Naperville	C, F, M, S
WB35	4.20	41.75396	-88.13423	115	118.2	Adj. Washington St. in Pioneer Park	C, F, M
WB08	0.85	41.78187	-88.17113	125	90.0	Knoch Knolls Park, Naperville	C, F, M, S
Unnamed Tributary (95-902)							
WB18	0.30	41.90387	-88.17410	3.0	3.4	Prairie Path trib, W. Chicago	C, F, M
Unnamed Tributary (95-904)							
WB22	0.15	41.98356	-88.16914	1.0	0.0	UST Coral Ave., Bartlett Village, Bartlett	F, M
Unnamed Tributary (95-905)							
WB23	0.15	41.96480	-88.14138	2.5	5.7	DST Schick Rd, Mallard Lake FP,	F, M

[5] DA – Drainage Area in square miles.

Site ID	Mile	Latitude	Longitude	DA[5]	Width (ft.)	Location	Samples
						Hanover	
Unnamed Tributary (95-906)							
WB29	2.20	41.98669	-88.17798	2.0	24.3	DST Devon Ave. adj. Leiseburg Park	C, F, M
WB30	1.90	41.98468	-88.17884	3.0	7.1	DST Amherst Drive/DST Bartlett WWTP	C, F, S
WB21	0.90	41.97220	-88.17770	4.2	0.0	DST Stearns Road	C, F, M
Kress Creek (95-910)							
WB02	5.10	41.89163	-88.24309	4.0	5.4	DST Prairie Path xing, adj. Kress Rd.	C, F, M
WB01	2.70	41.86271	-88.23458	14.5	19.9	UST Road A, Fermi Lab Compound	C, F, M, S
WB03	0.50	41.85701	-88.20567	19.0	29.8	UST intersection Joliet St./Wilson St. bridge	C, F, M, S
Ferry Creek (95-920)							
WB04	2.80	41.82527	-88.20142	3.0	22.7	DST SR 59 bridge adj. parking lot	C, F, M
WB06	0.70	41.80735	-88.18452	5.5	14.0	UST Ferry Rd bridge, Warrenville	C, F, M
West Branch Ferry Creek (95-925)							
WB05	0.25	41.79998	-88.18789	4.0	8.1	DST Raymond Ave, Naperville McDowell Grove FP	C, F, M
Cress Creek (95-930)							
WB07	0.20	41.78158	-88.17168	4.0	27.8	DST 5th Ave. bridge; South of Ogden Ave.	C, F, M
Bremme Creek (95-940)							
WB09	0.25	41.82457	-88.17131	1.0	6.3	DST Winfield Dr; ust bridge on W. Br. bike trail	F, M
Spring Brook (95-950)							
WB11	3.30	41.84597	-88.14260	4.0	20.7	UST Wheaton WWTP Sanitary discharge	C, F, M, S
WB26	3.00	41.84299	-88.14684	4.0	20.5	DST Mack Rd, WWTP at Allen Park, Wheaton	C, F, M, S
WB10	0.75	41.83518	-88.18279	7.0	27.3	Maintenance Bldg, Blackwell FP	C, F, M
Winfield Creek (95-960)							
WB15	5.40	41.88385	-88.10467	2.0	3.6	At St Mark's Catholic Church	C, F, M, S
WB14	3.50	41.86397	-88.12344	5.0	17.7	End of Liberty St., dst. Wheaton	C, F, M
WB13	0.40	41.86816	-88.15784	9.0	11.7	Ust. Winfield Rd. Creekside Park	C, F, M
Klein Creek (95-970)							
WB19	3.60	41.91849	-88.13046	5.0	19.3	UST Illini Drive, Armstrong Park, Carol Stream	C, F, M
WB16	1.00	41.89676	-88.15449	9.0	25.9	Klein Creek Farm, W. Chicago	C, F, M

Figure 2. Sampling locations (white dots with associated "LD" station numbers), WWTP discharges (outfall symbols), and significant mainstem dam impoundments (dam symbols) in the West Branch DuPage River watershed study area, June-Oct., 2012. Note: A low-head dam on Spring Brook, immediately upstream from WB10, is not shown.

for future identification in borax buffered 10% formalin and labeled by date, river or stream, and geographic identifier (e.g., river mile and site number). 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 including 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).

Habitat

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; Ohio EPA 2006b) and as recently modified by MBI for specific attributes. 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 assemblages closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments in the Midwestern U.S. have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support an assemblage consistent with baseline Clean Water Act goal expectations (e.g., the General Use in Illinois). QHEI scores greater than 75 often typify habitat conditions capable of supporting exceptional fish assemblages.

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 Fish Index of Biotic Integrity (fIBI) was calculated with the fish data using programming supplied by Illinois EPA. 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 utilizing the accompanying chemical/physical data and source information (e.g., point source loadings, land use). 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 (2008). The rationale for using the biological results in the role as the 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 biological 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; MBI 2010). Thus the assignment of principal 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 that 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.

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 based on environmental results. A tiered approach that links the results of administrative actions with true environmental measures was employed by our analyses. The integrated approach is outlined in Figure 3 and includes a hierarchical continuum that ranges 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 assemblage (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 measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers. Each 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 assemblage 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).

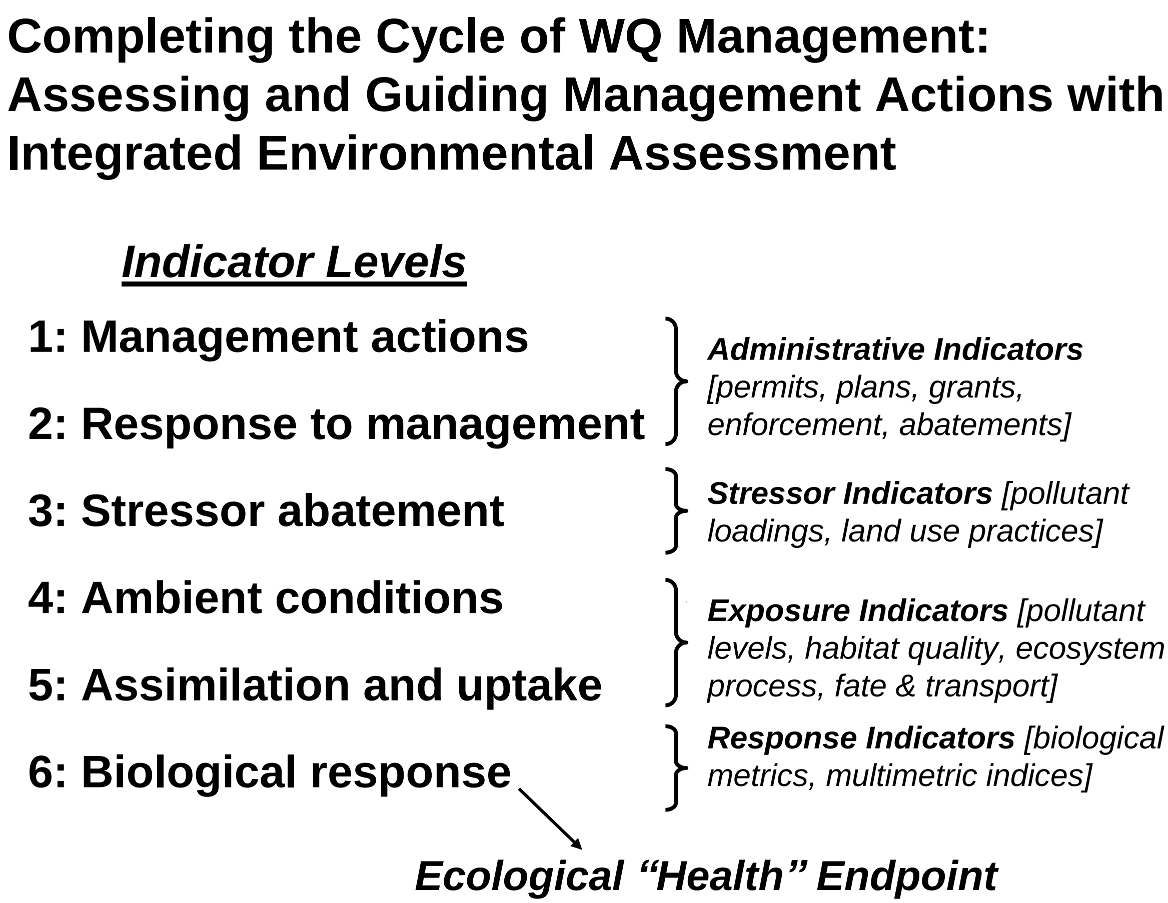


Figure 3. Hierarchy of administrative and environmental indicators that can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995) and further enhanced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

Determining Causal Associations

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves 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 within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Illinois Water Resource Inventory (305[b] report), the Illinois Nonpoint Source Assessment, and other technical products.

Illinois Water Quality Standards: Designated Aquatic Life Uses

The Illinois Water Quality Standards (WQS; IL Part 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 categories, aquatic 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 use. The system of use designations employed in the Illinois WQS constitutes a general approach in that one or two levels 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 assessments. In addition, an emphasis on protecting for aquatic life generally results in water quality suitable for all other uses.

Aquatic life use support for a water body in Illinois 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 the 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.

STUDY AREA DESCRIPTION

The 2012 study area included the West Branch DuPage River and its perennial tributaries (Figure 2). Sampling in 2012 largely duplicated past surveys in 2006 and 2009 and systematically covered the watershed down to an approximate 2-mi^2 drainage. Additional sites that bracket point sources or target specific segments of interest were also included (Table 3).

The West Branch DuPage River and its co-branch, the East Branch DuPage forms the DuPage River at Naperville in Knoch Knolls Park (Will County). The mainstem runs measures approximately 34 linear miles with a drop of 197 feet and drains 128 square miles of DuPage, Cook and northern Will Counties. Mean flow, measured at the USGS gage at Warrenville Road (station 05540095, Calculation Period is 1968-10-01 - 2014-09-30) was 123 cubic feet per second (cfs).

Twenty-one municipalities and seven publicly owned treatment plants are located in the watershed and discharge to the mainstem and two tributaries between RMs 31.2 and 15.3. There are no combined sewer overflows but the Bartlett WWTP overflow plant occasionally discharges to an unnamed tributary (95-906) in the upper headwaters. Like the adjacent East Branch, Salt Creek, and DuPage River catchments, land uses in the West Branch are dominated by residential and urban developments (Figure 4) which accounted for over 80% of the watershed (Table 4). In contrast, agriculture occupied only five percent of West Branch drainage.

West Branch DuPage River Dams

The updated status of former and remaining West Branch DuPage River dams that were initially described in the 2009 assessment report are described below.

Warrenville Grove Dam: The Warrenville Grove Dam was fully removed in September 2011 under a cooperative project administered by the DuPage County Department of Stormwater Management and the Forest Preserve District of DuPage County (FPDDC). It was located on the West Branch of the DuPage River within the Warrenville Grove Forest Preserve in the City of Warrenville. The dam was one third of a mile upstream from Warrenville Road and 0.4 miles downstream from Butterfield Road (IL Route 56). The site is owned by the Forest Preserve District of DuPage County (FPDDC) and the dam was approximately 75 years old. Access to the site 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 (see Plate 1). The dam was 107 feet across with a curving spillway face that has a total crest length of about 125 feet. Dam height was 8.5 feet above the downstream river channel bottom with a total hydraulic height of 5.7 feet (from spillway crest to tailwater elevation under average flow conditions). The site still maintains the original millrace that was partially retrofitted in 1995 to function as a fish ladder and canoe chute. The original dam impoundment was approximately 1.2 miles in length and covered 16.9 acres.

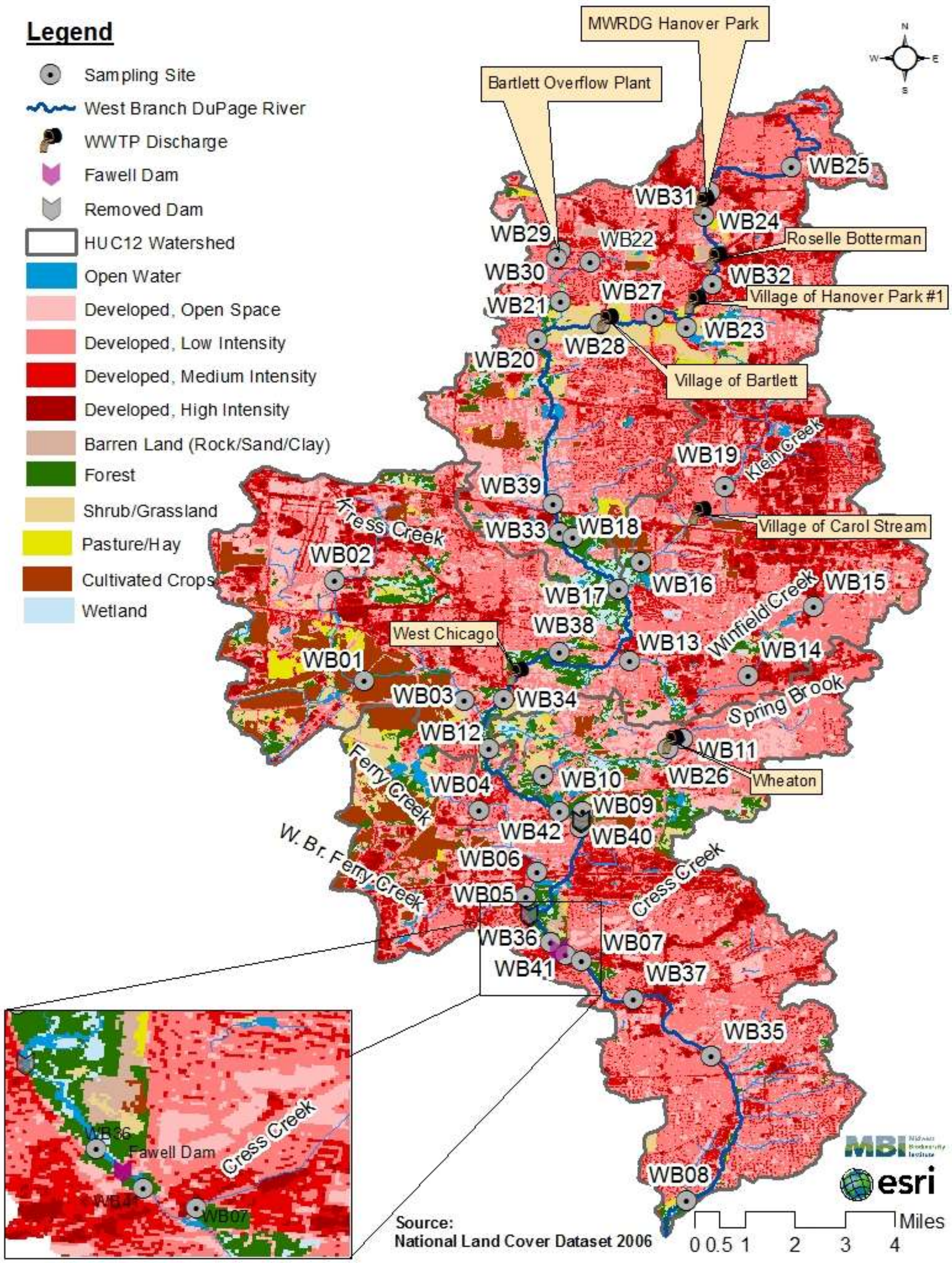


Figure 4. Land use types in the West Branch DuPage River watershed based on 2006 National Land Cover Dataset (NLCD). http://www.mrlc.gov/nlcd2006.php. Note: A low-head dam on Spring Brook, immediately upstream from WB10, is not shown.

Table 4. Land uses types by area and percent for the West Branch DuPage River watershed. Percentages are based on total watershed area. Land use data is based on Chicago Metropolitan Agency for Planning (CMAP) 2005 land use data.

Land Use Category	West Branch DuPage River Watershed	
	Area (acres)	Area (percent)
Developed, Open Space/Low Intensity	48,185	59.8
Developed, Medium/High Intensity	17,985	22.3
Agricultural Land	5,032	6.2
Forest	4,144	5.1
Grassland/Herbaceous	2,586	3.2
Wetland	1,359	1.6
Open Water	953	1.1
Barren Land (Rock/Sand/Clay)	0.001	1.1
Shrub/Scrub	193	0.2
Totals	**80,535**	**100**

The dam was designed by the National Park Service and constructed by the Civilian Conservation Corps between 1936 and 1938 as part of a dam building program conveyed as a means to “reduce bank erosion”. The dam site was chosen due to the presence of an older, abandoned milldam at the same location between 1847 and 1897.

***Plate 1**. The former Warrenville Grove Dam, looking upstream. The dam was removed in 2011.*

McDowell Grove Dam: The McDowell Grove Dam was removed in mid-2008 under a cooperative project administered by DuPage County Department of Stormwater Management and the FPDDC. 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 after its removal in 2008. The riffle and former structures remain in place.

Plate 3. Temporary cofferdam constructed upstream from the former McDowell Grove Dam in 2008. The cofferdam was removed in the fall of 2012, immediately after the 2012 survey.

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. During the 2012 survey, the majority of the impoundment still existed due to construction of a temporary steel sheet-piling cofferdam (see Plate 3) 0.8 miles upstream of the original dam. The cofferdam was needed until an ongoing thorium removal project was completed within the West Branch mainstem upstream. The temporary dam was removed entirely in September 2012. As shown in Plate 2, the foundation of the original dam was left in place to form a riffle feature.

Plate 4. Aerial view of the Fawell Dam.

Fawell Dam: The Fawell Dam is located on the West Branch of the DuPage River at river mile 8.1 (see Plate 4). It is a flood control structure operated by DuPage County Department of Stormwater Management. The dam consists of a set of three gate structures that can control flow through a three-barrel concrete box culvert to impound water, as necessary, upstream within the McDowell Grove Forest Preserve. The existing three-barrel concrete box culvert consists of an

11’-10” wide by 10’ high center barrel and 10’ by 10’ side barrels. The culvert barrels are 80’ long and the bottom slopes down at 5% from the upstream end to the downstream end. There are concrete wing walls on the upstream side of the culvert structure and a 50’ long concrete stilling basin structure on the downstream side (Plate 5). Atop the culvert, the grade slopes up from the ends to a 25’ wide path running perpendicular to the structure, which is approximately 10’ above the top elevation of the barrels. During low water events, when the structure is not operating, the upstream end of the culvert features a concrete sill set above the natural bed elevation of the river. The earth embankment is approximately 1000 feet in length.

Plate 5. Upstream view of the Fawell Dam.

Arrow Road /Spring Brook Marsh #1 Dam: The dam is located at river mile 0.85 on Spring Brook # 1 in the Blackwell Forest Preserve and has been in place since 1983 (Plate 6). The structure consists of a 4.5’ weir (approximately 35‘in width), which spills into a reinforced concrete pipe that passes under Arrow Road. When the weir is fully closed, the impoundment is approximately 15 acres, the majority of which is less than 1 foot deep. The dam site and impoundment are wholly owned by the DuPage County Forest Preserve District.

Plate 6. Arrow Road Dam on Spring Brook looking upstream.

Point Source Discharges

Seven major (>1 MGD design flow) permitted point sources were identified within the West Branch DuPage River watershed. The design flows and locations of each discharger are listed in Table 5 while measured effluent flows and estimated annual loadings of CBOD5, TSS and NH_3N are illustrated in Figure 5. Unfortunately, total nitrogen and phosphorus data were not available for all of the treatment plants we examined. The Hanover Park MWRDGC is the largest contributor to flow and CBOD5 load and is located in the upper part of the watershed (Figure 5). Although the Bartlett WWTP had relatively less effluent, it contributes a higher proportion of TSS and Total Ammonia loading than any other individual facility.

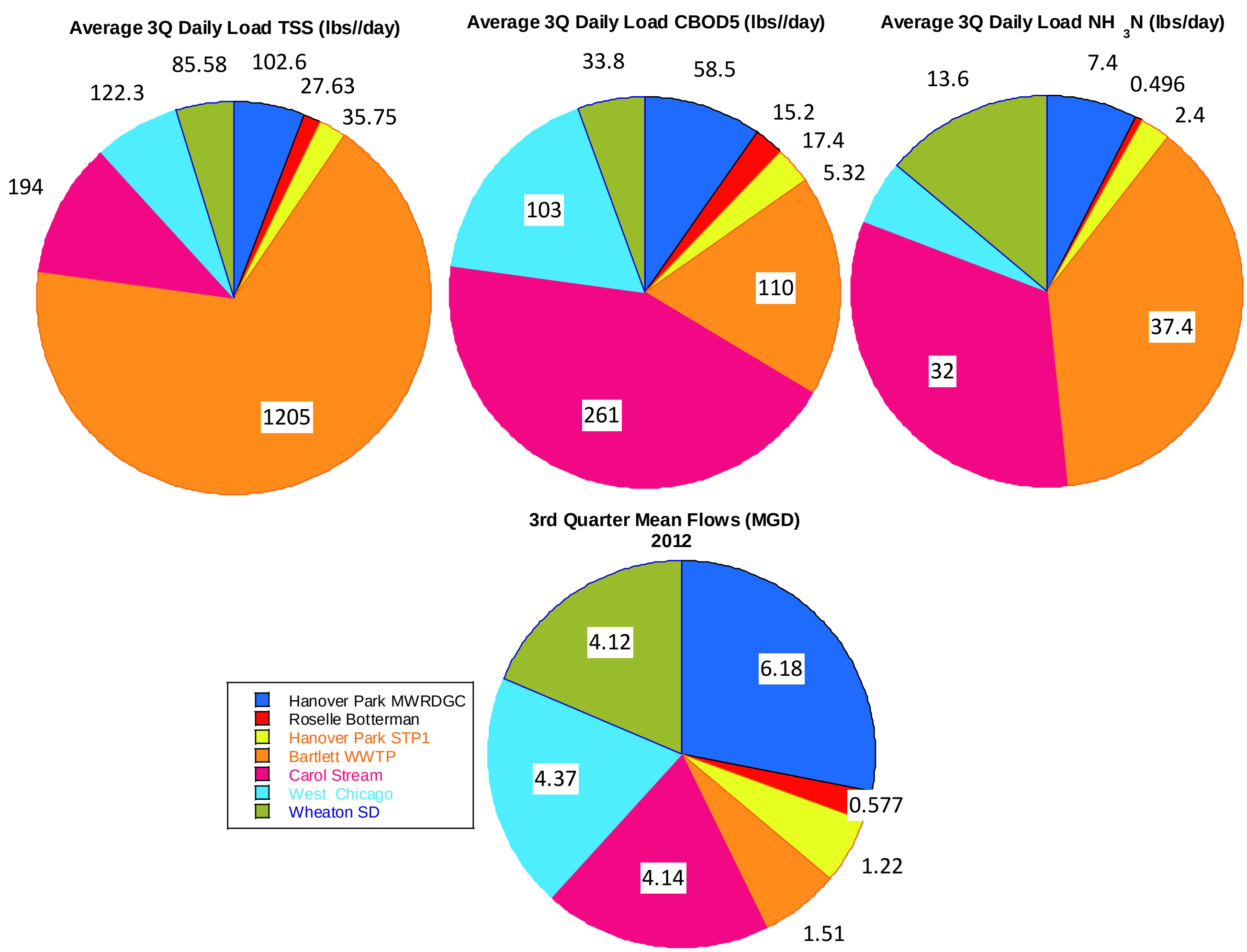


Figure 5. Pie chart of 2012 third quarter daily loadings (lbs./day) of TSS, CBOD5, and NH_3N (top) from significant WWTPs in the West Branch DuPage River watershed and mean average effluent flow in MGD (bottom) during this period.

Point source discharges in the West Branch of the DuPage River make flow in this river effluent dominated. For example, during a low flow period in the first week of August 2009 and the second week of July 2012, effluent from the seven major dischargers in Figure 5 composed approximately 89 percent of West Branch flow in 2009 and 87% in 2012 or, 89-92% of the long-term 25th percentile flows at the Warrenville USGS gage. While effluents dominated base flows during both sampling years, extended periods of low-base flow were much more prevalent in 2012 than in 2009 (see Figure 7).

Table 5. Municipal wastewater treatment plants located in the West Branch DuPage River watershed. ADF = average design flow in million gallons per day (MGD); MDF = maximum design flow (MGD).

NPDES	Name	ADF (MGD)	MDF (MGD)	Receiving Stream	Latitude	Longitude
IL0036137	MWRDGC Hanover Park STP	12	22	West Branch	42.0008	-88.1361
IL0048721	Roselle-J. Botterman WWTF	1.22	4.6	West Branch	41.9822	-88.1139
IL0034479	Hanover Park STP #1	2.42	8.68	West Branch	41.9722	-88.1386
IL0027618	Bartlett WWTP	3.68	13.0	West Branch	41.546944	-88.183333
IL0023469	West Chicago STP	7.64	20.3	West Branch	41.551667	-88.141667
IL0031739	Wheaton S.D.	8.9	19.1	Spring Brook	41.8447	-88.1450
IL0026352	Carol Stream WRC	6.5	13.0	Klein Creek	41.9094	-88.1353

It is clear from other assessments of effluent loading that total phosphorus and nitrogen loading are point source dominated (The Conservation Foundation 2011). Unlike nonpoint sources, that typically discharge during high flow events, point source loading persists at all flows and can have significant influences on aquatic life, particularly during periods of low flow.

Pollutant Loadings by Publicly Owned Treatment Works (West Branch 2009-2012)
Effluent flows from the seven major WWTPs in the West Branch watershed were similar to those in 2009 (Figure 6) but detailed characterization of their effluent were not conducted for the 2012 data. While it is likely there have not been significant changes in effluent quality, a more detailed analysis would be required to tease apart minor changes and trends in effluent conditions. Higher in-stream concentrations of some chemical parameters between 2009 and 2012 are mostly likely related to lower flows during most of the summer of 2012 vs. 2009. With the lower dilution from background, natural flows, changes in concentrations can be attributable to the changes in dilution.

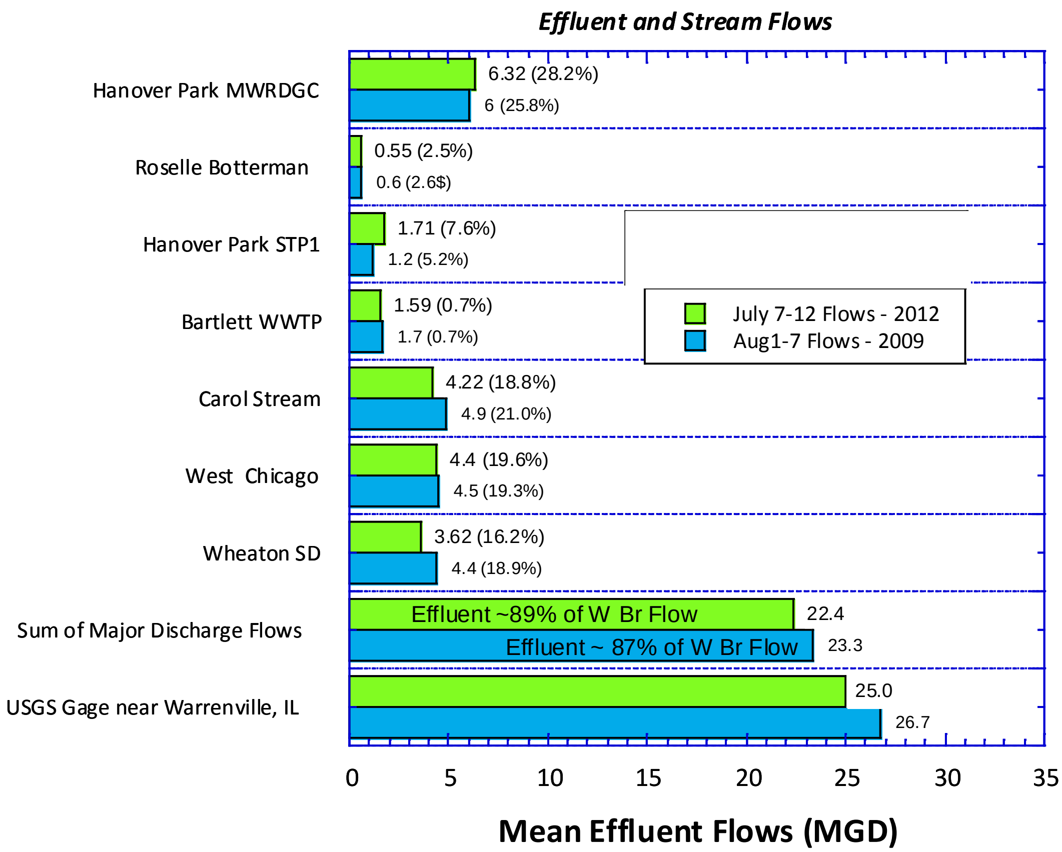
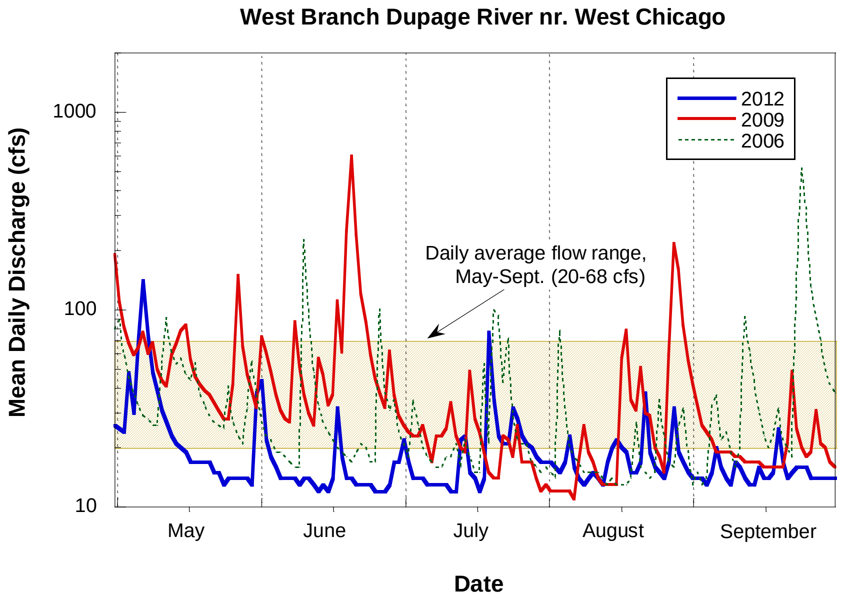


Figure 6. Effluent flows (MGD) for WWTPs in the West Branch of the DuPage River watershed calculated as a percentage of stream flow during two weeks of extended base-flows during the summers of 2012 and 2009. Also shown are the total effluent flows and percentage for these plant and West Branch DuPage River flows at the Warrenville USGS gage for a similar period (see text).

West Branch DuPage River flow Conditions

Measured at the USGS West Branch DuPage River gage near West Chicago, below average summer-fall base flow conditions dominated the West Branch DuPage River in 2012 (Figure 7). Three quarters of daily flow measurements averaged below normal for the period (Figure 7 - bottom). In contrast, the majorities of flows during the 2009 survey were within or exceeded normal daily averages, particularly in May and June. Summer flow trends in 2006 generally fell between those recorded in 2009 and 2012.



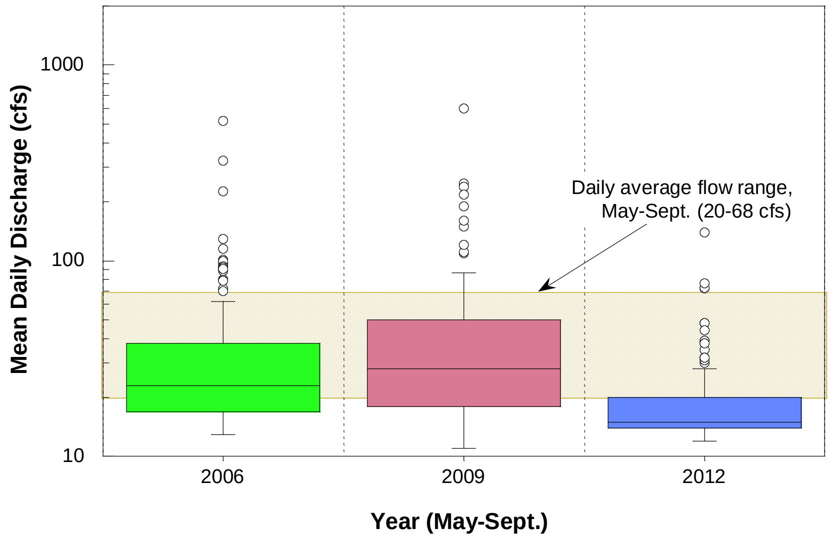


Figure 7. Flow hydrograph (top) and box and whisker plot (bottom) for the West Branch DuPage River near West Chicago (USGS station #05539900) from May through September, in 2006, 2009, and 2012. Shaded area depicts the range of daily average flows (52 years of records) during the May-Sept. period.

RESULTS

West Branch DuPage River Watershed - Chemical Water Quality

The 2012 sampling results generally match the 2009 bioassesment report conclusion that water quality in the West Branch DuPage mainstem is heavily influenced by treated wastewater while West Branch tributaries tend to reflect the pervasive urban land use. The influence of effluent on the mainstem (and two tributaries) remains most apparent in the highly elevated concentrations of total phosphorus (TP) and nitrate-nitrite nitrogen (NOx) found downstream (Figure 8, Figure 14). Conversely, ammonia concentrations below point sources have declined since 2006, most likely due to more efficient wastewater treatment and increased nitrification of point source effluents (Figure 10 –top). Chloride levels continue to increase throughout the basin, but WQS exceedances were limited to three tributary sites, one of which (Winfield Creek RM 0.4) was located downstream from a road salt storage facility. The majority of the elevated concentrations of total phosphorus (TP), nitrate-nitrite nitrogen (NOx), and chlorides in 2012 are likely a product of flow conditions.

Exceedances of chemical water quality criteria in chemical grab samples are listed in Table 7 while D.O. violations measured at three mainstem continuous monitors[6] are listed in Table 8. Overall, mainstem D.O. levels were an increasing issue of concern in 2012 as elevated nutrient levels under low-flow conditions contributed to WQS violations.

West Branch DuPage River

As noted in the point source discharge section (Figure 6), stream flow in the West Branch DuPage River is effluent dominated during summer months. As such, its water quality is highly influenced by the concentrations and composition of chemical constituents in the effluent as well as runoff from the urban and developed land cover in the watershed. Water quality sampling in 2012 during the summer low-flow periods suggest that the quality of treated effluent, with respect to regulated parameters (i.e., cBOD5, TSS, NH3), was generally good. Effluents did not result directly in exceedances of water quality standards for these parameters. However, increasingly elevated nutrient levels and their attendant influence on mainstem D.O. regimes remain problematic.

The 2012 survey results continue to show highly elevated nutrient levels downstream from point source discharges. These concentrations were typically an order of magnitude higher than background levels in tributaries and upstream controls. Since 2006, WWTP influenced phosphorus concentrations have remained highly elevated and have gradually increased during each sampling year (Figure 8-top). Following a sharp increase in 2006 compared to 2009, 2012 nitrates reflect a similar trend to phosphorus with highly elevated concentrations and slight but consistent increases since 2009 (Figure 8-bottom). Nitrate increases coincide with reductions in ammonia levels since 2006 (Figure 10-top) and are likely related to increased nitrification and

[6] Datasonde continuous monitors were located at three West Branch sites at Arlington Drive (WBAD RM 29.0) between the Roselle Botterman and Hanover Park WWTPs, Butterfield Road (RM 11.6) in the former Warrenville Grove dam pool, and downstream from the pool at RM 11.1 (WBWD).

more efficient treatment from point sources. Additional increases in both nitrate and phosphorus during the most recent survey likely reflect low flow conditions and corresponding effluent domination during the 2012 summer sampling period.

As mentioned above, a declining trend in mainstem ammonia since 2006 was attributed to more efficient wastewater treatment as 2012 median NH_3 concentrations fell at or near detection limits outside of the headwaters (Figure 9-top). In contrast, a plot of mean concentrations suggests occasionally elevated levels, particularly downstream from the West Chicago WWTP (Figure 9-bottom). In the extreme upper mainstem, a highly elevated concentration of both ammonia (WB25) and nutrients (WB31) deserves further investigation. Both sites were upstream from all known point source discharges.

TKN is a measure of organic nitrogen and ammonia in a waterbody and typically provides a strong signal of organic enrichment. There are no criteria for TKN in Illinois, but elevated levels of TKN above background levels can be used to infer significant enrichment. A TKN background level based on aggregated ecoregions (Nutrient Ecoregion VI) for the Corn Belt is estimated at 0.65 mg/l. Values in the East and West Branch exceed this concentrations although most sites on the DuPage River mainstem are near this ecoregion level of 0.65 mg/l (Figure 10). Between 2009 and 2012, most mainstem TKN concentrations fell from above target, to below target levels (Figure 10). The 2010 assessment report largely attributed the elevated levels to sampling under higher flows, which presumably carried more humic compounds from groundwater. Collection flows and TKN levels were subsequently lower during the 2012 survey.

Mainstem BOD trends were similar between sampling years but concentrations trended lower in 2012 below point sources. Two exceptions were at WB34 (mean = 3.2 mg/l), below the West Chicago WWTP, and WB19 (6.4 mg/l), immediately upstream from Klein Creek and the Carol Stream WWTP. While the increase at WB19 deserves investigation, the high value may reflect small sample size (1x) whereas the other concentrations were based on four sample passes.

Mainstem dissolved oxygen violations were common in 2012. Unlike 2009 results, when concentrations below the 7 day rolling average were limited to a few short duration events, violations in 2012 were more severe and widespread (Table 8, Figure 13). Violations of “Not to exceed” standards were measured at each site while exceedances of the 7-day minimum, and 7-day rolling average were measured at Arlington Drive and Butternut Road. Only the Rolling 30-day average criterion remained consistently above standards.

Despite limited exceedances of D.O. standards in the 2009 survey, concerns over wide diurnal swings in both D.O. and pH levels were raised in the report. The swings were considered both symptomatic of nutrient enrichment and a source of stress to aquatic life [Heiskary and Markus (2003) and Miltner (2010)]. Given the more severe flow conditions and greater incidence of D.O violations during 2012, it seems unlikely that these stresses to aquatic life were abated between surveys.

Throughout the West Branch mainstem, chloride concentrations suggest a pattern of slight but consistent increase first observed between the 2006 and 2009 surveys (Figure 12). In 2012, the increase was most pronounced in the extreme upper mainstem, upstream from all known point sources, but concentrations remained elevated from the headwaters to the mouth. Since 2009, median mainstem chloride concentrations consistently exceed both mIBI and fIBI DRSCW threshold levels associated with biological impairment, while with a few exceptions, being below the state water quality criterion. Loading analysis between 2009 and 2012 suggest that the 2012 increase was due wholly to decreased ambient flow as opposed to increased inputs of chloride.

Following the 2012 survey, the Conservation Foundation conducted effluent and stream sampling for chlorides at West Branch DuPage watershed sites bracketing the major WWTPs (Table 6). Most receiving stream concentrations were, on average, equivalent or only slightly higher below the treatment plants. However, in-stream concentrations exceeded DRSCW thresholds for fish and macroinvertebrates at nearly all sites, regardless of location. Sampling indicates summer low-flow chloride levels, while elevated, are maintained or experience only slight increase below the major WWTPs. Sites bracketing the Wheaton and Carol Stream plants, located in the upper reaches of small tributaries, experienced the greatest variability, both positive and negative.

Table 6. Chloride concentrations in effluent and stream samples collected upstream and downstream from the major wastewater treatment plants in the West Branch DuPage River watershed (2013).

	Concentration (mg/l)		
Wastewater Treatment Plant	**Upstream**	**Effluent**	**Downstream**
MWRD Hanover Park	203	114	120
V Hanover Park	139	144	140
Roselle	132	84	132
Bartlett	149	248	187
Carol Stream	224	112	154
West Chicago	125	225	137
Wheaton Sanitary District	71	142	134
Average	**140**	**159**	**147**

Seven heavy metals violations were sporadically detected at four mainstem and tributary locations, representing a substantial increase over the 2009 survey when no metals violations were recorded. High copper levels were encountered most often with five violations recorded at the four sites. When metals concentrations are evaluated against Reference Target Levels (see Table 10), elevated levels appear much more widespread, particularly in (but not restricted to) the effluent dominated reaches of the West Branch mainstem. Given the low-flow characteristics of the 2012 survey and effluent dominated nature of the sample sites, municipal point sources were likely contributors. However, the Ohio EPA targets used in Table 9 are associated with good to excellent quality (reference) streams that are generally located outside significant urban and point source influences. For this reason, and given the extensively urbanized landscape in the West Branch watershed, the background metals levels are considered more typical than alarming. Still, exceedances of WQS in 2012 indicate these metals sometimes reach levels that are potentially harmful to aquatic life and exceed Illinois water quality criteria at a few sites (Table 7).

West Branch DuPage River Tributaries

Like the West Branch mainstem, phosphorus consistently exceeded target levels in almost all West Branch tributaries but was markedly higher downstream from the Wheaton and Carol Stream WWTPs, located on Klein Creek and Spring Brook, respectively (Figure 14). Compared to other, mostly urban West Branch tributaries, the point-source influenced concentrations were about an order of magnitude higher and exceeded both the recommended 1.0 mg/l effluent limit and the 0.6 mg/l Illinois EPA non-standard based criterion. Intermittent discharges from the Bartlett WWTP Overflow plant on tributary 95-906 had no discernible effect on downstream water quality.

Nitrate concentrations were also highly elevated downstream from the Wheaton and Carol Stream WWTP but fell almost entirely below ecoregional target levels at the remaining, non-WWTP influenced tributary sites (Figure 14). Breeme Creek (WB09) was not sampled chemically in 2012 due to stream desiccation but was unique among non-WWTP influenced tributaries in 2009 and 2006 as elevated nitrate levels fell about midway between the WWTP influenced sites and other urban drainages. The Breeme Creek watershed is very small (1 square mile) and drains a large tract of cultivated farm fields. Fertilizer runoff associated with agriculture is considered a likely nitrate source. In 2012, elevated nitrates in a non-WWTP influenced tributary were limited to one sample from Spring Brook, immediately upstream from the Wheaton WWTP (WB11).

At tributaries and upstream control sites, concentrations of NH3-N and TKN were generally higher than at sites sampled downstream from treatment facilities reflecting diffuse organic enrichment from the urban landscape (Figure 14). BOD concentrations, another indicator of enrichment and oxygen demanding substances, were mostly below target levels in 2012 with the exception of eight sites (WB 04, 07, 11, 15, 19, 22, 29, and 30) from seven tributaries (Figure 16). These outlier sites were almost entirely restricted to small headwater drainages (avg. 3.1 sq. mi.) that were densely urbanized or drained nearby impoundments and stormwater retention basins. Discharges of suspended organic material and algae from the impoundments likely contributed to the enriched conditions.

Relative to 2006 and 2009 chloride concentrations increased throughout the West Branch basin, but the differences were most pronounced in tributaries (Figure 15-bottom right), particularly at headwater sites draining less than five square miles (Table 10). Actual WQS violations were limited to a Winfield Creek site (WB13) located 0.6 miles downstream from a DuPage County road salt storage facility (Plate 7), and two sites bracketing the Bartlett overflow plant (WB29 and WB30). Chloride levels downstream from the DuPage County road salt storage

Plate 7. Google Earth image of the DuPage County salt storage facility on Winfield Creek suspected of contributing to chloride violations 0.6 miles downstream in 2009 and 2012. An apparent stormwater outlet to Winfield Creek is noted immediately west (to the left) of the facility.

facility were sharply higher in 2009 and 2012 relative to 2006 (Figure 15 –bottom right and bottom left). Additional and more intensive sampling is suggested for this stretch of Winfield Creek.

Like 2009 tributary sampling results, WQS exceedances for D.O. were most commonly encountered in 2012 tributaries but the number increased from five to seven (Table 7). In addition, scattered or additional exceedances for ammonia, copper, chloride and pH were detected in 2012 that were not recorded in the previous survey. Low pH levels may be related to severe diurnal D.O. fluctuations that tend to result in lowest (most acidic) pH levels in the late evening and early morning hours. A D.O. violation was associated with at least one of the pH violations. The overall increase in 2012 exceedances suggest more severe conditions in the small drainages, most likely related to more severe low-flow stresses. As evidence, several tributary sites were not sampled chemically in 2012 because of stream desiccation.

Table 7. Chemical parameter concentrations (mg/l) in violation[a] of Illinois water quality standards in chemical grab samples from the West Branch DuPage River watershed, 2012. Exceedances detected in 2009 are also listed in red font.

Site ID	Basin	Stream	River Mile	Exceedance or Parameter of Interest	
				2012	**2009**
West Branch DuPage River					
WB25	95	900	34.0	T. Ammonia (3.24)	
WB31	95	900	31.9	D.O. (2.57)	
WB24	95	900	31.6		
WB32	95	900	30.1		
WBAD	95	900	29.0	¥ D.sonde D.O. violations (Table 8)	(Table 8)
WB27	95	900	28.7		
WB28	95	900	27.4		
WB20	95	900	25.6		
WB39	95	900	21.7		
WB33	95	900	21.3		
WB17	95	900	19.2	Cu (72.40)	
WB38	95	900	16.0		
WB34	95	900	15.1		
WB12	95	900	13.6	Cd (43.70); Cu (44.70); Pb (41.60)	Not sampled
WB42	95	900	11.6	D.O. (3.80)	Not sampled
WBBR	95	900	11.6	¥ D.sonde D.O. violations (Table 8)	(Table 8)
WB40	95	900	11.1	D.O. (4.60)	
WBWD	95	900	11.1	¥ D.sonde D.O. violations (Table 8)	
WB36	95	900	8.6	D.O. (3.80)	
WB41	95	900	8		
WB37	95	900	6.3		
WB35	95	900	4.2		
WB08	95	900	0.85		
Trib to West Branch DuPage River					
WB18	95	902	0.5		
Trib to West Branch DuPage River					
WB22	95	904	0.15	D.O. (3.80)	
Trib to West Branch DuPage River					
WB23	95	905	0.15	Not sampled	
Trib to West Branch DuPage River					
WB29	95	906	2.2	Chloride (533)	
WB30	95	906	1.9	pH (6.30), Chloride (503)	
WB21	95	906	0.9	D.O. (4.80)	D.O. (<5.0)
Kress Creek					
WB02	95	910	5.1	T. Ammonia (1.610), (1.370)	D.O. (<5.0)
WB01	95	910	2.7		
WB03	95	910	0.5	D.O. (4.20)	
Ferry Creek					
WB04	95	920	2.8	D.O. (3.30)	

Site ID	Basin	Stream	River Mile	Exceedance or Parameter of Interest	
				2012	2009
WB06	95	920	0.7		
W. Br. Ferry Creek					
WB05	95	925	0.25	D.O. (3.70)	D.O. (<5.0)
Cress Creek					
WB07	95	930	0.2	Not sampled	
Bremme Creek					
WB09	95	940	0.25	Not sampled	
Spring Brook					
WB11	95	950	3.3	D.O. (3.40); pH (6.40), Cu (13.30)	
WB26	95	950	3.0		
WB10	95	950	0.75		
Winfield Creek					
WB15	95	960	5.4		
WB14	95	960	3.5	D.O. (4.10)	D.O. (<5.0)
WB13	95	960	0.4	Chloride (904)	D.O. (<5.0) Chloride (603)
Klein Creek					
WB19	95	970	3.6		
WB16	95	970	1.0	Cu (38.80), (98.60)	

[a] Dissolved oxygen concentrations below the 5 mg/l water quality standard are listed in the table but do not qualify as actual violations because of inadequate sampling frequency.

Table 8. Dissolved oxygen concentrations (mg/l) in violation of Illinois water quality standards from the West Branch DuPage River at Arlington Drive (WBAD), Butternut Road (WBBR) and downstream from the former Warrenville Grove Dam (WBWD), in 2008, 2009, and 2012.

Site ID	River	Year	Date(s)	Parameter	Criteria	Standard
WBAD (RM 29.0)	W. Branch DuPage R.	2009	June – 27-27	D.O.	<6.0 mg/l	7-day Average
		2012	June 28-July 1	D.O.	<6.0 mg/l	7-day Average
			July 27-31	D.O.	<6.0 mg/l	7-day Average
			Sept. 27-31	D.O.	<6.0 mg/l	7-day Average
			Aug 5-10	D.O.	<4.0 mg/l	7-day Minimum
			Sept. 3-7	D.O.	<4.0 mg/l	7-day Minimum
			Sept. 17-19	D.O.	<4.0 mg/l	7-day Minimum
			July 20	D.O.	<5.0 mg/l	Not to exceed
			July 25-27	D.O.	<5.0 mg/l	Not to exceed
			Sept. 2-3	D.O.	<3.5 mg/l	Not to exceed
			Sept. 15-17	D.O	<3.5 mg/l	Not to exceed
WBBR (RM 11.6)	W. Branch DuPage R.	2008	July – 22-23	D.O.	<6.0 mg/l	7-day Average
		2012	June 20-27	D.O.	<6.0 mg/l	7-day Average
			June 29 – July 9	D.O.	<6.0 mg/l	7-day Average
			July 17-28	D.O.	<6.0 mg/l	7-day Average
			Aug. 21- Sept. 7	D.O.	<5.0 mg/l	7-day Minimum
			June 20- July 31	D.O.	<5.0 mg/l	Not to exceed
			Aug. 05	D.O.	<4.0 mg/l	Not to exceed
			Aug. 11-12	D.O.	<4.0 mg/l	Not to exceed
			Aug. 21-23	D.O.	<4.0 mg/l	Not to exceed
WBWD (RM 11.1)	W. Branch DuPage R.	2009	--	D.O.	--	--
		2012	July 18 - 29	D.O.	<5.0	Not to exceed
			July 31	D.O.	<5.0	Not to exceed
			Aug. 5-9	D.O.	<4.0 mg/l	Not to exceed

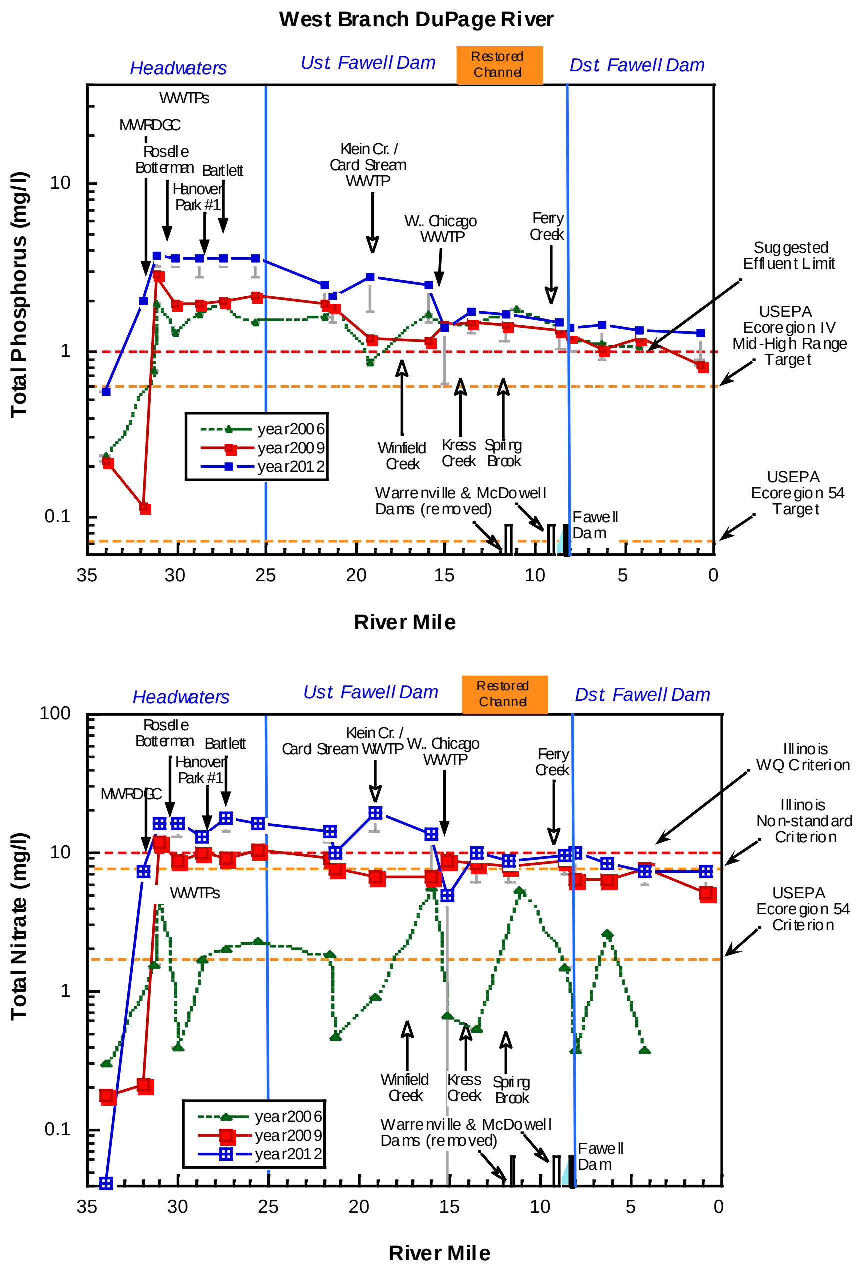
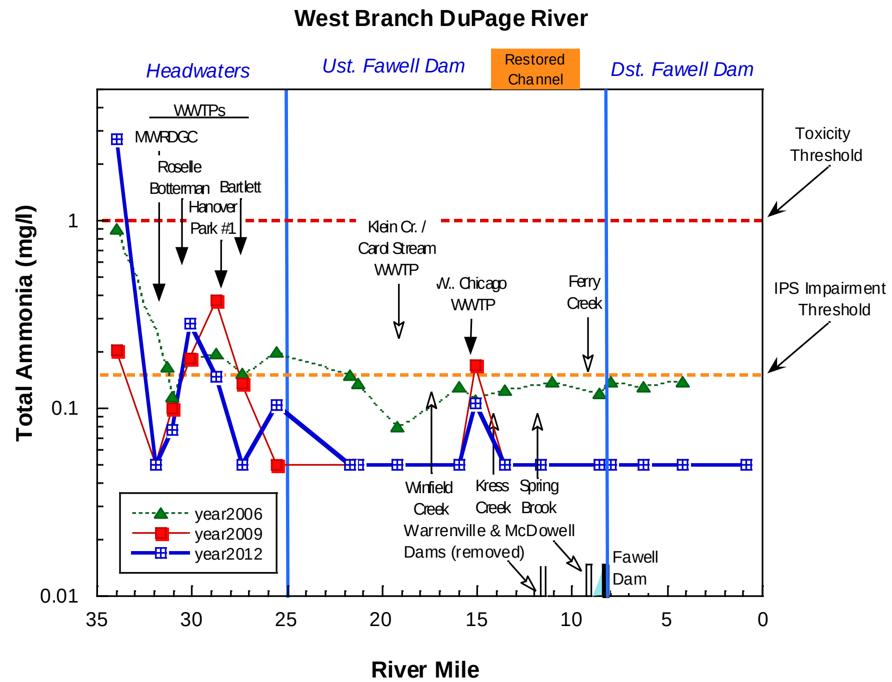


Figure 8. Median concentrations of total phosphorus (top) and nitrate (bottom) in the West Branch DuPage River in 2012, 2009 and 2006. Locations of municipal WWTP discharges and major tributaries are noted by arrows. Bars along the x-axis show locations of existing and removed dams. For phosphorus, orange dashed lines represent target total phosphorus concentrations for USEPA Ecoregion 54 (0.072 mg/l) and the middle to high range of US EPA nutrient Ecoregion VI (0.61 mg/l). The red dashed line (1.0 mg/l) represents a threshold concentration beyond which toxicity is likely. For nitrate, orange dashed lines represent target concentrations for USEPA Ecoregion 54 (1.798 mg/l) and the Illinois EPA non-standard based criteria (7.8 mg/l). The red dashed line is the water quality criterion (10 mg/l).



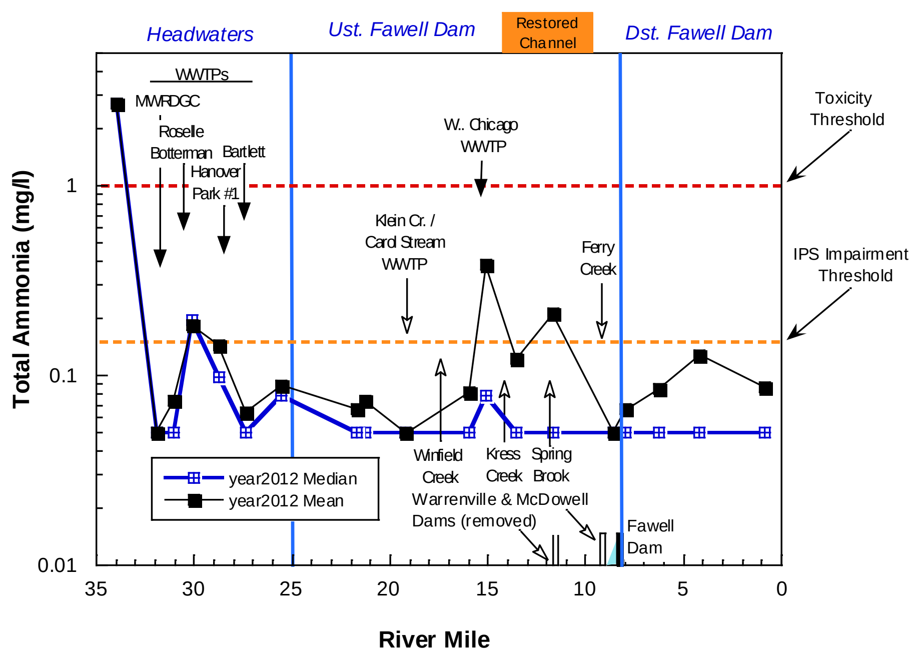


Figure 9. Median concentrations of ammonia nitrogen in the West Branch DuPage River in 2012, 2009 and 2006. (top) and a comparison of median vs. mean ammonia concentrations in 2012 (bottom) The upper dashed red line in the ammonia graph represents a threshold concentration beyond which toxicity is likely while the lower dashed orange line (0.15 mg/l) correlated with impaired biota in the IPS study.

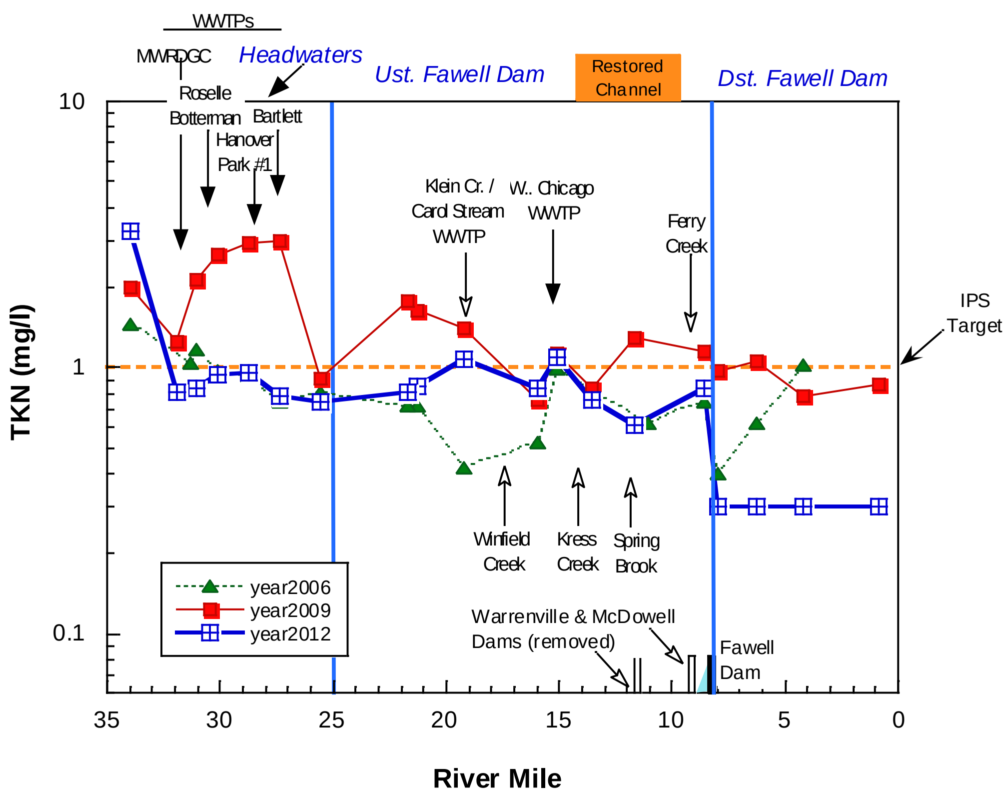


Figure 10. Median concentrations of total Kjeldahl nitrogen (TKN) in the West Branch DuPage River in 2012, 2009 and 2006. The dashed orange line represents the IPS TKN aquatic life target level.

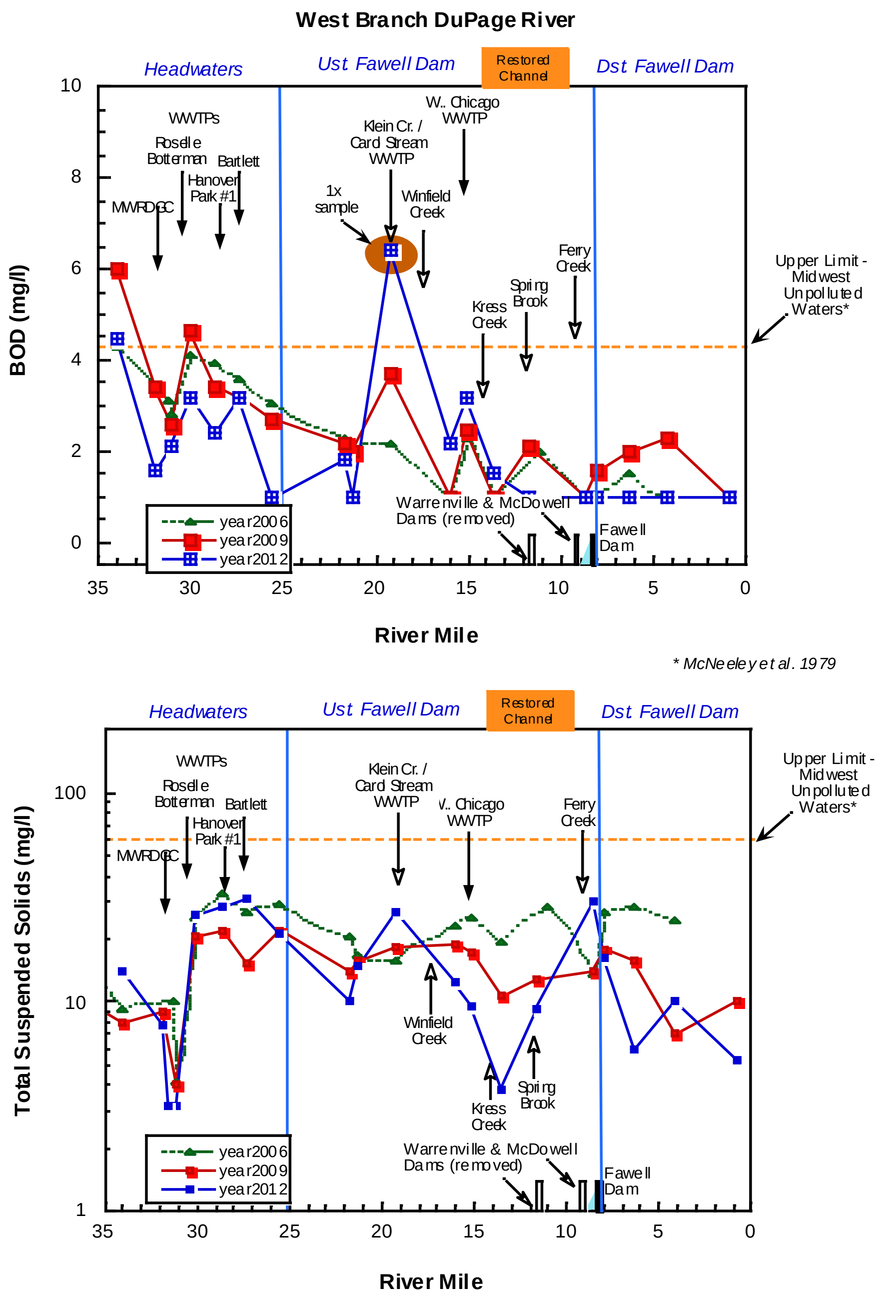


Figure 11. Median concentration of 5-day biological oxygen demand (BOD-top) and total suspended solids (TSS–bottom) in the West Branch DuPage River in 2012, 2009 and 2006. The dashed line in the BOD plot (4 mg/l) represents the upper limit of concentrations typical of unpolluted waters in the Midwest (McNeeley et al. 1979). The dashed line in the TSS plot represents the upper limit of concentrations typical of unpolluted waters in the Midwest.

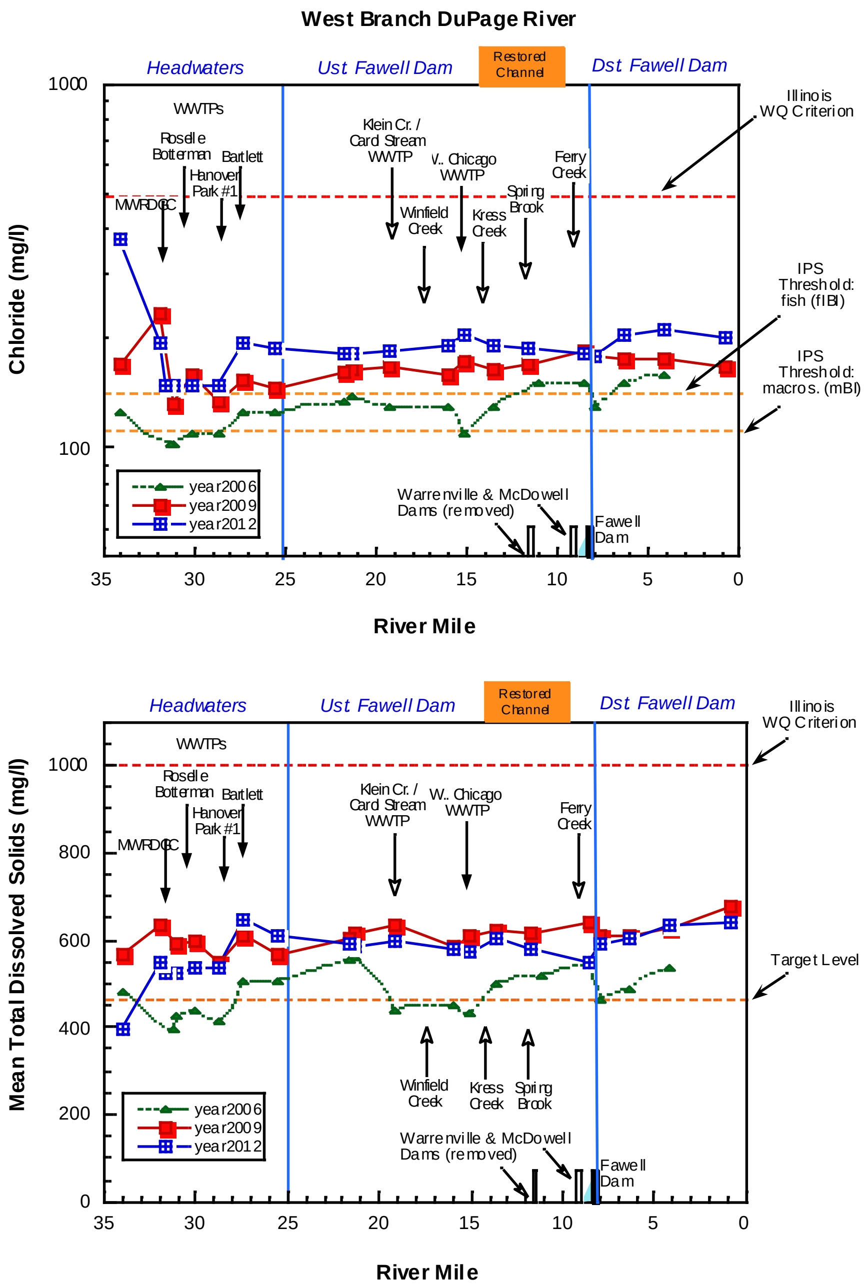


Figure 12. Median concentrations of total chloride (top) and total dissolved solids (TDS-bottom) in the West Branch DuPage River in 2012, 2009 and 2006. For chloride, the upper, red dashed line represents the existing Illinois water quality criteria (500 mg/l); the lower orange dashed lines show IPS quantile regression thresholds for the fIBI (141 mg/l) and mIBI (112 mg/l). For TDS, the orange dashed line represent the 75th percentile TDS level for small rivers in Ohio and the red dashed line is the existing Illinois water quality criterion (1000 mg/l).

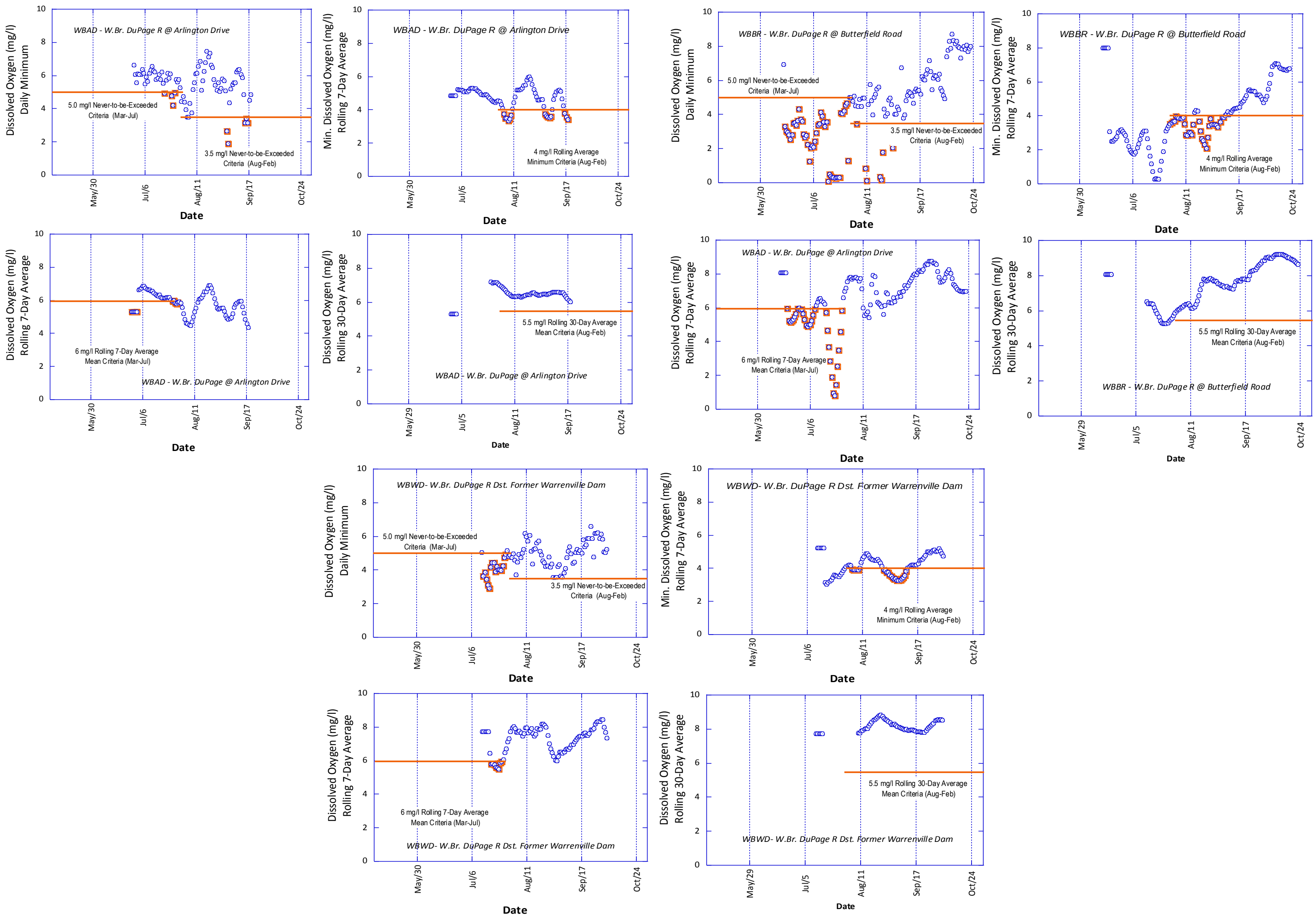


Figure 13. Continuous monitor D.O. concentrations from three West Branch DuPage River stations and presented in blocks of four plots per site. Stations were located at Arlington Dr. (upper left), Buttermilk Rd. (upper right), and McDowell Grove (bottom). Plots include daily minimum, rolling 7-day average, minimum 7-day average, and rolling 30-day average concentrations, July-August, 2012. Red lines in the graphs indicate applicable WQ criteria and red circles indicate WQS violations.

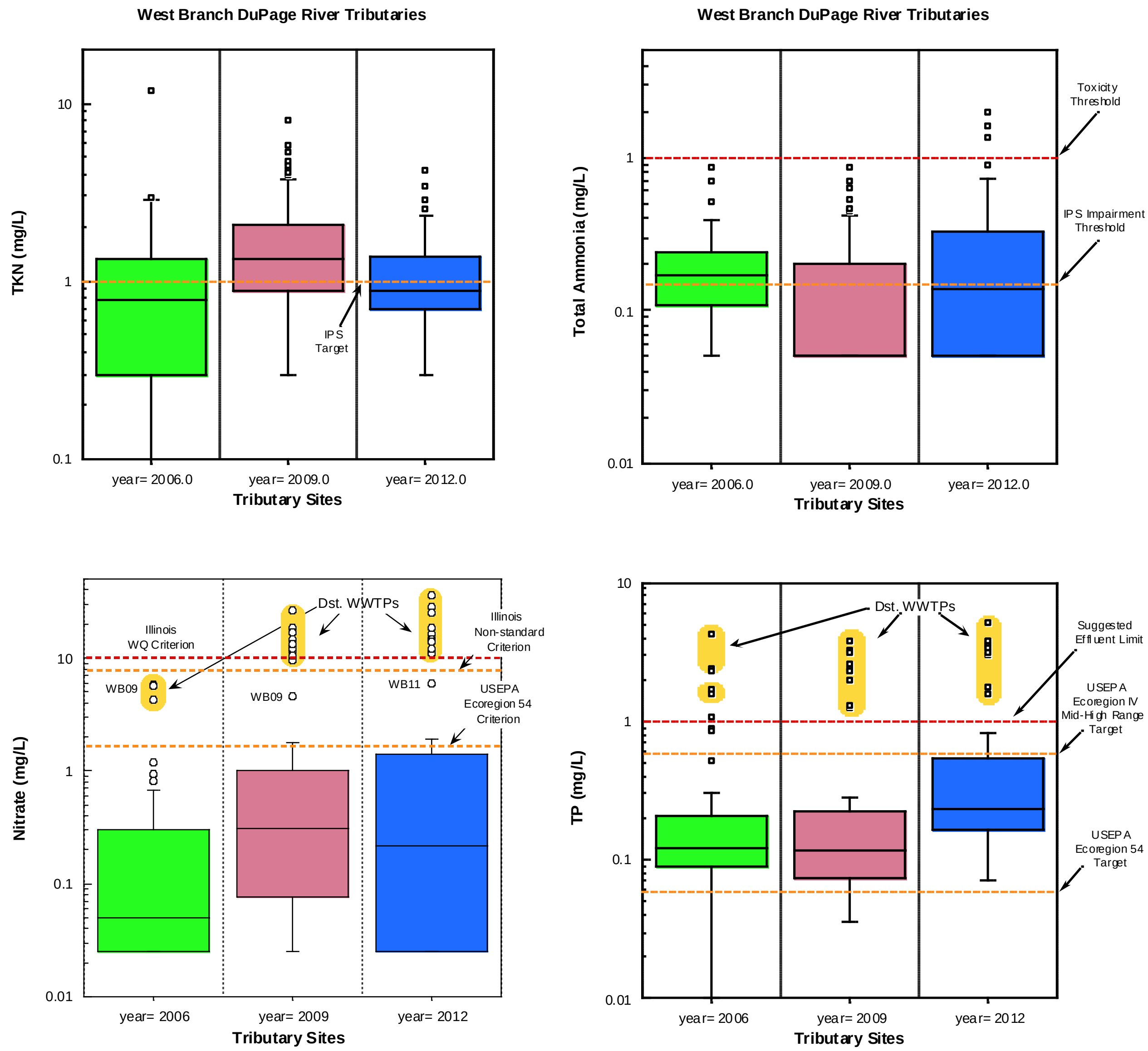


Figure 14. Box and whisker plots of TKN, ammonia, nitrate, and phosphorus concentrations from West Branch DuPage River tributary sites in 2006, 2009 and 2012. Yellow shaded outliers in the nitrate and phosphorus plots are samples collected downstream from the Wheaton and Carol Stream WWTPs on Klein Creek and Spring Brook.

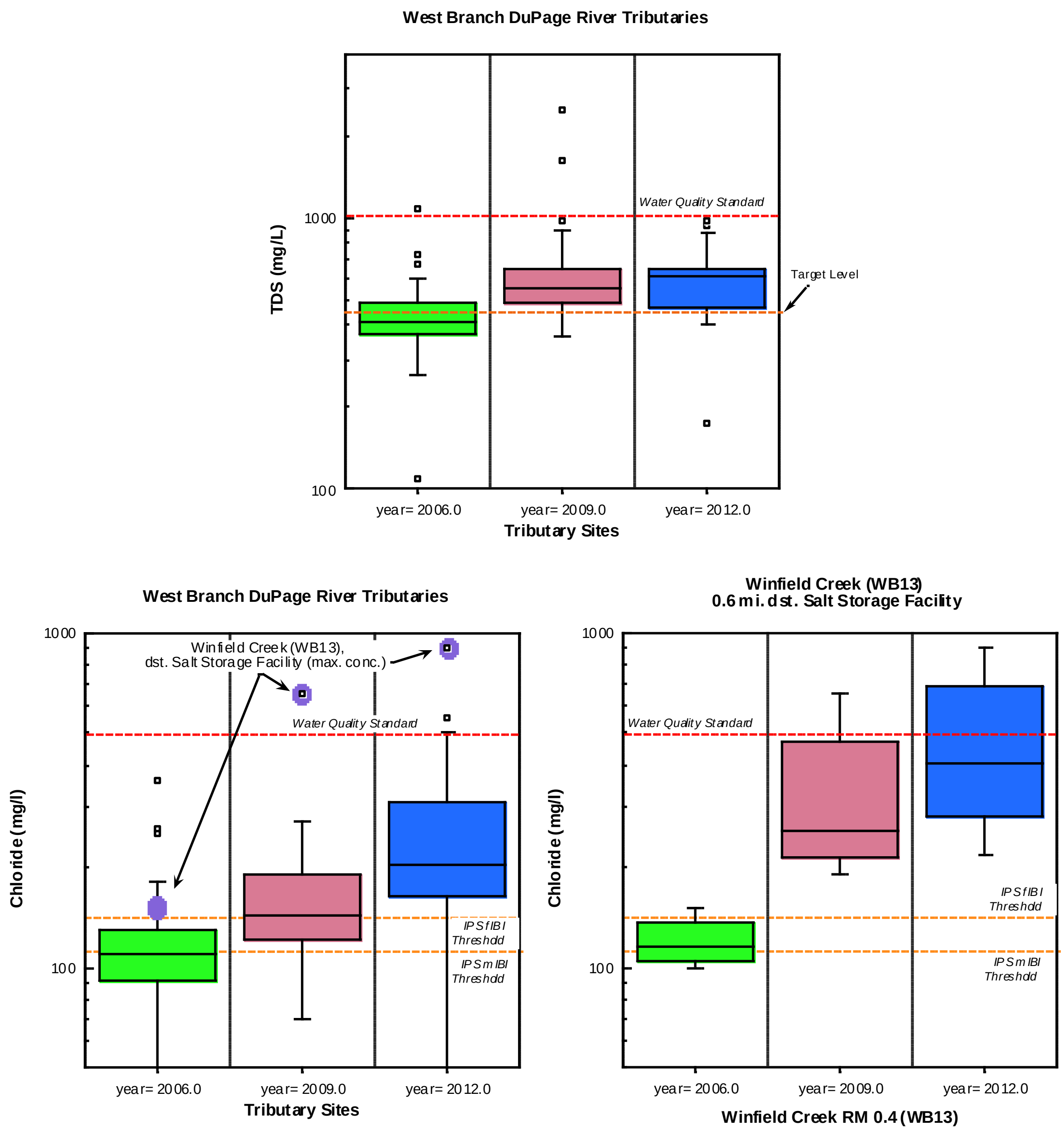


Figure 15. Box and whisker plots of TDS (top) and chloride (bottom right) from West Branch tributary sites in 2006, 2009, and 2012. Purple shading in the chloride plot denotes maximum concentrations from Winfield Creek site WB13, located 0.6 miles downstream from a DuPage County salt storage facility. The bottom right plot details the chloride results from WB13 during each survey year.

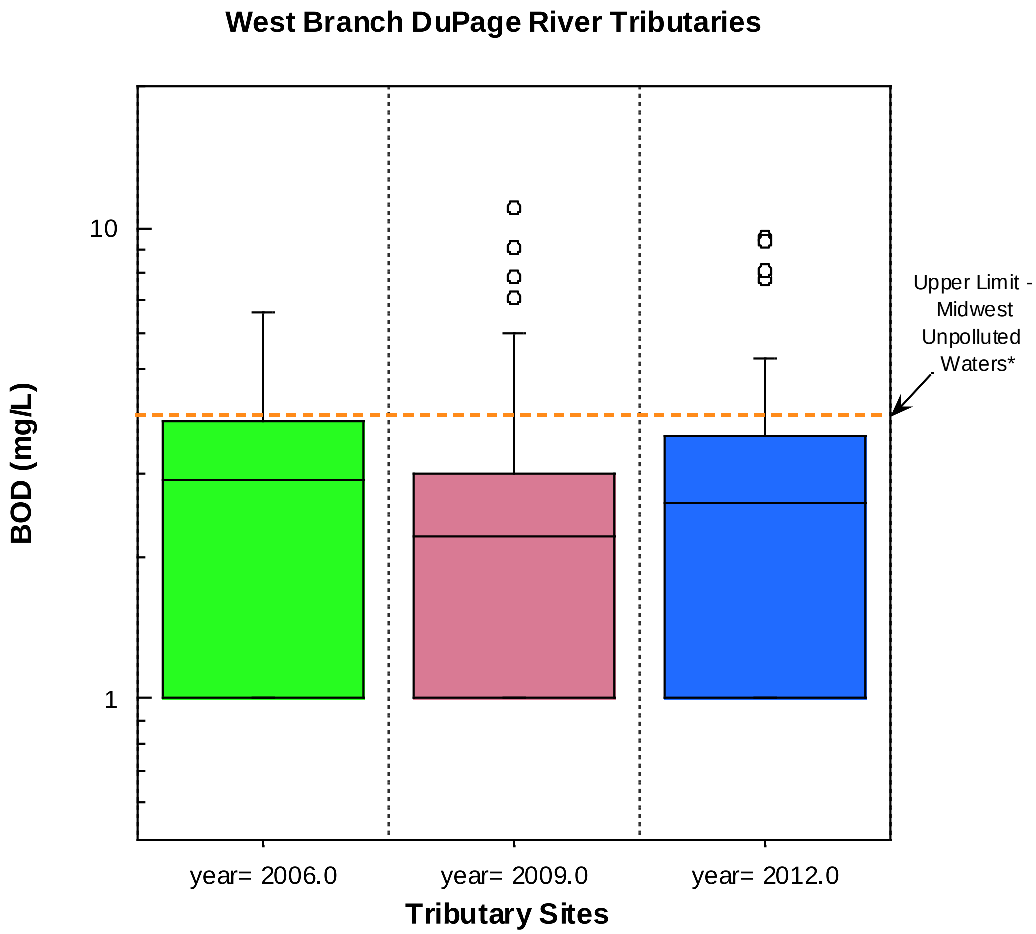


Figure 16. Box and whisker plots of biochemical oxygen demand (BOD) from West Branch tributary sites in 2006, 2009, and 2012.

Nutrient Conditions in the West Branch DuPage River Watershed

The impacts of nutrients on aquatic life has been well documented (e.g., Allan 2004) but the derivation of criteria and their form and application are controversial. Unlike toxicants, the influence of nutrients on aquatic life responses is predominantly indirect through pathways such as the effect of algal respiration on dissolved oxygen or through the influence of decomposition on dissolved oxygen dynamics. In addition, nutrients can have effects on food sources for macroinvertebrates and fish and the response of aquatic life to nutrient concentrations can be influenced by habitat (e.g., substrate composition), stream flow and scouring, temperature and shading. Illinois is the leading state in terms of percent of load exported of nitrogen (16.8%) and phosphorus (12.9%) to the Gulf of Mexico (US EPA 2009) where a large anoxic zone has been created (EPA SAB 2008).

In Illinois, as in other states, efforts are underway to derive nutrient water quality criteria for aquatic life. The U.S. EPA Inspector General (IG) concluded that the U.S. EPA, with regard to nutrient criteria, failed to adequately monitor and measure progress and "would consider promulgating numeric nutrient standards for a State if it had not substantially completed adopting numeric nutrient criteria in accordance with its plan by the end of 2004. (US EPA 2009)." The IG concluded that US EPA failed to sanction states who had not made progress and provided Illinois as an example because of Illinois EPA's "apparent belief that it did not need numeric nutrient criteria (USEPA 2009). Data from sites exceeding regional reference nutrient thresholds that are associated with excessive export of nutrients are used here. Table *9* lists four nutrient enrichment parameters in relation to various benchmarks that have been established to associate nutrient concentrations with impaired aquatic life. For aquatic life in Illinois, Illinois EPA derived targets for nitrates and other parameters without existing numeric criteria by using . . . "a statistically derived numeric value or a field observation may be used to identify potential causes of aquatic life use impairment". For example, for total phosphorus and suspended solids, a numeric threshold based on an 85th percentile value is used as a cause guideline; this threshold value is derived from all available data from water years 1978 through 1996, at Ambient Water Quality Monitoring Network sites."

There has been a wide range of approaches to deriving the targets used to assign nitrate a possible cause of impairment. A 10 mg/l water quality criterion is essentially a human health criterion for drinking water consumption by susceptible groups (e.g., pregnant women or infants) that might have health issues with this concentration of nitrates. The Illinois EPA derived target number for nitrate is 7.8 mg/l. In contrast, U.S. EPA (2000) developed nutrient ecoregion targets (e.g., 25th percentile) which for Ecoregion 54 in Nutrient Ecoregion VI would be 1.78 mg/l. In their Lower DuPage River watershed plan, the Conservation Foundation (2011) used a value of 3.2 mg/l that was selected as middle to high values of the recommended Ecoregion ranges "due to the wastewater treatment contributions in the watershed."

Sources of Nutrients

The nutrient profile of the West Branch watershed under summer base flows is well illustrated in Table 9. As in other recent surveys from the DuPage River basin (MBI 2014, MBI 2013) survey results show a generally strong segregation between nutrient levels in urban tributaries compared to sites located downstream from municipal WWTPs. The land uses in the watershed lead to common non-point sources of nutrients such as erosion and transport of soils and sediments in stormwater runoff, herbicide and fertilizer use on urban and agricultural properties, faulty septic systems, and waste from pets and livestock, as well as populations of the Canada Goose in and around detention basins. Wastewater sources of phosphorus are primarily human waste, food waste, and, to a lesser degree, soaps and detergents. Phosphorus generally exceeds target levels throughout the watershed but concentrations were often an order of magnitude higher immediately downstream from point sources. Under summer low flows, nitrates were almost entirely below target levels unless influenced by the WWTPs. in contrast, median ammonia concentrations were largely near, or below detection in point source influenced reaches, although some individual samples were occasionally higher (see Figure 9-bottom).

Urban tributaries (outside point source influences) were characterized by moderately elevated levels of ammonia, phosphorus, TKN and BOD but very low nitrates levels. One exception was Bremme Creek in 2009, where elevated nitrates were encountered downstream from a large tract of agricultural fields. The creek was not sampled in 2012 due to stream desiccation. A sharp increase in ammonia and nutrients at WB31 and WB25 (upper West Branch mainstem, upstream from known point sources) points to currently unknown sources and merits additional investigation.

Table 9. Median concentrations of key nutrient parameters including total ammonia, nitrate, TKN, and phosphorus in the West Branch DuPage River watershed in 2012. Shading represents exceedances of various criteria or thresholds for nutrient parameters (see footnotes). Where more than one target was used, the most stringent criteria is red and least stringent is yellow.

Site ID	River Mile	Drainage Area (sq. mi.)	Total Ammonia (mg/L)[1]	Nitrate (mg/L)[2,3,4]	TKN (mg/L)[5]	Total Phosphorus (mg/L)[6,7,8]
95-900 West Branch DuPage River						
WB25	34.0	2.1	2.72	0.0415	3.275	0.573
WB31	31.3	4.9	0.05	7.498	0.8095	1.8155
WB24	31.1	5.4	0.05	14.65	1.013	3.65
WB32	29.3	7.4	0.195	15.3	0.9435	3.22
WB27	27.8	12.9	0.05	12.2	0.956	2.43
WB28	27.4	14.0	0.05	17.55	0.753	3.365
WB20	25.6	19.7	0.0775	16.4	0.82	3.19
WB39	21.7	27.8	0.05	12.45	0.833	2.38
WB33	21.3	28.1	0.05	10.75	0.575	2.145
WB17	19.2	33.8	0.05	19.8	1.08	2.8
WB38	16.0	58.4	0.05	9.34	0.846	2.09
WB34	15.1	59.9	0.078	8.76	0.966	1.875
WB12	13.6	80.5	0.05	10.65	0.6635	1.72
WB42	11.6	90.0	Not Sampled			
WB40	11.1	91.3	0.05	11.5	0.4535	1.77
WB36	8.3	105	0.05	9.4	0.834	1.5
WB41	8.0	105	0.05	10.2	0.3	1.4
WB37	6.3	110	0.05	8.345	0.3	1.425
WB35	4.2	115	0.05	7.425	0.3	1.33
WB08	0.85	125	0.05	7.065	0.3	1.28
95-902 Trib to W. Br. DuPage River						
WB18	0.5	2.7	0.4095	0.127	1.85	0.2085
95-904 Trib to W. Br. DuPage River						
WB22	0.15	0.7	Not Sampled			
95-905 Trib to W. Br. DuPage River						
WB23	0.15	2.5	Not Sampled			
95-906 Trib to W. Br. DuPage River						
WB29	2.2	2.2	0.534	0.431	1.47	0.223
WB30	1.9	2.6	0.606	0.1055	1.23	0.352
WB21	0.9	4.2	0.229	0.4705	0.826	0.223
95-910 Kress Creek						
WB02	5.1	4.2	0.93	0.702	1.765	0.1265
WB01	2.7	14.5	0.05	0.025	0.478	0.146
WB03	0.5	18.6	0.117	0.544	0.7815	0.1865
95-920 Ferry Creek						
WB04	2.8	3.3	0.05	0.081	2.87	0.276

Site ID	River Mile	Drainage Area (sq. mi.)	Total Ammonia (mg/L)[1]	Nitrate (mg/L)[2,3,4]	TKN (mg/L)[5]	Total Phosphorus (mg/L)[6,7,8]
WB06	0.7	5.5	0.1195	0.0495	0.925	0.4455
95-925 W. Br. Ferry Creek						
WB05	0.25	4.3	0.216	0.0975	1.115	0.1665
95-930 Cress Creek						
WB07	0.2	3.8	0.05	0.025	0.802	0.23
95-940 Bremme Creek						
WB09	0.25	0.8	Not Sampled			
95-950 Spring Brook						
WB11	3.3	3.7	0.4265	0.0655	1.405	0.308
WB26	3.0	3.9	0.05	14.75	0.498	3.6
WB10	0.75	6.8	0.109	15	0.705	3.51
95-960 Winfield Creek						
WB15	5.4	2.0	0.0945	0.997	0.974	0.142
WB14	3.5	5.0	0.7225	0.065	1.76	0.399
WB13	0.4	9.0	0.05	0.025	1.1235	0.1735
95-970 Klein Creek						
WB19	3.6	5.0	0.098	0.0805	0.948	0.0839
WB16	1.0	9.0	0.05	27	0.5225	3.285

[1]MBI IPS ammonia aquatic life target level (0.15 mg/l).
[2]U.S. EPA Ecoregion 54 reference target for nitrate (1.798 mg/l).
[3]Non-standards based numeric criteria for total nitrate (7.8 mg/l) in water based on the 85th-percentile values determined from a statewide set of observations from the Ambient Water Quality Monitoring Network, for water years 1978-1996 (Illinois EPA 2011).
[4]Illinois water quality criteria for nitrate (10.0 mg/l).
[5]MBI IPS TKN aquatic life target level (1.0 mg/l).
[6]U.S. EPA Ecoregion 54 reference target for total phosphorus (0.072 mg/l).
[7]Non-standards based numeric criteria for total phosphorus (0.61 mg/l) in water based on the 85th-percentile values determined from a statewide set of observations from the Ambient Water Quality Monitoring Network, for water years 1978-1996 (Illinois EPA 2011).
[8]Suggested protective effluent limit for total phosphorus (1.0 mg/l).

Dissolved Materials in Urban Runoff

Dissolved material levels in West Branch tributaries as expressed by measurements of conductivity (µS/cm), total dissolved solids (TDS in mg/l) and chloride (mg/l) were almost universally elevated above IPS targets (Table 10). However, chlorides only exceeded WQS at Winfield Creek RM 0.4 (WB13) and at two unnamed tributary sites (WB29 and WB30) that bracket the Bartlett WWTP overflow plant. The Winfield Creek site has a history of chloride exceedances (see Figure 15); coincidentally, the site is located approximately 0.6 miles downstream from a road salt storage facility (see Plate 8, page 41). The unnamed tributary was largely culverted upstream from WB29 and WB30 and drained a dense urban/industrial landscape with large stretches of freeways, parking lots and housing.

Urban runoff, with its typically high concentration of dissolved constituents, can become limiting when concentrations reach toxic thresholds. Of particular concern in Northern climates in urban areas with high road density is the concentration of chlorides from nonpoint sources such as of road salt application and from point sources with loadings from water softener salts. Table 10 displays a series of dissolved materials, nutrients and metals often associated with urban runoff and highlights concentrations in excess of applicable reference targets. Work in Illinois and elsewhere has identified the increasing salinization of surface and groundwater from increased loadings of chlorides over time. The Illinois EPA conducted a total chloride TMDL for the East Branch DuPage River in 2004 (CH2MHill 2004) and identified road salt and WWTP effluents as two key sources in the watershed. Kelly et al. (2012) has demonstrated the recent increase in chloride concentrations in the Chicago area correlated with a pattern of increasing road salt applications, particularly over the past 20 years. Kelly et al. (2012) also identified a strong, steady increasing trend in chlorides in the Illinois River at Peoria where the median increased from about 20 mg/l in 1947 to nearly 100 mg/l in 2004 with high values in the 1940s of less than 40 and spikes in 2003 of greater than 300. Even higher values occur in small urban streams well above the 500 mg/l water quality criterion as evidenced by recent data from the E. and W. Branch DuPage watersheds. Winter conductivity data collected from the West Branch shows that the system regularly exceeds the state’s water quality standard.

Rather than a simple runoff and export mode of effect, chlorides and similar salt constituents accumulate in groundwater (Kelly 2008), soils, and land surfaces adjacent to the streams. Again, the West Branch demonstrates this by showing a steady decline in concentrations as we move from spring to fall. Seasonal sampling in studies have shown that high summer concentrations are typically highly correlated with acute concentrations during late winter and spring time periods (Kaushal et al. 2005) shows a group of parameters associated with urban runoff. The highlighted variables are values that exceed the IPS derived thresholds (total chloride, TKN) or statewide reference levels from similar Ohio waters (conductivity, TDS, TSS, metals; Ohio EPA 1999). For chloride, IPS threshold values for fish and macroinvertebrates (112 and 141 mg/l, respectively) are lower than the Illinois aquatic life water quality criterion (500 mg/l). These IPS thresholds were regularly exceeded at sites in the West Branch DuPage watershed and have been observed at consistently elevated levels in the adjacent East Branch and Lower DuPage River watersheds (MBI 2014, 2013). Levels of TDS and conductivity, a surrogate for chloride and other dissolved materials, were also elevated in the West Branch and historically in adjacent watersheds. Both West Branch and East Branch surveys have also shown increasing levels of chloride and conductivity compared to previous surveys. Increased concentrations in the East Branch followed several years of high snowfall between 2007 and 2010 (Figure 17).

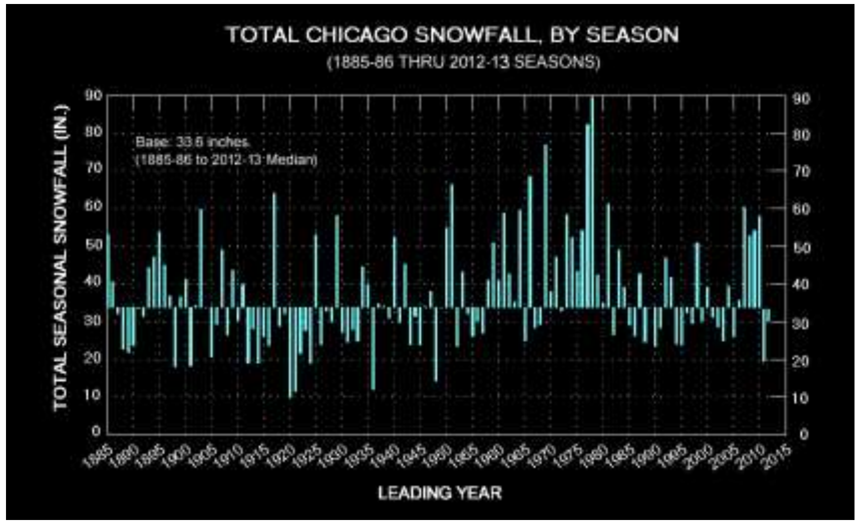


Figure 17. Total seasonal snowfall in inches in Chicago by year. Data from ClimateStations.com: http://www.climatestations.com/wp-content/uploads/2013/05/chisnow.gif

An abundance of heavy metals concentrations, particularly copper (Cu), zinc (Zn) and lead (Pb), were detected above Reference Target Levels throughout the watershed in both 2012 and 2009 (Table 10). While elevated levels were encountered in both small urban tributaries and large mainstream sample sites, they were most common in effluent dominated mainstem reaches, suggesting municipal point sources were metals contributors. Heavy metals target levels in Table 10 are derived from Ohio EPA databases and are associated with good to exceptional (i.e., reference quality) streams, that are generally located outside significant urban and point source influences. For this reason, and given the extensively urbanized landscape in the West Branch watershed, the elevated background metals levels are considered more typical than alarming. However, exceedances of WQS in 2012 indicate these metals sometimes reach levels harmful to aquatic life.

Within the adjacent Lower DuPage River watershed, nonpoint source modeling results demonstrated that 98.7% of chloride loading arose from non-point sources and a relatively minor percent of the loading originated from point sources (The Conservation Foundation 2011). This analysis did not include distinguishing point vs. nonpoint origins in the upstream East and West Branches but, given the developed nature of these watersheds, it was likely dominated by nonpoint sources at December-March high flows. However, at base flow, the contribution of chloride and TDS from point sources may be relatively larger because of the effluent dominance from upstream point sources (see Figure 12); however, recent sampling of effluent chloride levels by DRSCW indicated a majority of effluents had a moderating effect on receiving stream concentrations (see Table 6). In addition, chloride sampling conducted during the summer of 2011 in the effluent dominated East Branch DuPage River show elevated but gradually declining concentrations over time (Figure 18). The data suggest initial, non-point related contributions decrease over the summer months, resulting in residual, point-source related concentrations under late-season, low-flow conditions. Given the observed “tail off” in concentration, it seems that point sources only dictate ambient concentrations between September and December when deicing operations start again. Regardless, the thresholds generated by the IPS reflect a correlation between summer chloride concentrations and biological effects and do not necessarily reflect the absolute concentration where or when toxic effects occur (i.e. winter months). Actual concentrations that result in adverse effects on fish and invertebrates likely occur during peak runoff events in late winter and spring when values may approach or exceed the 230 mg/ US EPA recommended chronic criteria or the 500 mg/l Illinois criteria. The quantile regression thresholds are likely more meaningful in the tributaries where, given the nearly direct connection to runoff sources and less "dilution" from effluents, these concentrations are likely stronger signals for acute chloride levels. Work in New England (Kaushal et al. 2005) and Minnesota (Novotny et al. 2008) identify that chlorides are accumulating in watersheds and that there is a strong association between winter and summer concentrations. Novotny et al. (2008) identify that about 78% of road salt applied in a Minnesota watershed was accumulating in a given year and contributing to gradually increasing baseline (summer) chloride concentration. High levels of chloride during summer in all of the tributaries studied, with the exception of Spring Creek indicate late winter and early spring chloride levels are much higher during runoff events and likely contribute to the extent of impairment in headwater streams.

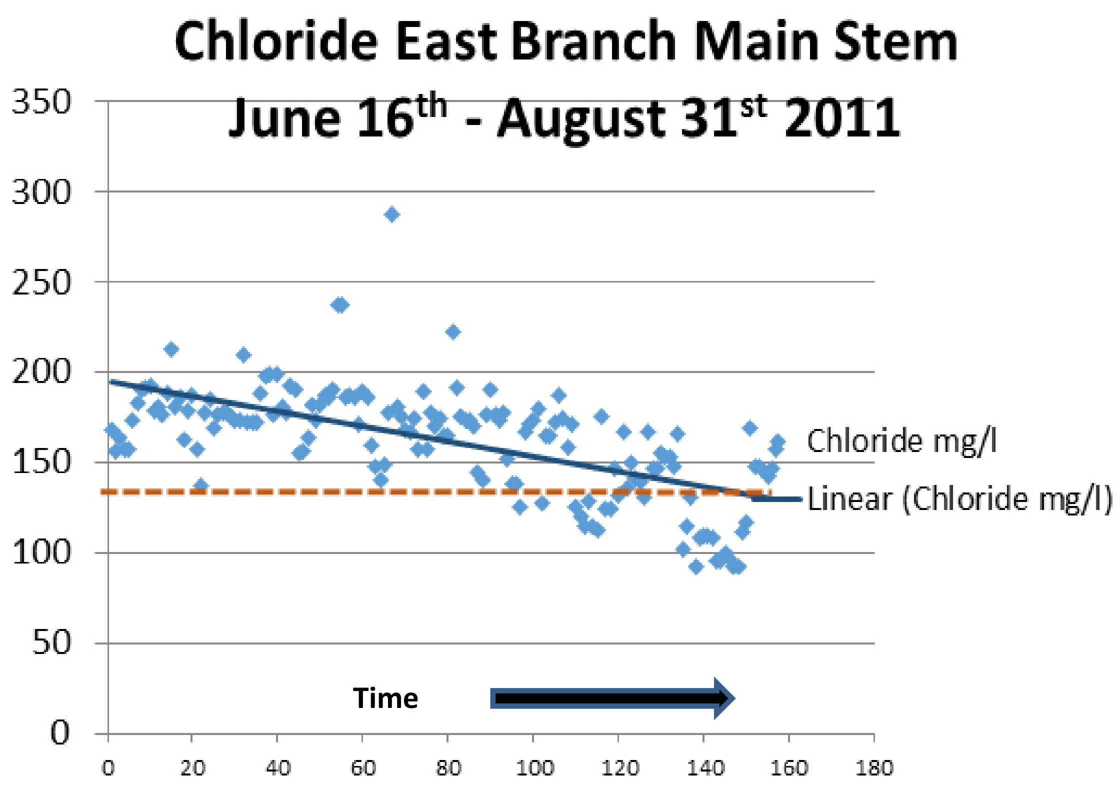


Figure 18. Chloride concentrations from the East Branch DuPage River during the summer of 2011.

*Table 10. Urban parameter sampling results in the West Branch DuPage River watershed, summer 2012. Values above applicable reference targets are highlighted in yellow. Individual metals sample concentrations that exceed Illinois WQS are in **red** font.*

Site ID	RM	DA (mi²)	Conductivity (µS/cm)			Chloride		TDS		TSS		Metals (Cd, Cu, Pb, Zn) > Targets[3] (Value)	
			MBI[a]	Median	Target[2]	Median	Target[1]	Median	Target[2]	Median	Target[2]	2012	2009
95-900 West Branch DuPage River													
WB25	34.0	2.1	1540	797	600	377	112	397	468	14	16		
WB31	31.3	4.9	1093	871	600	212	112	496	468	9	16	Cu(6.8); Zn(36.5)	Cu(5.1); Pb(2.8); Zn(19.3,19.7,15.7)
WB24	31.1	5.4	822	465	600	147	112	540	468	4	16	Cu(7.4, 7.0, 6.0); Zn(39.7,38.4)	Cu(7.7,9.5,9.8); Zn(29.9,27.5,31.5,24.7)
WB32	29.3	7.4	817	464	600	160	112	538	468	30	16	Not Sampled	Not Sampled
WB27	27.8	12.9	853	465	600	156	112	534	468	29	16	Cu(5.1,5.1,5.6); Zn(32.0,34.0,40.3)	Cu(6.1,5.6); Zn(24.1, 25.1,24.0)
WB28	27.4	14.0	1029	538	600	195	112	632	468	30	16	Cu(6.9,7.7,5.6); Zn(35.4,41.1,29.3)	Cu(8.5); Zn(24.8, 25.2, 23.0)
WB20	25.6	19.7	914	948	600	188	112	611	468	22	16	Cu(5.9); Zn(31.5,29.1,28.6,31.4)	Cu(6.4,5.5,5.8); Zn(24.6, 38.7, 20.9, 21.7)
WB39	21.7	27.8	941	592	610	186	112	593	522	11	25	Cu(5.3,5.1); Zn(25.2,24.0,27.4,21.6)	Cu(5.9); Zn(23.7, 19.6,22.6,23.1)
WB33	21.3	28.1	912	522	610	186	112	596	522	13	25	Zn(24.3,22.2,16.7,17.2)	Cu(5.5,5.2); Zn(18.3,22.2,25.6,23.1)
WB17	19.2	33.8	941	865	610	184	112	600	522	27	25	**Cu(72.40)**; Zn(24.3)	(Cu(5.6); Zn(23.5,22.2,15.6, 19.7)
WB38	16.0	58.4	901	524	610	196	112	561	522	15	25	Cu(7.1,8.3,5.9); Zn(23.0,27.6,18.7)	Cu(5.5,13.5); Pb(13.1); Zn(16.8,21.5,42.5)
WB34	15.1	59.9	974	586	610	204	112	601	522	8	25	Cu(6.4,8.7,8.7,6.1); Zn(21.0,24.3,19.5,15.4)	Cu(6.5,6.2,5.4); Zn(16.0,18.1,23.8,24.6)
WB12	13.6	80.5	963	556	610	194	112	607	522	3	25	**Cd(43.70)**; **Pb(41.60)**; **Cu(44.7**,6.9,6.7,5.5); Zn(44.8,21.1,21.4)	Cu(5.7,8.7); Zn(20.2,22.1,28.8)
WB42	11.6	90.0	Not Sampled									Not Sampled	Not Sampled
WB40	11.1	91.3	943	578	610	193	112	606	522	9	25	Cu(5.9,7.6,5.2,5.4,9.5); Zn(23.3,24.4,15.7,15.1,19.3)	Cu(5.1); Zn(15.1,21.2,16.0, 15.7)

Site ID	RM	DA (mi^2)	Conductivity (µS/cm)			Chloride		TDS		TSS		Metals (Cd, Cu, Pb, Zn) > Targets[3] (Value)	
			MBI[a]	Median	Target[2]	Median	Target[1]	Median	Target[2]	Median	Target[2]	2012	2009
WB36	8.3	105	--	--	--	182	112	572	522	32.5	25	Cu(11.0,6.8,16.2); Pb(3.9,5.2); Zn(26.0,15.3,43.8)	Cu(5.4); Zn(17.8,17.5,20.6, 16.2)
WB41	8.0	105	915	943	610	179	112	594	522	16	25	Cu(6.9,5.7,6.8,8.5); Zn(18.7)	Cu(5.4); Zn(16.2,22.7,22.4)
WB37	6.3	110	968	586	610	206	112	630	522	8	25	Cu(5.4,6.3,5.2,5.0); Zn(19.3,19.9,15.7)	Cu(6.3,5.7); Zn(21.1,15.2,25.3, 29.0)
WB35	4.2	115	1007	832	610	217	112	646	522	10	25	Cu(5.4,6.5); Zn(16.7)	Cu(5.0); Zn(26.2,28.6,16.6)
WB08	0.85	125	997	942	610	209	112	661	522	5	25	Cu(5.3); Zn(16.0,28.6)	Cu(5.0)
95-902 Trib to W. Br. DuPage River													
WB18	0.5	2.7	956	522	600	171	112	566.5	468	22	16		
95-904 Trib to W. Br. DuPage River													
WB22	0.15	0.7	Not Sampled									Not Sampled	Not Sampled
95-905 Trib to W. Br. DuPage River													
WB23	0.15	2.5	Not Sampled									Not Sampled	Not Sampled
95-906 Trib to W. Br. DuPage River													
WB29	2.2	2.2	1304	1050	600	553	112	13	468	90	16	Zn16.3)	
WB30	1.9	2.6	1141	845	600	377	112	309	468	8	16	Cu(5.3); Zn(26.4)	
WB21	0.9	4.2	946	808	600	288	112	658	468	7	16		
95-910 Kress Creek													
WB02	5.1	4.2	480	520	600	139	112	491	468	22	16		
WB01	2.7	14.5	643	504	600	176	112	514	468	6	16		
WB03	0.5	18.6	702	525	600	202	112	608	468	11	16		
95-920 Ferry Creek													
WB04	2.8	3.3	570	309	600	87	112	405	468	90	16		
WB06	0.7	5.5	803	701	600	215	112	577	468	18	16	Cu(6.1); Zn(19.6)	
95-925 W. Br. Ferry Creek													
WB05	0.25	4.3	814	644	600	307	112	716	468	10	16		
95-930 Cress Creek													
WB07	0.2	3.8	NC	839	600	361	112	440	468	12	16		

Site ID	RM	DA (mi²)	Conductivity (µS/cm)			Chloride		TDS		TSS		Metals (Cd, Cu, Pb, Zn) > Targets[3] (Value)	
			MBI[a]	Median	Target[2]	Median	Target[1]	Median	Target[2]	Median	Target[2]	2012	2009
95-940 Bremme Creek													
WB09	0.25	0.8	Not Sampled									Not Sampled	Not Sampled
95-950 Spring Brook													
WB11	3.3	3.7	649	519	600	156	112	528	468	29	16	Cu(13.3); Pb(3.2)	
WB26	3	3.9	917	464	600	165	112	546	468	3	16	Cu(5.6,5.3,5.7); Zn(34.6,35.4,41.1)	Zn(29.4,29.6,26.4, 27.4)
WB10	0.75	6.8	893	507	600	181	112	606	468	38	16	Cu(11.9,12.4); Pb(4.1,3.4); Zn(43.0,42.7)	Cu(5.5); Zn(23.3,18.7)
95-960 Winfield Creek													
WB15	5.4	2.0	681	726	600	210	112	601	468	12	16		Cu(6.8); Zn(17.7)
WB14	3.5	5.0	769	739	600	307	112	735	468	13	16		
WB13	0.4	9.0	917	1541	600	410	112	259	468	16	16		
95-970 Klein Creek													
WB19	3.6	5.0	1049	1060	600	241	112	642	468	11	16		
WB16	1	9.0	563	762	600	200	112	612	468	2	16	**Cu(38.8,98.6,97.9)**; Zn(50.4,25.2)	Cu(10.3,11.1); Zn(34.4, 35.0)

[1]IPS thresholds (lowest) derived in the IPS study (total chloride)
[2]Median values above statewide reference levels (75th percentiles) from similar Ohio waters (e.g., headwater, wadeable streams).
[3]Single date values above statewide reference levels (75th percentiles) from similar Ohio waters (Cd-0.25; Cu-5.0; Zn 15.0; Pb 2.5).
[a] Note: conductivity listings above are from field measurements during fish sampling.

West Branch DuPage River Watershed Sediment Chemistry

Sediment samples were analyzed for heavy metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides from twenty-one locations in the West Branch DuPage River watershed in 2012 (Table 11, Table 12). Samples were evaluated against guidelines compiled by McDonald et al. (2000) and the Ontario Ministry of Environment (1993) that list ranges of contaminant values by probable toxicity to aquatic life (Table 11). Specifically, threshold effects levels (TEL) are those where toxicity is initially apparent, and likely to affect only the most sensitive organisms. Probable effects levels (PEL) are those where toxicity is likely to be observed over a range of organisms.

Concentrations of heavy metals were below probable effects levels (PEL) at all but four locations, where copper (3) or manganese (1) exceeded the PEL. Metals were detected, however, at all of the sampling locations in concentrations that exceed threshold effect levels (TEL). No clear spatial pattern to the detections was evident in terms of geographic location or stream size, other than them being prevalent throughout the watershed.

As with metals, PAH concentrations exceeding threshold effects levels (TEL) were detected at all sites and exceeded probable effects levels at all but two sites. Like metal concentrations, no spatial pattern was immediately evident, other than their prevalence in this urban watershed. A common source of PAHs is the incomplete combustion of gasoline. There has been some recent work examining ratios of various PAH compounds (Yunker et al. 2002) to estimate sources of PAHs (e.g., distinguishing between vehicle emissions vs. wood sources and between combustion vs. petroleum) but would require further analyses. It is likely, given the high road density in the surrounding urban landscape, that sources are related to vehicle emissions and petroleum in the West Branch. Another common source of PAHs is a popular parking lot sealant, particularly those made from coal tar (USGS 2011). Coal tar is a byproduct of the carbonization of coal to produce coke. Coal tar sealants are used extensively in the watershed to protect and improve the aesthetic appearance of driving and parking surfaces. As the sealant erodes from weatherization and wear, it erodes into particles that wash or blow into waterways.

Some authors have distinguished PAHs classified as low molecular weight (LMW) from high molecular weight (HMW) compounds with LMW compounds generally more toxic because of their high solubility in water (CCME 1999). The three most common PAH compounds found above the PEL guidelines in the West Branch watershed were benzo(g,h,i)perylene, fluoranthene, and Dibenzo(a,h)anthracene (Table 12) and are all HMW compounds. No clear trend in the number of detections of either PAHs or metals was detected between 2012 and 2006-2009.

Table 11. Number of metals, polychlorinated biphenyls (PCBs), pesticides and polycyclic aromatic hydrocarbons (PAHs) detections in sediment samples from the West Branch DuPage River watershed in 2012. Concentrations that exceed threshold effects levels (TEL) or probable effect levels (PEL) listed in McDonald et al. (2000) or Ontario Ministry of Environment (1993) are listed. Key: T – tested; D – detected.

Site ID	Basin Code	Stream Code	River Mile	Collection Date	All Parameters		Metals				PCBs				Pesticides				PAHs			
					T	D	T	D	>TEL	>PEL	T	D	>TEL	>PEL	T	D	>TEL	>PEL	T	D	>TEL	>PEL
West Branch DuPage River																						
WB31	95	900	31.3	10-Oct-12	103	23	13	11	5	0	6	0	0	0	22	0	0	0	16	11	6	2
WB24	95	900	31.1	10-Oct-12	103	16	13	10	2	0	6	0	0	0	22	0	0	0	16	5	3	0
WB32	95	900	30.1	10-Oct-12	103	23	13	11	3	0	6	0	0	0	22	1	0	0	16	10	5	2
WB27	95	900	28.7	10-Oct-12	103	23	13	11	3	0	6	0	0	0	22	0	0	0	16	10	5	2
WB28	95	900	27.4	28-Sep-12	102	21	13	10	4	0	6	0	0	0	22	0	0	0	16	11	4	2
WB20	95	900	25.6	20-Sep-12	102	21	13	11	3	0	6	0	0	0	22	0	0	0	16	10	6	1
WB33	95	900	21.3	17-Sep-12	102	17	13	12	4	0	6	0	0	0	22	0	0	0	16	5	4	0
WB17	95	900	19.2	18-Sep-12	102	22	13	11	4	0	6	0	0	0	22	1	0	0	16	10	8	1
WB38	95	900	16.0	18-Sep-12	102	23	13	12	4	0	6	0	0	0	22	1	0	0	16	10	8	1
WB34	95	900	15.1	24-Sep-12	102	23	13	11	3	1	6	0	0	0	22	0	0	0	16	11	1	3
WB12	95	900	13.6	21-Aug-12	102	23	13	12	6	2	6	0	0	0	22	0	0	0	16	11	3	2
WB40	95	900	11.1	24-Sep-12	102	22	13	12	4	0	6	0	0	0	22	0	0	0	16	10	7	1
WB41	95	900	8.0	15-Aug-12	102	23	13	13	4	0	6	0	0	0	22	0	0	0	16	10	8	1
WB37	95	900	6.3	08-Aug-12	102	21	13	11	3	1	6	0	0	0	22	0	0	0	16	10	5	1
WB08	95	900	0.85	08-Aug-12	102	21	13	11	4	0	6	0	0	0	22	0	0	0	16	10	5	1
Trib to West Branch DuPage River																						
WB30	95	906	1.9	21-Sep-12	102	23	13	11	5	0	6	0	0	0	22	0	0	0	16	12	4	8
Kress Creek																						
WB01	95	910	2.7	27-Sep-12	102	18	13	10	4	0	6	0	0	0	22	0	0	0	16	7	6	1
WB03	95	910	0.5	27-Sep-12	102	24	13	12	6	0	6	0	0	0	22	0	0	0	16	11	4	3
Spring Brook																						
WB11	95	950	3.3	20-Aug-12	102	26	13	12	6	2	6	0	0	0	22	2	0	0	16	12	3	7
WB26	95	950	3.0	12-Sep-12	102	26	13	12	6	0	6	0	0	0	22	3	0	0	16	11	3	2
Winfield Creek																						
WB15	95	960	5.4	13-Sep-12	102	28	12	11	5	0	6	0	0	0	22	3	0	0	16	11	5	1

Table 12. Metals, polychlorinated biphenyls (PCBs), pesticides and polycyclic aromatic hydrocarbons (PAHs) concentrations in sediment samples from the West Branch DuPage River watershed in 2012 that exceed threshold effects levels (TEL) or probable effect levels (PEL) listed in McDonald et al. (2000) or Ontario Ministry of Environment (1993).

Site ID	Basin	Stream	RM	Collection Date	Parameters > TEL Benchmark (Value, mg/l)	Parameters > PEL Benchmark (Value, mg/l)
West Branch DuPage River						
WB31	95	900	31.3	10-Oct-12	Cadmium (1.15); Copper (44.80); Lead (32.70); Nickel (24.30); Zinc (177.00); Benzo(b)fluoranthene (2280.00); Benzo(k)fluoranthene (726.00); Indeno(1,2,3-cd)pyrene (633.00); Phenanthrene (805.00); Benzo(a)anthracene (789.00); Dibenzo(a,h)anthracene (1	Fluoranthene (2700.00); Benzo(g,h,i)perylene (609.00)
WB24	95	900	31.1	10-Oct-12	Copper (34.40); Nickel (23.30); Benzo(b)fluoranthene (270.00); Benzo(a)pyrene (189.00); Chrysene (171.00)	
WB32	95	900	30.1	10-Oct-12	Copper (45.90); Nickel (20.90); Zinc (167.00); Benzo(b)fluoranthene (2750.00); Benzo(k)fluoranthene (885.00); Indeno(1,2,3-cd)pyrene (732.00); Phenanthrene (818.00); Benzo(a)anthracene (778.00)	Fluoranthene (3290.00); Benzo(g,h,i)perylene (697.00)
WB27	95	900	28.7	10-Oct-12	Copper (44.80); Nickel (19.30); Zinc (170.00); Benzo(b)fluoranthene (2350.00); Benzo(k)fluoranthene (730.00); Indeno(1,2,3-cd)pyrene (652.00); Phenanthrene (680.00); Benzo(a)anthracene (739.00)	Fluoranthene (2970.00); Benzo(g,h,i)perylene (613.00)
WB28	95	900	27.4	28-Sep-12	Copper (43.00); Manganese (464.00); Nickel (20.50); Zinc (177.00); Benzo(k)fluoranthene (573.00); Indeno(1,2,3-cd)pyrene (885.00); Phenanthrene (585.00); Benzo(a)anthracene (612.00)	Fluoranthene (2350.00); Dibenzo(a,h)anthracene (196.00)
WB20	95	900	25.6	20-Sep-12	Copper (38.70); Nickel (17.80); Zinc (140.00); Benzo(k)fluoranthene (382.00); Benzo(a)pyrene (623.00); Chrysene (724.00); Indeno(1,2,3-cd)pyrene (689.00); Phenanthrene (352.00); Benzo(a)anthracene (364.00)	Benzo(g,h,i)perylene (867.00)
WB33	95	900	21.3	17-Sep-12	Copper (32.60); Manganese (605.00); Nickel (17.80); Zinc (140.00); Benzo(b)fluoranthene (334.00); Benzo(a)pyrene (191.00); Chrysene (205.00); Pyrene (200.00)	
WB17	95	900	19.2	18-Sep-12	Copper (29.70); Manganese (895.00); Nickel (18.80); Zinc (135.00); Benzo(b)fluoranthene (996.00); Benzo(k)fluoranthene (347.00); Benzo(a)pyrene (537.00); Chrysene (596.00); Indeno(1,2,3-cd)pyrene (331.00); Phenanthrene (260.00); Pyrene (740.00); Benz	Benzo(g,h,i)perylene (320.00)
WB38	95	900	16	18-Sep-12	Copper (53.80); Manganese (713.00); Nickel (17.40); Zinc (163.00); Benzo(b)fluoranthene (855.00); Benzo(k)fluoranthene (262.00); Benzo(a)pyrene (534.00); Chrysene (561.00); Indeno(1,2,3-cd)pyrene (340.00); Phenanthrene (260.00); Pyrene (698.00); Benz	Benzo(g,h,i)perylene (325.00)
WB34	95	900	15.1	24-Sep-12	Manganese (804.00); Nickel (18.50); Zinc (212.00); Benzo(b)fluoranthene (3270.00)	Copper (111.00); Fluoranthene (4410.00); Pyrene (3480.00); Dibenzo(a,h)anthracene (509.00)
WB12	95	900	13.6	21-Aug-12	Cadmium (1.00); Chromium (35.80); Copper (108.00); Lead (41.70); Nickel (29.40); Zinc (220.00); Benzo(k)fluoranthene (628.00); Phenanthrene (644.00); Benzo(a)anthracene (795.00)	Manganese (2260.00); Fluoranthene (2510.00); Dibenzo(a,h)anthracene (213.00); Potassium (4760.00)
WB40	95	900	11.1	24-Sep-12	Copper (80.80); Manganese (476.00); Silver (1.89); Zinc (191.00); Benzo(b)fluoranthene (584.00); Benzo(a)pyrene (400.00); Chrysene (410.00); Fluoranthene (779.00); Indeno(1,2,3-	Benzo(g,h,i)perylene (475.00)

					cd)pyrene (382.00); Pyrene (609.00); Benzo(a)anthracene (248.00)	
WB41	95	900	8	15-Aug-12	Copper (60.60); Manganese (816.00); Nickel (26.10); Zinc (139.00); Benzo(b)fluoranthene (824.00); Benzo(k)fluoranthene (319.00); Benzo(a)pyrene (551.00); Chrysene (615.00); Indeno(1,2,3-cd)pyrene (392.00); Phenanthrene (256.00); Pyrene (771.00); Benz	Benzo(g,h,i)perylene (435.00)
WB37	95	900	6.3	08-Aug-12	Manganese (1050.00); Nickel (17.90); Zinc (195.00); Benzo(b)fluoranthene (2090.00); Benzo(k)fluoranthene (574.00); Indeno(1,2,3-cd)pyrene (909.00); Phenanthrene (733.00); Benzo(a)anthracene (843.00)	Copper (129.00); Fluoranthene (2650.00)
WB08	95	900	0.85	08-Aug-12	Copper (93.30); Manganese (784.00); Nickel (18.00); Zinc (198.00); Benzo(k)fluoranthene (446.00); Fluoranthene (2060.00); Indeno(1,2,3-cd)pyrene (610.00); Phenanthrene (624.00); Benzo(a)anthracene (709.00)	Benzo(g,h,i)perylene (768.00)
Trib to West Branch DuPage River						
WB30	95	906	1.9	21-Sep-12	Cadmium (1.01); Chromium (29.80); Copper (43.00); Nickel (23.60); Zinc (153.00); Anthracene (218.00); Benzo(b)fluoranthene (6010.00); Benzo(k)fluoranthene (2240.00); Indeno(1,2,3-cd)pyrene (2160.00)	Benzo(a)pyrene (3860.00); Chrysene (4270.00); Fluoranthene (8470.00); Phenanthrene (2350.00); Pyrene (6040.00); Benzo(g,h,i)perylene (2240.00); Benzo(a)anthracene (2250.00); Dibenzo(a,h)anthracene (491.00)
Kress Creek						
WB01	95	910	2.7	27-Sep-12	Chromium (30.00); Copper (29.80); Manganese (804.00); Nickel (25.30); Benzo(b)fluoranthene (643.00); Benzo(a)pyrene (360.00); Chrysene (436.00); Fluoranthene (691.00); Indeno(1,2,3-cd)pyrene (321.00); Pyrene (449.00)	Benzo(g,h,i)perylene (391.00)
WB03	95	910	0.5	27-Sep-12	Chromium (27.90); Copper (46.40); Lead (31.50); Manganese (912.00); Nickel (21.90); Zinc (203.00); Benzo(b)fluoranthene (2290.00); Benzo(k)fluoranthene (789.00); Phenanthrene (714.00); Benzo(a)anthracene (819.00)	Fluoranthene (2810.00); Pyrene (2400.00); Dibenzo(a,h)anthracene (277.00)
Spring Brook						
WB11	95	950	3.3	20-Aug-12	Cadmium (1.37); Chromium (46.50); Lead (89.00); Manganese (632.00); Nickel (31.90); Zinc (308.00); Anthracene (216.00); Benzo(b)fluoranthene (5180.00); Indeno(1,2,3-cd)pyrene (2580.00)	Copper (212.00); Silver (4.34); Benzo(a)pyrene (3710.00); Chrysene (3670.00); Fluoranthene (6940.00); Pyrene (4480.00); Benzo(g,h,i)perylene (2870.00); Benzo(a)anthracene (2150.00); Dibenzo(a,h)anthracene (629.00)
WB26	95	950	3.0	12-Sep-12	Copper (93.20); Lead (34.20); Manganese (503.00); Nickel (17.30); Silver (1.82); Zinc (223.00); Benzo(k)fluoranthene (636.00); Phenanthrene (672.00); Benzo(a)anthracene (746.00)	Fluoranthene (2530.00); Dibenzo(a,h)anthracene (250.00)
Winfield Creek						
WB15	95	960	5.4	13-Sep-12	Copper (44.60); Lead (46.20); Manganese (512.00); Nickel (24.60); Zinc (152.00); Benzo(k)fluoranthene (415.00); Benzo(a)pyrene (953.00); Indeno(1,2,3-cd)pyrene (872.00); Phenanthrene (676.00); Benzo(a)anthracene (595.00)	Dibenzo(a,h)anthracene (199.00)

West Branch DuPage River Watershed Physical Habitat for Aquatic Life – QHEI

Qualitative Habitat Evaluation Index (QHEI) scores were calculated at each fish collection site in the West Branch watershed. The scores and their associated narrative ratings are displayed in Figure 20.

West Branch DuPage River

Mainstem habitat quality in 2012 was good to excellent throughout most of its length and, with the exception of the extreme headwaters (upstream RM 30.1) and Fawell Dam pool (RM 8.3), stream habitats were clearly adequate to support warmwater assemblages (Figure 19; Table 13). Beginning downstream from RM 30.1 QHEI scores averaged 74.4, nearly meeting the 75.0 benchmark for exceptional potential. In contrast, habitat ratings in the upper, historically modified reach between RMs 35 and 31 were in the fair range and averaged 51.4. Immediately upstream from Fawell Dam and under the very low flow conditions of 2012, fine depositional substrates of muck and silt characterized the impoundment and the QHEI dipped into the poor range.

Fish assemblage performance in the mainstem headwaters was severely impaired but mirrored the trend in QHEI (Figure 19). However, fIBI scores were virtually unchanged and remained in the poor to marginally fair range over an approximate 20-mile stretch between RM 30 and the Fawell Dam. Additional but incomplete recovery in the fish was observed in the free-flowing reach between the dam and the mouth.

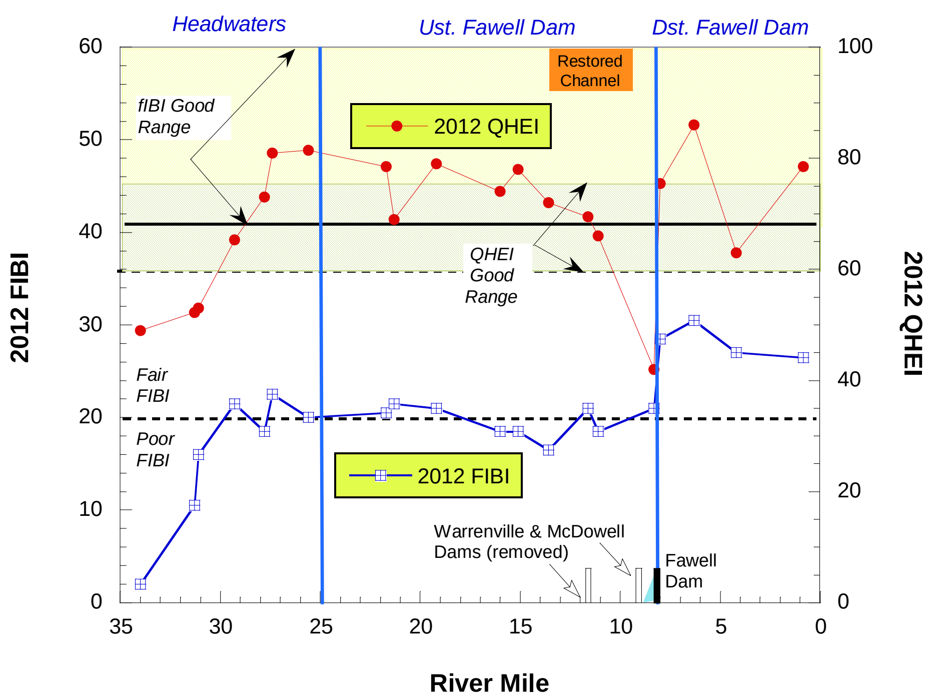


Figure 19. Fish IBI and QHEI scores from the West Branch DuPage River, 2012.

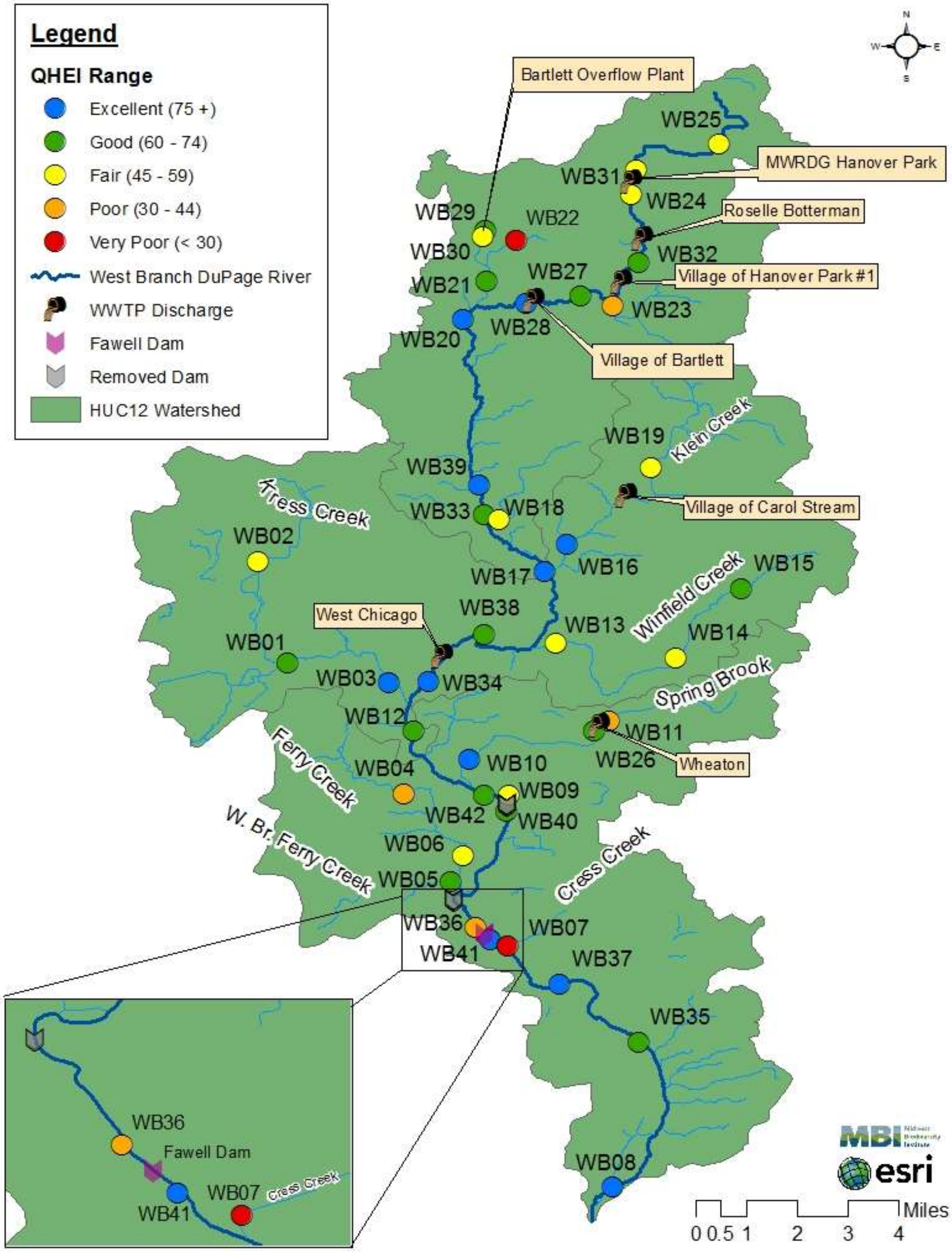


Figure 20. West Branch DuPage River watershed QHEI scores in 2012 mapped by narrative range. Square symbols denote dams and discharge pipes denote WWTP locations. Note: A low-head dam on Spring Brook, immediately upstream from WB10, is not shown.

Longitudinal trends in mainstem habitat quality were generally similar to 2006-2009 but 2012 results show changes at some locations (Figure 21; Table 13). At WB20 (RM 25.6) QHEIs have increased by 18.5 points since 2006 (from 63 to 81.5) indicating recovery from past channelization. Station WB17 (RM 19.2) scores suggest a significant impact and recovery trend following channelization as QHEIs dropped 22 points from 2006-2009 and rebounded by 14 points in 2012. Good habitat quality continues to be maintained in the restored channel reach between Kress Creek and the former McDowell Grove Dam (~ RM 14-9) after work to remove thorium-contaminated sediments was completed in 2010. A drastically lower QHEI in 2012 within the Fawell pool (RM 8.3) was likely a function of low, stagnant flows and the preponderance of silt and muck substrates that accumulated behind the dam.

West Branch DuPage River Tributaries

The 2009 Bioassessment Report concluded habitat quality in West Branch tributaries remained static between 2009 and 2006 and that general trend continued in 2012 (Figure 22). The median QHEI score for the tributaries increased from 49 to 52 to 56 between surveys, an indication of marginal but slightly improving conditions. Reasons for specific changes between surveys varied from site to site. For example, at WB18 and WB15, the respective 17-21 point increases in QHEI between 2006 and 2012 suggest gradual habitat recovery following historical channelization. In other instances (e.g., WB29 and WB30), the QHEI increase appeared a function of very small drainage coupled with an isolated rainfall event. This short-term enhancement in stream flow led to a largely illusory increase in habitat ratings in 2012. Conversely, the greatest decline in QHEI occurred at WB04 (Ferry Creek RM 2.8) which dropped from fair (QHEI = 48.5) in 2009 to poor (QHEI = 30.5) in 2012. From field observations, the stream channel had been “dipped” or cleared of vegetation at some point after 2009, resulting in lower quality habitat features in 2012.

By 2012, habitat quality in West Branch tributaries was largely in the upper fair to good ranges, and was not severely limiting to fish assemblages. However, fish performance at the associated tributary sites was consistently poor or barely reached into the fair range (Figure 23). The results suggest water quality conditions and storm water associated with the surrounding urban landscape have the most significant influence on the fish and the effects of habitat quality were secondary.

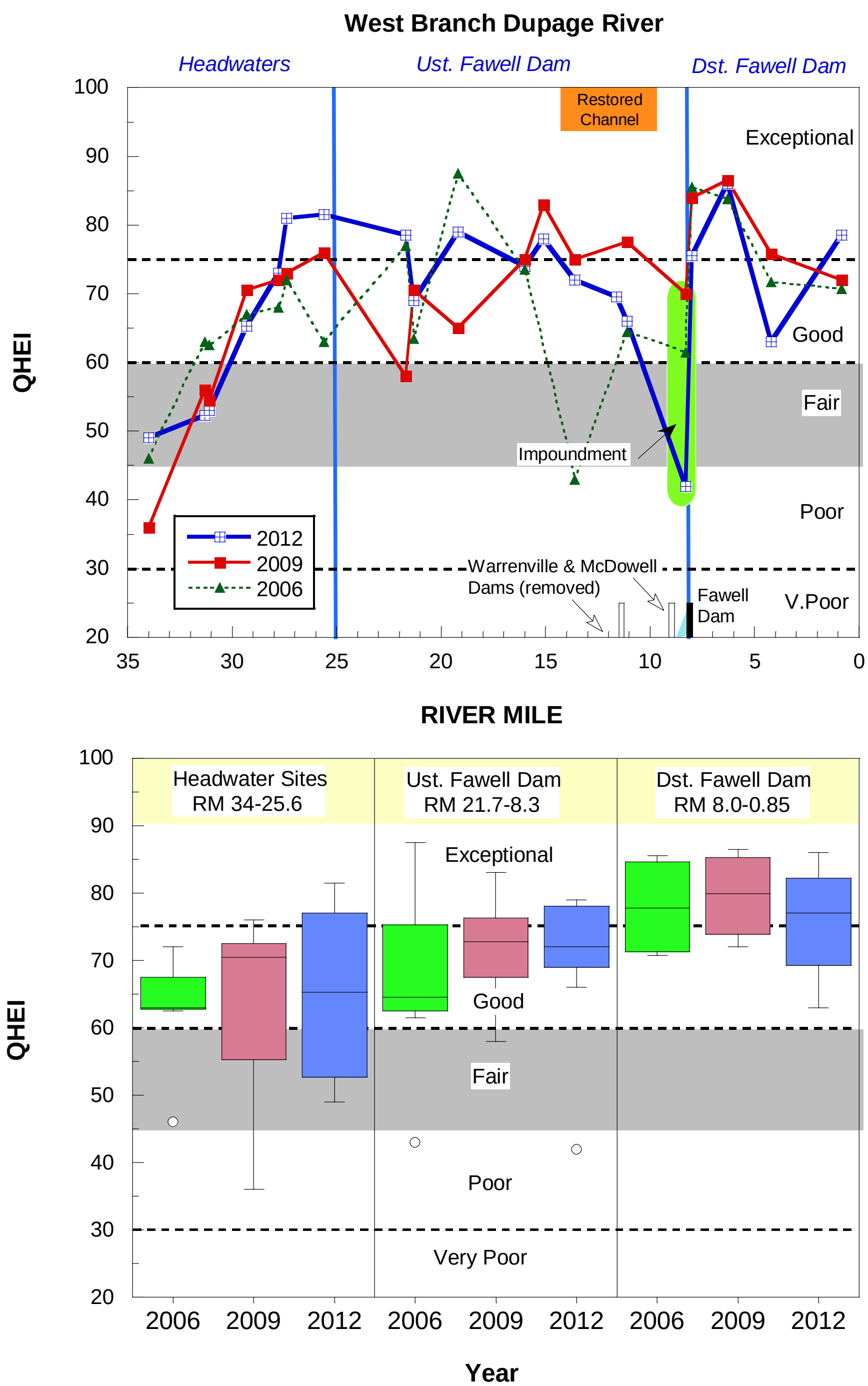


Figure 21. Longitudinal trends (top) and box and whisker plots (bottom) of Qualitative Habitat Evaluation Index (QHEI) scores from the West Branch DuPage River mainstem in 2006, 2009 and 2012. For display and data analysis purposes, the mainstem was subdivided into three sections: 1) headwaters 2) upstream Fawell Dam and 3) downstream Fawell Dam. The grey shaded region depicts fair range scores where habitat quality is limiting to aquatic life. QHEI scores less than 45 are typical of highly modified channels or dam pools.

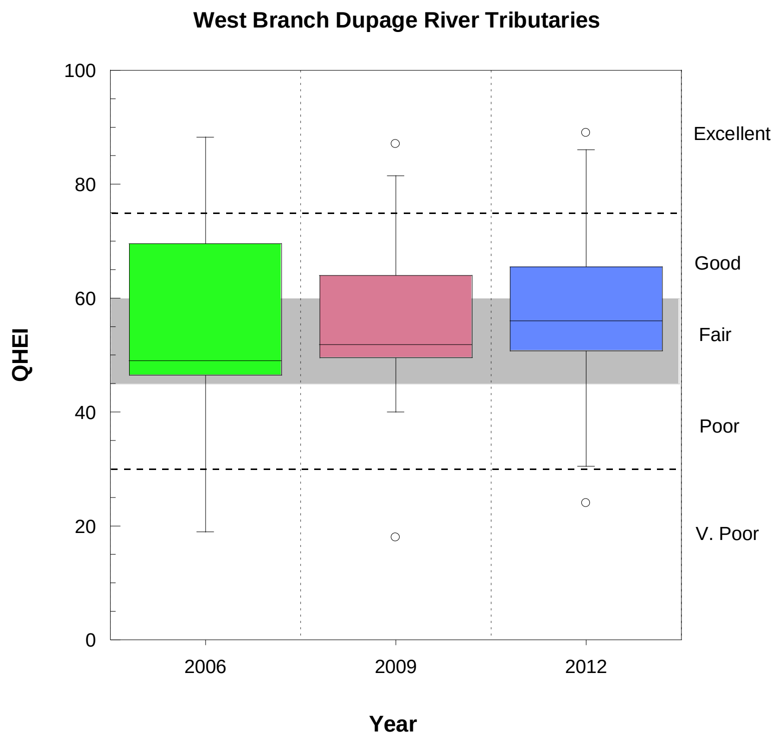


Figure 22. Distributions of QHEI scores in West Branch tributaries in 2006, 2009 and 2012.

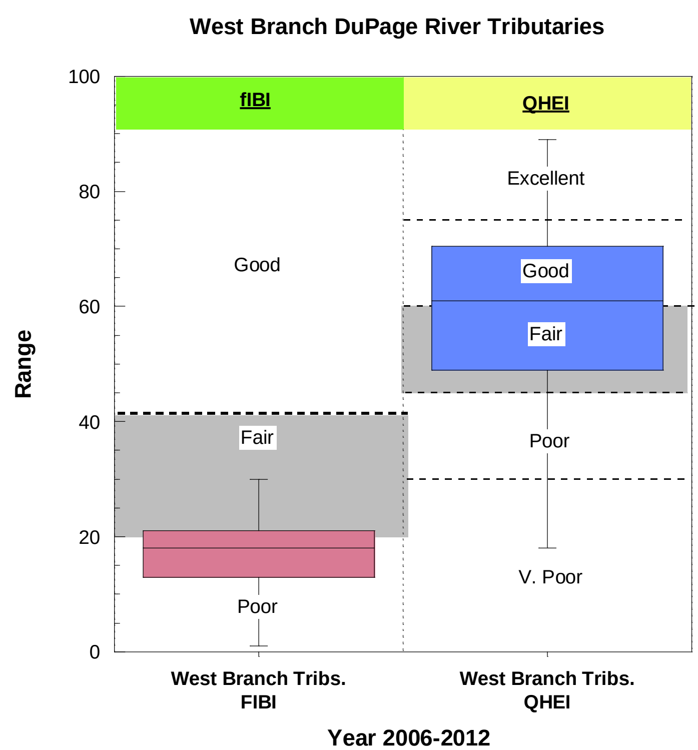


Figure 23. Box and whisker plot comparing fIBI scores and associated QHEI scores from West Branch tributaries in 2006, 2009 and 2012.

Relationships Between Habitat Quality and Biological Performance from Urban Headwater Tributaries (≤ 20 sq. mi.) in the West Branch DuPage and Adjacent Watersheds

All West Branch tributary sites in 2012 and previous West Branch surveys were considered headwater catchments of less than ≤ 20 sq. mi. The large majority were quite small, averaging 6.3 sq. mi. in drainage. While habitat quality in West Branch tributaries falls mostly in the fair and good ranges, all fish assemblages and the large majority of macroinvertebrates fell in the fair and poor ranges.

Based on fIBI and mIBI scores, biological condition in tributaries from the West Branch and throughout the entire DuPage River and nearby Salt Creek basins are universally impaired, regardless of habitat quality (Figure 24). Within this pool of sites, no headwater fish scored above fair and only a handful of macroinvertebrates have reached the good range. Adequate habitat quality is clearly a "prerequisite" for attaining general use goals. However, factors associated with urban development and runoff is clearly limiting headwater sites where habitat is otherwise adequate to support a warmwater aquatic life use. The suite of stressors in small urban streams shown to be important to aquatic life impairment includes alteration of natural flow regimes, dissolved constituents (e.g., chlorides and total dissolved solids), nutrients, and sedimentation. In some cases, toxicants association with road runoff and industrial and commercial development (e.g., metals, organic chemicals) can also accumulate in sediments.

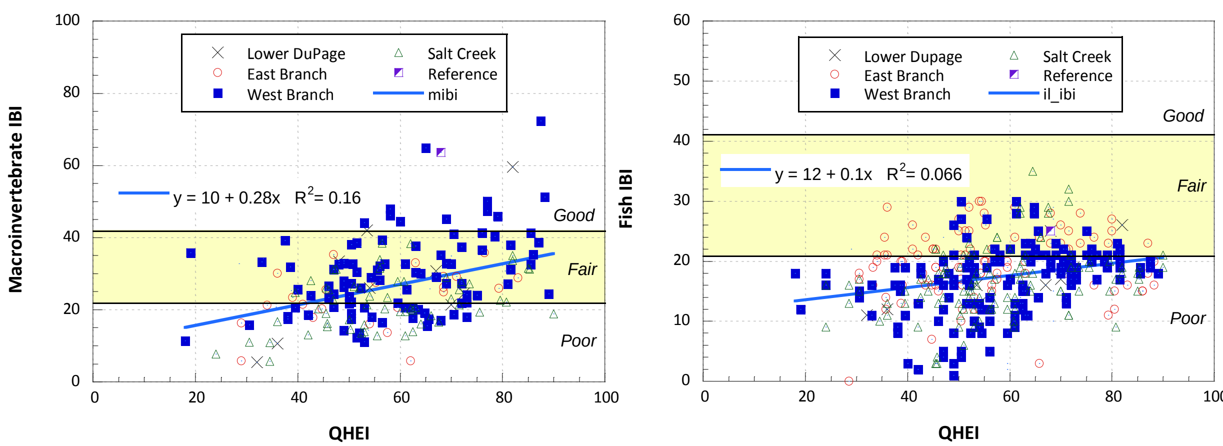


Figure 24. Plots of QHEI vs. Fish IBI (left) and Macroinvertebrate IBI (right) for headwater sites (< 20. Sq. mi.) sampled between 2006 and 2012 in the Lower DuPage, East Br., and West Br. DuPage Rivers, Salt Creek, and reference sites located in adjacent watersheds.

Table 13. Qualitative Habitat Evaluation Index (QHEI) scores showing Good and Modified Habitat attributes at sites in the West Branch DuPage River watershed during 2006, 2009, and 2012. ■ - good habitat attribute; ● - high influence modified attribute; ● - moderate influence modified attribute). Note: Site ID codes are updated to their most recent versions.

				Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	Year	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95-900 West Branch DuPage River – Year 2012																																			
WB25	2012	34.0	**49**		■		■		■					**3**		●			●	**2**	●	●				●			●	●	●		**6**	0.57	1.75
WB31	2012	31.3	**52.3**		■				■			■		**3**	●					**1**		●			●	●			●	●	●		**6**	0.57	1.75
WB24	2012	31.1	**53**		■				■	■		■		**4**	●		●			**2**					●					●	●		**3**	1.25	0.8
WB32	2012	29.3	**65.3**		■		■	■	■	■	■	■		**7**						**0**	●										●		**2**	2.67	0.38
WB27	2012	27.8	**73**	■	■			■	■		■	■	■	**7**						**0**		●		●	●				●				**4**	1.6	0.63
WB28	2012	27.4	**81**	■	■		■	■	■	■	■	■	■	**9**						**0**		●									●		**2**	3.33	0.3
WB20	2012	25.6	**81.5**	■	■		■	■	■	■	■	■	■	**9**						**0**		●											**1**	5	0.2
WB39	2012	21.7	**78.5**	■	■		■	■	■	■		■	■	**8**						**0**		●								●			**2**	3	0.33
WB33	2012	21.3	**69**	■	■			■	■	■		■		**6**						**0**		●			●					●	●		**4**	1.4	0.71
WB17	2012	19.2	**79**	■	■		■	■	■	■		■		**7**						**0**										●	●		**2**	2.67	0.38
WB38	2012	16	**74**	■	■		■	■	■	■	■	■		**8**						**0**		●		●					●		●		**4**	1.8	0.56
WB34	2012	15.1	**78**	■	■		■	■	■	■	■	■	■	**9**						**0**		●											**1**	5	0.2
WB12	2012	13.6	**72**		■				■		■	■	■	**5**						**0**	●				●	●			●				**4**	1.2	0.83
WB42	2012	11.6	**69.5**		■		■		■	■	■	■	■	**7**			●			**1**	●												**1**	4	0.25
WB40	2012	11.1	**66**		■				■	■		■		**4**						**0**	●				●	●				●	●		**5**	0.83	1.2
WB36	2012	8.3	**42**						■			■		**2**		●				**1**		●			●	●			●	●		●	**6**	0.43	2.33
WB41	2012	8.1	**75.5**		■				■	■	■	■	■	**6**	●		●			**2**		●			●								**2**	2.33	0.43
WB37	2012	6.3	**86**	■	■		■	■	■	■	■	■	■	**9**						**0**													**0**	10	0.1

Site ID	Year	River Mile	QHEI	Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
				No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
WB35	2012	4.2	63		■		■		■			■	■	5			●			1	●	●			●				●	●			5	1	1
WB08	2012	0.85	78.5	■	■		■		■		■	■	■	7						0						●			●				2	2.67	0.38
95-900 West Branch DuPage River – Year 2009																																			
WB25	2009	34.0	38		■			■	■					3	●	●			●	3		●			●				●	●	●		5	0.67	1.5
WB31	2009	31.3	56		■				■			■		3	●					1		●			●	●			●	●	●		6	0.57	1.75
WB24	2009	31.1	54.5		■				■		■	■	■	5	●		●			2					●				●				2	2	0.5
WB32	2009	29.3	70.5		■		■	■	■		■	■	■	7						0	●								●				2	2.67	0.38
WB27	2009	27.8	72	■	■		■	■	■			■		6						0		●							●	●	●		4	1.4	0.71
WB28	2009	27.4	73		■		■	■	■		■	■		6						0	●								●		●		3	1.75	0.57
WB20	2009	25.6	76		■		■	■	■		■	■	■	7						0	●								●				2	2.67	0.38
WB39	2009	21.7	58		■			■	■			■		4				●		1	●	●			●				●	●	●		6	0.71	1.4
WB33	2009	21.3	70.5	■	■					■	■	■	■	6				●		1					●	●							2	2.33	0.43
WB17	2009	19.2	65		■				■			■		3						0	●	●			●	●			●	●	●		7	0.5	2
WB38	2009	16	75	■	■		■	■	■		■	■		7						0									●		●		2	2.67	0.38
WB34	2009	15.1	83		■		■	■	■		■	■	■	7						0	●								●				2	2.67	0.38
WB12	2009	13.6	75	■	■		■		■	■	■	■	■	8				●		1						●							1	4.5	0.22
WB40	2009	11.6	77.5		■		■	■	■	■	■	■	■	8						0	●												1	4.5	0.22
WB36	2009	8.3	70		■			■	■			■	■	5						0		●			●				●	●			4	1.2	0.83
WB41	2009	8	84		■		■	■	■	■	■	■	■	8						0	●												1	4.5	0.22
WB37	2009	6.3	86.5		■		■	■	■	■	■	■	■	8						0	●												1	4.5	0.22
WB35	2009	4.2	75.8		■		■	■	■	■	■	■	■	8	●					1		●											1	4.5	0.22
WB08	2009	0.85	72		■				■	■	■	■	■	6						0	●				●	●							3	1.75	0.57
95-900 West Branch DuPage River – Year 2006																																			

Site ID	Year	River Mile	QHEI	Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
				No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
WB25	2006	34.0	**46**		■		■	■	■					**4**		●			●	**2**	●	●							●	●	●	●	**6**	0.71	1.4
WB31	2006	31.3	**63**		■				■	■	■	■	■	**6**	●					**1**		●			●	●							**3**	1.75	0.57
WB24	2006	31.1	**62.5**		■	■			■	■	■	■		**6**	●		●			**2**					●							●	**2**	2.33	0.43
WB32	2006	29.3	**67**		■		■	■	■	■	■	■	■	**8**						**0**	●												**1**	4.5	0.22
WB27	2006	27.8	**68**		■				■	■		■	■	**5**						**0**	●	●			●	●				●			**5**	1	1
WB27	2006	27.8	**68**	■			■	■	■			■		**5**		●				**1**		●							●	●	●		**4**	1.2	0.83
WB28	2006	27.4	**72**	■	■		■	■				■		**5**				●		**1**		●							●	●	●		**4**	1.2	0.83
WB20	2006	25.6	**63**	■			■	■				■		**4**		●		●		**2**		●							●	●		●	**4**	1	1
WB39	2006	21.7	**77**		■		■	■	■	■	■	■	■	**8**						**0**	●												**1**	4.5	0.22
WB33	2006	21.3	**63.5**		■				■		■	■		**4**						**0**	●				●	●			●			●	**5**	0.83	1.2
WB17	2006	19.2	**87.5**	■	■		■	■	■	■	■	■	■	**9**						**0**													**0**	10	0.1
WB38	2006	16.0	**73.5**	■	■		■	■	■		■	■		**7**						**0**		●							●		●		**3**	2	0.5
WB12	2006	13.6	**43**		■						■	■		**3**	●		●	●		**3**					●				●			●	**3**	1	1
WB40	2006	11.1	**64.5**	■			■	■	■			■		**5**		●				**1**		●							●	●		●	**4**	1.2	0.83
WB36	2006	8.3	**61.5**	■			■	■	■			■		**5**		●		●		**2**		●			●				●	●		●	**5**	1	1
WB41	2006	8.0	**85.5**	■	■		■	■	■	■		■	■	**8**						**0**		●							●	●			**3**	2.25	0.44
WB37	2006	6.3	**83.8**		■		■	■	■	■	■	■	■	**8**						**0**	●												**1**	4.5	0.22
WB35	2006	4.2	**71.8**		■				■	■		■	■	**5**						**0**	●	●			●	●				●			**5**	1	1
WB08	2006	0.85	**70.8**		■				■		■	■		**4**						**0**	●				●	●			●			●	**5**	0.83	1.2
95-902 Trib to West Branch DuPage River – Year 2006-2012																																			
WB18	2012	0.5	**55.5**		■				■					**2**					●	**1**	●	●			●	●			●	●	●		**7**	0.38	2.67
WB18	2009	0.5	**51.5**	■	■							■		**3**				●		**1**		●			●	●			●	●	●		**6**	0.57	1.75
WB18	2006	0.3	**37.5**						■					**1**		●			●	**2**	●	●			●	●			●	●		●	**7**	0.25	4

Site ID	Year	River Mile	QHEI	Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
				No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95-904 Trib to West Branch DuPage River – Year 2006-2012																																			
WB22	2012	0.15	**24**											**0**	●	●	●	●	●	**5**		●			●				●	●	●		**5**	0.17	6
WB22	2009	0.15	**18**									■		**1**	●	●	●	●		**4**		●			●		●		●	●		●	**6**	0.29	3.5
WB22	2006	1	**19**											**0**	●	●	●	●	●	**5**		●			●				●	●		●	**5**	0.17	6
95-905 Trib to West Branch DuPage River – Year 2006-2012																																			
WB23	2012	0.15	**33**						■			■		**2**	●	●	●			**3**		●			●				●	●		●	**5**	0.5	2
WB23	2009	0.15	**42.5**						■			■		**2**	●	●	●			**3**		●			●				●	●	●		**5**	0.5	2
WB23	2006	0.15	**38.5**						■					**1**	●	●			●	**3**		●			●	●			●	●		●	**6**	0.29	3.5
95-906 Trib to West Branch DuPage River - 2012																																			
WB29	2012	2.2	**61**		■		■		■					3					●	**1**	●					●			●	●	●		**5**	0.67	1.5
WB30	2012	1.9	**54**		■				■					2					●	**1**	●	●			●	●			●	●	●		**7**	0.38	2.67
WB21	2012	0.9	**61.3**		■			■	■			■		4						**0**	●	●			●				●	●		●	**6**	0.71	1.4
95-906 Trib to West Branch DuPage River - 2009																																			
WB29	2009	2.2	**40**											**0**	●		●	●	●	**4**		●			●				●	●	●		**5**	0.17	6
WB30	2009	1.9	**42**		■							■		**2**	●			●		**2**		●			●	●			●	●	●		**6**	0.43	2.33
WB21	2009	0.9	**64.8**	■				■	■			■		**4**						**0**		●		●	●				●	●	●		**6**	0.71	1.4
95-906 Trib to West Branch DuPage River - 2006																																			
WB29	2006	2.2	**47**		■				■					**2**	●		●		●	**3**		●			●				●	●		●	**5**	0.5	2
WB30	2006	1.9	**49**		■			■	■			■		**4**	●					**1**		●			●				●	●		●	**5**	0.83	1.2
WB21	2006	0.9	**49**					■	■			■		**3**	●	●				**2**		●			●				●	●		●	**5**	0.67	1.5
95-910 Kress Creek - 2012																																			
WB02	2012	5.1	**52**		■				■			■		3	●		●			**2**		●			●				●	●	●		**5**	0.67	1.5
WB01	2012	2.7	**61**		■				■			■		3	●					**1**		●			●	●			●	●	●		**6**	0.57	1.75
WB03	2012	0.5	**89**	■	■		■	■	■	■	■	■	■	9						**0**													**0**	10	0.1

Site ID	Year	River Mile	QHEI	Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
				No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95-910 Kress Creek - 2009																																			
WB02	2009	5.1	**47**						■			■		2		🔴	🔴			**2**	🟡	🟡			🟡				🟡	🟡	🟡		**6**	0.43	2.33
WB01	2009	2.7	**53**		■							■		2	🔴		🔴	🔴		**3**		🟡			🟡				🟡	🟡		🟡	**5**	0.5	2
WB03	2009	0.5	**81.5**		■		■	■	■		■	■	■	7						**0**	🟡								🟡				**2**	2.67	0.38
95-910 Kress Creek - 2006																																			
WB02	2006	5.1	**48**						■			■		2		🔴	🔴			**2**	🟡	🟡			🟡				🟡	🟡		🟡	**6**	0.43	2.33
WB01	2006	2.7	**60**		■				■			■		3			🔴			**1**	🟡	🟡			🟡				🟡	🟡	🟡	🟡	**7**	0.5	2
WB03	2006	0.5	**85.5**		■		■	■	■	■	■	■	■	8						**0**	🟡												**1**	4.5	0.22
95-920 Ferry Creek - 2012																																			
WB04	2012	2.8	**30.5**											0	🔴	🔴	🔴	🔴	🔴	**5**		🟡			🟡				🟡	🟡	🟡		**5**	0.17	6
WB06	2012	0.7	**51.5**		■				■					2			🔴	🔴	🔴	**3**	🟡	🟡			🟡				🟡	🟡	🟡		**6**	0.43	2.33
95-920 Ferry Creek - 2009																																			
WB04	2009	2.8	**49.5**						■			■		2		🔴				**1**	🟡	🟡			🟡	🟡			🟡	🟡		🟡	**7**	0.38	2.67
WB06	2009	0.7	**57**		■				■			■		3						**0**	🟡	🟡			🟡	🟡			🟡	🟡	🟡	🟡	**8**	0.44	2.25
95-925 West Branch Ferry Creek – Year 2006-2012																																			
WB05	2012	0.25	**65.5**	■	■		■	■	■					5					🔴	**1**		🟡							🟡	🟡	🟡		**4**	1.2	0.83
WB05	2009	0.25	**72**		■		■	■	■			■		5						**0**	🟡	🟡							🟡	🟡	🟡		**5**	1	1
WB05	2006	0.25	**70**	■	■		■	■	■		■			6					🔴	**1**		🟡							🟡	🟡	🟡		**4**	1.4	0.71
95-930 West Branch Cress Creek – Year 2006-2009																																			
WB07	2009	0.20	**69**		■			■	■		■	■	■	6				🔴		**1**	🟡	🟡			🟡				🟡				**4**	1.4	0.71
WB07	2006	0.20	**75**		■			■	■		■	■	■	6						**0**	🟡	🟡			🟡				🟡				**4**	1.4	0.71
95-940 Trib to West Branch DuPage River – Year 2006-2012																																			
WB09	2012	0.25	**50.5**	■				■	■					3		🔴			🔴	**2**		🟡			🟡				🟡	🟡	🟡		**5**	0.67	1.5
WB09	2012	0.25	**66**		■		■	■	■		■	■		6						**0**	🟡	🟡							🟡		🟡		**4**	1.4	0.71

				Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	**Year**	**River Mile**	**QHEI**	**No Channelization**	**Boulder, Cobble, Gravel**	**Silt Free**	**Good-Excellent Development**	**Moderate-High Sinuosity**	**Moderate-Extensive Cover**	**Fast Flow w Eddies**	**Little to No Embeddedness**	**Max Depth > 40 cm**	**No Riffle Embeddedness**	**"Good" Habitat Attributes**	**Channelized or No Recovery**	**Silt/Muck Substrates**	**No Sinuosity**	**Sparse No Cover**	**Max Depths <40 cm**	**High Influence Poor Attributes**	**Recovering from Channelization**	**Mod-High Silt Cover**	**Sand Substrates (Boatable sites)**	**Hardpan Origin**	**Fair- Poor Development**	**Low Sinuosity**	**≤ 2 Cover Types**	**Intermittent or Pools <20 cm**	**No Fast Current Types**	**Mod-Extensive Embeddedness**	**Mod-Extens. Riff. Embeddedness**	**No Riffle**	**Poor Habitat Attributes**	**Ration of Poor (High) to Good**	**Ration of Poor (All) to Good**
WB09	2009	0.25	**56**				■	■	■		■			4		●			●	**2**	●				●				●			●	**4**	1	1
WB09	2006	0.25	**47**	■	■			■						3		●		●	●	**3**		●			●				●	●	●	●	**6**	0.57	1.75
95-950 Spring Brook 2012																																			
WB11	2012	3.3	**39.5**		■				■			■		3	●		●			**2**		●			●				●	●		●	**5**	0.67	1.5
WB26	2012	3	**63.5**		■				■	■		■	■	5	●		●			**2**					●					●			**2**	2	0.5
WB10	2012	0.75	**76**		■		■		■	■	■	■		6						**0**	●	●				●					●		**4**	1.4	0.71
95-950 Spring Brook 2009																																			
WB11	2009	3.3	**51.5**		■				■			■		3	●		●			**2**		●			●	●			●	●	●		**6**	0.57	1.75
WB26	2009	3	**59.5**		■						■	■	■	4	●			●		**2**		●			●	●			●				**4**	1	1
WB10	2009	0.75	**64**		■		■				■	■	■	5				●		**1**	●	●				●			●	●			**5**	1	1
95-950 Spring Brook 2006																																			
WB11	2006	3.3	**49**		■				■					2	●		●		●	**3**		●			●				●	●		●	**5**	0.5	2
WB26	2006	3	**71**		■		■		■	■	■	■	■	7	●		●			**2**													**0**	8	0.13
WB10	2006	0.75	**81.5**		■		■		■	■	■	■	■	7						**0**	●					●							**2**	2.67	0.38
95-960 Winfield Creek 2012																																			
WB15	2012	5.4	**68**		■		■	■	■		■	■		**6**						**0**	●								●		●		**3**	1.75	0.57
WB14	2012	3.5	**53**		■		■		■					**3**	●		●		●	**3**		●							●	●	●		**4**	0.8	1.25
WB13	2012	0.4	**56.5**		■		■		■			■		**4**				●		**1**	●	●				●			●	●	●		**6**	0.71	1.4
95-960 Winfield Creek 2009																																			
WB15	2009	5.4	**50**		■									**1**	●			●	●	**3**		●			●	●			●	●	●		**6**	0.29	3.5
WB14	2009	3.5	**50.5**		■							■		**2**	●		●	●		**3**		●			●				●	●	●		**5**	0.5	2
WB13	2009	0.4	**50.5**		■				■			■	■	**4**	●			●		**2**		●			●	●			●	●			**5**	0.83	1.2
95-960 Winfield Creek 2006																																			
WB15	2006	5.4	**47**		■									1	●			●	●	**3**		●			●	●			●	●	●	●	**7**	0.25	4

				Good Habitat Attributes											High Influence Modified Attributes						Moderate Influence Modified Attributes													Ratios	
Site ID	Year	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth > 40 cm	No Riffle Embeddedness	"Good" Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boatable sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤ 2 Cover Types	Intermittent or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extens. Riff. Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
WB14	2006	3.5	**46**		■						■	■		3	●		●	●		**3**		●			●				●	●	●		**5**	0.67	1.5
WB13	2006	0.4	**45.5**		■				■			■		**3**	●					**1**		●			●	●			●	●		●	**6**	0.57	1.75
95-970 Klein Creek 2012																																			
WB19	2012	3.6	**50.8**		■				■					**2**	●		●		●	**3**					●				●	●	●		**4**	0.6	1.67
WB16	2012	1	**86**	■	■		■	■	■	■	■	■	■	**9**						**0**													**0**	10	0.1
95-970 Klein Creek 2009																																			
WB19	2009	3.6	**54.3**		■				■		■	■		**4**	●		●			**2**					●				●	●	●		**4**	1	1
WB16	2009	1	**87**		■		■	■	■	■	■	■	■	**8**						**0**	●												**1**	4.5	0.22
95-970 Klein Creek 2006																																			
WB19	2006	3.6	**56.5**		■		■		■		■		■	**5**	●		●		●	**3**		●							●				**2**	2	0.5
WB16	2006	1	**88.3**		■		■	■	■	■	■	■	■	**8**						**0**	●												**1**	4.5	0.22

West Branch DuPage River Watershed Biological Assemblages – Macroinvertebrates

Macroinvertebrates were collected from 42 mainstem and tributary sites in 2012. Figure 25 depicts associated mIBI narrative evaluations for each location. As a rule, tributary and upper mainstem sites were in the poor to fair ranges while middle and lower mainstem sites vacillated between the fair and good ranges.

West Branch DuPage River

With few exceptions, West Branch macroinvertebrate assemblages from the upper, headwater reach (*i.e.,* upstream RM 25) reflected degraded but similar quality between 2006 and 2012 (Figure 27). The combination urban drainage, marginal habitat quality and a series of four major WWTP discharges in the small drainage were considered major contributors.

In both 2009 and 2006, major improvement in mIBI scores and clearly good mIBI ratings were first detected at station WB17 (RM 19.2), immediately upstream from Klein Creek and the Carol Stream WWTP. In 2009, consistently good quality was maintained along the remaining length of the West Branch downstream to the mouth. In 2006, this downstream improving trend was more erratic; still 5 of the 8 sites between Klein Creek and the mouth exceeded Illinois criteria. In contrast, the 2012 trend was much less distinct as narrative ratings vacillated between a fair or lower good range status through most of the lower 20 mainstem river miles.

There are several possible explanations for the differences in quality between surveys. In the three instances where mIBI scores decline from “good” to “fair” between 2009 and 2012, differences in sampling location, substrate composition or habitat quality may account for some declines. Included was site WB35 (RM 4.2) which was sampled downstream from the Pioneer Park bridge in 2009 and included riffle habitats with an abundance of coarse substrates. Sampling in 2012 was conducted just upstream from the bridge in a sluggish reach with a bottom of fine silts, sands and gravels that could produce comparatively lower quality populations. At WB36 (RM 8.3) direct comparisons between surveys are not considered valid as 2012 samples was collected immediately behind the Fawell Dam and 2009 sampling was conducted entirely upstream from the impoundment (Re-named as site WB36”B” at RM 8.6). WB12 at RM 13.6 was sampled from roughly the same reach but 2009 sampling included a greater proportion of riffle/run habitat and coarse substrates. Even when these scores are removed from consideration, a trend of decline over the lower 20 mainstem river miles in 2009-12 remains apparent.

Sampling variation between surveys does not entirely explain the differences in mIBI trends. When compared to summer flow conditions, 2006-2012 survey performance follows the higher to lower base flow conditions recorded during each sampling period (see flow hydrographs in Figure 7). For example, outside of the mainstem headwaters, highest quality assemblages over the lower 20 river miles in 2009 (Avg. mIBI = 59.4) were collected under higher base flows and with presumably greater dilution. In 2012, low base flows coincide with comparatively lower macroinvertebrate performance (Avg. mIBI = 40.7) and a greater potential for summer low-flow stresses and increased effluent dominance. In 2006, base flows and mIBI scores (Avg. mIBI= 48.0) tended to fall between the extremes of 2009 and 2012. Based on 2006-2012 results,

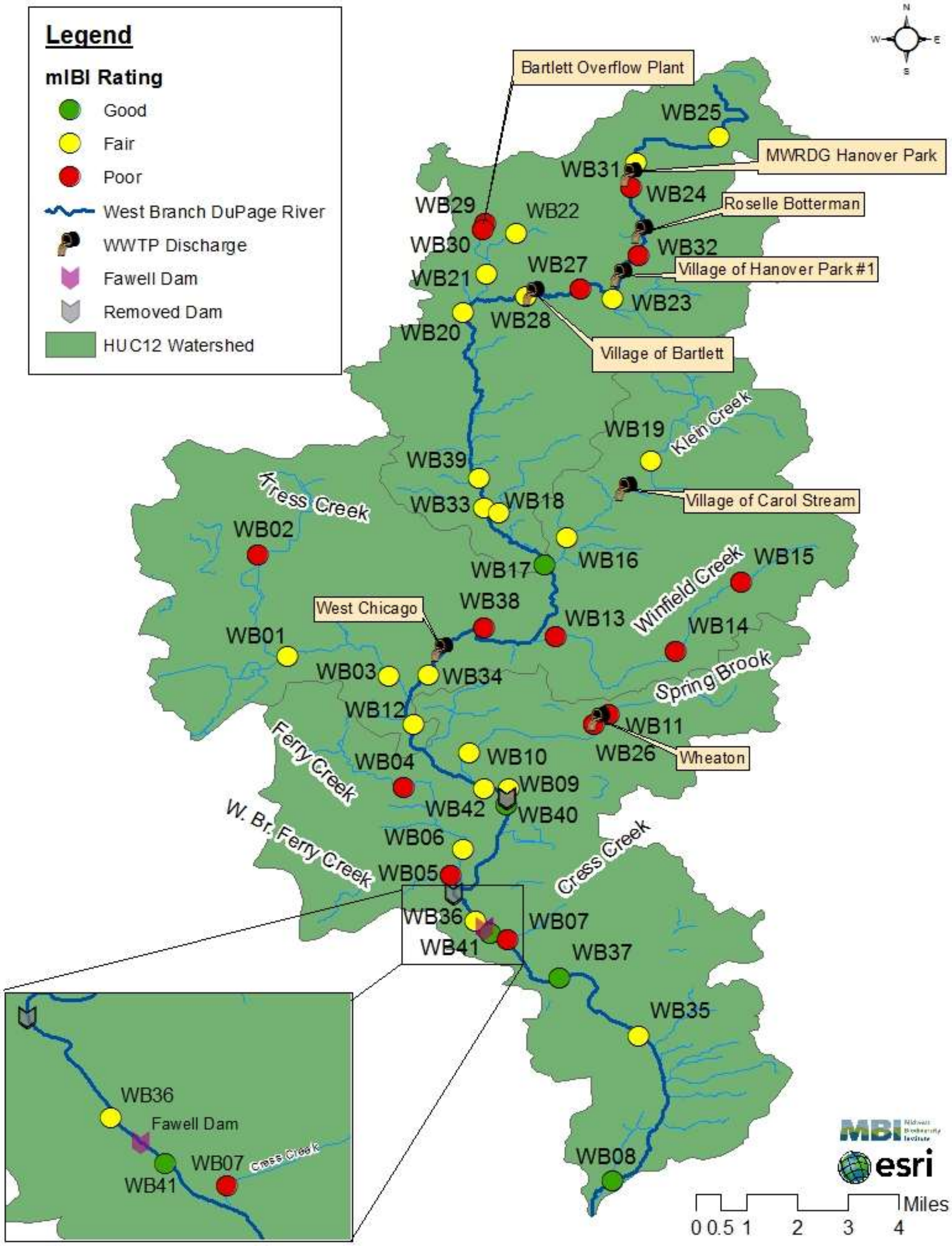


Figure 25. West Branch DuPage River watershed mIBI scores in 2012 mapped by Illinois EPA narrative ranges. Wedge-shaped symbols denote existing and former dams while discharge pipes denote WWTP locations. Note: A low-head dam on Spring Brook, immediately upstream from WB10, is not shown.

trends in mIBI performance appear partially related to physical habitat or stream sampling location variability. However, the combination of low flow stresses in the increasingly effluent dominated reach was considered the primary driver of benthic performance. Persistent, severe impairment in the upper mainstem suggest overriding habitat, urban runoff, and point source influences at the small drainage level.

West Branch DuPage River Tributaries

After declining between 2006 and 2009, macroinvertebrate IBI scores from West Branch tributaries were stable from 2009 to 2012 (Figure 26). Narrative ratings in 2006 were almost entirely fair and included one site (WB01/Kress Creek RM 2.7) that exceeded Illinois criteria. Since that time, median mIBI scores have declined over 8 points and by 2012, all scores reflected poor to fair quality. Declines since 2006 happen to coincide with increasingly higher chloride levels in the tributaries over the same period (see Figure 15, lower left). In 2009, better than 75% of chlorides exceeded levels associated with macroinvertebrate impairment (120 mg/l) and by 2012, over 75% exceeded less stringent levels associated with fish impairment (140 mg/l). In contrast to the larger mainstem sites, where variation in quality from year to year tended to follow the contrasting summer base flow and effluent contributions, flow did not have a noticeable effect at the small drainage level. In this instance, the overriding influences associated with the surrounding urban landscape exceeded flow variability.

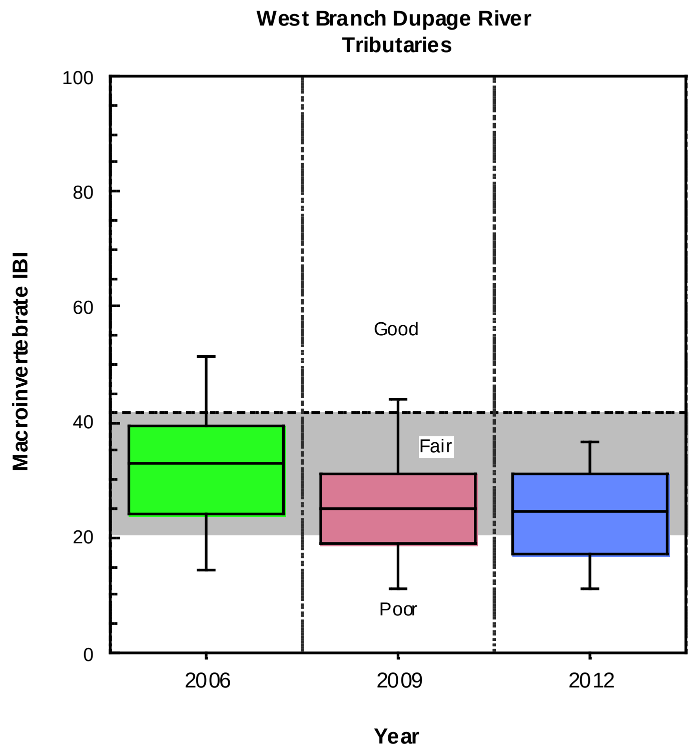


Figure 26. Box and whisker plot of mIBI scores from West Branch DuPage River basin tributaries in 2006, 2009 and 2012.

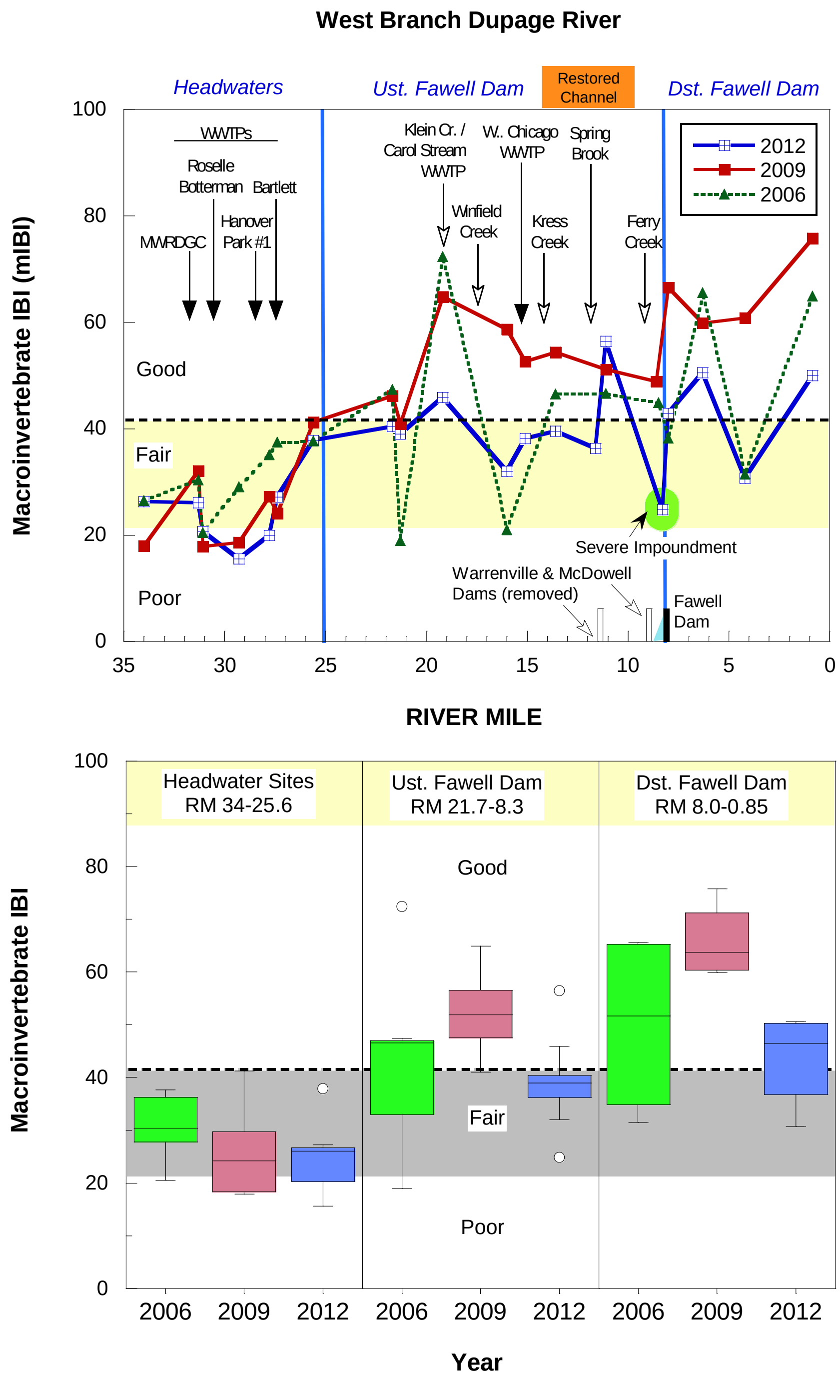


Figure 27. Longitudinal trends (top) and box and whisker plots (bottom) of macroinvertebrate Index of Biotic Integrity scores from the West Branch DuPage River mainstem, 2006, 2009 and 2012 in relation to publicly owned sewage treatment plants (top) and the existing Fawell Dam. For display and data analysis purposes, the mainstem was subdivided into three sections: 1) headwaters 2) Upstream Fawell Dam and 3) Downstream Fawell Dam. The dashed horizontal line corresponds to the benchmark score for unimpaired streams.

West Branch DuPage River Watershed Biological Assemblages – Fish

Fish assemblages were sampled from 42 West Branch mainstem and tributary sites in 2012. Figure 28 depicts associated fIBI narrative evaluations for each location. All survey sites fell consistently in the poor or lower fair ranges with slightly higher scores downstream from RM 8.1 and the Fawell Dam. No West Branch sites met the 41-point criterion synonymous with a good quality assemblage.

West Branch DuPage River

Like previous surveys in 2006 and 2009, fish were sampled at twenty locations along the length of the West Branch mainstem in 2012 and no fIBI scores met the benchmark score of 41. As in the past, the best scores were observed downstream from the Fawell Dam (RM 8.1) in the lower eight river miles. Upstream from the dam, the longitudinal pattern of poor to marginally fair fIBI scores continued and remained nearly identical to that found in 2006-2009 (Figure 29). All 16 sites upstream from the Fawell Dam were poor or within two fIBI points of the poor range (Avg. fIBI = 17.7), indicating consistently low performance.

The most recent survey results continue to indicate little relation in fish quality to the locations of wastewater plants (see Figure 21). Mainstem assemblages were already severely impaired in the highly urbanized headwaters and experienced minimal change downstream between the headwaters and Fawell Dam. To date, removal of the Warrenville and McDowell Grove low head dams between 2011 and 2012 has not resulted in any significant improvement through the same reach, although potential movement after removal of the McDowell Grove dam was offset by the immediate construction of a temporary cofferdam just upstream. In the restored channel between RMs 14 and 9, improved fish performance was considered a possibility since work was completed immediately prior to sampling in 2009. However, only minimal positive change occurred within the reach by 2012, after allowing three additional years for recovery.

Fish performance upstream from the Fawell Dam remains essentially unchanged despite improved or adequate habitat quality, stream channel restoration, removal of contaminated sediments, and variable flow and effluent quality. In contrast, a sharp and consistent trend of improved quality has been noted downstream from the dam during the same period. Results suggest a strong link between this remaining impediment to fish movement and the quality of West Branch populations up and downstream. As a result, fish distribution patterns in the West Branch mainstem were evaluated to assess further, the influence of the structure.

Influence of Dams on West Branch DuPage River Fish Assemblages

West Branch fish species collected upstream and downstream from the Fawell Dam were examined to assess the potential effect of the structure on fish distribution and performance. Twenty-seven species were found in the 25 mile reach upstream from the dam while 29 were found in the 8.1 mile reach downstream (Table 14). While the numbers of species between reaches are close, the upstream catch is based on four times the collection effort (i.e., 4x the number of sampling sites) as downstream since 2006. When all collection years are included, species richness totals 33 upstream from the dam and 40 downstream. Excluding hybrids, eight species have been collected solely upstream from the dam while 15 were restricted

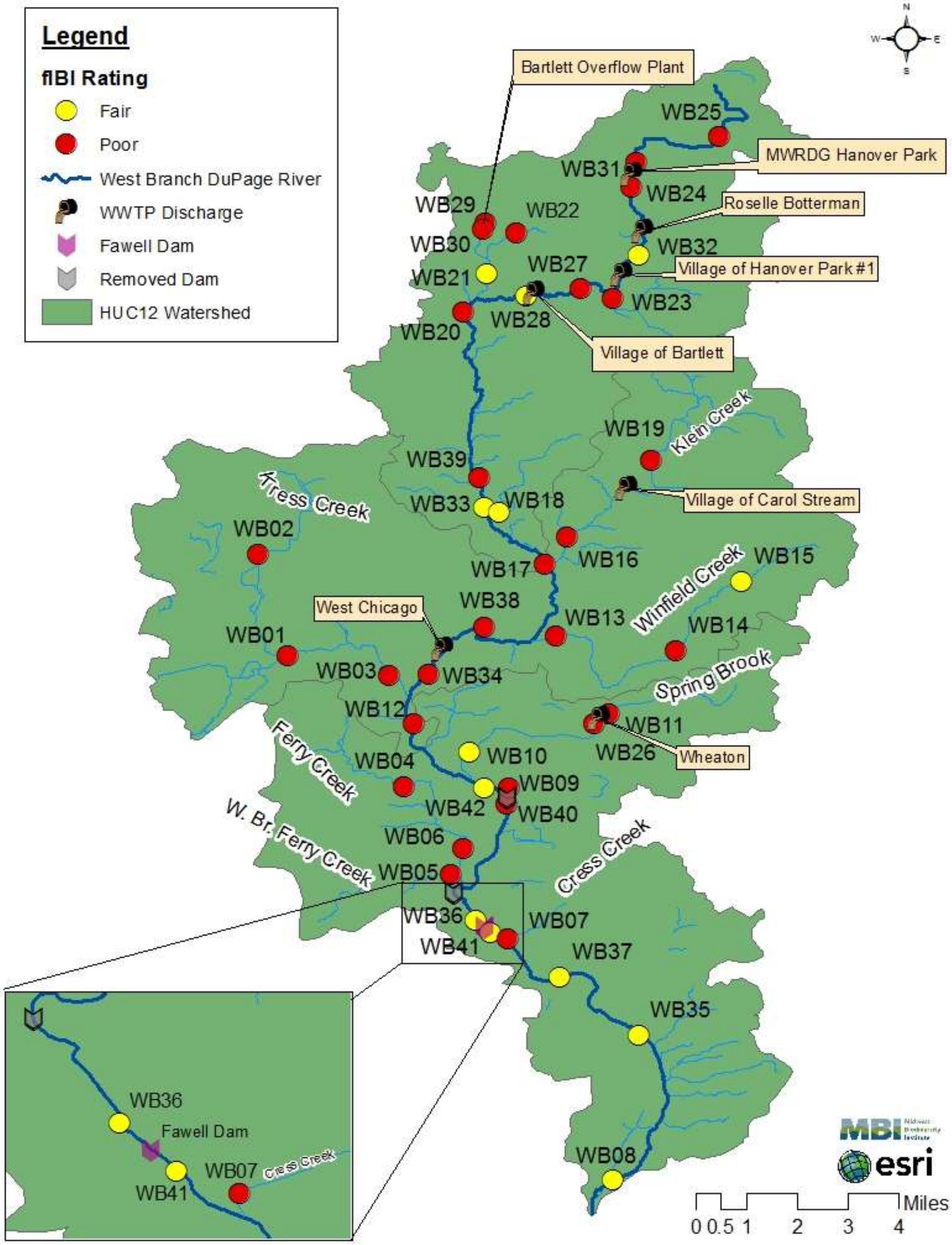


Figure 28. W. Br. DuPage River watershed fIBI scores in 2012 mapped by Illinois EPA narrative range (no sites met good or exceptional criteria). Wedge-shaped symbols denote existing and former dams while discharge pipes denote WWTP locations. Note: A low-head dam on Spring Brook, immediately downstream from WB10, is not shown.

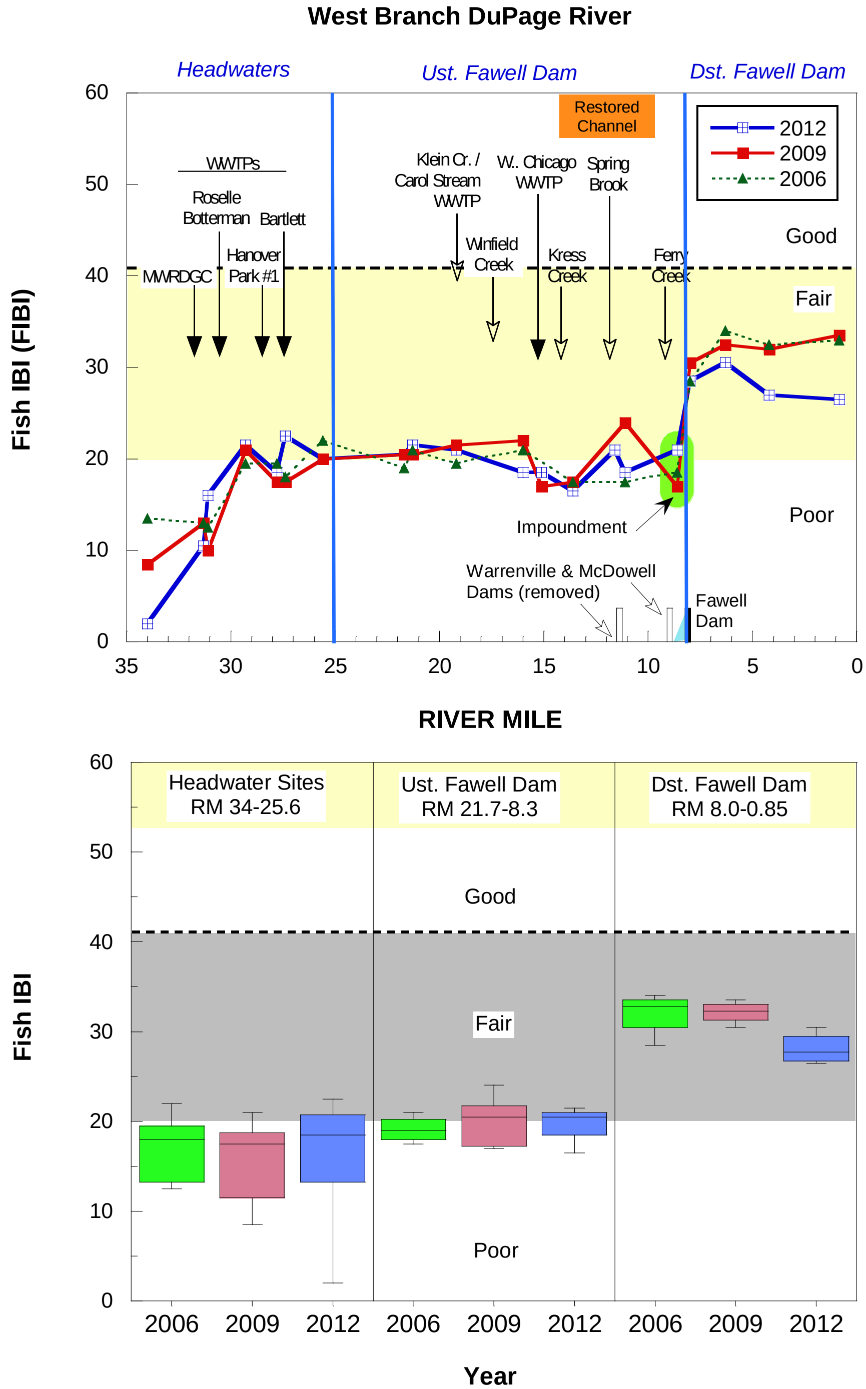


Figure 29. Longitudinal trends (top) and box and whisker plots (bottom) of fish Index of Biotic Integrity scores from the West Branch DuPage River mainstem, 2006, 2009 and 2012 in relation to publicly owned sewage treatment plants (top) and the existing Fawell Dam. For display and data analysis purposes, the mainstem was subdivided into three sections: 1) headwaters 2) Upstream Fawell Dam and 3) Downstream Fawell Dam. The dashed horizontal line corresponds to the benchmark score for unimpaired streams.

to the downstream reach.

The 2012 collections represent the highest number of species found in any sampling year, both in the upstream and downstream reaches. However, fish community performance, as reflected by fIBI scoring trends, has remained consistently impaired. Certainly, elimination or modification of the Fawell Dam will enhance population movements upstream. At the same time, continued water quality impairment along the mainstem will likely inhibit biological performance and potentially limit improvements in the reach.

In contrast to the middle and lower mainstem, the influence of the Fawell Dam on fish at headwater and small tributary sites was not considered as significant. West Branch populations from the middle and lower river reaches tend to be associated with larger drainages and were less typical of headwater collections. In addition, levels of impairment observed at most tributary sites were more attributable to the pervasive urban landscape than the impoundments located well downstream.

Table 14. West Branch DuPage River fish species collected upstream and downstream from the Fawell Dam in between 1976 and 2012. Species unique to a reach are highlighted in blue. Years each species was collected in a reach is given by a superscript.

Fish Species Common Name	Fish Species Latin Name	Ust. Fawell Dam (Ust. RM 8.1)	Downstream of Fawell Dam (RM 0.0-8.0)
Hornyhead chub	*Nocomis biguttatus*		$X^{06,09,12}$
Central stoneroller	*Campostoma anomalum*		$X^{76,83,06,09,12}$
Northern hog sucker	*Hypentelium nigricans*		X^{12}
Striped shiner	*Luxilus chrysocephalus*		$X^{76,03,12}$
Banded darter	*Etheostoma zonale*		X^{12}
Blackstripe topminnow	*Fundulus notatus*		$X^{03,12}$
Rock bass	*Ambloplites rupestris*		$X^{03,09,12}$
Bigmouth shiner	*Notropis dorsalis*		$X^{76,83,03}$
Shorthead redhorse	*Moxostoma macrolepidotum*		X^{09}
Emerald shiner	*Notropis atherinoides*		$X^{76,09}$
Largescale stoneroller	*Campostoma oligolepis*		X^{06}
Flathead catfish	*Pylodictis olivaris*		X^{09}
Tadpole madtom	*Noturus gyrinus*		$X^{06.09}$
White perch	*Morone americana*		X^{09}
Longear sunfish	*Lepomis megalotis*		X^{06}
Northern Pike	*Esox lucius*	X^{12}	
Grass pickerel	*Esox americanus vermiculatus*	$X^{83,12}$	
Yellow perch	*Perca flavescens*	X^{12}	
Gizzard Shad	*Dorosoma cepedianum*	X^{12}	
Central mudminnow	*Umbra limi*	$X^{09,12}$	
Yellow Bass	*Morone mississippiensis*	X^{06}	
Redear sunfish	*Lepomis microlophus*	X^{09}	
White crappie	*Pomoxis annularis*	$X^{83, 06}$	
River carpsucker	*Carpiodes carpio carpio*	$X^{06, 12}$	X^{12}
White sucker	*Catostomus commersoni*	$X^{83, 03, 06,09,12}$	$X^{76,83,03,06,09,12}$
Common carp	*Cyprinus carpio*	$X^{83,06,09,12}$	$X^{76,83,06,09,12}$
Golden shiner	*Notemigonus crysoleucas*	$X^{83, 06,09,12}$	$X^{76,83,12}$
Creek chub	*Semotilus atromaculatus*	$X^{83,03,06,09,12}$	$X^{76,83,03,06,09,12}$
Spotfin shiner	*Cyprinella spiloptera*	$X^{03,06,09,12}$	$X^{76,83,03,06,09,12}$
Sand shiner	*Notropis stramineus*	$X^{83,03,06,09,12}$	$X^{76,83,03,06,09,12}$
Bluntnose minnow	*Pimephales notatus*	$X^{76,83,03,06,09,12}$	$X^{76,83,03,06,09,12}$
Fathead minnow	*Pimephales promelus*	$X^{76,83,03,06,09,12}$	$X^{76,83,03,12}$
Yellow Bullhead	*Ameiurus natalis*	$X^{03, 06,09,12}$	$X^{83,03,06,09,12}$
Black bullhead	*Ameiurus melas*	$X^{76,83,03,06,09,12}$	$X^{76,83,03,06,09,12}$
Stonecat madtom	*Noturus flavus*	$X^{09,12}$	$X^{03,09,12}$
Black crappie	*Pomoxis nigromaculatus*	$X^{03,06,09,12}$	$X^{76,83,03,06,09,12}$
Smallmouth bass	*Micropterus dolomieui*	$X^{03,06,09,12}$	$X^{03,06,09,12}$
Largemouth bass	*Micropterus salmoides*	$X^{83,06,09,12}$	$X^{83,03,06,09,12}$

Fish Species Common Name	Fish Species Latin Name	Ust. Fawell Dam (Ust. RM 8.1)	Downstream of Fawell Dam (RM 0.0-8.0)
Green sunfish	*Lepomis cyanellus*	X[76,83,03,06,09,12]	X[76,83,03,06,09,12]
Bluegill sunfish	*Lepomis macrochirus*	X[03,06,09,12]	X[76,83,03,06,09,12]
Orangespotted sunfish	*Lepomis humilis*	X[76,83,03,06,09,12]	X[06,09,12]
Pumpkinseed sunfish	*Lepomis gibbosus*	X[09,12]	X[12]
Western mosquitofish	*Gambusia affinis*	X[12]	X[03,12]
Channel catfish	*Ictalurus punctatus*	X[12]	X[12]
Johnny darter	*Etheostoma nigrum*	X[12]	X[03,06,09,12]
Quillback carpsucker	*Carpiodes cyprinus*	X[03]	X[83,03]
Goldfish	*Carassius auratus*	X[83,06,09]	X[83]
Brown bullhead	*Ameiurus nebulosus*	X[06]	X[06]
Total Species: All Years (2012)		**33 (27)**	**40 (29)**

* Hybrids are not included in the species list.

Longitudinal Patterns in the MIwb

The Modified Index of well-being (MIwb) is a composite fish index that includes measure of diversity based on abundance and biomass as well as log-weighted factors related to the total biomass and abundance at a site. The index ranges from zero to approximately 12, but the "good" criterion value of 8.0 is considered a reasonable expectation in the West Branch DuPage, especially at sites above 20 square miles in drainage. This is particularly true where habitat scores approach or exceed 60-70.

The MIwb values at West Branch mainstem sites greater than headwater size are below what would be expected for the existing habitat and represent a lowering of diversity and biomass likely related to the point source impacts and enrichment identified in this river (Figure 30). In general, the MIwb sites from 2012 are more impaired than in 2009 and 2006 particularly in the downstream reaches of the river. The only sites that are approaching of exceeding an 8.0 are in the lower reach downstream from all dams during 2009. Although sites with better habitat generally perform better than sites with poorer habitat, the MIwb values are not habitat limited, but likely impaired by nutrients and other chemical stressors. The MIwb stressor signal is consistent with that observed in the IBI and several of its metrics.

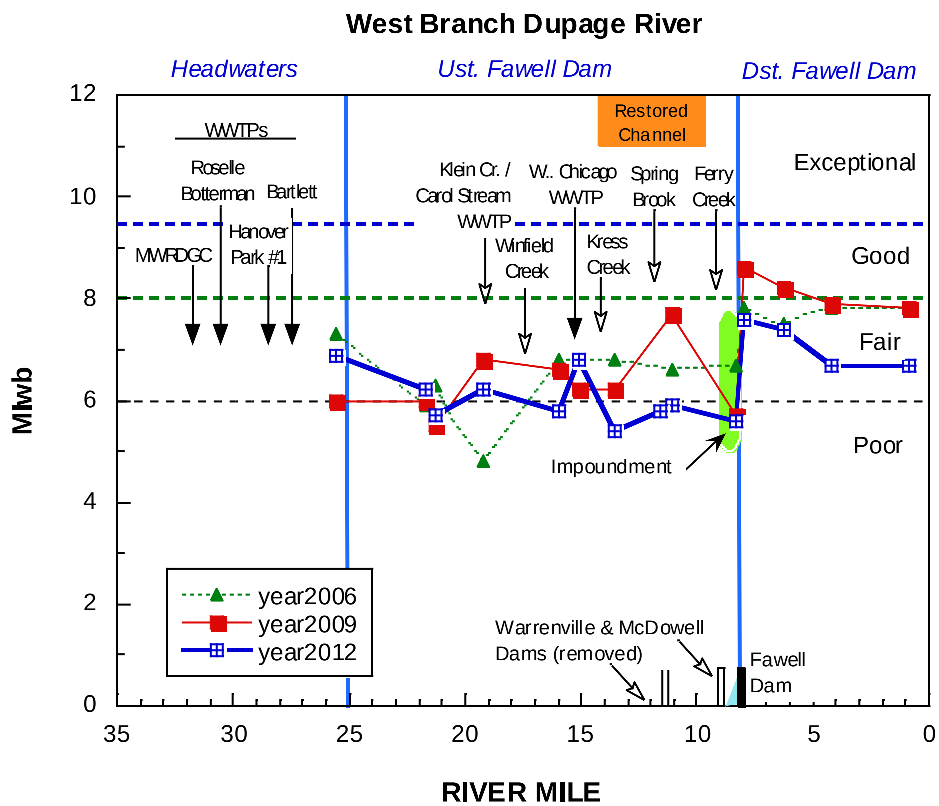


Figure 30. Mean Modified Index of well-being (MIwb) in the West Branch of the DuPage River. Bars along the x-axis note locations of existing dams. The dashed green line represents a general threshold between good and fair ranges of the MIwb and the dashed blue line between good and excellent

West Branch DuPage River Tributaries

Fish assemblages from West Branch tributary sites reflected nearly identical conditions to that found in 2009 and 2006 (*Figure 31*). During each survey, performance based on fIBI scores reflect chronic and severe impairment; most assemblages were poor quality and no fIBI scores approached the benchmark of 41. To illustrate, out of 20 tributary sites replicated between 2012 and 2009, 16 remained in the poor range, 3 improved from the poor to lower fair range (WB18, WB21 and WB15) and one declined from lower fair to poor (WB06). As in previous surveys throughout the DuPage watershed, tributary sampling was mostly restricted to small, urban drainages. In fact, 73% of sites were in the 2-5 square mile range (n = 22) and 91% were less than 10 sq. mi.

Modest improvements in the fIBI at WB15 and WB18 coincided with an average 19-point increase in the QHEI since 2006. From field observations, the increase in QHEI appeared to reflect recovery of the historically modified channel. In contrast, no obvious cause of improvement was apparent at WB21, where the fIBI increased from 18 to 29 and habitat quality was very stable between surveys (QHEI = 61.3 and 64.8, respectively). The site is located about a mile downstream from the Bartlett WWTP excess flow plant, a potential, but intermittent, discharge source.

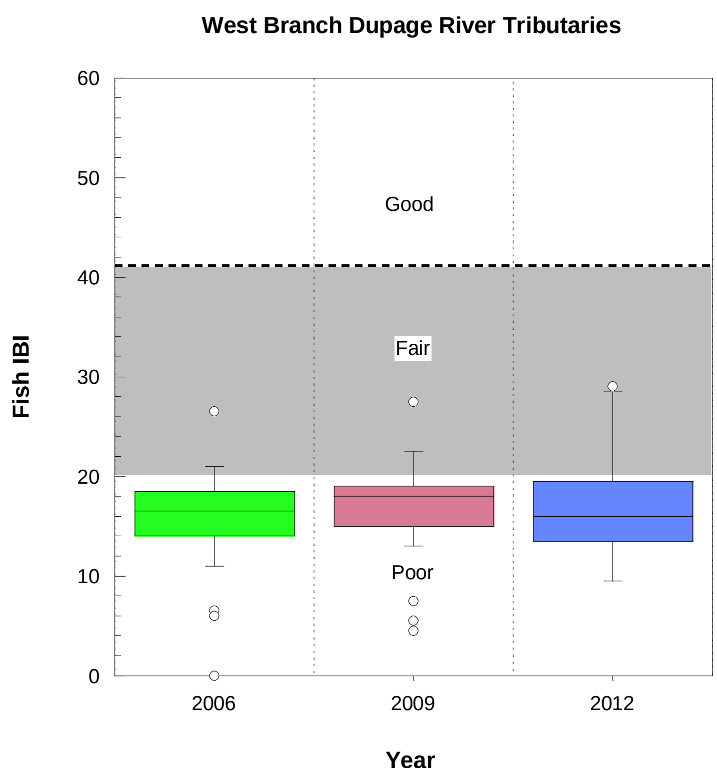


Figure 31. Box and whisker plot of fish Index of Biotic Integrity scores from West Branch DuPage River basin tributaries in 2006, 2009 and 2012.

The 2009 bioassessment report concluded that habitat quality and drainage area (considered a proxy for stormwater in the largely urbanized landscape) were the primary causes of impairment in the basin and this trend was largely confirmed in 2012. The most recent survey results were also in line with other tributary sampling conducted throughout the DuPage River basin. In fact, no stream or tributary site draining less than 20 sq. mi. has fully attained the Illinois biological thresholds within the DuPage River basin or the adjacent, Salt Creek watershed, since MBI assessments were initiated in 2006 (see Figure 24).

The Arrow Road low-head dam impoundment is located on lower Spring Brook, immediately upstream from station WB10. Two impaired Spring Brook sites were located upstream from the dam at stations WB11 (RM 3.3) and WB26 (RM 3.0). Loss of connectivity with downstream fish populations could have a potential negative effect on these assemblages. For this reason, species richness, catch lists, and fIBI trends were examined and compared to other small tributary sites in the watershed to detect potential differences. However, the pervasive levels of West Branch fish impairment at the small drainage level (i.e., <5 sq. mi.) made it difficult to evaluate the potential effects of the dam. Analysis was further confounded by the presence of the Wheaton WWTP discharge, which brackets the two Spring Brook sites, and poor habitat quality (QHEI=39.5) at the most upstream site.

REFERENCES

Allan, J. D. 2004. Landscapes and riverscapes: The influence of land use on stream ecosystems. Annu. Rev. Ecol. Evol. Syst. 35:257-284.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian sediment quality guidelines for the protection of aquatic life: Polycyclic aromatic hydrocarbons (PAHs). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

CH2MHill. 2004. Total Maximum Daily Loads for the East Branch of the DuPage River, Illinois. Prepared by CH2M HILL Inc., 727 North First Street, Suite 400, St. Louis, Mo 63102-2542 for the Illinois EPA P.O. Box 19276, 1021 North Grand Avenue East, Springfield, IL 62794-9276.

Chicago Metropolitan Agency for Planning (CMAP) 2005. Land use data.

Cooly, J.L. 1976. Nonpoint pollution and water quality monitoring. J. Soil Water Cons., March-April: 42-43.

Conservation Foundation. 2011. Lower DuPage River Watershed Plan, June 2011, Technical Report. The Conservation Foundation, Naperville, Illinois.

Conservation Foundation. 2003a, ASSESSMENTS OF THE IMPACTS OF DAMS ON THE DUPAGE RIVER, JENNIFER HAMMER AND ROBERT LINKE P.E. PRINCIPAL INVESTIGATORS. OCTOBER 2003

Conservation Foundation. 2003b, ASSESSMENTS OF THE IMPACTS OF DAMS ON THE DUPAGE RIVER, Section 4 – Hammel Woods Dam. JENNIFER HAMMER AND ROBERT LINKE P.E. PRINCIPAL INVESTIGATORS. OCTOBER 2003

Ervin, G. N. and R. G. Wetzel. 2003. An ecological perspective of allelochemical interference in land–water interface assemblages. Plant and Soil 256: 13–28, 2003

Heiskary, Steven, and Markus, Howard, 2003, Establishing relations among in-stream nutrient concentrations, phytoplankton and periphyton abundance and composition, fish and macroinvertebrate indices, and biological oxygen demand in Minnesota USA rivers—Final Report to USEPA Region V: St. Paul, Minn., Minnesota Pollution Control Agency, 100 p.

Illinois EPA. 2011. Illinois Integrated Water Quality Report and Section 303(D) List – 2010, Clean Water Act Sections 303(d), 305(b) and 314 Water Resource Assessment Information and Listing of Impaired Waters, Volume I: Surface Water, December 2011, Illinois Environmental Protection Agency. Bureau of Water.

Illinois EPA. 2005. Methods of collecting macroinvertebrates in streams (July 11, 2005 draft). Bureau of Water, Springfield IL. BOW No. xxxx. 6 pp.

Illinois EPA. 2004a. Total maximum daily loads for the East Branch of the DuPage River, Illinois (final report). CH2M Hill, Inc., St. Louis, MO. 53 pp. + appendices.

Illinois EPA. 2004b. Total maximum daily loads for the West Branch of the DuPage River, Illinois (final report). CH2M Hill, Inc., St. Louis, MO. 73 pp. + appendices.

Illinois EPA. 2004a. Total maximum daily loads for Salt Creek, Illinois (final report). CH2M Hill, Inc., St. Louis, MO. 73 pp. + appendices.

Illinois EPA. 2002. Water monitoring strategy 2002-2006. Bureau of Water, Springfield, IL.

Illinois EPA. 1997. Quality assurance methods manual. Section G: Procedures for fish sampling, electrofishing safety, and fish contaminant methods. Bureau of Water, Springfield, IL. 39 pp.

Karr, J.R. and C.O. Yoder. 2004. Biological assessment and criteria improve TMDL planning and decision-making. Journal of Environmental Engineering 130(6): 594-604.

Karr, J. R., K. D. Fausch, P. L. Angermier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5: 28 pp.

Karr, J. R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1: 66-84.

Kaushal, S.S., P. M. Groffman, G. E. Likens, K. T. Belt, W. P. Stack, V. R. Kelly, L. E. Band, and G. T. Fisher. 2005. Increased salinization of fresh water in the northeastern United States. PNAS 2005 102 (38) 13517-13520

Kelly, W.R. 2008. Long-term trends in chloride concentrations in shallow aquifers near Chicago. Ground Water 46(5): 772-781.

Kelly, W.R., S.V. Panno, and K. Hackley. 2012. The sources, distribution, and trends in chloride in the waters of Illinois. Illinois State Water Survey, Bulletin B-74, Prairie Research Institute, University of Illinois at Urbana-Champaign, Champaign, Illinois

McNeeley, R.N., V.P. Neimanis, and L. Dwyer. 1979. Water Quality Source Book: a Guide to Water Quality Parameters. Inland Waters Directorate, Water Quality Branch, Ottawa, 1979.

Midwest Biodiversity Institute (MBI). 2014. 2012 Biological and Water Quality Study of the Lower DuPage River Watershed. Cook and DuPage Counties, Illinois. Technical Report MBI/2014-03-01. March 31, 2014. Prepared for: Lower DuPage River Watershed Coalition 10 S. 404 Knoch Knolls Road Naperville, IL 60565

Midwest Biodiversity Institute (MBI). 2013. (Final Review) Biological and Water Quality Study of the East Branch DuPage River Watershed; DuPage and Will Counties, Illinois. Technical Report MBI/2011-12-8. October 31, 2013. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561

Midwest Biodiversity Institute (MBI). 2012. 2010 Biological and Water Quality Study of the Salt Creek Watershed DuPage, Cook and Will Counties, Illinois. Technical Report MBI/2011-12-8. July 12, 2012. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561

Midwest Biodiversity Institute (MBI). 2010a. 2009 Biological and Water Quality Study of the West Branch DuPage River DuPage, Cook and Will Counties, Illinois. Technical Report MBI/2010-8-4. October 31, 2010. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561

Midwest Biodiversity Institute (MBI). 2010. Priority Rankings based on Estimated Restorability for Stream Segments in the DuPage-Salt Creek Watersheds. Technical Report MBI/2010-11-6. November 8, 2010. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561.

Midwest Biodiversity Institute (MBI). 2008a. Biological and Water Quality Study of the East and West Branches of the DuPage River and the Salt Creek Watersheds; Cook, DuPage, Kane and Will Counties, Illinois. Technical Report MBI/2008-12-3. December 31, 2008. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561

Midwest Biodiversity Institute (MBI). 2008b. Errata Supplement to the Biological and Water Quality Study of the East and West Branches of the DuPage River and the Salt Creek Watersheds Cook, DuPage, Kane and Will Counties, Illinois. Technical Report MBI/2008-12-3. Prepared for: DuPage River Salt Creek Workgroup, 10 S. 404 Knoch Knolls Road, Naperville, IL 60565. Submitted by: Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute, P.O. Box 21561, Columbus, Ohio 43221-0561

Midwest Biodiversity Institute (MBI). 2006a. Bioassessment Plan for the DuPage and Salt Creek Watersheds. DuPage and Cook Counties, Illinois. Technical Report MBI/03-06-1. Submitted to Conservation Foundation, Naperville, IL. 45 pp.

Midwest Biodiversity Institute (MBI). 2006b. Quality Assurance Project Plan: Biological and Water Quality Assessment of the DuPage and Salt Creek Watersheds. DuPage River-Salt Creek Watershed Group, Naperville, IL. 28 pp. + appendices.

Midwest Biodiversity Institute (MBI). 2003a. Establishing a biological assessment program at the Miami Conservancy District. MBI Tech. Rept. 01-03-2. Columbus, OH. 26 pp.

Midwest Biodiversity Institute (MBI). 2003b. State of Rhode Island and Providence Plantations five-year monitoring strategy 2004-2009. MBI Tech. Rept. 02-07-3. Columbus, OH. 41 pp. + appendices.

Midwest Biodiversity Institute (MBI). 2004. Region V state bioassessment and ambient monitoring programs: initial evaluation and review. Report to U.S. EPA, Region V. Tech. Rept. MBI/01-03-1. 36 pp. + appendices (revised 2004).

Miltner, R.J., D. White, and C.O. Yoder. 2003. The biotic integrity of streams in urban and suburbanizing landscapes. Landscape and Urban Planning 69 (2004): 87-100

Miltner, R. J., and Rankin, E. T. 1998. Primary nutrients and the biotic integrity of rivers and streams. Freshwater Biology 40, 145–158.

Miltner, R. J. 2010. A method and rationale for deriving nutrient criteria for small rivers and streams in Ohio. Environmental Management 45:842-855.

Miner, R., and D. Barton. 1991. Considerations in the development and implementation of biocriteria. Pages 115-119 in G. H. Flock (editor). Water Quality Standards for the 21st Century. Proceedings of a National Conference. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Novotny, E., A. Sander, O. Mohseni and H. Stefan. 2008. A Salt (Chloride) Balance for the Minneapolis/St. Paul Metropolitan Area Environment. Project Report No. 513. Prepared for Local Road Research Board (LRRB), Minnesota Department of Transportation, St. Paul, Minnesota by St. Anthony Falls Laboratory, University of Minnesota.

Ohio Environmental Protection Agency. 2006a. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2006b. Ohio EPA manual of surveillance methods and quality assurance practices, updated edition. Division of Environmental Services, Columbus, Ohio.

Ohio EPA. 1999. Association between nutrients, habitat, and the aquatic biota in Ohio Rivers and streams. Ohio EPA Technical Bulletin MAS/1999-1-1. Jan. 7, 1999.

Ohio Environmental Protection Agency. 1999. Ohio EPA Five Year Monitoring Surface Water Monitoring and Assessment Strategy, 2000-2004. Ohio EPA Tech. Bull. MAS/1999-7-2. Division of Surface Water, Monitoring and Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1998. Empirically derived guidelines for determining water quality criteria for iron protective of aquatic life in Ohio rivers and streams. Ohio Environmental Protection Agency, Columbus, OH. Technical Bulletin MAS\1998-0-1.

Ohio Environmental Protection Agency. 1996a. The Ohio EPA bioassessment comparability project: a preliminary analysis. Ohio EPA Tech. Bull. MAS/1996-12-4. Division of Surface Water, Monitoring and Assessment Section, Columbus, Ohio. 26 pp.

Ohio Environmental Protection Agency. 1989. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate assemblages. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life. volume II: User's manual for the biological assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life. volume III: Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate assemblages, Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

Ontario Ministry of the Environment. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. OMOE, Toronto.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pages 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1989. The qualitative habitat evaluation index (QHEI), rationale, methods, and application, Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.

Sanders, R. E., Miltner, R. J., Yoder, C. O., & Rankin, E. T. (1999). The use of external deformities, erosions, lesions, and tumors (DELT anomalies) in fish assemblages for characterizing aquatic resources: A case study of seven Ohio streams. In T. P. Simon (Ed.), Assessing the sustainability and biological integrity of water resources using fish assemblages (pp. 225–248). Boca Raton, FL: CRC.

Smith, P. W. 1979. The Fishes of Illinois. University of Illinois Press.

U.S. Environmental Protection Agency (U.S. EPA). 2009. EPA Needs to Accelerate Adoption of Numeric Nutrient Water Quality Standards, Report No. 09-P-0223, August 26, 2009, OFFICE OF INSPECTOR GENERAL, U.S. ENVIRONMENTAL PROTECTION AGENCY

U.S. Environmental Protection Agency (U.S. EPA) Science Advisory Board. 2008. Hypoxia in the Northern Gulf of Mexico. An Update by the EPA Science Advisory Board. Washington, DC. EPA Science Advisory Board. EPA-SAB-08-003. Available on EPA's Science Advisory Board Web site at: http://yosemite.epa.gov/sab/sabproduct.nsf/ C3D2F27094E03F90852573B800601D93/$File/EPA-SAB-08-003complete. unsigned.pdf

U.S. Environmental Protection Agency (U.S. EPA). 2000. Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Lakes and Reservoirs in Nutrient, Ecoregion VI. EPA 822-B-00-008. Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 1995a. Environmental indicators of water quality in the United States. EPA 841-R-96-002. Office of Water, Washington, DC 20460. 25 pp.

U.S. Environmental Protection Agency. 1995b. A conceptual framework to support development and use of environmental information in decision-making. EPA 239-R-95-012. Office of Policy, Planning, and Evaluation, Washington, DC 20460. 43 pp.

U.S. Geological Survey. 2011. Coal-Tar-Based Pavement Sealcoat, Polycyclic Aromatic Hydrocarbons (PAHs), and Environmental Health. (USGS Fact Sheet 2011-3010; PDF 3.24 MB)

Yoder, C.O. and 9 others. 2005. Changes in fish assemblage status in Ohio's nonwadeable rivers and streams over two decades, pp. 399-429. *in* R. Hughes and J. Rinne (eds.). Historical changes in fish assemblages of large rivers in the America's. American Fisheries Society Symposium Series.

Yoder, C.O. and J.E. DeShon. 2003. Using Biological Response Signatures Within a Framework of Multiple Indicators to Assess and Diagnose Causes and Sources of Impairments to Aquatic Assemblages in Selected Ohio Rivers and Streams, pp. 23-81. *in* T.P. Simon (ed.).

Biological Response Signatures: Patterns in Biological Integrity for Assessment of Freshwater Aquatic Assemblages. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1998. Important concepts and elements of an adequate State watershed monitoring and assessment program. Prepared for U.S. EPA , Office of Water (Coop. Agreement CX825484-01-0) and ASIWPCA, Standards and Monitoring. Ohio EPA, Division of Surface Water, Columbus, OH. 38 pp.

Yoder, C.O. and E.T. Rankin. 1998. The role of biological indicators in a state water quality management process. J. Env. Mon. Assess. 51(1-2): 61-88.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C. O. 1989. The development and use of biological criteria for the Ohio surface waters. Pages 39-146 in G. H. Flock (editor). Water Quality Standards for the 21st Century. Proceedings of a National Conference. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Yoder, C. O. 1991. The integrated biosurvey as a tool for evaluation of aquatic life use attainment and impairment in Ohio surface waters. Pages 110-122 in Biological Criteria: Research and Regulation, Proceedings of Symposium, 12-13 December 1990, Arlington, Virginia. EPA-440-5-91-005. Us. Environmental Protection Agency, Office of Water, Washington, D.C.

Yunker, M.B., R.W. Macdonald, R. Vingarzan, R.H. Mitchell, D. Goyette, and S. Sylvestre. 2002. PAHs in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH source and composition. Organic Geochemistry 33: 489–515.