Midwest Biodiversity Institute
Center for Applied Bioassessment & Biocriteria
P.O. Box 21561
Columbus, OH 43221-0561

Biological and Water Quality Study of the E. Branch DuPage River Watershed, 2011

DuPage and Will Counties, Illinois

Midwest Biodiversity Institute
Center for Applied Bioassessment & Biocriteria
P.O. Box 21561
Columbus, OH 43221-0561
mbi@mwbinst.com

Peter A. Precario, Executive Director
Dr. David J. Horn, Board President

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Final Report

Technical Report MBI/2011-12-8

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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

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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 this study in that the E. Branch DuPage River and its tributaries represent a defined watershed of approximately 81 square miles. The study area contains a complex mix of overlapping stressors and sources in a highly developed urban and suburban landscape. This assessment is a follow-up to a similar survey of the E. Branch DuPage River and its tributaries performed in 2007 (MBI 2008), the first of this scope for the watershed. In contrast, previous assessments by Illinois EPA and DNR were done with less intense spatial detail. 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, may also be assessed.

Scope of the E. 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; and,

3) add to the broader databases for the E. Branch DuPage River watershed to track and understand changes through time that occur as the result of abatement actions or other factors.

The 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 2007, 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; Miltner et al. 2010) that was developed to help determine and prioritize remedial projects.

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INTRODUCTION

A biological and water quality study of the E. Branch DuPage River and its tributaries was conducted in 2011 to assess aquatic life condition status, identify proximate stressors, and examine chemical/ physical water quality and biological conditions relative to publicly owned treatment works and physical habitat modifications. Additional sampling was conducted in the upper E. Branch in 2012 to provide post-removal data following elimination of the Churchill Woods low-head dam in February 2011. Survey data were also used to assess trends relative to a baseline survey conducted in 2007, the results of which were published in the *Biological and Water Quality Study of the East and West Branches of the DuPage River and the Salt Creek Watersheds* (MBI 2008). That report is hereafter referred to as the 2008 Bioassessment Report.

For the 2011 report, some aspects of data presentation varied from the 2008 Bioassessment Report. The earlier survey design was organized using geometric drainage area categories that displayed chemical and biological results from 2, 5, 9, 19, 38, 75, and 150 sq. mi. panels. Within this construct, it became obvious that size categories efficiently segregated data between small 2-5 sq. mi. drainage sites (located mostly on tributaries), and larger drainages along the East Branch mainstem. In fact, 85% of tributary sites fell within a 0.8-5 sq. mile range while 86% of mainstem sites were greater than 5 square miles. Also, from a stressor standpoint, most municipal point source discharges were restricted to reaches ≥5 sq. mi.; two exceptions were the Bloomingdale Reeves WWTP (RM 23.3) at 2 sq. mi. and the Glendale WWTP on Armitage Ditch near the E. Branch confluence. For these reasons, the 2011-12 presentation was simplified and drainage panel results were grouped as *Tributary* sites and *East Branch mainstem* sites. Mainstem results were further subdivided into upper (RM 23.5-19) and lower (RM 18-1.3) segments to better display and assess the Churchill Woods dam removal (RM 18.7).

SUMMARY

Biological assemblages from the E. Branch DuPage River watershed were rated poor to fair (in accordance with Illinois EPA methods) at almost all locations in 2011-12. No fish IBI (fIBI) values met the “good” IEPA criterion and “good” macroinvertebrate IBIs (mIBI) were limited to only three of 36 sites; the good quality scores were restricted to just the lower 7.6 miles of the East Branch mainstem. Because of the low biological performance, no sites fully supported Illinois EPA aquatic life goals (Table 1; Figure 1).

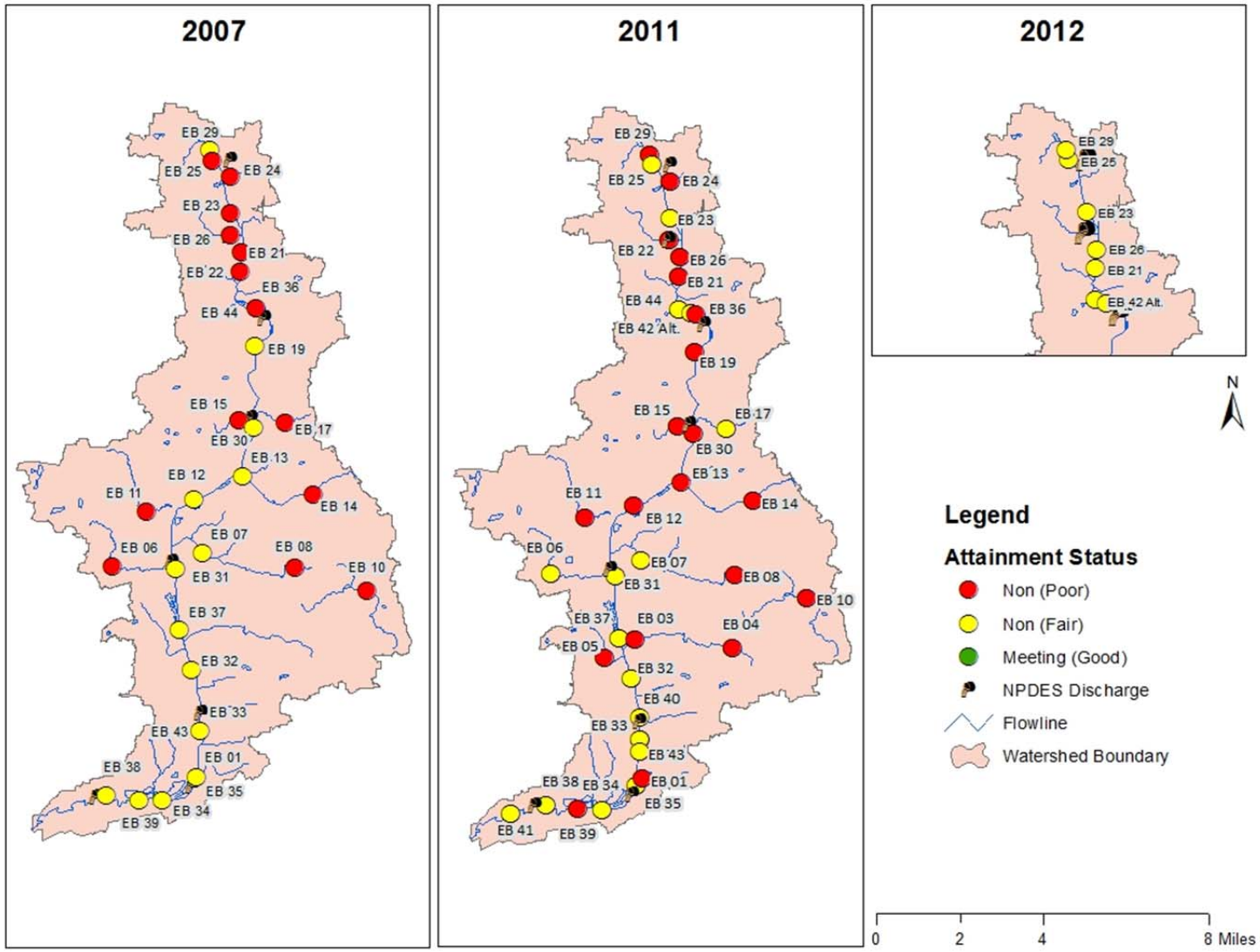


Figure 1. Aquatic life use attainment at biological sampling sites from the E. Branch DuPage River study area in 2007, 2011, and 2012 (upper mainstem only).

Compared to 2007 sampling, the condition of the fish and macroinvertebrates was either unchanged or of lower quality in 2011 (Figure 2). For fish, all 2011 fIBI scores were in the fair or poor quality ranges and 74% of sites common to both surveys (n=27) scored lower. Poor quality assemblages continued to occur in the smaller streams draining <5 mi.^{2}. In contrast, E. Branch mainstem fish (particularly from the lower reaches) were generally fair. However, these same lower E. Branch sites demonstrated the most consistent declines in quality since 2007, particularly in the lower 18 river miles between the former Churchill Woods dam and the mouth (see Figure 42). All 2011 scores in this reach were lower than in 2007, declining by 5.8 fIBI points per site. In contrast, scores improved by an average of 4.1 points upstream of the former dam over the same period. Macroinvertebrates exhibited a similar trend with lower index scores at 56% of comparable sampling sites. Like the fish, the declining trend in macroinvertebrates was most apparent in the lower mainstem, especially the lower 15 river miles where mIBI scores declined by an average of 11.8 points.

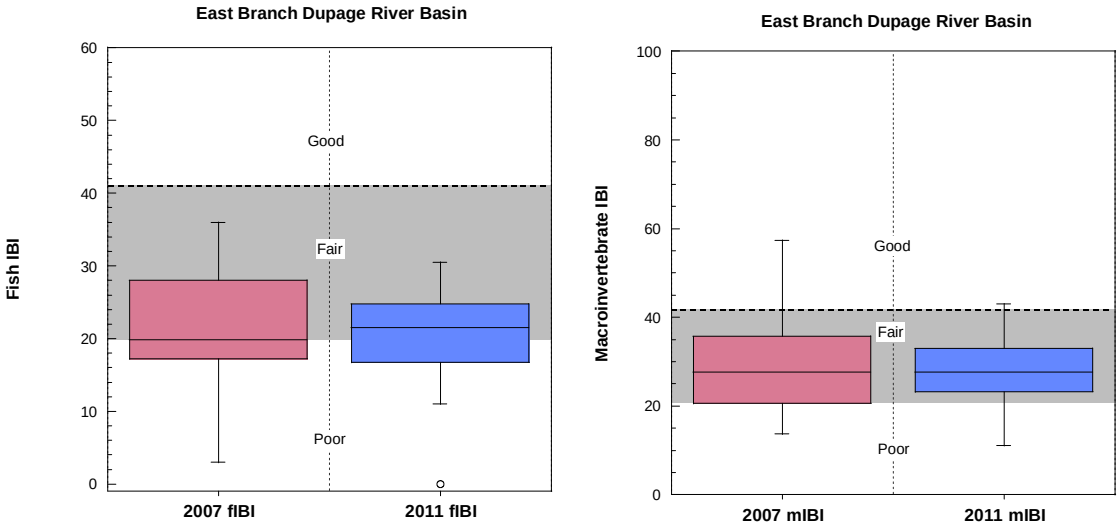


Figure 2. Box and whisker plots of fish (left) and macroinvertebrate (right) IBI scores from common sampling sites in the E. Branch DuPage River study area in 2011 and 2007.

The severity of biological and habitat impairments in the East Branch watershed were greatest in tributaries or sites <5 sq. mi. In these small channels, the negative influences of stormwater and its associated pollutants along with habitat alterations were especially apparent. Chemical results showed noticeable increases in chloride and TDS, both in the tributaries and throughout the mainstem. In addition to loadings from point sources, heavier than normal snowfalls during preceding winters and subsequent increases in road salt applications were considered a likely source of chloride. Research by the Illinois EPA cites chloride as a source of impairment and statewide research by Kelly et al. (2012) and Kaushal et al. (2005) show that elevated chloride levels can linger long after winter application (see page 53). The already elevated

concentrations encountered during the summer of 2011 suggest much higher and potentially toxic levels during colder parts of the year.

Compared to tributaries, mainstem biological results reflected better quality at most sites. However, these same assemblages experienced the greatest declines between 2007 and 2011 and the mainstem reach was consistently more degraded chemically. Pronounced increases in nutrients and greater diurnal dissolved oxygen swings, as well as persistently elevated concentrations of dissolved solids, appeared related to the large point sources that discharge along the E. Branch's approximate 24-mile length. Some increases, such as a near order of magnitude increase in nitrate (see Figure 28), may be partially related to reductions in effluent ammonia, a positive trend indicative of improved nitrification. However, the E. Branch is also effluent dominated and, under late summer base flow conditions, point sources can account for as much as 98% of stream flow (see pages 40-41). Given this large contribution of treated and partially treated sewage effluents, maintaining consistent, acceptable water quality and improving biological performance in the East Branch is a challenge.

In contrast to the declines in the lower E. Branch, initial monitoring of biological and habitat quality upstream and immediately downstream from the former Churchill Woods dam suggest a positive response to that structure's removal (Figure 3). Slight improvements were first dam, followed by additional, more pronounced changes in 2012 (fish and habitat sampling only). Current-associated fish species such as sand shiner, johnny darter, and hornyhead chub are reinvading the newly formed riverine habitats and are expanding their range upstream.

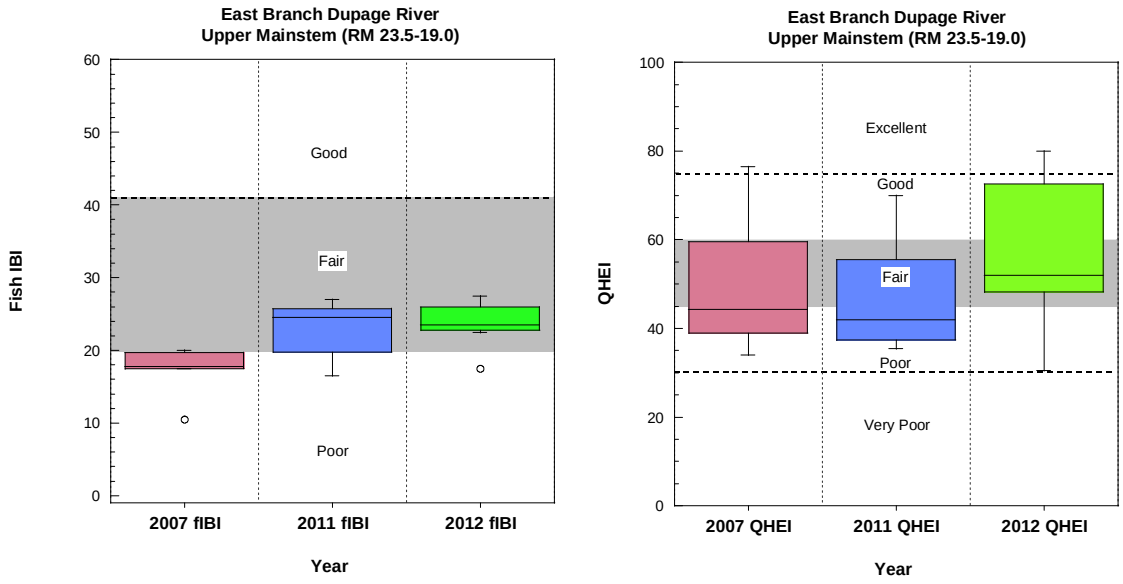


Figure 3. Box and whisker plots of fish IBI (left) and QHEI (right) scores at common sampling sites from the upper E. Branch DuPage River (RMs 19.0-23.5) in 2007 (salmon), 2011 (blue), and 2012 (green).

The shift from lentic to lotic habitat conditions in the former pool has resulted in incremental improvements in habitat diversity and subsequent, gradual improvement in biological performance. Fish assemblages now approach the quality of assemblages from free-flowing reaches further downstream and, within the former impoundment itself, the process of recovery and stabilization of the river channel is progressing. However, low stream gradient and lingering accumulations of fine depositional substrates will likely result in a longer recovery time.

Following removal of the Churchill Woods dam, fish passage along the E. Branch mainstem is largely unimpeded. Remaining gabion or high-flow impoundment structures allow upstream passage under elevated flow conditions. Only the West Lake dam, in the extreme upper mainstem (RM 23.8), remains as a permanent mainstem barrier.

Additional monitoring efforts in the East Branch DuPage River could enhance the current assessment. For example, mainstem survey results suggest a potential dissolved oxygen sag in the lower 10 river miles, but continuous D.O. monitoring only extended downstream to river mile 8.5. Additional continuous monitoring in the lower reaches could confirm or pinpoint the magnitude, extent, and location of low D.O. In addition, excess wastewater discharges (e.g., CSO and WWTP bypasses following secondary treatment) were not directly addressed in the most recent survey. Better monitoring of these contributions would help clarify the relative contribution of all sources of nutrients and pollutants in the study area.

*Table 1. Status of aquatic life use support for stream segments sampled in the E. Branch DuPage River study area in 2011. Sites with poor biological performance are shaded in red; fair quality sites are shaded in yellow and index scores in the good range are **bold**. MBI assigned causes associated with impaired fIBI and/or mIBIs are compared to previously assigned IEPA causes.*

Site ID	River Mile	fIBI 2011	mIBI 2011	QHEI	Aquatic Life Use Status	MBI Associated Causes	fIBI 2007	mIBI 2007
95-980 E. Branch DuPage River								
EB 29	23.50/23.50	22.5	11.2	35.5	Non (Poor)	TDS/Chloride, TKN, TSS, BOD, Habitat Alt., D.O.	10.5	21.3
EB 25	23.00/23.00	26.5	27.9	61.0	Non (Fair)	TDS/Chloride, TKN, D.O., nutrients (Dst B-Reeves WWTP)	19.7	19.4
EB 23	22.00/22.00	24.5	34.9	70.0	Non (Fair)	TDS/Chloride, D.O., nutrients	20.0	35.8
EB 26	21.00/21.00	17.0	24.8	42.0	Non (Poor)	TDS/Chloride, TKN, TSS, Habitat Alt., D.O., nutrients (Dst Glendale WWTP)	17.5	25.5
EB 21	20.50/20.50	16.5	25.4	38.8	Non (Poor)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	18.0	23.4
EB 42 Alt.	19.50/19.50	25.0	30.1	36.0	Non (Fair)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	17.5[a]	17.9[a]
EB 44	19.30/ --	27.0	--	50.0	Non (Fair)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	17.5[a]	17.9[a]
EB 19	18.00/18.00	20.5	37.5	52.3	Non (Poor)	TDS/Chloride, TKN, TSS, Habitat Alt., D.O., nutrients (Dst. Glenbard-Lombard WWTP)	23.0	27.6
EB 30	15.50/15.50	21.5	18.8	65.0	Non (Poor)	TDS/Chloride, TKN, D.O., nutrients (Dst. Glenbard WWTP)	24.0	31.1
EB 12	13.00/13.00	20.0	29.0	51.5	Non (Poor)	TDS/Chloride, Habitat Alt. D.O., nutrients	25.0	39.4
EB 31	11.00/11.00	27.0	29.8	37.5	Non (Fair)	TDS/Chloride, Habitat Alt., D.O., nutrients (Dst. D. Grove WWTP)	36.0	32.3
EB 37	9.50/9.50	24.5	23.0	42.8	Non (Fair)	TDS/Chloride, Habitat Alt., D.O., nutrients	32.5	41.7
EB 32	8.50/8.50	30.5	27.4	48.8	Non (Fair)	TDS/Chloride, Habitat Alt., D.O., nutrients	35.0	**45.5**
EB 40	7.60/7.60	28.0	**53.4**	58.3	Non (Fair)	TDS/Chloride, TKN, Habitat Alt., D.O., nutrients	--	--
EB 33	7.00/7.00	26.0	28.3	63.3	Non (Fair)	TDS/Chloride, D.O., nutrients (Dst. Woodridge WWTP)	35.5	**49.7**
EB 43	6.60/6.60	27.5	37.5	54.5	Non (Fair)	TDS/Chloride, Habitat Alt., D.O., nutrients	--	--
EB 35	6.00/6.00	23.5	33.4	45.0	Non (Fair)	TDS/Chloride , Habitat Alt., D.O., nutrients	30.0	--

Site ID	River Mile	fIBI 2011	mIBI 2011	QHEI	Aquatic Life Use Status	MBI Associated Causes	fIBI 2007	mIBI 2007
EB 34	5.00/5.00	21.5	**43.1**	63.0	Non (Fair)	TDS/Chloride, D.O., nutrients (Dst. BBrook #1 WWTP)	25.5	40.8
EB 39	4.00/4.00	20.5	37.5	56.5	Non (Fair)	TDS/Chloride, Habitat Alt., D.O., nutrients	28.0	NA
EB 38	3.00/3.00	28.0	23.7	69.0	Non (Fair)	TDS/Chloride, D.O., nutrients Unknown (see mIBI)	33.5	**57.3**
EB 41	1.30/1.30	24.0	**43.4**	76.5	Non (Fair)	TDS/Chloride, D.O., nutrients (Dst. BBrook #2 WWTP)	--	--
95-980 E. Branch DuPage River (2012)								
EB 29	23.50/23.50	17.5	--	30.5	Non (Poor)	TDS/Chloride, TKN, TSS, BOD, Habitat Alt., D.O.	10.5	21.3
EB 25	23.00/23.00	25.5	--	73.8	Non (Fair)	TDS/Chloride, TKN, D.O., nutrients	19.7	19.4
EB 23	22.00/22.00	26.0	--	80.0	Non (Fair)	TDS/Chloride, D.O., nutrients	20.0	35.8
EB 26	21.00/21.00	23.5	--	71.5	Non (Fair)	TDS/Chloride, TKN, TSS, Habitat Alt., D.O., nutrients	17.5	25.5
EB 21	20.50/20.50	22. 0	--	45.0	Non (Fair)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	18.0	23.4
EB 42 Alt.	19.50/19.50	27. 0	--	52.0	Non (Fair)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	17.5[a]	17.9[a]
EB 44	19.30/ --	23.0	--	51.3	Non (Fair)	TDS/Chloride, TSS, Habitat Alt., D.O., nutrients	17.5[a]	17.9[a]
95-951 Army Trail Creek								
EB 24	0.25/0.25	20.0	19.4	43.5	Non (Poor)	TDS/Chloride, Habitat Alt.	17.5	16.1
95-952 Armitage Ditch								
EB 22	0.50/0.50	17.5	34.1	33.3	Non (Poor)	TDS/Chloride, Habitat Alt.	17.5	13.7
95-953 Glencrest Creek								
EB 15	0.50/0.50	13.5	25.8	65.8	Non (Poor)	TDS/Chloride	17.0	25.9
95-954 Lacey Creek								
EB 14	2.00/2.00	13.0	21.2	35.8	Non (Poor)	TDS/Chloride, TKN, TSS, BOD, Habitat Alt.	15.0	20.3
EB 13	0.25/0.25	0.0	32.7	28.5	Non (Poor)	TDS/Chloride, TSS, BOD, Habitat Alt.	24.0	21.4

Site ID	River Mile	fIBI 2011	mIBI 2011	QHEI	Aquatic Life Use Status	MBI Associated Causes	fIBI 2007	mIBI 2007
95-955 Willoway Brook								
EB 11	1.00/1.00	13.5	30.7	80.5	Non (Poor)	TDS/Chloride, TKN [b]	16.0	28.8
95-956 22nd St. trib to E. Branch DuPage River								
EB 17	1.00/1.00	21.0	23.6	54.5	Non (Fair)	TDS, TSS, *Habitat Alt.*	14.5	29.2
95-957 Rott Creek								
EB 06	2.00/2.00	24.0	27.2	55.0	Non (Fair)	Conductivity/Chloride, *Habitat Alt.*	18.0	33.1
95-986 Prentiss Creek								
EB 04	3.80/3.80	13.5	5.8	62.0	Non (Poor)	Conductivity/Chloride, Flow Alt. (Intermittent)	--	--
EB 03	1.10/1.10	12.5	24.9	68.5	Non (Poor)	TDS/Chloride	--	--
95-989 Trib to E. Br. DuPage River, #6								
EB 05	0.60/0.60	20.5	35.3	47.0	Non (Poor)	Conductivity/Chloride, Flow Alt. (Intermittent)	--	--
95-987 St. Joseph Creek								
EB 10	6.00/6.00	13.0	19.6	63.0	Non (Poor)	Conductivity/Chloride, TSS	14.5	14.6
EB 08	4.00/4.00	11.0	16.2	53.8	Non (Poor)	TDS/Chloride, *Habitat Alt.*	3.0	20.6
EB 07	1.00/1.00	24.0	33.5	49.0	Non (Fair)	TDS/Chloride, *Habitat Alt.*	28.0	27.7
95-988 Trib. to E. Br. DuPage River								
EB 01	0.25/0.25	22.0	11.1	29.0	Non (Poor)	TDS/Chloride, TSS, Flow Alt. (Intermittent)	--	--

[a] The corresponding 2007 sample was collected at Station EB36 (RM 19.0), within the Churchill Woods dam pool.
[b] Willoway Brook was not sampled chemically in 2011. Causes listed are based on 2007 sampling.

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

Sampling sites (Table 2, Figure 4) were determined systematically using a geometric design that was supplemented by an intensive pollution survey design. The geometric site process starts at the downstream terminus of the watershed as the first site, and then continues by selecting additional "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 in the E. Branch watershed, starting at 150 sq. mi. and continuing through drainage area panels of 75, 38, 19, 9, 5 and 2 sq. mi. Additional sites that targeted stream reaches of particular interest such as those that are impacted by wastewater treatment plants (WWTPs), major stormwater sources, dams, and to fill gaps left by the geometric design in the larger mainstem reaches for a total of 37 sampling sites.

For this report, some aspects of the data presentation vary from the 2008 Bioassessment Report. Chemical and biological data from 2007 were reported within the seven 2-150 sq. mi. geometric panels and those results showed a strong differentiation between the smaller 2-5 sq. mi. sites and the larger drainage panels. Within this construct, it became obvious that size categories efficiently segregated data between small drainage sites, located mostly on tributaries, and larger drainages along the East Branch mainstem. In fact, 85% of tributary sites fell within a 0.8-5 sq. mile size while 86% of mainstem sites were greater than 5 square miles. Also, from a stressor standpoint, most municipal point source discharges in the East Branch watershed were restricted to reaches $\geq$5 sq. mi.; one exception was the Bloomingdale Reeves WWTP near RM 23.3 at 2 sq. mi. and the Glendale WWTP, located on Armitage Ditch near the East Branch confluence. For these reasons, the 2011-12 presentation was simplified and results were grouped and separated as *Tributary* and *East Branch mainstem* sites. Mainstem results were further subdivided into upper (RM 23.5-19) and lower (RM 18-1.3) segments to better display and assess the February 2011 removal of the Churchill Woods dam (RM 18.7).

To assess the Churchill Woods dam removal further, seven upper mainstem sites between RM 23.5 and 19.3 were resampled for fish and habitat in 2012. Sites at RMs 19.0 (2007), 19.3 (2011), and 19.5 (2011) were located within the existing or former impoundment.

Each 2011 site was sampled for macroinvertebrates (excluding EB 44/RM 19.3), fish, stream habitat, and water quality. Water quality parameters at all sites included nutrients (nitrates 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 (D.O.), and water temperature. Water column metals (Ca, Cd, Cu, Fe, Mg, Pb and Zn) were included at 22 locations. Additionally, sediment chemical quality was sampled at 16 locations, and continuous D.O. monitoring was conducted at five locations. Sediment samples were analyzed for heavy metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides.

Table 2. Sites sampled during the 2011-2012 survey of the E. Branch DuPage River study area.

Site ID	Stream Name	River Code	River Mile	Latitude	Longitude	Location
EB 29	E. Br. DuPage R.	95-980	23.50	41.94090	-88.06220	Glen Ellyn Drive and Byron Ave.
EB 25	E. Br. DuPage R.	95-980	23.00	41.93730	-88.06130	EBAT, Brookdale Ave. (+ Datasonde)
EB 23	E. Br. DuPage R.	95-980	22.00	41.91870	-88.05270	End of Fullerton Ave. on E. Br. F.P.
EB 26	E. Br. DuPage R.	95-980	21.00	41.90490	-88.04790	North Ave., dst. Glendale WWTP
EB 21	E. Br. DuPage R.	95-980	20.50	41.89830	-88.04860	Lyon St. Apts. Parking lot
EBSC	E. Br. DuPage R.	95-980	20.00	41.8903	-88.0507	St. Charles Rd. (Datasonde only)
EB 42	E. Br. DuPage R.	95-980	19.50			Former Churchill Woods dam pool
EB 44	E. Br. DuPage R.	95-980	19.30	41.88566	-88.04312	Former C.Hill. Woods pool @ art. riffle
EB 36	E. Br. DuPage R.	95-980	19.00	41.88510	-88.04110	Churchill Woods dam pool (2007)
EB 19	E. Br. DuPage R.	95-980	18.00	41.87190	-88.04150	End of Roslyn Road
EB 30	E. Br. DuPage R.	95-980	15.50	48.21100	-88.04220	School yard at end of 22nd St.
EBBR	E. Br. DuPage R.	95-980	14.30	41.8315	-88.0532	Butterfield Rd. (Datasonde only)
EBHL	E. Br. DuPage R.	95-980	14.00	41.8315	-88.0532	Hidden Lake Preserve (Datasonde only)
EB 12	E. Br. DuPage R.	95-980	13.00	41.81820	-88.07020	Ust Park Blvd.-Morton Arboretum
EB 31	E. Br. DuPage R.	95-980	11.00	41.79360	-88.07900	Ust Short St. bridge
EB 37	E. Br. DuPage R.	95-980	9.50	41.77110	-88.07730	Ust footbridge at 7 Bridges GC
EB 32	E. Br. DuPage R.	95-980	8.50	41.76800	-88.07160	EBHR, ust Hobson Rd (+ Datasonde)
EB 40	E. Br. DuPage R.	95-980	7.60	41.73672	-88.06777	Ust footbridge
EB 33	E. Br. DuPage R.	95-980	7.00	41.73670	-88.06780	Ust footbridge at Green Valley F.P.
EB 43	E. Br. DuPage R.	95-980	6.60	41.73211	-88.06749	Dst F.P. footbridge
EB 35	E. Br. DuPage R.	95-980	6.00	41.72020	-88.06950	Ust Royce Ave
EB 34	E. Br. DuPage R.	95-980	5.00	41.71210	-88.08560	Ust Trout Farm canoe launch
EB 39	E. Br. DuPage R.	95-980	4.00	41.71230	-88.09160	Dst 2nd large mine discharge
EB 38	E. Br. DuPage R.	95-980	3.00	41.71390	-88.11180	DuPage R. Park off Naperville/Royce Rd
EB 41	E. Br. DuPage R.	95-980	1.30	41.71090	-88.12797	S Washington St/Naperville Rd.
EB 24	Army Trail Cr.	95-951	0.25	41.93170	-88.05300	Dst Valley View Road
EB 22	Armitage Ditch	95-952	0.50	41.91110	-88.05300	End of Armitage Rd. off Glen Ellyn
EB 15	Glencrest Creek	95-953	0.50	41.84550	-88.04860	Ust Danby and Glencrest St.
EB 14	Lacey Creek	95-954	2.00	41.81940	-88.01490	Ust Saratoga Ave.
EB 13	Lacey Creek	95-954	0.25	41.82680	-88.04830	Ust culvert-Hidden Lake F.P.
EB 11	Willoway Brook	95-955	1.00	41.81410	-88.09230	Dst Leask Lane at Morton Arboretum
EB 17	22nd St. trib. to E. Br. DuPage R.	95-956	1.00	41.84510	-88.02800	Dst Finley Ave.
EB 06	Rott Creek	95-957	2.00	41.79400	-88.10890	Footbridge at end of Wellington Ave
EB 04	Prentiss Creek	95-986	3.80	41.768180	-88.02426	Dst Bridge at Springside St.
EB 03	Prentiss Creek	95-987	1.10	41.77149	-88.07004	Dst SR. 53 adj. to Mulligan Drive
EB 05	Trib to E. Br. #6	95-989	0.60	41.76508	88.08408	Dst Caddie Corner Park bridge
EB 10	St. Joseph Cr.	95-987	6.00	41.78580	-87.99060	Deer Park Blvd. adj. 56th St.
EB 08	St. Joseph Cr.	95-988	4.00	41.79390	-88.02390	Dst Jacquelyn Drive in park
EB 07	St. Joseph Cr.	95-989	1.00	41.79980	-88.06750	St. Joseph St. at St. Joseph condominiums
EB 01	Trib. to E. Br.	95-988	0.25	41.72274	-88.06653	East of Home Landscaping parking lot

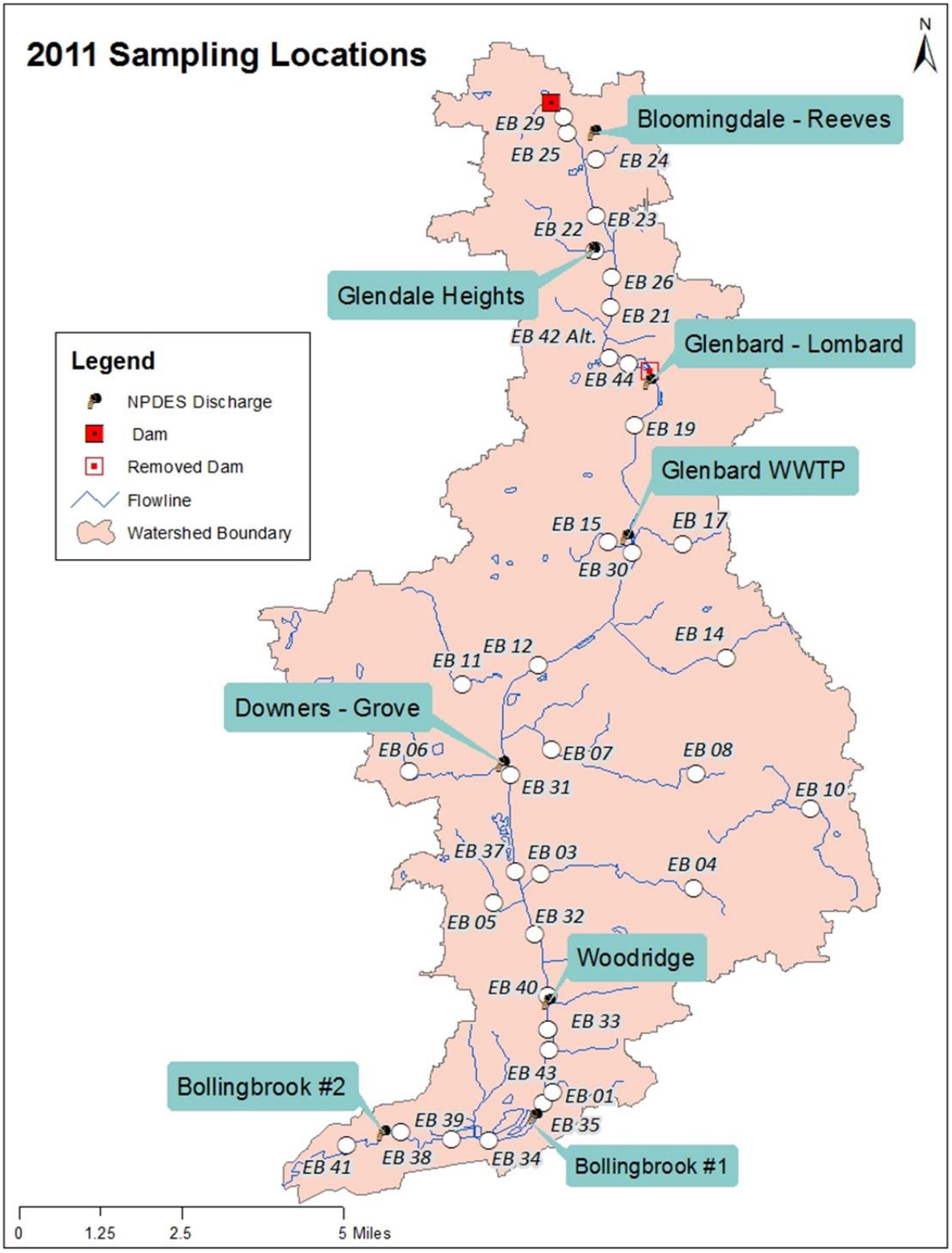


Figure 4. Sampling locations (white dots with associated "EB" station numbers), municipal WWTP discharges (outfalls), and significant mainstem dam impoundments (red squares) in the E. Branch DuPage River study area, June-Oct., 2011. Note: the Churchill Woods dam (open red square) was removed in Feb. 2011.

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. The sampling reach also has flow conditions that approximate typical summer base flows, has no highly influential tributary streams, contains one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present, and is at least 300 feet in length. This method is applicable if conditions allow the 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[1] or to estimate with reasonable accuracy via visual or tactile cues the amount of each of several bottom-zone and bank-zone habitat types. If conditions (e.g., inaccessibility, water turbidity, or excessive water depths) prohibit the sampler from estimating with reasonable accuracy the composition of the bottom zone or bank zone throughout the entire sampling reach, then the multi-habitat method is not applicable. In most cases, if more than one-half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of the bottom-zone and bank-zone habitat types are attainable, thus, the multi-habitat method is not applicable. Multi-habitat samples were field preserved in 10% formalin then transferred to 70% ethyl alcohol at the MBI lab in Hilliard, OH.

Laboratory procedures generally followed the IEPA (2005) methodology. For the multi-habitat method, this requires the production of a 300-organism subsample with a scan and pre-pick of large and/or rare taxa from a gridded tray. Taxonomic resolution was performed at the lowest practicable resolution for the common macroinvertebrate assemblage groups such as mayflies, stoneflies, caddisflies, midges, and crustaceans. This goes beyond the genus level requirement of 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

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

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 (y-o-y, 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 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 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 was 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 communities 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 (outlined in
Figure *5*) includes a hierarchical continuum, from administrative to true environmental indicators.

The six "levels" of indicators include:

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

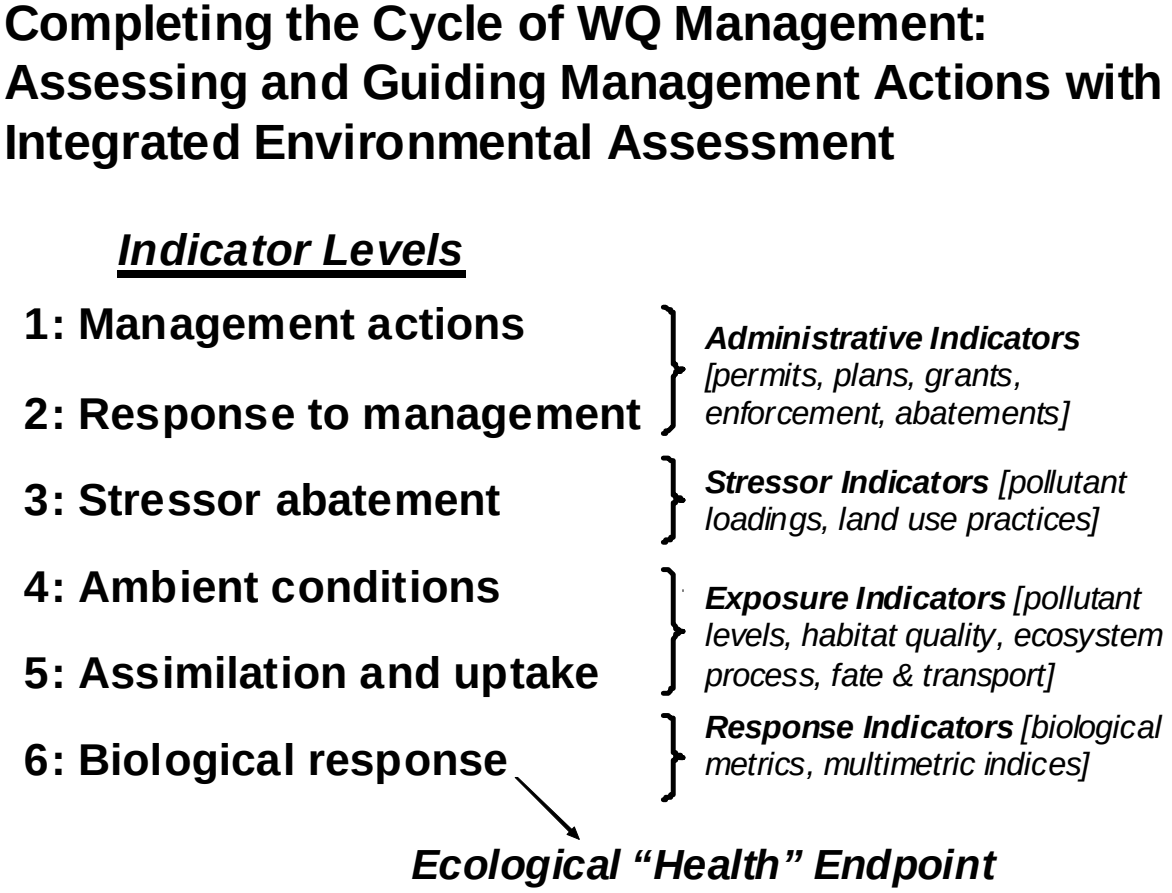


Figure 5. Hierarchy of administrative and environmental indicators that can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995) and further enhanced by Karr and Yoder (2004).

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 of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise the Illinois EPA biological endpoints. Other response indicators can include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels that serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each (Yoder and Rankin 1998).

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 stressors and exposure, the 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. For example, the biological thresholds for the mIBI and the fIBI are listed at the end of Table 1 and most derived Illinois water chemistry criteria are available on the Illinois EPA web site (http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria-list.pdf). 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. However, in the E. Branch DuPage River survey biological data was available for each site.

Background Concentrations of Chemical Stressors

For this analysis, MBI compared water chemistry results to water quality criteria where they exist. However, comparisons to levels in reference or "unpolluted" waters are also useful when a risk-based approach is used to estimate likely causes of impairment. In this respect, the IPS report (MBI 2010) derived local thresholds where correlational analyses were used to derive benchmarks, above which fish or macroinvertebrate impairment would be more likely. For example, for chloride, the mIBI threshold was 141 mg/l and the fIBI threshold was 112 mg/l. For TKN and ammonia, the mIBI relationships were continuous while fIBI thresholds were 1.0 and 0.15 mg/l, respectively. For some parameters, Ohio EPA's (1999) background concentrations associated with attaining IBI scores or reference sites were examined. Nutrient concentrations associated with "unpolluted" waters as derived by USGS NAWQA data by Mueller et al. (1995) include ammonia (0.1 mg/l), total phosphorus (0.1 mg/l), nitrate (0.6 mg/l) and total nitrogen (1.0 mg/l). In contrast, Illinois developed "non-standards based" nutrient criteria for total nitrate (7.8 mg/l) and total phosphorus (0.61 mg/l) that are substantially higher. The criteria were based on 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). US EPA has also derived initial Ecoregion (54) reference targets for nitrate (1.798 mg/l) and total phosphorus (0.072 mg/l). A 1.0 mg/l suggested protective effluent limit for total phosphorus is widely applied to WWTPs with the goal of reducing ambient total phosphorus to prevent "nuisance algae" in streams and rivers.

STUDY AREA DESCRIPTION

The E. Branch DuPage River watershed includes 81 square miles of central DuPage and northern Will Counties (Figure 6). The major tributaries are St. Joseph and Prentiss Creeks. The East Branch mainstem is approximately 26 linear miles, joining the West Branch DuPage River on the Bolingbrook municipal line to form the mainstem of the DuPage River, a tributary to the Des Plains River. Sixteen (16) municipalities are located within the watershed. Eleven publicly owned treatment plants (7 majors) discharge to the East Branch, as does one combined sewer overflow. Over 85% of land use in the watershed is developed with nearly half (48.5%) composed of low intensity suburban development (Table 3; Figure 6). Higher intensity development tends to be clustered in the municipalities and along major highways.

Table 3. Land use types by area and percent for the E. 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	E. Branch DuPage River Watershed	
	Area (acres)	Area (percent)
Developed, Low Intensity	25258	48.5
Developed, Medium Intensity	7774	14.9
Developed, High Intensity	3127	6.0
Developed, Open Space	8156	15.7
Forest	3572	6.9
Grassland/Herbaceous	1238	2.4
Wetland	970	1.9
Agriculture	859	1.7
Open Water	571	1.1
Shrub/Scrub	253	0.5
Barren Land (Rock/Clay/Sand)	248	0.5
Totals	**52,026**	**100.0**

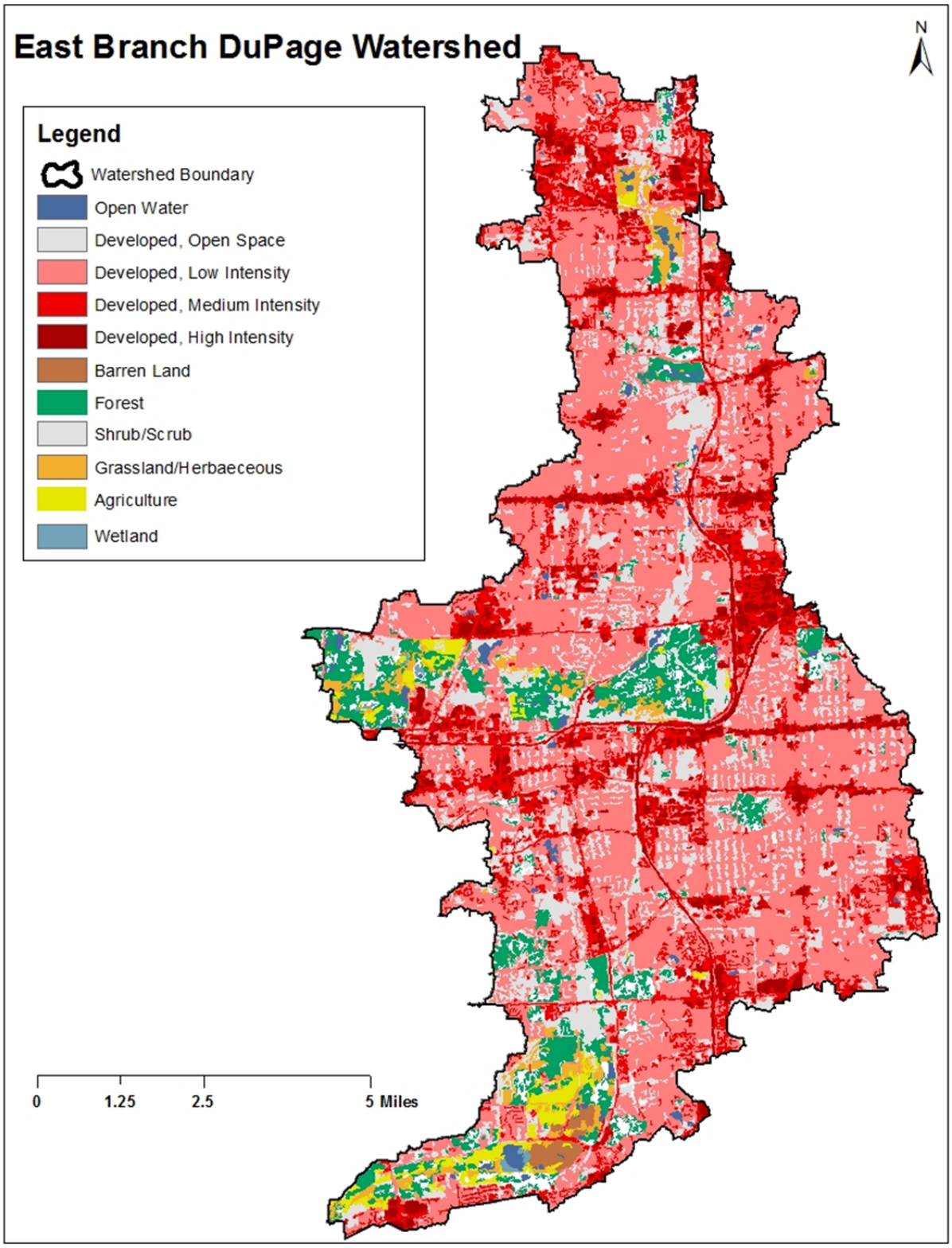


Figure 6. Land use types in the E. Branch DuPage River watershed based on 2006 National Land Cover Dataset (NLCD). http://www.mrlc.gov/nlcd2006.php

E. Branch DuPage River Dams

A summary of the status of dams in E. Branch DuPage watershed in 2011 appears in Table 4.

Table 4. Known dams or bed control structures in the E. Branch DuPage River watershed. Impoundment sizes listed as N/A (not applicable) are stormwater control structures and do not maintain significant impoundments under non-storm conditions. Letters next to dam names correspond to those in the sampling site locations map (see Figure 1).

Dam Name	Affected Waterway	River Mile	Impoundment Size (acres)	Impedes Fish Passage
a) West Lake Dam	East Branch	23.8	13	Y
d) Churchill Woods Dam[a] (removed Feb. 2011)	East Branch	18.7	12	N
e) Mary knoll Gabion Weir	East Branch	16.8	None	N
g) Prentiss Creek flow-through Dam	Prentiss Cr.[b]/E. Branch	0.1/8.6	N/A	N

[a] The dam was removed in February 2011 and is no longer an impediment to fish passage.
[b] A series of three additional dams w/impoundments on lower Prentiss Creek are impediments to fish passage.

West Lake Dam: Bloomingdale, West Lake Park, ½ mile north of Army Trail Road, 500 feet west of Glen Ellyn Road. The existing concrete inlet and outlet channels, and the existing lake outfall structure were constructed in the early 1970's in conjunction with the development of the Westlake Subdivision. The primary purpose of the lake is to provide retention for excess stormwater runoff from the upstream Westlake development. The secondary benefit of the lake is to provide for aesthetic benefits and recreational uses as a public park area, on land owned and operated by the Bloomingdale Park District. Maintenance to sustain the lake's function as a stormwater retention facility is handled by the Village.

Churchill Woods Dam: The Churchill Woods Dam was located on the E. Branch (RM 18.7) within the Churchill Woods Forest Preserve in Glen Ellyn. Originally built in the 1930's as part of the Works Progress Administration, the 50-foot long and 3.5 feet high concrete gravity dam was removed in February 2011. The former impoundment created by the dam was approximately 31 acres in size and extended from Crescent Boulevard to approximately St. Charles Road (RM 18.7-20.0). The river is still somewhat impounded at the site with the new elevation being set by three box culvers under Crescent Boulevard. The impoundment is estimated to be 12 acres in size.

Mary knoll Gabion Weir Dam: The Mary knoll gabion weir dam is located on the E. Branch, adjacent to the Mary knoll residential subdivision in Glen Ellyn. The dam is located east of Mary knoll Circle, approximately ¼ mile south of Route 38, and 200 feet west of I-355. Access to the dam is best granted from Mary knoll Circle.

Former Churchill Woods dam (E. Branch RM 18.6 at Crescent Rd. (Note: dam removed in February 2011).

The dam was constructed in the early 1980's as part of Mary knoll Development to provide stormwater detention for the development. Flow at normal water level is not impeded. The dam consists of gabions with no concrete caps. The impoundment does not extend further upstream than Route 38.

Prentiss Creek Dam (flow-through): The Prentiss Creek Dam is located on the E. Branch within the Seven Bridges Golf Club in Woodridge. The dam actually consists of two structures, one on the East Branch and one at the mouth of Prentiss Creek, both located immediately upstream from Hobson Road. The structures are owned by the Village of Woodridge and are 19 years old. Access to the dams is best granted from the golf course but it is possible to access the dam from Double Eagle Drive using the sidewalk.

The dam was constructed in 1989 to provide on line stormwater detention for the adjacent development. The dams are gravity structures consisting of rock-filled gabions that impound water at a greater rate as the flow rate increases. The East Branch structure is 20 feet wide while the Prentiss Creek structure is 10 feet wide.

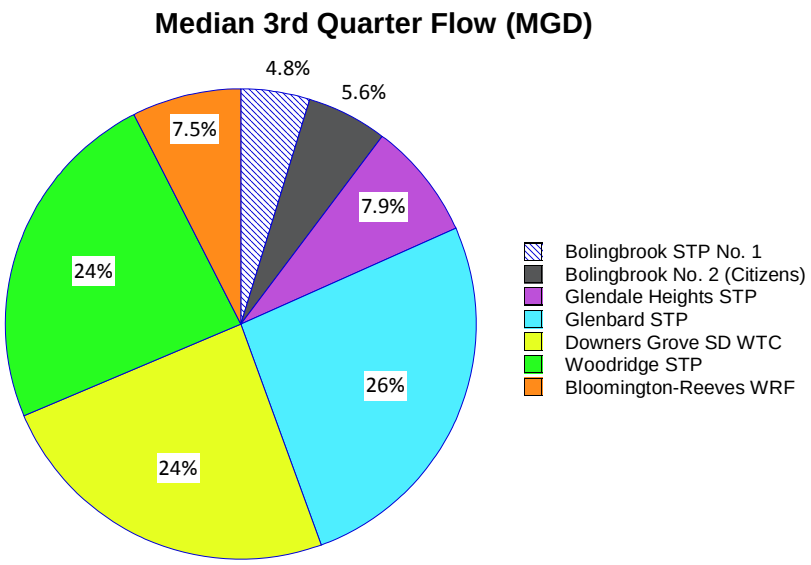
Prentiss Creek stormwater control dam on E. Branch DuPage R. at the Seven Bridges Golf Club.

Point Source Discharges

Point sources in the East Branch watershed consisted of seven major wastewater treatment plants designed to discharge an average of 52.77 MGD of treated wastewater (Table 5). The Lombard CSO discharges during wet weather. The East Branch mainstem is effluent dominated during the July-October summer-fall base-flow period. For example, during September 2007, effluent comprised approximately 76% of river flow and reached 98% in September 2011 (see pages 40-41). Effluent quality data from the major dischargers were evaluated against NPDES permit limits to gauge plant performance, especially with respect to plant flows relative to treatment capacity and concentrations of key effluent constituents including biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), and ammonia-nitrogen (NH_3-N).

Table 5. Municipal wastewater treatment plants located in the E. Branch DuPage River study area. DAF = design average flow; DMF = design maximum flow. The accompanying figure shows the relative contribution as a percent of each plant to the average effluent volume in million gallons per day (MGD) for September 2011.

NPDES	Name	DAF	DMF	Receiving Stream/(RM)	Long.	Lat.
IL0021130	Bloomingdale-Reeves	3.45	8.625	East Branch (23.3)	-88.0528	41.9375
IL0028967	Glendale Heights	5.26	10.52	Armitage Ditch (21.4, 0.4)	-88.0534	41.9111
IL0022741	Glenbard WW Auth.-Lombard	-[2]	58.0	East Branch (18.6)	-88.0367	41.8817
IL0021547	Glenbard WW Auth.-Glenbard	16.02	47.0	East Branch (15.9)	-88.0436	41.8469
IL0028380	Downers Grove SD	11	22.0	East Branch (11.35)	-88.0808	41.7961
IL0031844	DuPage Co.- Woodridge	12	28.6	East Branch (7.59)	-88.0675	41.7429
IL0032689	Bolingbrook #1	2.04	4.51	East Branch (5.66)	-88.0714	41.7172
IL0032735	Bolingbrook #2 (Citizens Utility Co.)	3.0	7.5	East Branch (2.8)	-88.1167	41.7136



[2] The Lombard facility discharges only during peak flow events.

Direct comparison of flow percentages from the major East Branch NPDES dischargers in 2007 and 2011 is hampered by the fact the Bolingbrook #2 (Citizens Utility Co.) was not included in 2007. However, the general discharge trends remained steady as the larger, Glenbard, Woodridge, and Downers Grove plants continued to contribute about 75% of total effluent flows in 2011.

Bolingbrook #2 (Citizens Utility Company) [IL0032689]
The Bolingbrook #2 WWTP discharges to the E. Branch at approximately RM 2.8. The design average flow (DAF) is 3.0 MGD and the design maximum flow (DMF) is 7.5 MGD. Treatment consists of screening, primary clarification, aeration, secondary clarification, chlorination/dechlorination, aerobic-digestion, thickening, filter press and disposal of sludge.

Since 2008, third quarter average daily flows have remained well below the design maximum limit and rarely exceeded the 3 MGD daily limit (Figure 7*, top*). Effluent concentrations of cBOD5 have consistently remained well within applicable permit limits (Figure 7, bottom). Since 2010, ammonia concentrations remained below or rarely exceeded applicable permit limits (Figure 8, top). In addition, nearly all third Quarter TSS effluent concentrations remained well below permit limits during the 2008-2011 period of record (Figure 8, bottom).

Bolingbrook #1 [IL0032689]
The Bolingbrook #1 WWTP discharges to the E. Branch at approximately RM 5.66. The 7-day, 10-year low flow for the East Branch at the discharge point is 28 cubic feet per second (cfs) or 18.1 MGD. The design average flow described in the 2006 NPDES permit remains at 2.04 MGD and the design maximum flow is 4.51 MGD. Treatment features include an excess flow 5.3 MG capacity lagoon, two rotary screens, influent magnetic flow meter, two rectangular primary tanks, and seven aeration tanks operated in the single stage activated sludge mode. The treatment works also include two final 55 feet diameter circular clarifiers, an effluent flow measurement facility, effluent disinfection and dechlorination facilities, a gravity belt sludge thickener and three aerobic digestion/sludge storage tanks.

Since last assessed in the *2008 Bioassessment Report*, a majority of 3rd quarter flows from Bolingbrook #1 remain below daily average limits but occasionally exceeded the design maximum in 2008-2010 (Figure 9, top). Slightly higher concentrations of $cBOD_5$ (Figure 9, bottom) and TSS (Figure 10, bottom) may have been associated with increased flows but both parameters remained well below their average monthly permit limits of 20 and 25 mg/l, respectively. In the case of NH_3-N (Figure 10, top), effluent concentrations have remained below permit limits and are essentially unchanged since 2005.

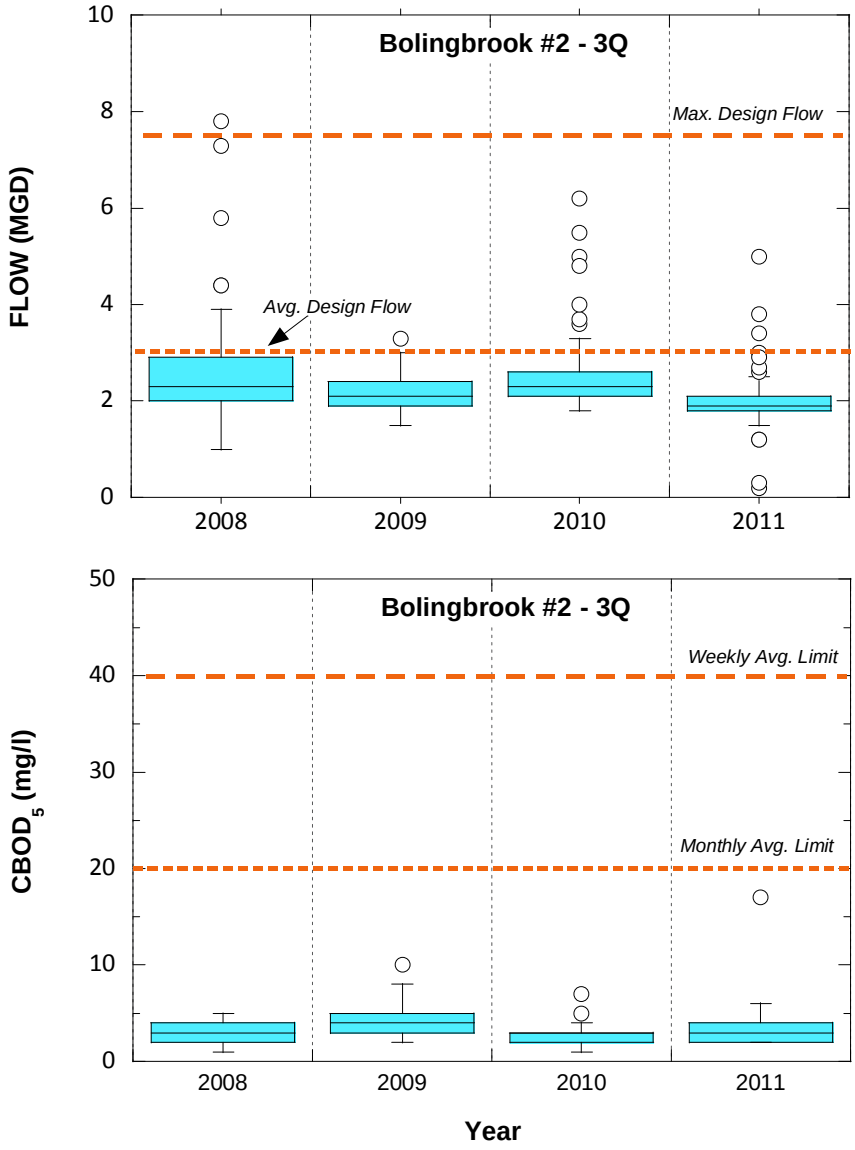


Figure 7. Third quarter effluent flows (top panel) and cBOD5 concentrations (bottom panel) from the Bolingbrook #2 WWTP by year. Design maximum and average daily flows are shown by dashed lines in the flow plot. Dashed lines in the cBOD5 plot depict the monthly and weekly average effluent limits.

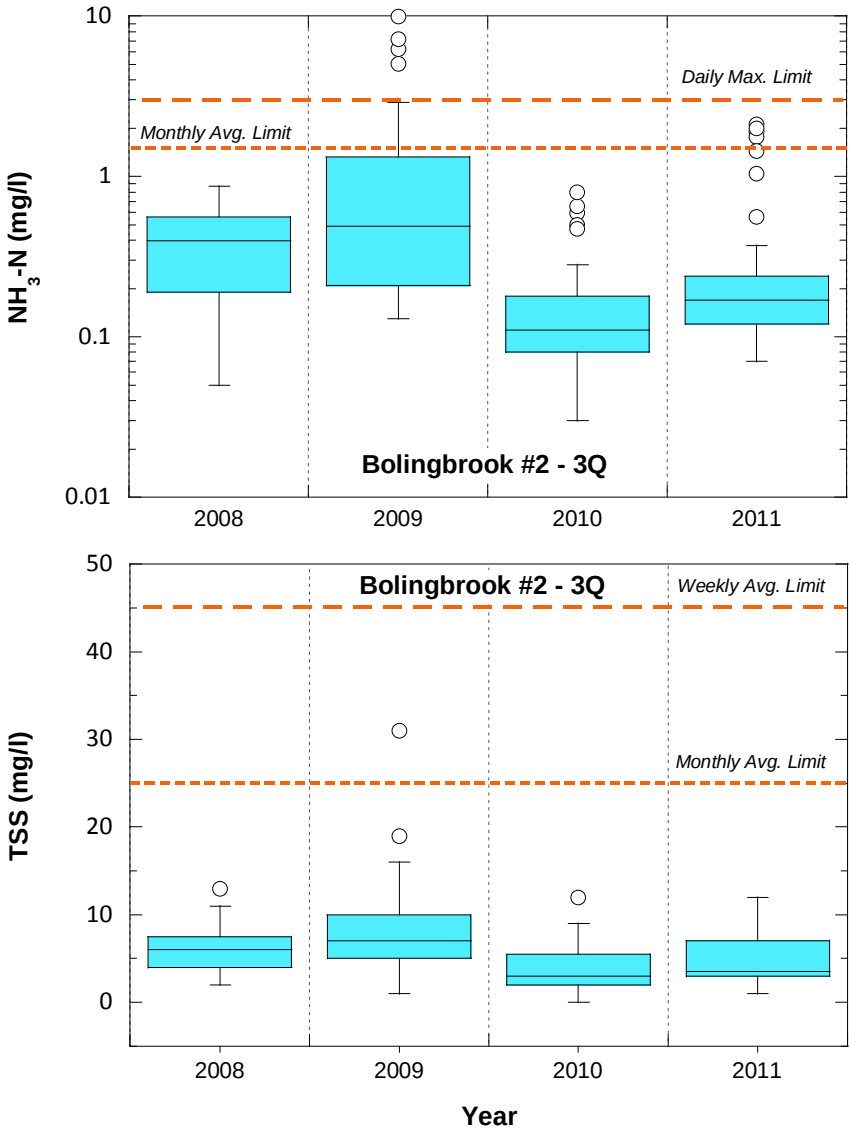


Figure 8. Third quarter concentrations of NH3-N (top panel) and TSS (bottom panel) from the Bolingbrook #2 WWTP by year. Dashed lines in the ammonia plot show the April-October monthly average (3.0 mg/l) and daily maximum (1.5 mg/l) permit limits. Dashed lines in the TSS plot depict the monthly and weekly average permit limits.

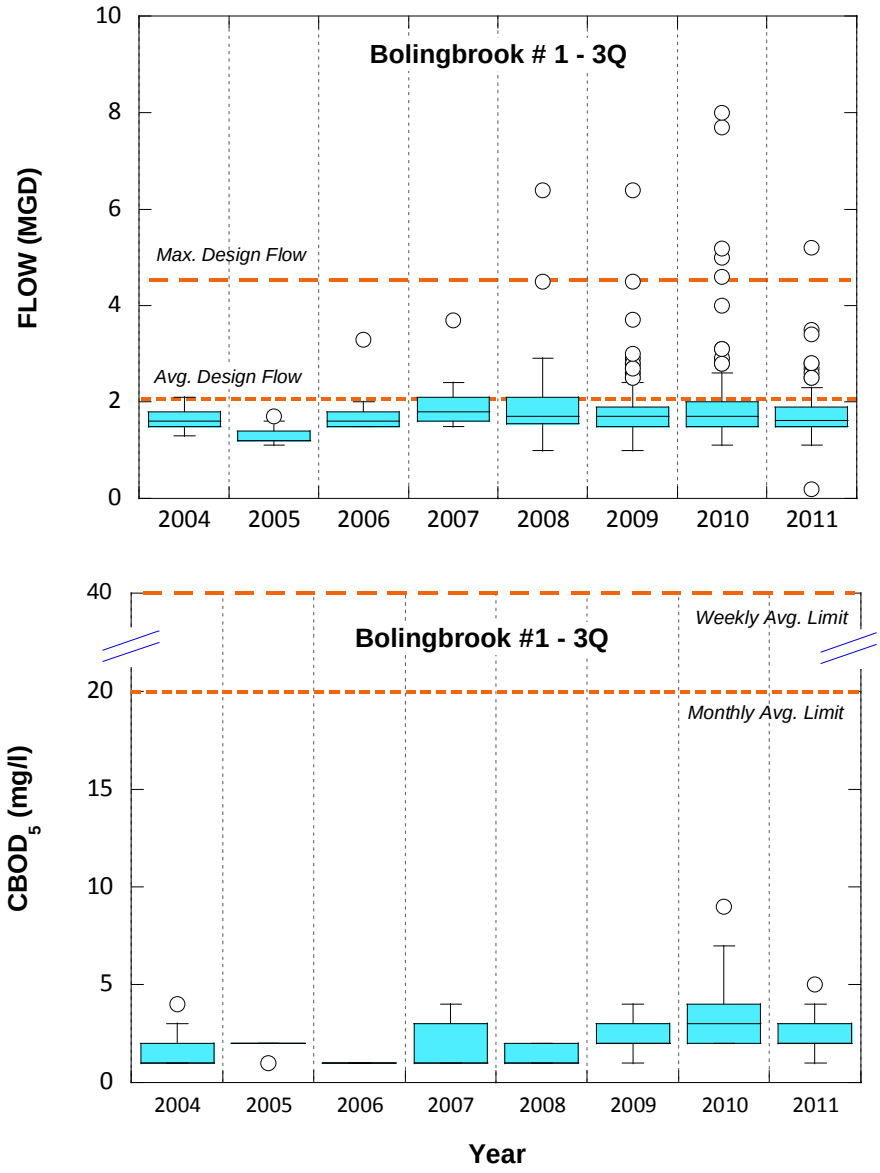


Figure 9. Third quarter effluent flows (top panel) and $cBOD_5$ concentrations (bottom panel) from the Bolingbrook #1 WWTP by year. Design maximum and average daily flows are shown by dashed lines in the flow plot. Dashed lines in the cBOD5 plot depict the weekly and monthly average permit limits.

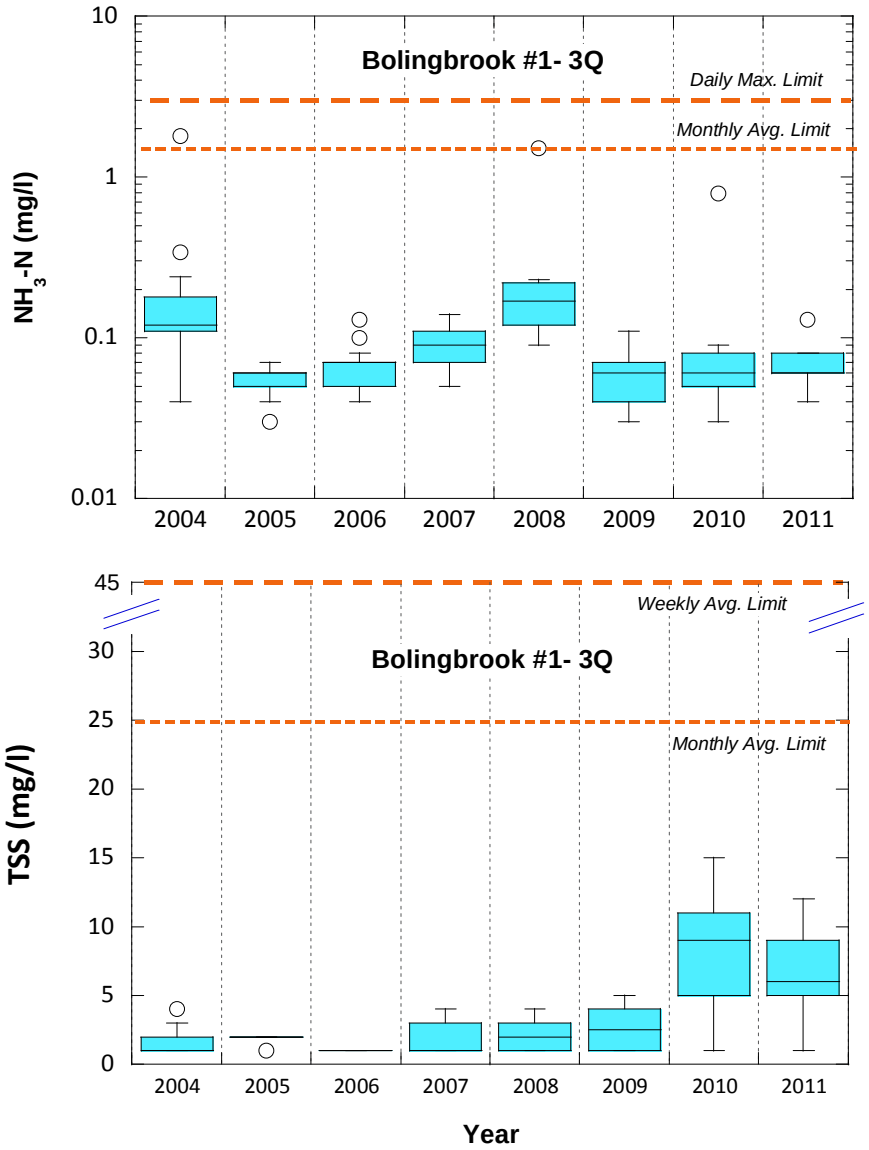


Figure 10. Third quarter concentrations of NH3-N (top panel) and TSS (bottom panel) from the Bolingbrook #1 WWTP by year. Dashed lines in the ammonia plot show the April-October monthly average (3.0 mg/l) and daily maximum (1.5 mg/l) permit limits. Dashed lines in the TSS plot depict the weekly and monthly average permit limits.

DuPage Co. – Woodridge [IL 0031844]

Since the *2008 Bioassessment Report*, flow and effluent permit limits at the Woodridge WWTP have remained constant. The treatment facility has a design average flow of 12.0 MGD and design maximum flow of 28.6 MGD. Since 1999, third quarter effluent flows remained well below the maximum flow and only exceeded the average on one occasion (Figure 11, top). The vast majority of third quarter cBOD5 concentrations were less than both the monthly average (10 mg/l) and 20 mg/l daily maximum allowed by permit but did trend higher in 2008-10 before declining to consistently low levels by 2011 (Figure 11, bottom).

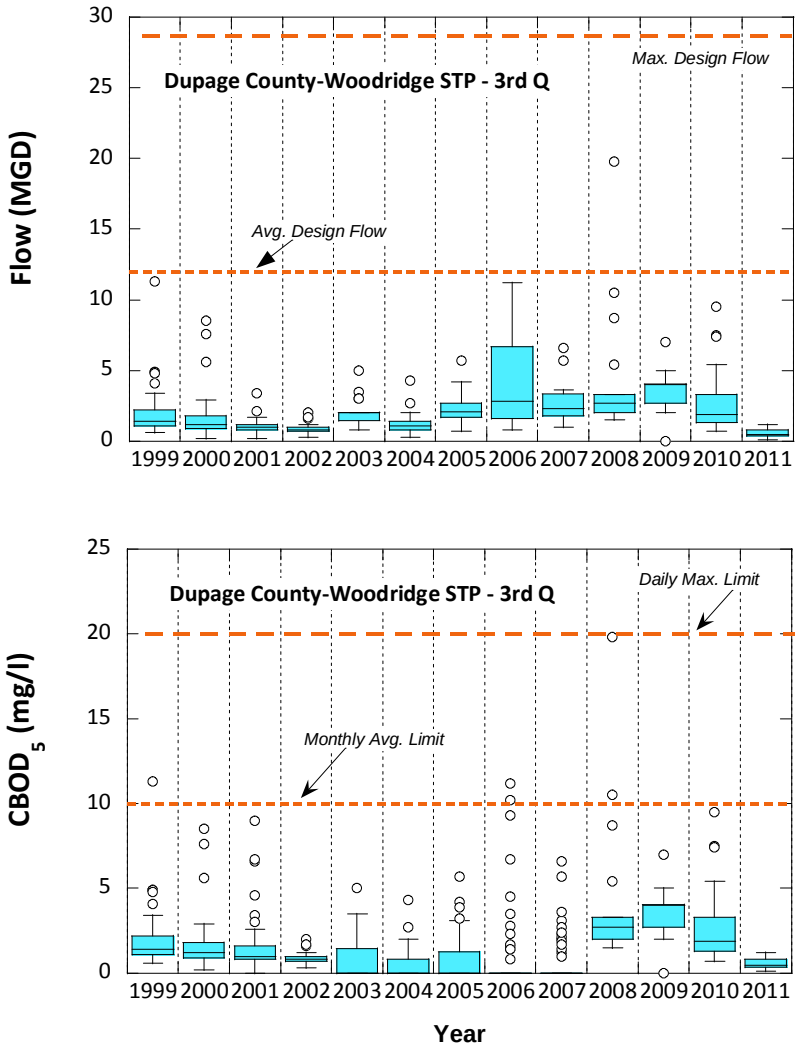


Figure 11. Third quarter effluent flows and cBOD5 concentrations from the DuPage County Woodridge-Green Valley WWTP by year. Design maximum and average daily flows are shown by dashed lines in the flow plot. Dashed lines in the cBOD5 plot depict monthly average and daily maximum effluent limits.

Similarly, third quarter concentrations of both TSS (Figure 12, top) and NH_3-N (Figure 12, bottom) increased sharply in 2008 and 2009 before experiencing steady declines and reaching

2006-2007 levels by 2011. In particular, median and 75th percentile ammonia concentrations were above daily permit limits in 2009, indicating the plant was not operating at peak efficiency. For several years prior to the *2008 Bioassessment*, efforts were initiated to address nutrient removal at the Woodridge Green Valley Facility due to occasional exceedences of NPDES permit limitations.

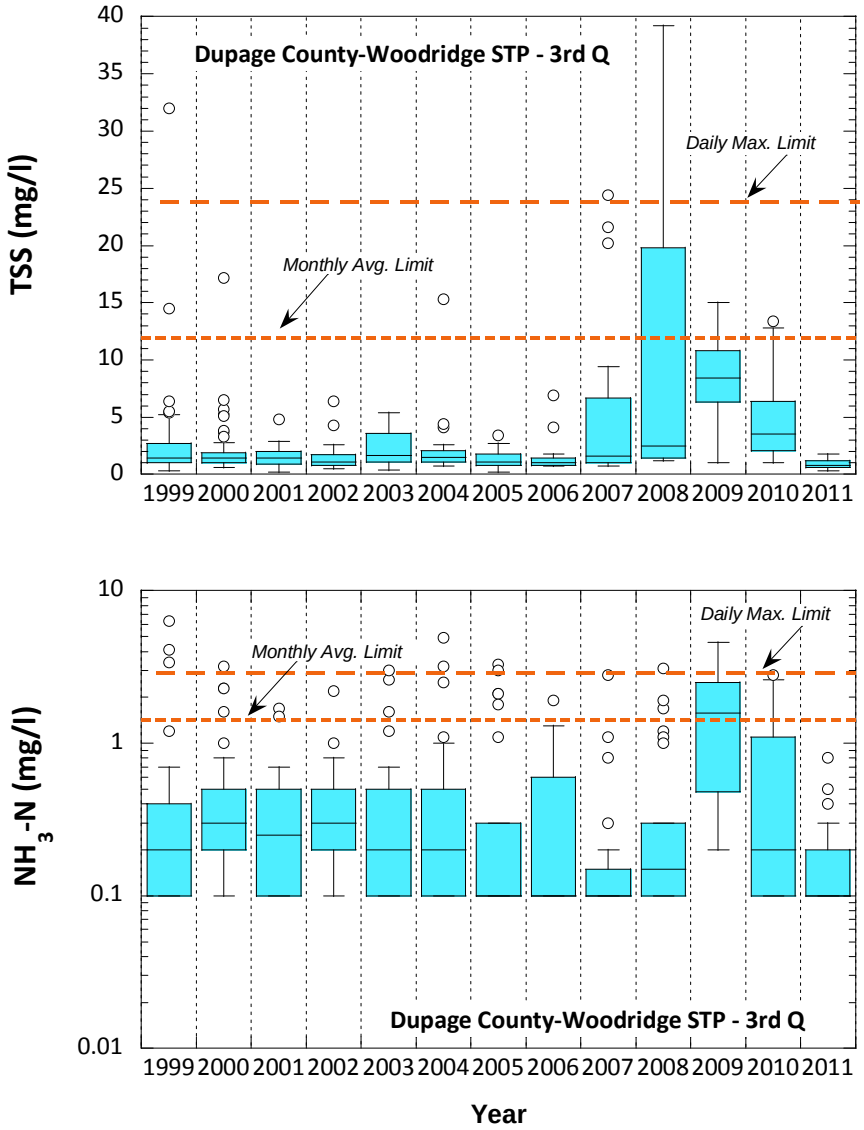


Figure 12. Third quarter effluent concentrations for TSS and NH3 reported by the DuPage County Woodridge-Green Valley WWTP by year. The monthly average and daily maximum effluent limits for TSS and ammonia (April through October) are shown by dashed lines.

Downers Grove SD [IL0028380]

The average design flow for the Downers Grove SD WWTP is 11 MGD and the maximum design flow for the facility is 22 MGD. Treatment consists of screening, grit removal, primary clarification, activated sludge, secondary clarification, filtration, excess flow treatment,

disinfection and sludge treatment. The 10-year recurrent 7-day low flow (Q7/10) of the receiving E. Branch at the discharge is 14 cfs [9.05 MGD].

Since the *2008 Bioassessment*, third quarter median and 75th percentile flows continue to fall below the design average, and extreme flows very rarely exceeded the design maximum (Figure 13, top). However, 75th percentile flows have shown an increase in recent years. Despite the increases, effluent concentrations of $cBOD_5$ (Figure 13, bottom), TSS and NH3-N (Figure 14) have been steady or trended downward and all were well below permit limits. The data indicate consistent and efficient treatment over the reporting period.

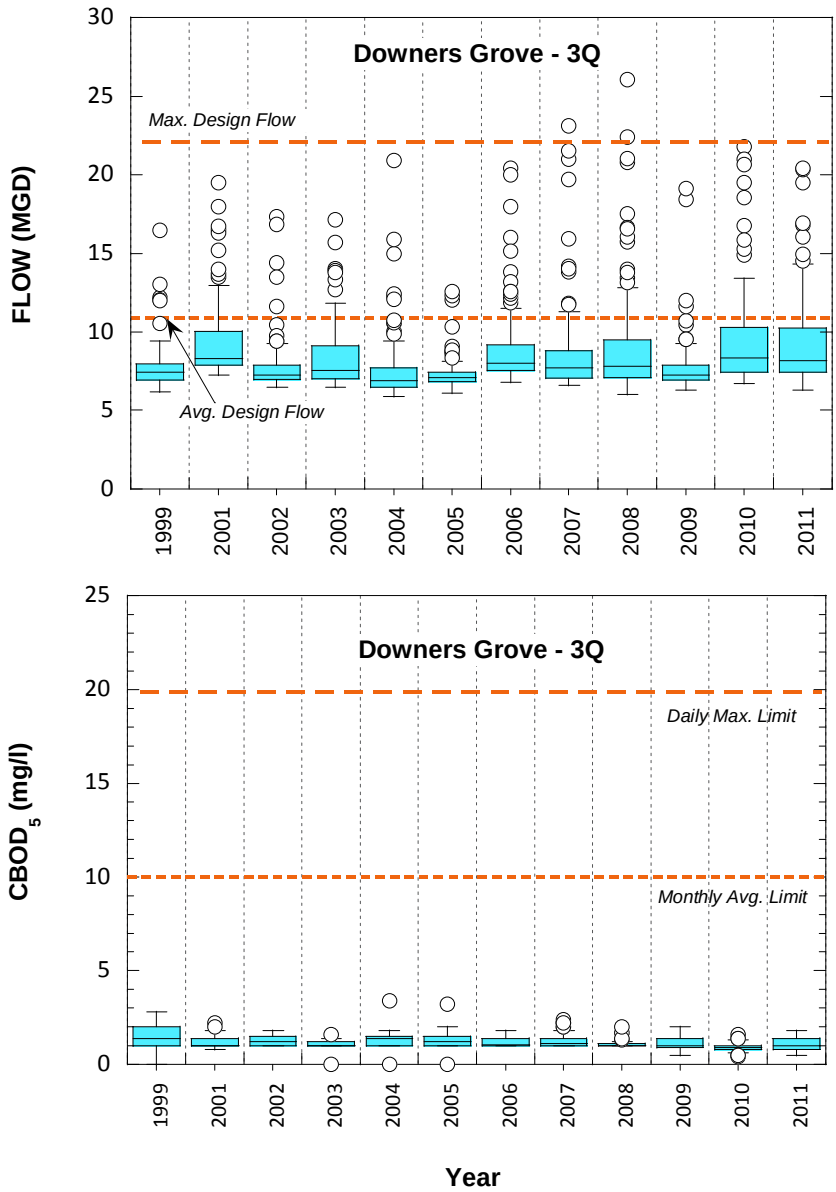


Figure 13. Third quarter effluent flows (top panel) and $cBOD_5$ concentrations (bottom panel) from the Downers Grove WWTP by year. Design maximum and average daily flows are shown by dashed lines in the flow plot. Dashed lines in the cBOD5 plot depict the daily maximum and monthly average permit limits.

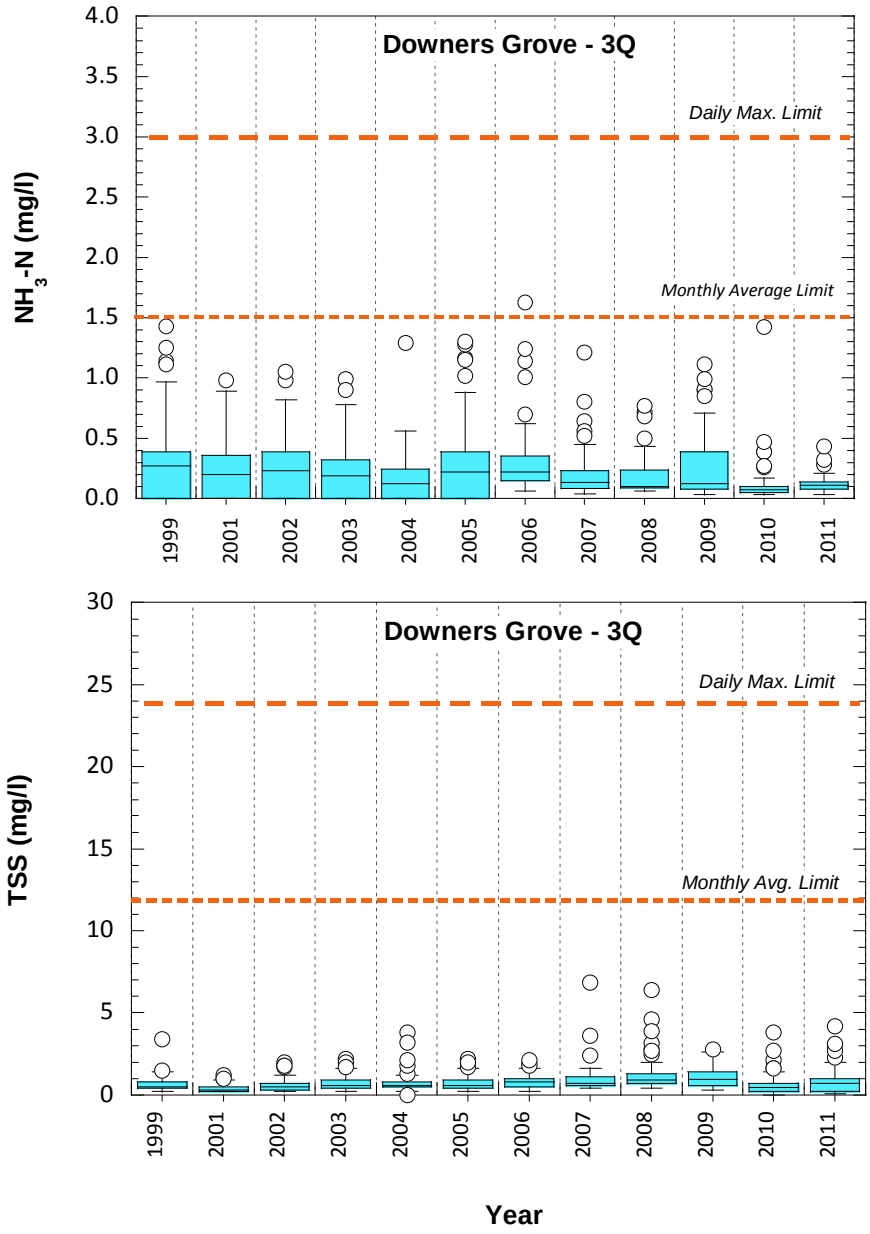


Figure 14. Third quarter concentrations of NH3-N (top panel) and TSS (bottom panel) from the Downers Grove WWTP. Dashed lines in the ammonia plot show the April-October monthly average (3.0 mg/l) and daily maximum (1.5 mg/l) permit limits. Dashed lines in the TSS plot depict the daily maximum and monthly average permit limits.

Glenbard – Glenbard [IL0021547]

The design average flow for the treatment facility is 16.02 million MGD and the maximum design flow (DMF) is 47 MGD. Treatment consists of screening, primary settling tanks, aeration tanks, intermediate clarifiers, final settling tanks, filtration, ultraviolet disinfection

system, and sludge handling facilities. The facility also has an approved pretreatment program.

Since 1998, third quarter median and maximum monthly flows at Glenbard averaged 9.91 MGD and 24.55 MGD, respectively. Flows from the plant trended downward and stabilized between 1998 and the early 2000s but have shown a gradual increasing trend since about 2005 (Figure 15). Despite increasing flows, effluent concentrations of cBOD5 and TSS have declined since 1998 and remained consistently below respective permit limits for both daily maximums and monthly averages (Figure 16, top and middle). Third quarter effluent concentrations of ammonia-nitrogen frequently exceeded permit limits between 1998 and 2003; however, concentrations between 2004 and 2011 trended downward and remained consistently below applicable monthly average and daily maximum limits (Figure 16, bottom).

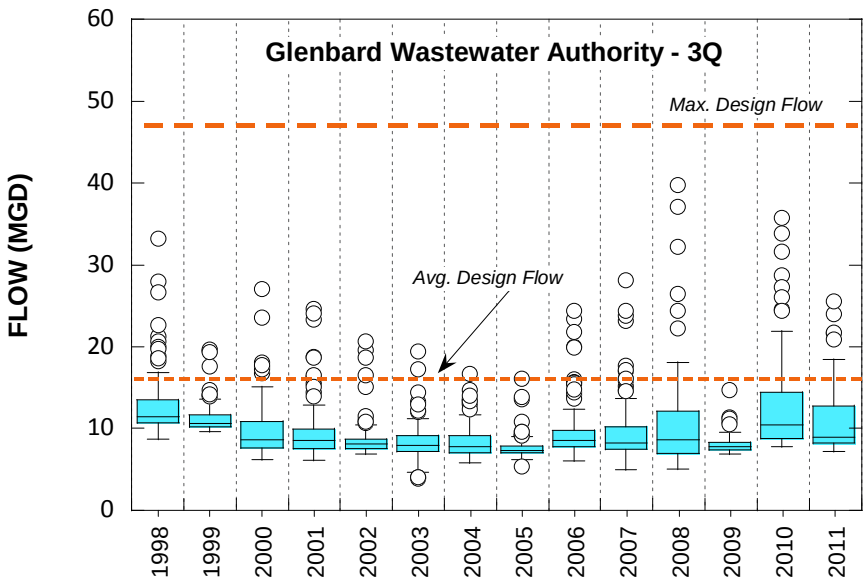


Figure 15. Third quarter effluent flows from the Glenbard Wastewater Authority-Glenbard WWTP. Design maximum and average daily flows are shown by dashed lines.

Glenbard – Lombard Combined Facility [IL0022471]

The 10-year recurrent 7-day low flow (Q7/10) of the E. Branch at the discharge is 4 cfs (2.6 MGD). This facility treats excess flows during runoff events thus it does not have an average design flow. The maximum design flow is 58.0 MGD. Treatment consists of screening, grit removal, sedimentation and disinfection.

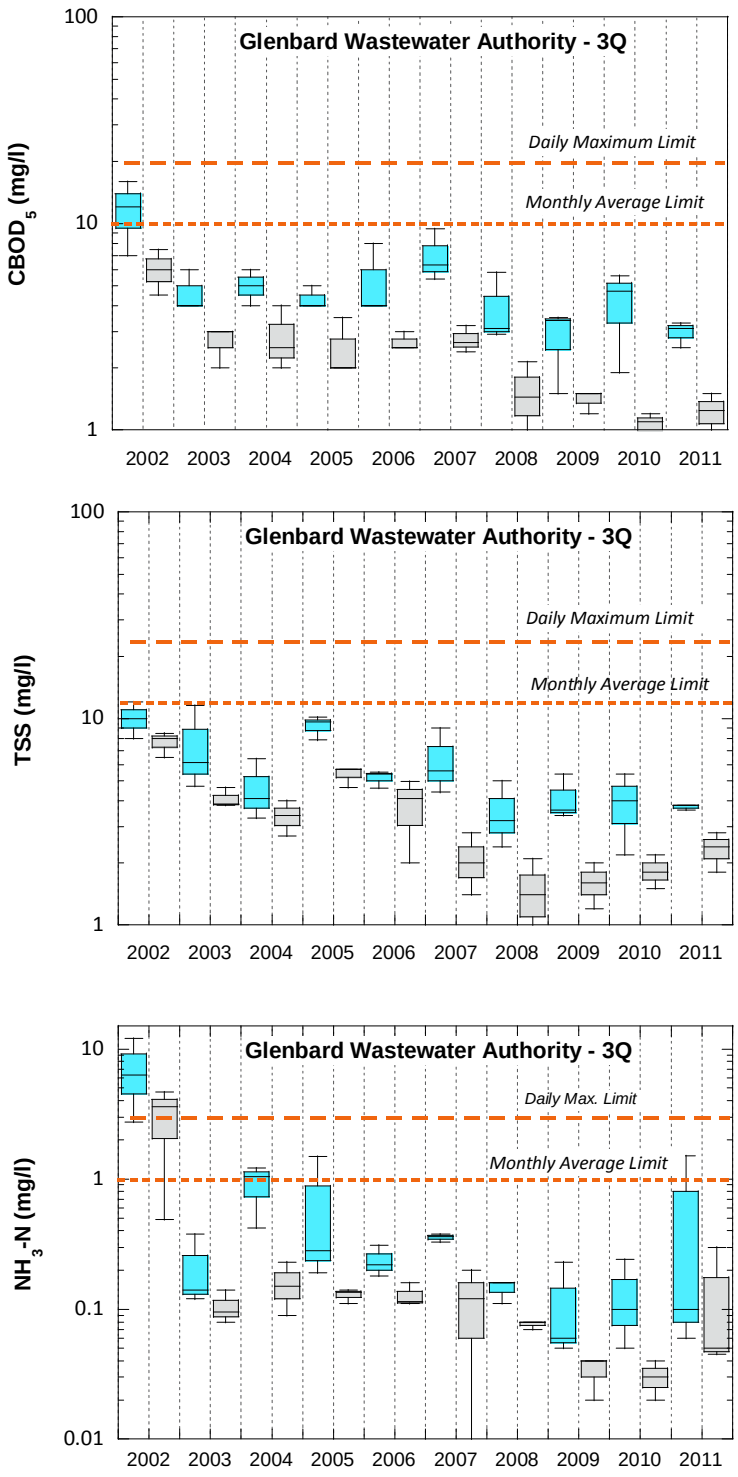


Figure 16. Third quarter monthly maximum (shaded boxes) and median (open boxes) effluent concentrations of cBOD5 (top panel), TSS (middle panel) and NH_3-N (lower panel) for the Glenbard Wastewater Authority-Glenbard WWTP. Dashed lines show the respective permit limits for the daily maximum and monthly average.

Glendale Heights [IL0028967]
The Glendale Heights WWTP discharges to Armitage Ditch, 0.4 miles upstream from the E. Branch confluence. The design average flow is 5.25 MGD and the design maximum is 10.52 MGD. Treatment consists of two mechanical bar screens, influent pumping station, grit removal system, three primary sedimentation tanks, four activated sludge aeration tanks, two secondary clarifiers, three tertiary sand filters, two post aeration tanks, chlorine disinfection system, sodium bisulfite dechlorination, two aerobic digesters, two belt filter presses, and two excess flow clarifiers.

Daily flows from the plant were typically less than the design average for the 2008-2011 period of record (Figure 17). Third quarter concentrations of TSS and ammonia-nitrogen were consistently below the monthly average limits and cBOD5 only occasionally exceeded these limits in 2008 (Figure 18). Third quarter concentrations of NH_3-N appeared to trend downward from 2008 to 2011.

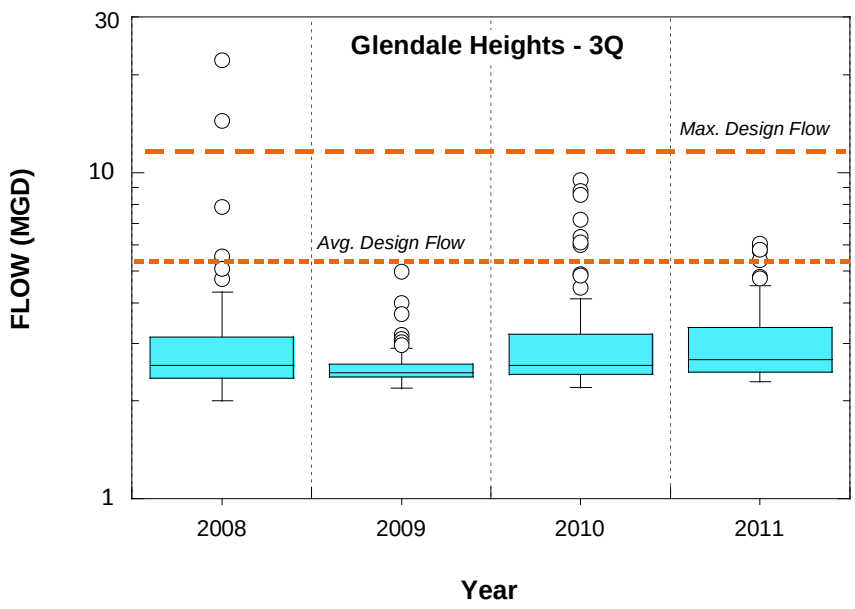


Figure 17. Third quarter effluent flow data (MGD) for the Glendale Heights WWTP from 2008 to 2011. Design maximum and average daily flows are shown by dashed lines.

Bloomingdale-Reeves [IL0021130]
The 10-year recurrent 7-day low flow (Q7/10) of the E. Branch at the discharge is 0 cfs. The average design flow for the treatment facility is 3.45 MGD and the maximum design flow for the facility is 8.625 MGD. Treatment consists of screening, aeration, final clarifiers, intermittent sand filters, chlorination, dechlorination, aerobic digesters, sludge handling, and excess flow treatment.

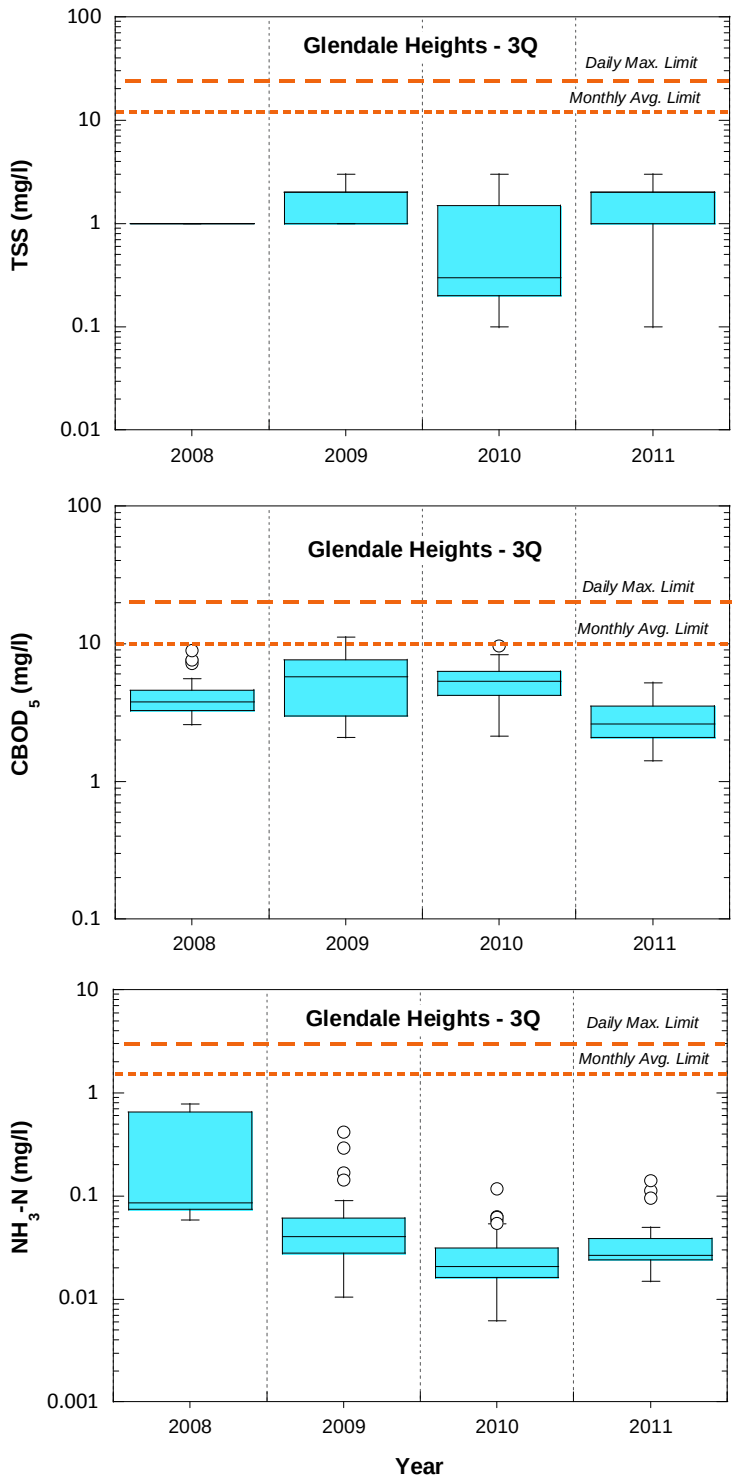


Figure 18. Third quarter effluent data for the Glendale Heights WWTP. Upper panel: total suspended solids in milligrams per liter (mg/l); middle panel: 5-day carbonaceous biological oxygen demand (mg/l); and lower panel: ammonia nitrogen (mg/l). Dashed lines show the respective permit limits for the daily maximum and monthly average.

Third quarter effluent flows did not exceed the plant design maximum between 1998 and 2011 and were typically less than the design daily average (Figure 19). Effluent concentrations of NH_3-N, cBOD5 and TSS were usually less than applicable permit limits except for a few ammonia exceedences in 2005 and 2008 and frequent TSS exceedences in 2005 when concentrations exceeded both monthly average and daily maximum limits (Figure 20). Elevated ammonia-nitrogen concentrations, though rarely exceeding the daily maximum limit, were coincident with the high TSS concentrations. Concentrations of all three parameters have shown a general downward trend since the 2007 survey.

The 2008 Bioassessment Report evaluated excess flow trends at Bloomingdale-Reeves (i.e., bypasses after secondary treatment). The study found that prior to 2007, bypasses commonly occurred when effluent flows were less than the average design capacity and appeared to have been minimally treated. However, by 2007-2008 excess discharges were comparatively less frequent and mostly occurred when the flows exceeded average design capacity. Excess flow trends were not evaluated for the 2011 survey.

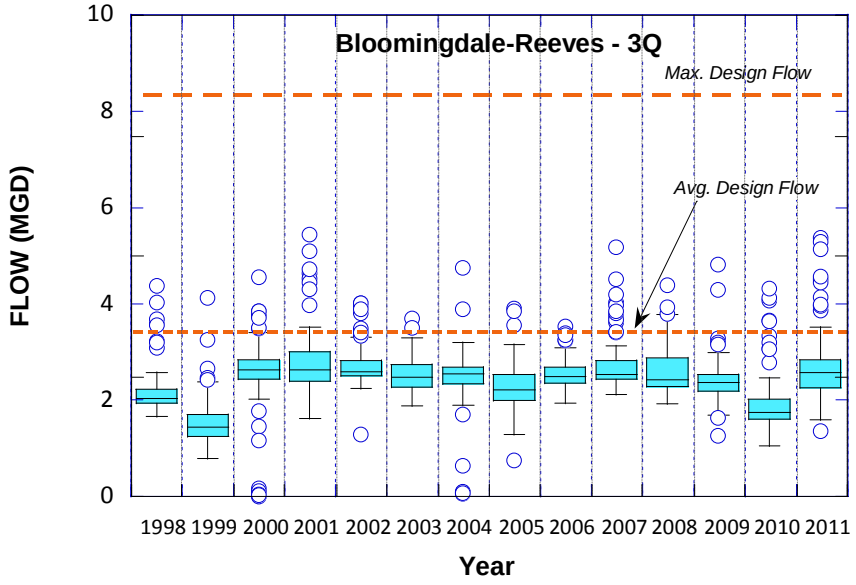


Figure 19. Third quarter effluent flows from the Bloomingdale-Reeves WWTP. Design maximum and average daily flows are shown by dashed lines.

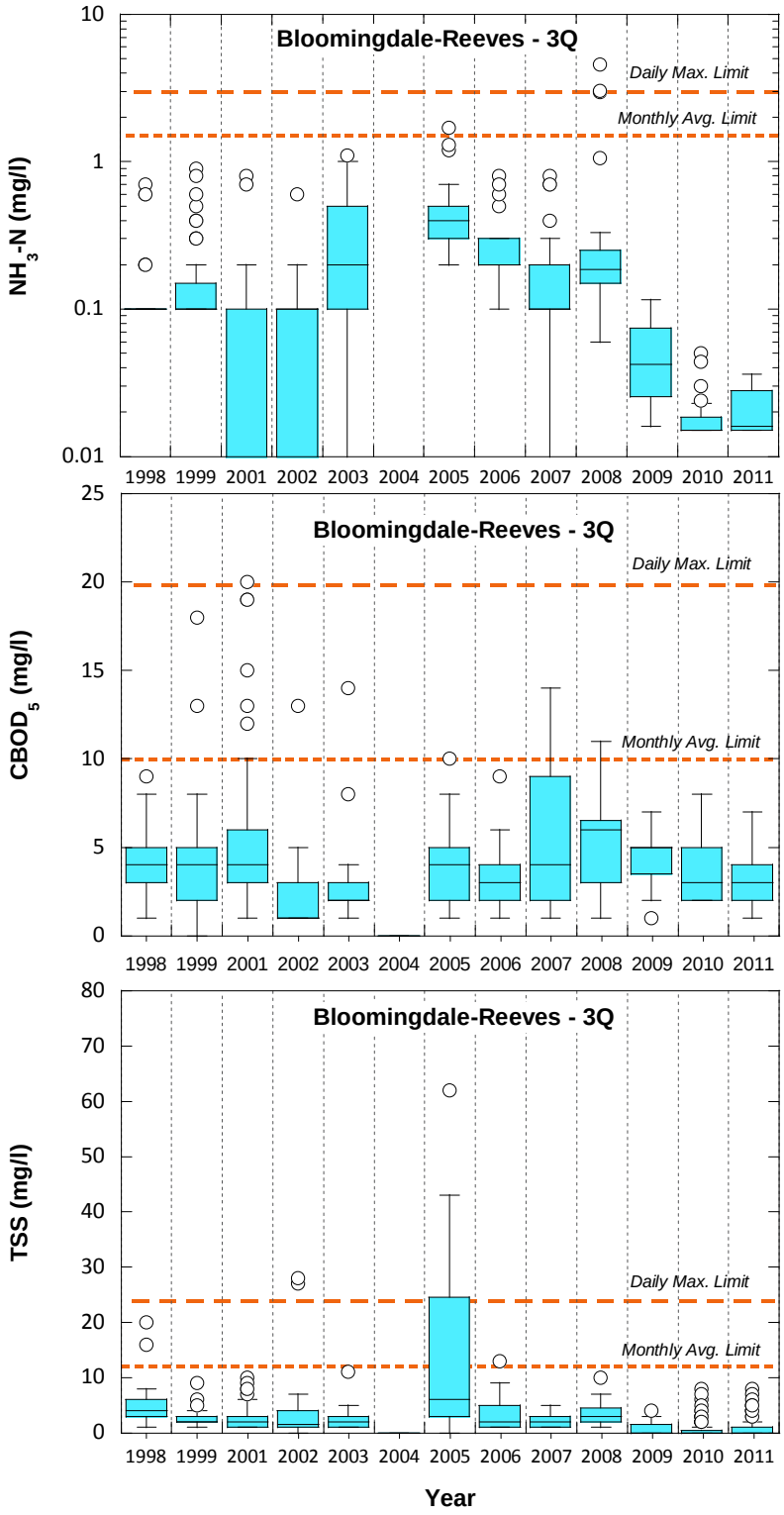


Figure 20. Third quarter effluent concentrations of NH3-N (top panel), cBOD5 (middle panel), and TSS (lower panel) for the Bloomingdale-Reeves WWTP. Dashed lines show the respective permit limits for the daily maximum and monthly average.

E. Branch DuPage River Flow Conditions

Stream flows were seasonally variable in both the spring and summer of 2007 and 2011, but were generally higher during the latter survey (Figure 21). Measured at the USGS East Branch gage in Downers Grove, daily minimum and peak flows were nearly identical between surveys. However, 2011 flows averaged 20 cfs higher over the entire period.

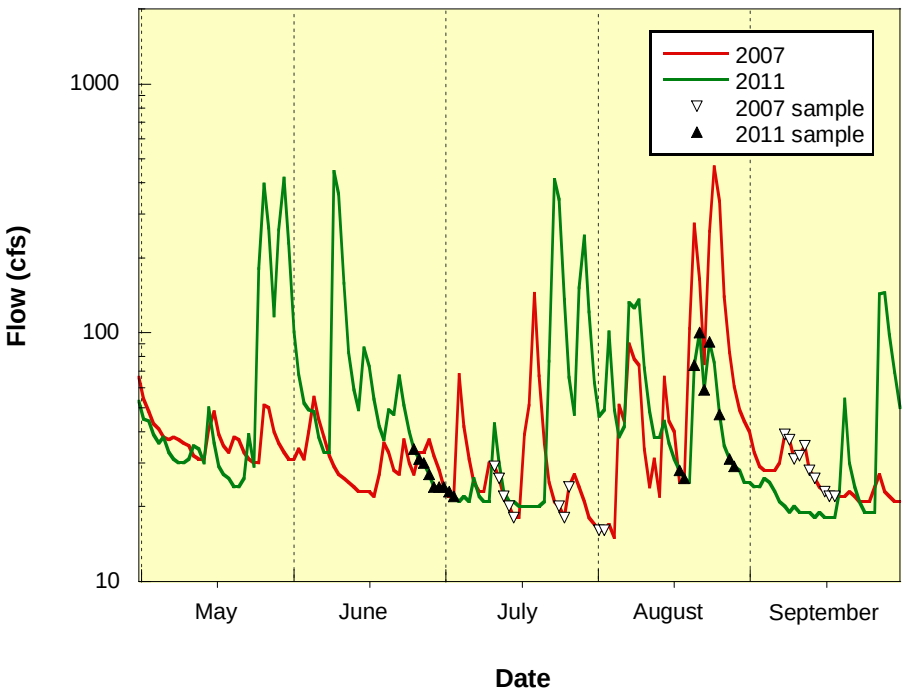


Figure 21. Flow hydrographs for E. Branch DuPage River near Downers Grove (USGS station #) from May through September, 2007 and 2011. Solid and open triangles indicate river discharge on fish sampling days on the East Branch mainstem.

Percent of E. Branch DuPage River Baseflow as Effluent

The East Branch mainstem at summer-fall baseflow is largely an effluent dominated river. The USGS gage at Bolingbrook was used to estimate the daily flow statistics for September 2011. The median daily flow was 48 cfs while the average flow of 80.4 cfs was influenced by storms late in the month (Figure 21). By using the total average daily flows from WWTPs upstream from the gage (see pie chart attached to Table 5; total excludes Bolingbrook #1 and #2 WWTPs) the average effluent flow is 30.445 MGD or 47.105 cfs. This average flow is 98.1% of the median flow of 48 cfs for September 2011. There is variability in effluent flow over this period, but in any case, at low flow, WWTP effluent is a dominant fraction of the river flow. The mean daily river flow from the Bolingbrook USGS gage is plotted vs. the daily WWTP effluent flow averages (converted to cfs) in Figure 22; the plot illustrates the potential predominance of WWTP effluents in river flow under low-flow conditions.

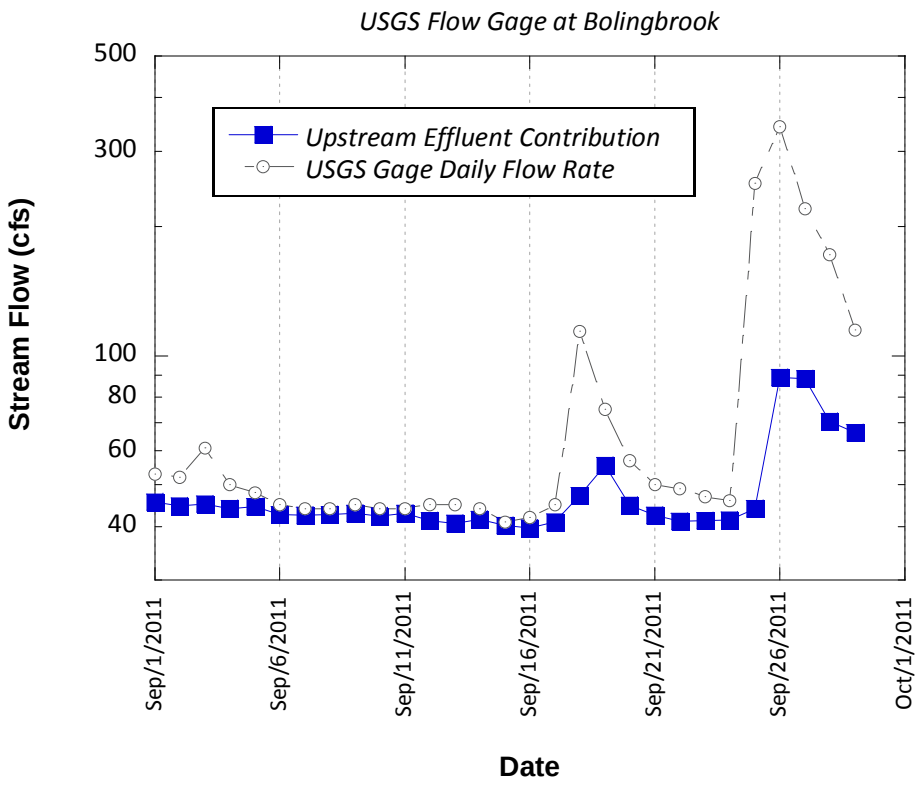


Figure 22. Mean daily flow in September 2011 at the USGS gage at Bolingbrook [05540250] vs. the contribution of effluent flows from five upstream dischargers on the E. Branch DuPage River and tributaries.

RESULTS

E. Branch DuPage River Watershed - Chemical Water Quality

East Branch mainstem flows are effluent dominated during late summer-early fall months, reaching 75% treated wastewater in 2007 and up to 98% in 2011. As such, chemical water quality is highly influenced by the concentration and composition of chemical constituents in effluents, as well as urban runoff in the highly developed watershed. Sampling in 2011 during low flow periods indicate that treated effluent quality, with respect to regulated parameters (i.e., $cBOD_5$, TSS, NH_3-N), did not result in exceedences of Illinois water quality criteria.

Concentrations of NH_3-N were generally less than 1.0 mg/l in all samples collected along the mainstem (Figure 23). Elevated ammonia-N concentrations are symptomatic of poorly or untreated sewage, and ammonia-N concentrations greater than 1.0 mg/l represents a threshold beyond which chronic toxicity is likely. However, secondary or indirect effects from high concentrations of nutrients can also negatively affected water quality. The 2009 IPS study (Miltner et al. 2010) identified a threshold of 0.15 mg/l associated with impaired biological assemblages and many values in 2011 were above this threshold (Figure 23, top).

While Nitrate-N values in 2007 were considered high compared to unpolluted streams (MBI 2008), there was a substantial, nearly one order of magnitude increase in nitrate-N during 2011 (Figure 23, bottom). High nitrate-N values were first observed immediately downstream from the Bloomingdale-Reeves WWTP and with only two exceptions, remained elevated throughout the mainstem. In contrast, almost all Nitrate-N values upstream from the Bloomingdale-Reeves WWTP and from East Branch tributaries were less than 1.0 mg/l (see Figure 28). Concentrations of total phosphorus (TP) were elevated in 2007 and remained high, relative to unpolluted streams, during 2011 (Figure 24). The high concentrations of these nutrients appear to stimulate high levels of autotrophic productivity. Concentrations of TKN, an indicator of the living or recently dead fraction of the sestonic algae, were high during both years although data were variable between dates; there was an increasing downstream trend in outliers in the 2007, whereas in 2011 values were high throughout the river (Figure 24).

The East Branch mainstem essentially begins at the West Lake dam and impoundment (RM 23.8). Chemical sampling from the ditched channel immediately downstream revealed high concentrations of $cBOD_5$ in both 2007 and 2011 (Figure 25, top). Additional spikes downstream in 2007 were largely attributed to autotrophic activity from additional impoundments and excess flows from CSOs or WWTPs. During both surveys, $cBOD_5$ concentrations declined immediately downstream from the Bloomingdale-Reeves WWTP as the discharge dominates the flow. A sharp reduction in $cBOD_5$ in 2011 below the former Churchill Woods dam points to the benefits of the dam's removal. Further downstream $cBOD_5$ concentrations in 2011 declined, but tended to increase over the lower, approximate 10 river miles.

Total suspended solids (TSS) followed a similar pattern to $cBOD_5$. Most concentrations were within ranges associated with relatively unpolluted streams (Figure 25, bottom), but showed a sharp spike immediately downstream from the former Churchill Woods impoundment in 2011.

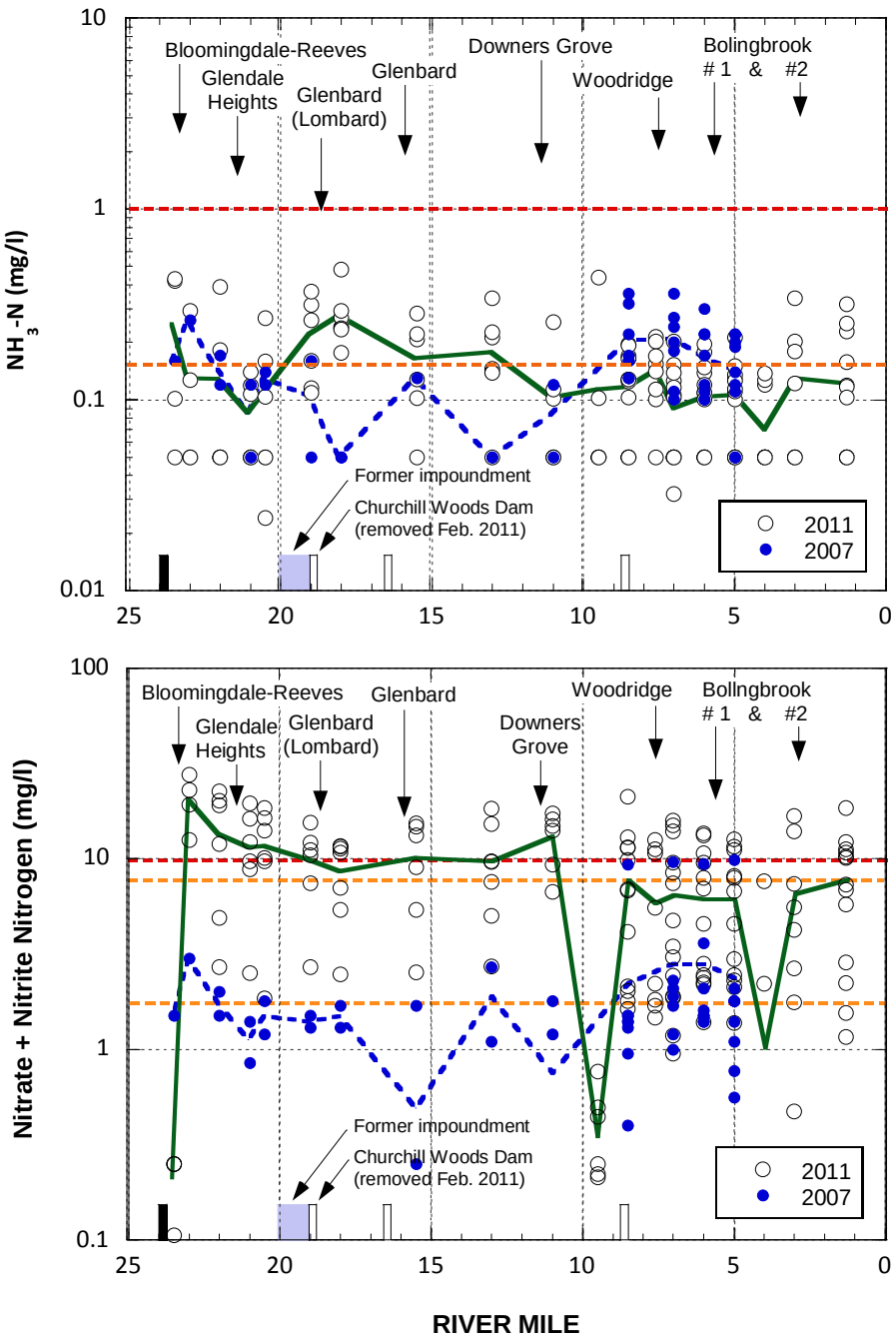


Figure 23. Concentrations of ammonia nitrogen (top panel) and nitrate-nitrite nitrogen (lower panel) from E. Branch DuPage River samples in 2007 (solid blue dots) and 2011 (open circles) in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). For ammonia, the red dashed line (1.0 mg/l) represents a threshold concentration beyond which toxicity is likely; the orange dashed line (0.15 mg/l) is correlated with impaired biota in the IPS study. For nitrate-nitrite, 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).

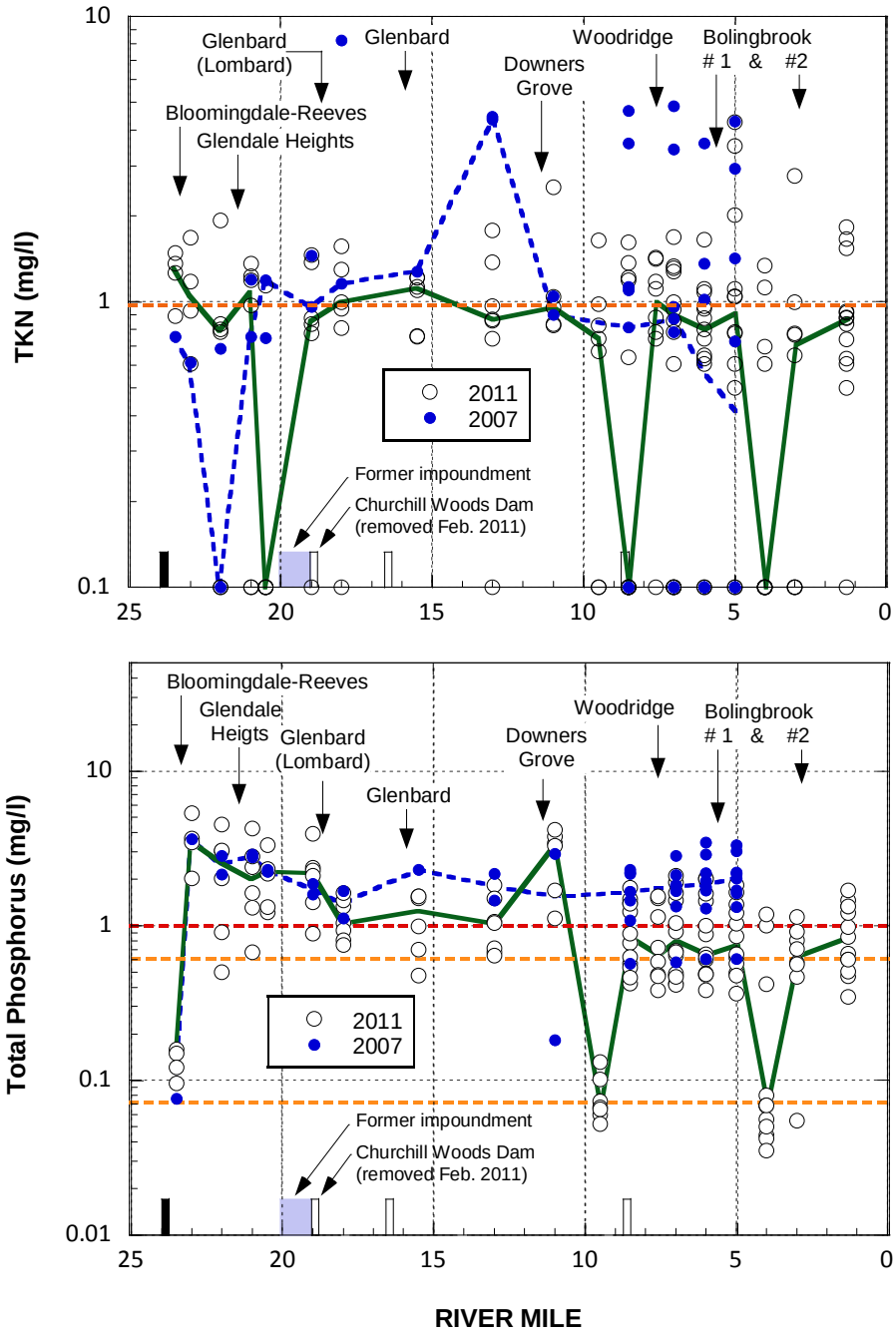


Figure 24. Concentrations of total Kjeldahl nitrogen (top panel) and total phosphorus (lower panel) from E. Branch DuPage River samples in 2007 (solid blue dots) and 2011 (open circles) in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage).For TKN, the orange dashed line represents the IPS aquatic life target level (1.0 mg/l). For phosphorus, orange dashed lines represent target concentrations for USEPA Ecoregion 54 (0.072 mg/l) and the Illinois EPA non-standard based criteria (0.61 mg/l). The 1.0 mg/l dashed red line is the suggested protective effluent limit.

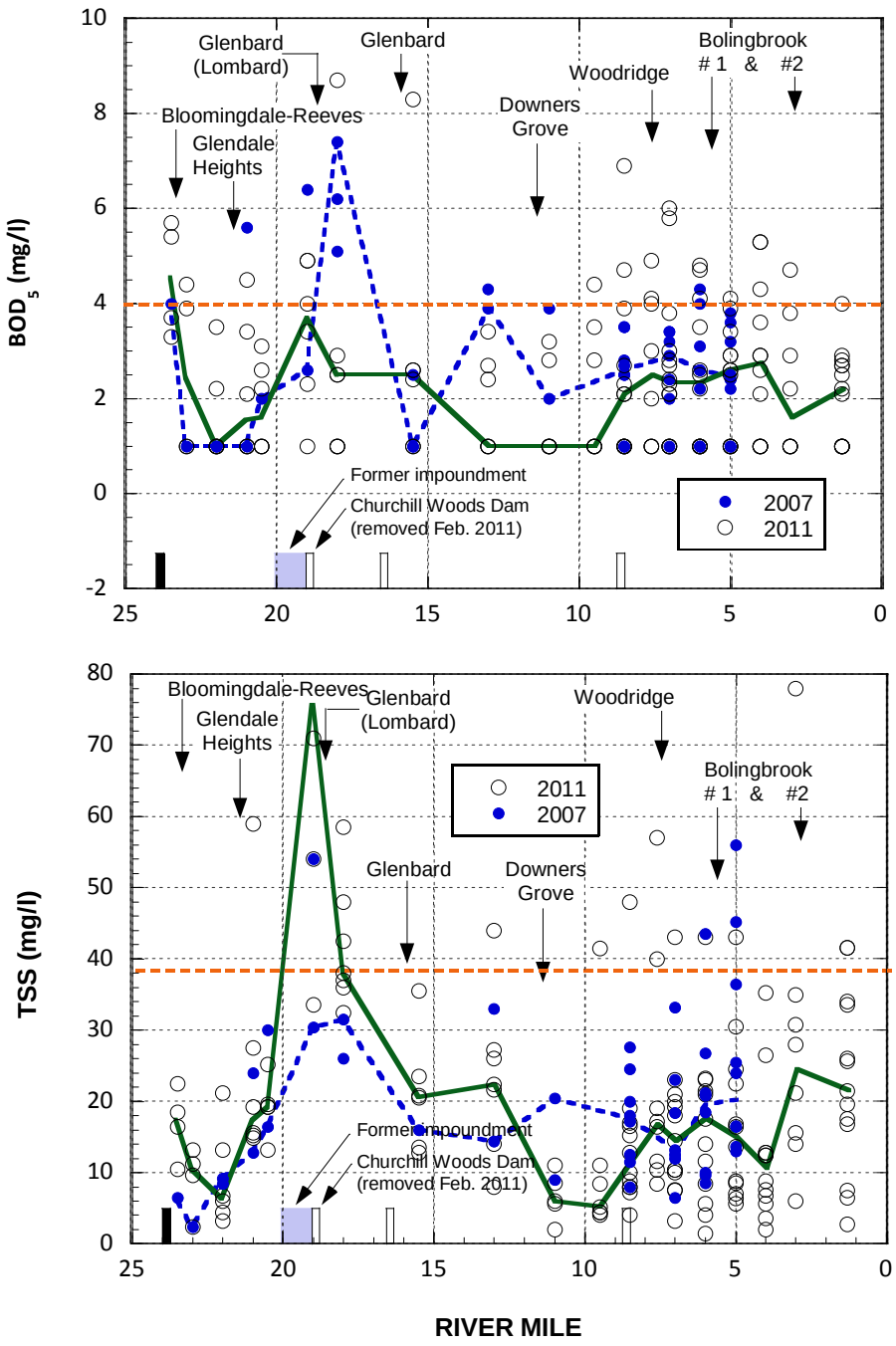


Figure 25. Concentrations of 5-day biological oxygen demand (top panel) and total suspended solids (lower panel) from E. Branch DuPage River samples in 2007 (solid blue dots) and 2011 (open circles) in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). The dashed line in each plot shows the upper limit of concentrations typical for relatively unpolluted waters.

A localized release of soft, mucky fines from the former impoundment was considered a likely source. TSS levels declined with increased distance downstream and experienced a similar trend of increase to $cBOD_5$ over the lower approximate ten stream miles. Increased algal productivity may be related to the increase in suspended material.

Higher algal activity also drove wider swings in dissolved oxygen (D.O.) resulting in periodic exceedences of water quality criteria between 2009 and 2011at five mainstem sites where continuous monitors were deployed. Minimum at any time criteria were exceeded at each station and at some point during each sampling years [Table 6, Figure 26). In addition, exceedences of rolling 7-day averages for both minimum and mean values were measured for many stations and periods (Appendix A Figures A1-A5). The pattern reflects an overly enriched urban river where D.O. values are likely an important limitation to fish and macroinvertebrate assemblages during periods of most summers.

Table 6. *Dissolved oxygen concentrations (mg/l) in violation of Illinois water quality standards from the E. Branch DuPage River, 2009-2011.*

Site ID	River	Year	Date(s)	Parameter	Criteria	Standard
EBAT (RM 23.0)	E. Branch DuPage R.	2009	June - 22	D.O.	<6.0	7-day Average
			Aug 1-3	D.O.	<4.0 mg/l	7-day Minimum
			Aug 8-22	D.O.	<4.0 mg/l	7-day Minimum
			Aug - 2	D.O.	<3.5 mg/l	Not to exceed
			July - 28	D.O.	<5.0 mg/l	Not to exceed
			June - 19	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2010	May 26 - July 31	D.O.	<6.0	7-day Average
			Aug 3 - Sep 29	D.O.	<4.0 mg/l	7-day Minimum
			Aug - 15	D.O.	<3.5 mg/l	Not to exceed
			July - 26	D.O.	<5.0 mg/l	Not to exceed
			June - 26	D.O.	<5.0 mg/l	Not to exceed
			Sep - 29	D.O.	<3.5 mg/l	Not to exceed
	E. Branch DuPage R.	2011	June 10 - 14	D.O.	<6.0	7-day Average
			July 6 - 31	D.O.	<6.0	7-day Average
			Aug 4 - 9	D.O.	<4.0 mg/l	7-day Minimum
			Aug 15 - 21	D.O.	<4.0 mg/l	7-day Minimum
			Sep 1 - 6	D.O.	<4.0 mg/l	7-day Minimum
			July - 24	D.O.	<5.0 mg/l	Not to exceed
			June - 7	D.O.	<5.0 mg/l	Not to exceed
EBSC (aka, EBCB) (RM 20.0)	E. Branch DuPage R.	2009	Aug - 2	D.O.	<3.5 mg/l	Not to exceed
			July - 3	D.O.	<5.0 mg/l	Not to exceed
			June - 4	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2010	June 10 - 11	D.O.	<6.0	7-day Average
			June 13	D.O.	<6.0	7-day Average
			June 16 - 17	D.O.	<6.0	7-day Average
			June 19 - 21	D.O.	<6.0	7-day Average
			June 24 - July 2	D.O.	<6.0	7-day Average
			July 28 - 31	D.O.	<6.0	7-day Average
			Aug 1 - 18	D.O.	<4.0 mg/l	7-day Minimum

Site ID	River	Year	Date(s)	Parameter	Criteria	Standard
			Aug - 4	D.O.	<3.5 mg/l	Not to exceed
			July - 10	D.O.	<5.0 mg/l	Not to exceed
			June - 18	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2011	Aug 7 - 10	D.O.	<4.0 mg/l	7-day Minimum
			Aug 23 - Sep 15	D.O.	<4.0 mg/l	7-day Minimum
			Sep - 4	D.O.	<3.5 mg/l	Not to exceed
EBBR (RM 14.3)	E. Branch DuPage R.	2009	July 6 - 30	D.O.	<6.0	7-day Average
			July - 15	D.O.	<5.0 mg/l	Not to exceed
			June - 6	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2010	June 4 - 7	D.O.	<6.0	7-day Average
			June 20 - 21	D.O.	<6.0	7-day Average
			June 23 - July 7	D.O.	<6.0	7-day Average
			July 17 - 31	D.O.	<6.0	7-day Average
			July - 18	D.O.	<5.0 mg/l	Not to exceed
			June - 5	D.O.	<5.0 mg/l	Not to exceed
EBHL (RM 14.0)	E. Branch DuPage R.	2009	July 16	D.O.	<6.0	7-day Average
			July 28 - 31	D.O.	<6.0	7-day Average
			Aug 1 - 9	D.O.	<4.0 mg/l	7-day Minimum
			Aug - 4	D.O.	<3.5 mg/l	Not to exceed
			July - 7	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2010	June 4 - 10	D.O.	<6.0	7-day Average
			June 16 - 17	D.O.	<6.0	7-day Average
			June 19 - July 2	D.O.	<6.0	7-day Average
			Aug 2 - 8	D.O.	<4.0 mg/l	7-day Minimum
			Sep 3 - 5	D.O.	<4.0 mg/l	7-day Minimum
			Sep 22 - 24	D.O.	<4.0 mg/l	7-day Minimum
			Aug - 1	D.O.	<3.5 mg/l	Not to exceed
			July - 9	D.O.	<5.0 mg/l	Not to exceed
			June - 8	D.O.	<5.0 mg/l	Not to exceed
			Sep - 4	D.O.	<3.5 mg/l	Not to exceed
	E. Branch DuPage R.	2011	July 23 - 31	D.O.	<6.0	7-day Average
			July - 16	D.O.	<5.0 mg/l	Not to exceed
EBHR (RM 8.5)	E. Branch DuPage R.	2009	June 1 - 4	D.O.	<6.0	7-day Average
			June 20 - 28	D.O.	<6.0	7-day Average
			July 8 - 22	D.O.	<6.0	7-day Average
			June - 3	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2010	May 12 - 17	D.O.	<6.0	7-day Average
			June 1 - July 31	D.O.	<6.0	7-day Average
			July - 28	D.O.	<5.0 mg/l	Not to exceed
			June - 7	D.O.	<5.0 mg/l	Not to exceed
	E. Branch DuPage R.	2011	June 14-July 31	D.O.	<6.0	7-day Average
			Aug 2 - 10	D.O.	<4.0 mg/l	7-day Minimum
			Aug 21 - 27	D.O.	<4.0 mg/l	7-day Minimum
			Sep 2 - 6	D.O.	<4.0 mg/l	7-day Minimum
			July - 29	D.O.	<5.0 mg/l	Not to exceed

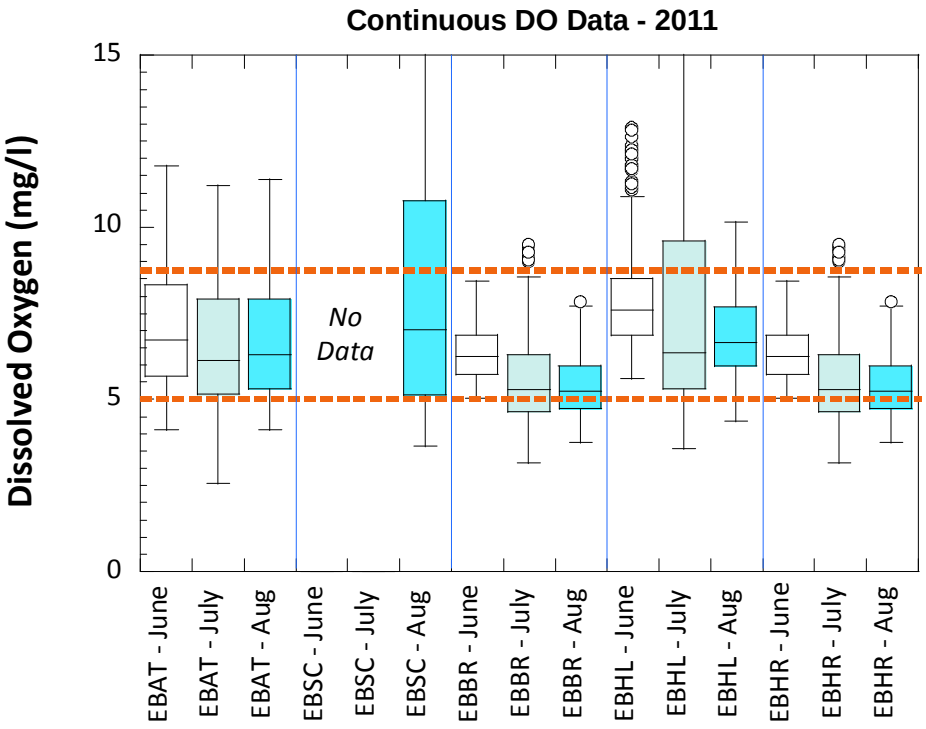


Figure 26. *Box and whisker plots of monthly dissolved oxygen concentrations (mg/l) measured by continuous monitors in the East Branch DuPage River July-August, 2011. East Branch monitor stations were located at EBAT near Army Trail Road (RM 23.0), EBSC (aka EBCB) at St. Charles Road (RM 20.0), EBBR at Butterfield Road (RM 14.3), EBHL at Hidden Lake (RM 14.0) and EBHR at Hobson Road (RM 8.5).*

Nutrient Conditions in the E. Branch DuPage River

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 only now emerging. Unlike toxicants, the influence of nutrients on aquatic life is generally indirect via pathways such as the effect of algal photosynthesis and respiration on diel D.O. swings or by the influence of algal decomposition on D.O. concentrations. Nutrients can also affect food sources for macroinvertebrates and fish and the response of aquatic life to nutrient concentrations can be co-influenced by habitat (e.g., substrate composition), stream flow (e.g., scouring), temperature, and shading. Illinois is the leading state in terms of percent of nitrogen (16.8%) and phosphorus (12.9%) loadings exported to the Gulf of Mexico (U.S. EPA 2009) where a large anoxic zone has developed (U.S. EPA 2008). In Illinois, as in other Midwestern states, efforts are underway to derive nutrient water quality criteria for aquatic life.

Table 7 lists four nutrient enrichment parameters in relation to various benchmarks that have been established to associate nutrient concentrations with impaired aquatic life. At this point, there are no established water quality criteria for aquatic life for nitrate-N, TKN, or total P in Illinois streams and rivers. We used U.S. EPA regional nutrient targets (U.S. EPA 2000) for the Central Corn Belt Plains (CCBP) ecoregion for nitrate-N and total P and which *"represent*

conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses" (U.S. EPA, 2000). The TKN and total ammonia-N values represent change points associated with aquatic assemblage impacts derived by quartile regressions in the MBI IPS report (Miltner et al. 2010). We also used Illinois statistical thresholds "non-standards-based numeric criteria" for total P (0.61 mg/l) and nitrate-N (7.8 mg/l). Criteria are based on 85th-percentile values from a statewide dataset from the Illinois EPA Ambient Water Quality Monitoring Network (AWQMN) for water years 1978-1996 (Illinois EPA 2011). Finally, the 10 mg/l human health-based water quality criterion was used for nitrate. The nutrient enriched condition of the East Branch mainstem is illustrated in Table 7 with very high total P levels in 2007 and 2011 and extremely high nitrate-N levels in 2011. Nutrients were particularly elevated in the mainstem between river miles 11.0 and 23.0 where the 10 mg/l criteria was exceeded at all but one site. Lower mainstem reaches (downstream from RM 11.0) remained enriched and at higher levels in 2011 compared to 2007.

No ammonia-N exceedences were detected in grab samples but many values were above the aquatic life response-derived target of 0.15 mg/l (Miltner et al. 2010). Based on this data, continuous temperature and pH values were used to demonstrate the potential effect of swings in pH due to algal activity (under nutrient enriched conditions) on the unionized ammonia fraction. The data suggest concentrations could reach toxic levels during periods of high algal photosynthesis when pH values spike and temperatures are high (Figure 27).

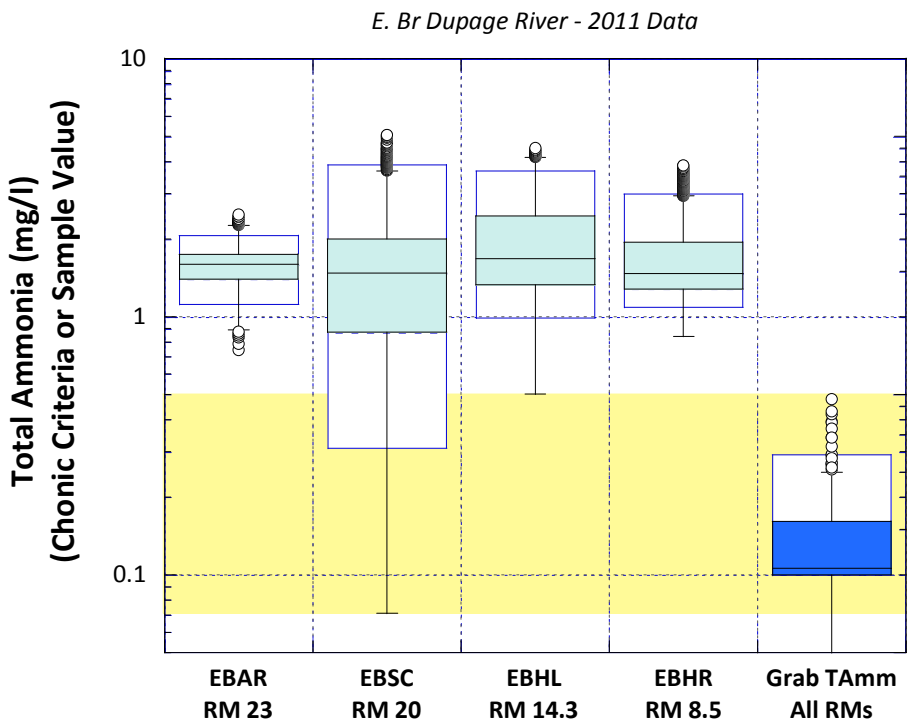


Figure 27. Box and whisker plots of total ammonia criteria estimates based on E. Branch DuPage River Datasonde temperature and pH data, 2011. Rightmost box represents all mainstem grab sample results during 2011. Yellow shaded area represents range of total NH_3-N that could exceed the ammonia criterion during critical periods of high pH and temperature.

Sources of Nutrients

Figure 28 illustrates concentrations of nitrate-N and total P in East Branch tributaries vs. the East Branch mainstem in 2007 and 2011. In 2007, nitrite-N levels were similar in the tributaries and mainstem. However, in 2011 mainstem concentrations were nearly one order of magnitude higher compared to both the 2007 survey and the 2011 tributaries (note log scale in graph, Figure 28, left). Mainstem total P concentrations were also substantially higher than the tributaries during both 2007 and 2011 (Figure 28, right). The consistently and comparatively higher levels of mainstem nutrients coupled with sampling during relatively base flow conditions strongly suggests they originate from point sources more than nonpoint source runoff. This is also supported by the dominance of East Branch flows by WWTP effluent, which can exceed 75% and approach 98% during extreme low flow periods (see Figure 22). Tributary enrichment is still higher than "reference" levels, but much lower than in the mainstem (Table 7).

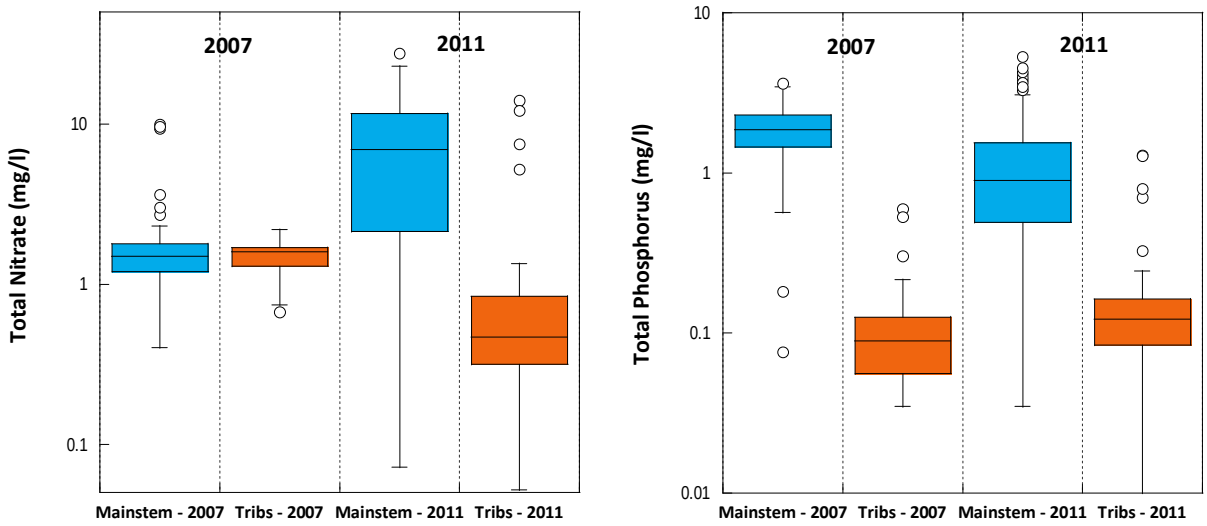


Figure 28. Box and whisker plots of total nitrate (left) and total phosphorus (right) in mainstem stations (blue boxes) vs. tributaries (orange boxes) between 2007 and 2011.

Table 7. Concentrations of key nutrient parameters including total ammonia, nitrate, TKN, and total phosphorus in the E. Br. DuPage River study area, 2007 and 2011. Shading represents exceedences of various criteria or thresholds for nutrient parameters (see footnotes).

Site ID	Stream code	RM	Year	D. Area (sq mi)	Ammonia[1] (mg/l)	Nitrate[2,3,4] (mg/l)	TKN[5] (mg/l)	T-Phosphorus[6,7,8] (mg/l)
95-980 - E. Branch DuPage River								
EB 29	980	23.50	2007	2.0	0.160	1.500	0.760	0.080
			2011		0.260	0.250	1.310	0.140
EB 25	980	23.00	2007	2.0	0.260	3.000	0.610	3.620
			2011		0.090	21.100	1.060	3.550
EB 23	980	22.00	2007	5.0	0.150	1.750	0.370	2.490
			2011		0.050	15.500	0.790	2.530
EB 26	980	21.00	2007	12.0	0.090	1.130	0.980	2.830
			2011		0.080	10.990	1.080	2.020
EB 21	980	20.50	2007	14.2	0.130	1.500	0.970	2.270
			2011		0.080	12.050	0.050	2.240
EB 36	980	19.00	2007	16.0	0.110	1.400	1.200	1.740
			2011		0.210	10.750	0.850	2.200
EB 19	980	18.00	2007	18.0	0.050	1.500	4.690	1.400
			2011		0.240	10.800	1.000	1.040
EB 30	980	15.50	2007	27.2	0.130	0.130	1.280	2.300
			2011		0.170	11.170	1.120	1.250
EB 12	980	13.00	2007	50.0	0.050	1.900	4.400	1.810
			2011		0.150	9.650	0.870	1.040
EB 31	980	11.00	2007	58.0	0.090	0.610	0.980	1.550
			2011		0.080	14.450	0.960	3.360
EB 37	980	9.50	2011	60.1	0.050	0.250	0.750	0.070
EB 32	980	8.50	2007	61.0	0.170	1.400	0.960	1.660
			2011		0.130	6.870	0.050	0.830
EB 40	980	7.60	2011	63.0	0.150	3.890	1.000	0.650
EB 33	980	7.00	2007	64.0	0.200	1.900	0.870	1.810
			2011		0.080	4.120	0.900	0.800
EB 35	980	6.00	2007	76.4	0.150	1.550	0.050	1.860
			2011		0.110	4.560	0.800	0.650
EB 34	980	5.00	2007	78.0	0.140	1.800	0.050	2.030
			2011		0.110	5.640	0.910	0.750
EB 39	980	4.00	2011	78.0	0.050	0.250	0.050	0.070
EB 38	980	3.00	2011	81.0	0.090	4.920	0.710	0.640
EB 41	980	1.30	2011	85.0	0.100	7.330	0.880	0.850
95-951 - Army Trail Creek								
EB 24	951	0.25	2007	0.5	0.150	2.000	0.790	0.050
			2011		0.160	0.200	0.050	0.050
95-952 - Armitage Ditch (trib to E. Branch DuPage)								
EB 22	952	0.50	2007	2.2	0.140	1.750	1.300	0.110

Site ID	Stream code	RM	Year	D. Area (sq mi)	Ammonia[1] (mg/l)	Nitrate[2,3,4] (mg/l)	TKN[5] (mg/l)	T-Phosphorus[6,7,8] (mg/l)
			2011		0.170	0.720	0.050	0.090
95-953 - Glencrest Creek								
EB 15	953	0.50	2007	2.8	0.050	1.600	1.160	0.090
			2011		0.080	0.770	0.800	0.100
95-954 - Lacey Creek								
EB 14	954	2.00	2007	1.8	0.300	1.240	5.680	0.410
			2011		0.090	0.170	1.380	0.220
EB 13	954	0.25	2007	4.6	0.050	1.400	0.770	0.040
			2011		0.200	9.790	0.960	1.030
95-955- Willoway Brook								
EB 11	955	1.00	2007	4.3	0.230	1.300	1.950	0.060
95-956 - 22nd St. trib to E. Branch DuPage River								
EB 17	956	1.00	2007	0.5	0.110	0.740	2.980	0.030
			2011		0.120	0.260	0.450	0.130
95-957 - Rott Creek								
EB 06	957	2.00	2007	4.5	0.380	1.350	1.260	0.060
			2011		0.120	0.150	0.430	0.080
95-986 - Prentiss Creek								
EB 04	986	3.80	2007	2.3	0.120	1.550	1.210	0.080
			2011		0.050	0.430	0.050	0.140
EB 03	986	1.10	2007	6.6	0.050	0.700	0.670	0.060
			2011		0.050	0.370	0.660	0.090
95-987 - St. Joseph Creek								
EB 10	987	6.00	2007	1.8	0.260	1.800	1.080	0.140
			2011		0.120	0.340	0.920	0.130
EB 08	987	4.00	2007	6.0	0.090	1.650	0.780	0.110
			2011		0.050	0.480	0.800	0.130
EB 07	987	1.00	2007	9.7	0.050	1.450	5.160	0.420
			2011		0.050	0.860	0.680	0.150
95-988 - Trib. to E. Br. DuPage River								
EB 01	988	0.25	2011	0.7	0.110	0.290	0.390	0.120
95-989 - Trib to E. Br. DuPage River, #6								
EB 05	989	0.60	2007	1.0	0.050	2.200	0.050	0.110
			2011		0.090	0.250	0.050	0.050

[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

Urban runoff, with its high concentration of dissolved constituents, can become limiting when concentrations become elevated enough to elicit harmful responses. Of particular concern in Northern climates in urban areas with high road density is the concentration of chlorides from sources such as application of road salts and from point sources with loadings from water softener salts. Recent work in Illinois has demonstrated highly elevated chloride concentrations and conductivity in the greater Chicago area (Kelly et al. 2012). Illinois EPA conducted a chloride TMDL in 2004 (CH_2MHill 2004) and identified road salt and WWTP effluents as two key sources. Kelly et al. (2012) showed that the recent increase in chloride concentrations in the greater Chicago area corresponded with increased road salt applications, particularly over the past 20 years. Rather than a simple runoff and export mode of effect, chlorides accumulate in ground waters (Kelly 2008), soils, and land surfaces adjacent to streams. Seasonal sampling in these studies show that high summer concentrations are typically correlated with acute concentrations that occur during late winter and spring periods (Kaushal et al. 2005).

The MBI IPS document (Miltner et al. 2010) identified summer impairment threshold values of 141 mg/l for macroinvertebrates and 112 mg/l for fish. These chloride values were exceeded at multiple sites in 2007 survey and were even higher in 2011 (Figure 30, top). Conductivity, a surrogate for chloride and other dissolved materials, showed a similar increasing trend in the East Branch mainstem between 2007 and 2011 (Figure 30, bottom; Figure 31). Table 8 and Table 9 show results for a group of parameters that are commonly associated with urban runoff. The highlighted values exceed the MBI IPS thresholds (total chloride, TKN) or statewide reference levels from Ohio rivers and streams (conductivity, TDS, TSS; Ohio EPA 1999). These values generally show the same trend between 2007 and 2011 with values in both years exceeding both background and IPS threshold values. The threshold values for fish (112 mg/l) or macroinvertebrate (141 mg/l) assemblages are lower than the current Illinois aquatic life water quality criterion of 500 mg/l. The MBI IPS thresholds were derived from summer-fall data and represent elevated instream concentrations likely correlated with higher, toxic concentrations that occur during winter and spring. The increased chloride levels in the East Branch followed several years of high snowfall between 2007 and 2010 (Figure 29). Work in Illinois and elsewhere has identified the increasing salinization of surface and ground waters from increased loadings of chlorides over time.

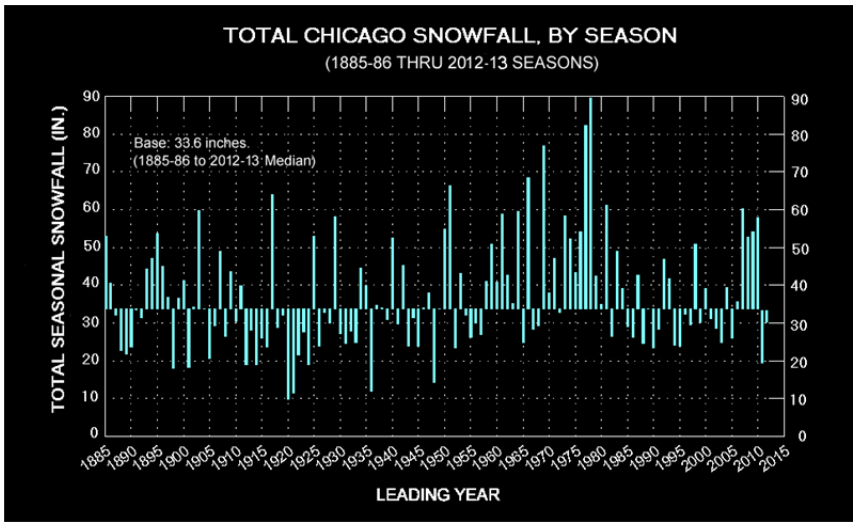


Figure 29. Total seasonal snowfall in inches in Chicago by year. Data from ClimateStations.com: http://www.climatestations.com/wp-content/uploads/2013/05/chisnow.gif

*Table 8. Urban parameter sampling results in the E. Br. DuPage study area, summer **2007**. Values above applicable reference targets are highlighted in yellow.*

		Conductivity		Chloride		TKN		TDS		TSS	
Site ID	**RM**	**Median**	**Target**	**Median**	**Target**	**Median**	**Target**	**Median**	**Target**	**Median**	**Target**
95-951 Army Trail Creek											
EB 24	0.25	1500.0	600.0	290.0	112.0	0.790	1.0	946.0	443.0	15.0	16.0
95-952 Armitage Ditch (trib to E. Branch DuPage)											
EB 22	0.50	680.0	600.0	102.0	112.0	1.300	1.0	366.0	443.0	13.4	16.0
95-953 Glencrest Creek											
EB 15	0.50	830.0	600.0	150.0	112.0	1.160	1.0	526.0	443.0	8.0	16.0
95-954 Lacey Creek											
EB 14	2.00	1600.0	600.0	348.5	112.0	5.680	1.0	871.0	443.0	327.0	16.0
EB 13	0.25	915.0	600.0	135.0	112.0	0.770	1.0	579.0	443.0	7.200	16.0
95-955 Willoway Brook											
EB 11	1.00	1120.0	600.0	250.5	112.0	1.950	1.0	640.0	443.0	11.8	16.0
95-956 22nd St. trib to E. Branch DuPage River											
EB 17	1.00	990.0	600.0	130.0	112.0	2.980	1.0	612.0	443.0	32.0	16.0
95-957 Rott Creek											
EB 06	2.00	1185.0	600.0	195.0	112.0	1.260	1.0	677.0	443.0	22.6	16.0
95-980 E. Branch DuPage River											
EB 29	23.50	800.0	600.0	120.0	112.0	0.760	1.0	494.0	443.0	6.5	16.0
EB 25	23.00	960.0	600.0	130.0	112.0	0.610	1.0	482.0	443.0	2.4	16.0
EB 23	22.00	955.0	600.0	135.0	112.0	0.370	1.0	450.0	443.0	8.8	16.0
EB 26	21.00	910.0	600.0	120.0	112.0	0.980	1.0	408.0	443.0	18.4	16.0
EB 21	20.50	920.0	600.0	135.0	112.0	0.970	1.0	518.0	443.0	23.2	16.0
EB 36	19.00	950.0	600.0	130.0	112.0	1.200	1.0	544.0	443.0	42.2	16.0
EB 19	18.00	980.0	600.0	135.0	112.0	4.690	1.0	490.0	443.0	28.75	16.0
EB 30	15.50	1000.0	610.0		112.0	1.280	1.0	638.0	463.5	16.0	24.75
EB 12	13.00	1045.0	610.0	140.0	112.0	4.400	1.0	602.0	463.5	23.7	24.75
EB 31	11.00	980.0	610.0	135.0	112.0	0.980	1.0	643.0	463.5	14.7	24.75
EB 32	8.50	900.0	610.0	140.0	112.0	0.960	1.0	536.0	463.5	17.6	24.75
EB 33	7.00	910.0	610.0	140.0	112.0	0.870	1.0	556.0	463.5	13.2	24.75
EB 35	6.00	905.0	610.0	140.0	112.0	0.050	1.0	539.0	463.5	19.65	24.75
EB 34	5.00	950.0	610.0	130.0	112.0	0.050	1.0	518.0	463.5	24.0	24.75
95-986 Prentiss Creek											
EB 04	3.80	1015.0	600.0	204.5	112.0	1.210	1.0	520.0	443.0	5.20	16.0
EB 03	1.10	800.0	600.0	160.0	112.0	0.670	1.0	460.0	443.0	10.5	16.0
95-987 St. Joseph Creek											
EB 10	6.00	575.0	600.0	77.250	112.0	1.080	1.0	302.0	443.0	40.9	16.0
EB 08	4.00	635.0	600.0	89.5	112.0	0.780	1.0	389.0	443.0	4.8	16.0
EB 07	1.00	700.0	600.0	107.0	112.0	5.160	1.0	401.0	443.0	10.9	16.0
95-989 Trib to E. Br. DuPage River, #6											
EB 05	0.60	510.0	600.0	110.0	112.0	0.050	1.0	332.0	443.0	6.4	16.0

*Table 9. Urban parameter sampling results in the E. Branch DuPage River study area, summer **2011**. Values above applicable reference targets are highlighted in yellow; values above reference targets that also increased compared to 2007 are highlighted in orange.*

		Conductivity		Chloride		TKN		TDS		TSS	
Site ID	RM	Median	Target	Median	Target	Median	Target	Median	Target	Median	Target
95-951 Army Trail Creek											
EB 24	0.25	2301.5	600.0	556.0	112.0	0.05	1.0	944.0	443.0	5.4	16.0
95-952 Armitage Ditch (trib to E. Branch DuPage)											
EB 22	0.50	1127.0	600.0	220.5	112.0	0.05	1.0	612.0	443.0	11.6	16.0
95-953 Glencrest Creek											
EB 15	0.50	975.0	600.0	165.0	112.0	0.80	1.0	668.0	443.0	4.600	16.0
95-954 Lacey Creek											
EB 14	2.00	1269.0	600.0	295.5	112.0	1.38	1.0	657.0	443.0	31.8	16.0
EB 13	0.25	1169.0	600.0	186.5	112.0	0.96	1.0	707.0	443.0	21.75	16.0
95-956 22nd St. trib to E. Branch DuPage River											
EB 17	1.00	810.5	600.0	110.2	112.0	0.45	1.0	451.0	443.0	101.3	16.0
95-957 Rott Creek											
EB 06	2.00	810.0	600.0	142.0	112.0	0.43	1.0	430.0	443.0	14.25	16.0
95-980 E. Branch DuPage River											
EB 29	23.50	907.0	600.0	166.0	112.0	1.31	1.0	473.0	443.0	17.45	16.0
EB 25	23.00	936.0	600.0	147.5	112.0	1.06	1.0	567.0	443.0	10.4	16.0
EB 23	22.00	956.0	600.0	154.0	112.0	0.79	1.0	546.0	443.0	6.4	16.0
EB 26	21.00	960.0	600.0	147.0	112.0	1.08	1.0	560.0	443.0	17.4	16.0
EB 21	20.50	1040.0	600.0	173.0	112.0	0.05	1.0	595.0	443.0	19.2	16.0
EB 36	19.00	1044.0	600.0	164.0	112.0	0.85	1.0	602.0	443.0	76.75	16.0
EB 19	18.00	1121.0	600.0	168.0	112.0	1.00	1.0	636.0	443.0	38.0	16.0
EB 30	15.50	1125.0	610.0	176.0	112.0	1.12	1.0	651.0	463.5	20.65	24.75
EB 12	13.00	1138.0	610.0	185.0	112.0	0.87	1.0	686.0	463.5	22.4	24.75
EB 31	11.00	1065.5	610.0	176.0	112.0	0.96	1.0	636.0	463.5	6.0	24.75
EB 37	9.50	1086.0	610.0	223.0	112.0	0.75	1.0	636.0	463.5	5.2	24.75
EB 32	8.50	1011.5	610.0	161.5	112.0	0.05	1.0	583.0	463.5	11.4	24.75
EB 40	7.60	957.5	610.0	158.0	112.0	1.00	1.0	522.0	463.5	16.8	24.75
EB 33	7.00	958.5	610.0	158.5	112.0	0.90	1.0	582.0	463.5	14.5	24.75
EB 35	6.00	953.0	610.0	158.0	112.0	0.80	1.0	506.0	463.5	17.6	24.75
EB 34	5.00	1001.5	610.0	164.5	112.0	0.91	1.0	557.0	463.5	15.0	24.75
EB 39	4.00	1099.0	610.0	181.0	112.0	0.05	1.0	641.0	463.5	10.6	24.75
EB 38	3.00	1060.5	610.0	170.0	112.0	0.71	1.0	606.0	463.5	24.6	24.75
EB 41	1.30	1051.0	610.0	172.0	112.0	0.88	1.0	592.0	463.5	21.5	24.75
95-986 Prentiss Creek											
EB 04	3.80	559.0	600.0	35.7	112.0	0.05	1.0	310.0	443.0	10.8	16.0
EB 03	1.10	1104.0	600.0	221.0	112.0	0.66	1.0	555.0	443.0	14.3	16.0
95-987 St. Joseph Creek											
EB 10	6.00	652.5	600.0	117.7	112.0	0.92	1.0	272.0	443.0	22.0	16.0
EB 08	4.00	818.5	600.0	142.5	112.0	0.80	1.0	457.0	443.0	7.75	16.0
EB 07	1.00	938.0	600.0	164.0	112.0	0.68	1.0	504.0	443.0	7.6	16.0
95-989 Trib to E. Br. DuPage River, #6											
EB 01	0.25	953.0	600.0	207.5	112.0	0.39	1.0	506.0	443.0	43.25	16.0
95-989 Trib to E. Br. DuPage River, #6											
EB 05	0.60	663.0	600.0	122.0	112.0	0.05	1.0	343.0	443.0	8.680	16.0

Kelly et al. (2012) identified a strong and 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 peak values in the 1940s of <40 mg/l and spikes in 2003 of >300 mg/l. This is in a larger river, thus high values in smaller urban streams and rivers likely produce acute events well above the current Illinois 500 mg/l water quality criterion. In fact, the DRSCW regularly sees spikes of chloride in the region of 800-1,000 mg/l under winter conditions.

While episodic runoff events in winter and early spring are often thought to deliver the most toxic concentrations of chloride, point sources in the East Branch contribute to an already relatively high base concentration of chloride (Table 10). The Illinois EPA TMDL for chloride in the E. Branch DuPage River (CH2MHill 2004) provided a table with observed chloride concentrations from key East Branch dischargers that show high effluent concentrations. DRSCW will be sampling at the same dischargers in 2014.

Table 10. Chloride concentrations (mg/l) from selected WWTP Effluents in the E. Branch DuPage River watershed (from Illinois EPA TMDL for chloride for the E. Branch DuPage River).

Point Source	Observed Chloride Concentration (mg/l) on September 16, 1997
Woodridge WWTP	159
Downers Grove SD WWTP	135
Bloomingdale Reeves WWTP	113
Glendale Heights WWTP	90
Glenbard WWTP	122
Bolingbrook #1 WWTP	555
Bolingbrook Citizens Utility Company #2 WWTP	432

E. Branch DuPage River Watershed - Sediment Chemistry

Sediment 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 toxic effects on aquatic life (Table 11). Specifically, threshold effects levels (TEL) are those where toxic effects are initially apparent and likely to affect the most sensitive organisms. Probable effects levels (PEL) are those where toxic effects are more likely to be observed over a wide range of organism sensitivities.

Threshold effects levels for polycyclic aromatic hydrocarbons (PAHs) were exceeded in every sample in both 2007 and 2011 (Table 11) and probable effect levels were exceeded in all but four samples. PAHs result from the incomplete combustion of hydrocarbons and are a common component of stormwater runoff in urban areas. The mean number of PAH TEL exceedences were slightly higher in 2007 vs. 2011 (10.8 vs. 8.8), but PEL exceedences were much lower in 2011 (9.2 vs. 1.1). Thus, it seems that the most extreme PAH concentrations have declined.

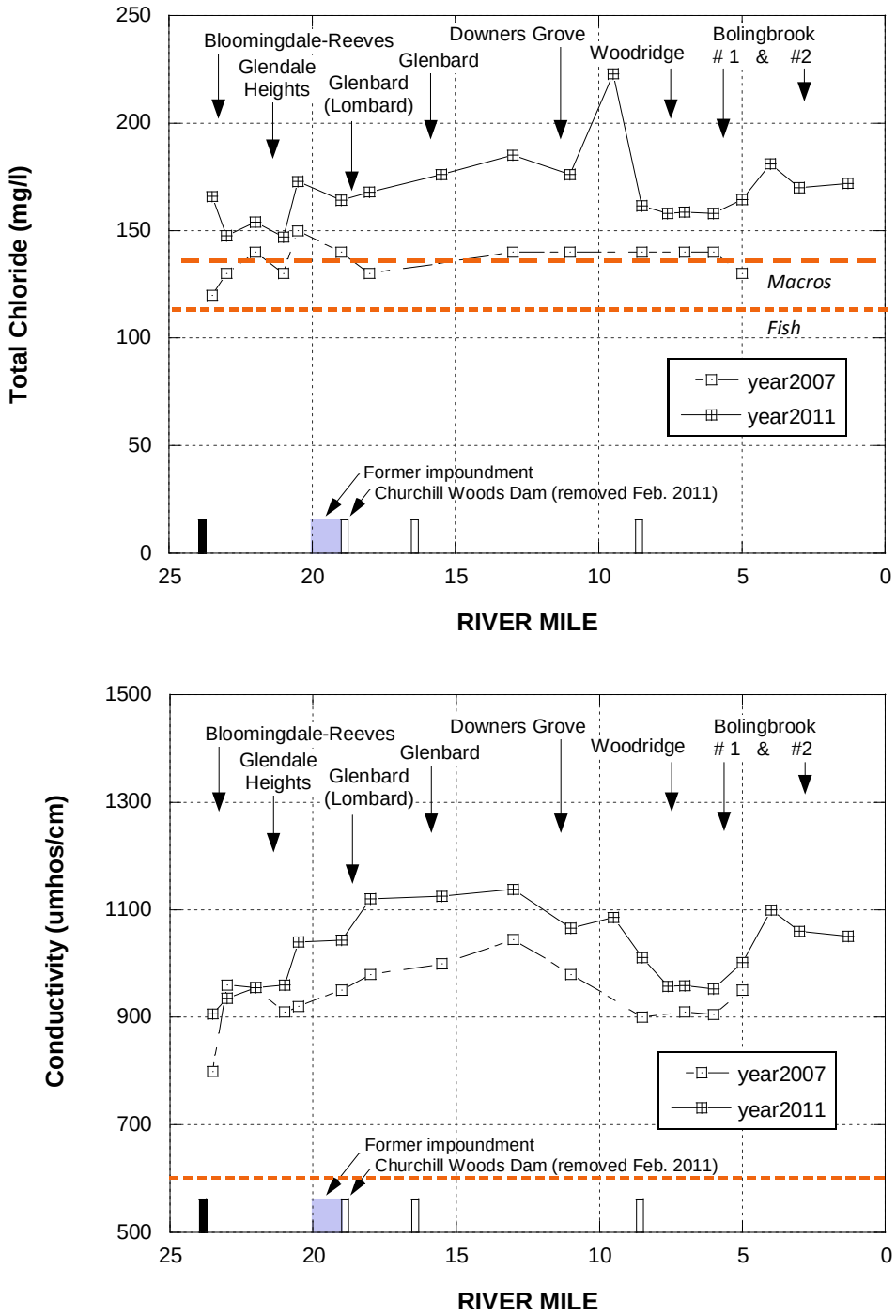


Figure 30. Concentrations of total chloride (top panel) and conductivity (lower panel) from E. Branch DuPage River samples in 2007 (open squares) and 2011 (hatched squares). Municipal WWTP discharges are shown by arrows while bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). Dashed lines in the chloride plot show the threshold levels for macroinvertebrate and fish assemblages and in the conductivity plot show the upper limit of concentrations typical for unpolluted waters.

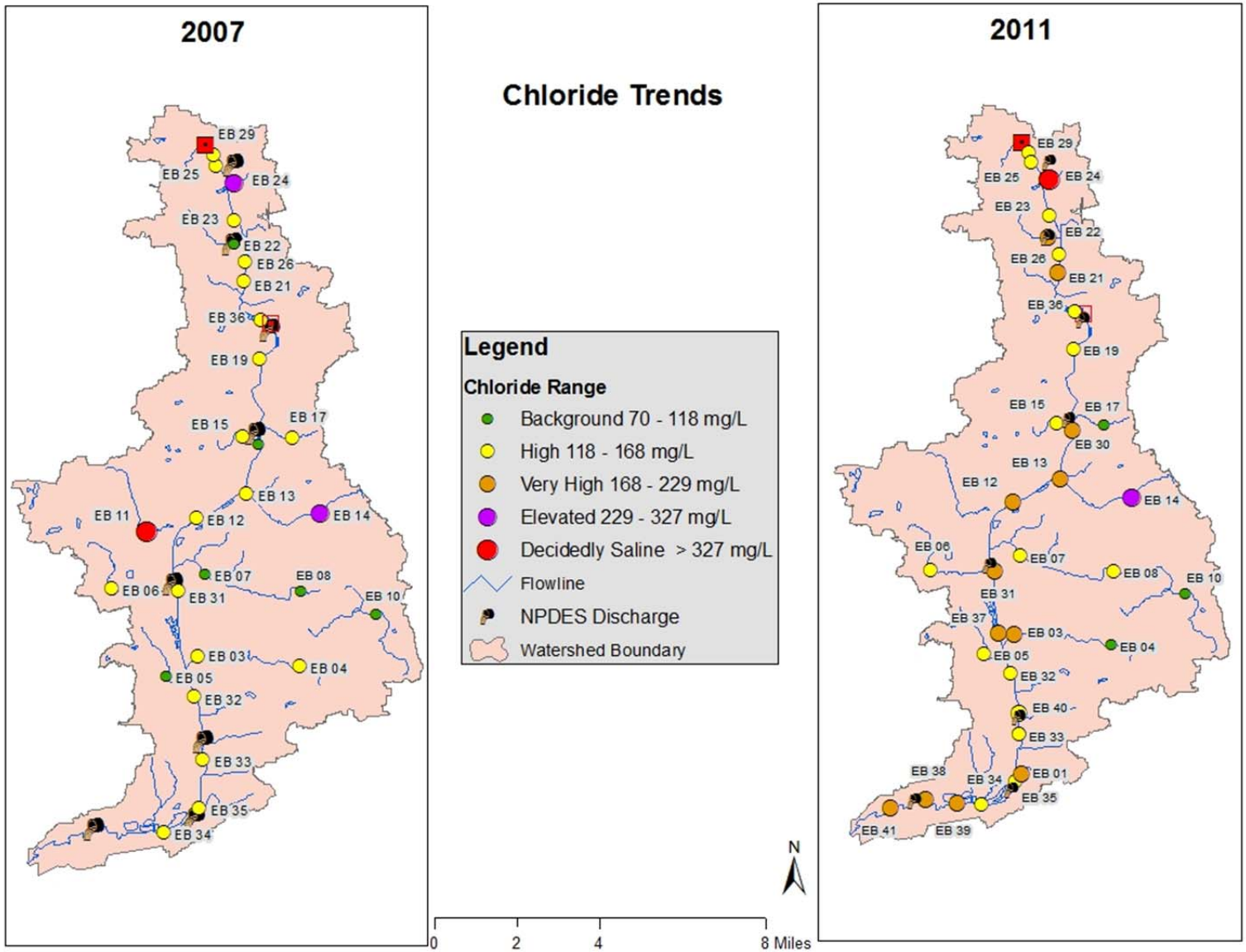


Figure 31. Mean chloride concentrations and ranges from E.Br. DuPage River water chemistry sampling sites in 2007 and 2011.

Conversely the number of heavy metal TEL exceedences increased somewhat between 2007 and 2011 (mean = 1.5 vs. 3.9) although PEL exceedences increased only slightly between 2007 and 2011 (mean = 0.0 vs. 0.25, 1 >PEL at four sites in 2011). Heavy metals are also common in urban runoff from roads and highways or from industrial and municipal sources. Elevated PCBs and pesticide exceedences of TELs in 2011 were limited as they were in 2007 (MBI 2008).

Table 11. Number of polycyclic aromatic hydrocarbons (PAHs), metals, polychlorinated biphenyls (PCBs), and pesticide detections in sediment samples from the E. Branch DuPage River and its tributaries, in 2007 and 2011 (shaded), with concentrations that exceed threshold effects levels (TEL) or probable effect levels (PEL) listed in McDonald et al. (2000) or Ontario Ministry of Environment (1993).

			PAHs		Metals		PCBs		Pesticides	
Site ID	**River Mile**	**Year**	**TEL**	**PEL**	**TEL**	**PEL**	**TEL**	**PEL**	**TEL**	**PEL**
E. Branch DuPage River										
EB 23	22.00	2011	10	1	3	0	0	0	0	0
EB 23	22.00	2007	10	6	1	0	0	0	0	0
EB 26	21.00	2007	10	6	1	0	0	0	0	0
EB 21	20.50	2011	9	1	3	0	0	0	0	0
EB 21	20.50	2007	10	9	2	0	0	0	0	0
EB 36	19.00	2011	9	0	4	0	0	0	0	0
EB 19	18.00	2011	9	3	5	0	0	0	0	0
EB 30	15.50	2011	9	3	5	1	0	0	0	0
EB 30	15.50	2007	10	7	2	0	0	0	1	0
EB 12	13.00	2011	9	2	4	0	0	0	3	2
EB 12	13.00	2007	10	6	1	0	0	0	3	1
EB 31	11.00	2011	10	1	4	1	0	0	0	0
EB 31	11.00	2007	12	12	1	0	0	0	2	0
EB 37	9.50	2011	10	1	4	1	0	0	0	0
EB 32	8.50	2011	8	2	5	0	0	0	3	0
EB 32	8.50	2007	11	11	1	0	0	0	0	0
EB 33	7.00	2011	11	1	4	0	0	0	0	0
EB 33	7.00	2007	11	11	2	0	0	0	0	0
EB 35	6.00	2011	10	0	5	0	1	1	0	0
EB 35	6.00	2007	12	11	1	0	0	0	0	0
EB 34	5.00	2011	10	1	5	0	0	0	0	0
EB 34	5.00	2007	11	11	3	0	0	0	0	0
EB 39	4.00	2011	0	0	5	0	0	0	0	0
EB 39	4.00	2011	12	1	0	0	0	0	0	0
EB 41	1.30	2011	4	0	2	0	0	0	0	0
St. Joseph Creek										
EB 07	1.00	2011	10	1	5	1	0	0	0	0
EB 07	1.00	2007	12	11	2	0	0	0	0	0

E. Branch DuPage River Watershed Physical Habitat Quality for Aquatic Life - QHEI

The physical habitat of a stream is a strong determinant of biological quality. Streams in the glaciated Midwest, left in their natural state, typically possess riffle-pool-run sequences, high sinuosity, and well-developed channels with deep pools, heterogeneous substrates and cover in the form of woody debris, glacial tills, and aquatic macrophytes. The Qualitative Habitat Evaluation Index (QHEI) categorically scores the basic components of stream habitat into ranks according to the degree to which those components are found in a natural state, or conversely, in an altered or modified state. In the E. Branch study area, QHEI scores and physical habitat attribute were recorded in conjunction with fish collections from each site (Table 12).

E. Branch DuPage River

Habitat quality trends in the East Branch mainstem varied by location (Figure 32-35). In the upper East Branch, the former Churchill Woods low-head dam impoundment extended approximately 1.5 river miles upstream between RMs 18.7 and 20.0. Following removal in February 2011, incremental improvements in habitat occurred within the former impoundment, particularly by the summer of 2012. QHEI scores in this reach averaged an approximate 9-point increase by 2012, reflecting the appearance of riffles and increased habitat heterogeneity (Figure 34; Table 12). While recovery and stabilization of impounded habitats is ongoing, low stream gradient, the remaining impoundment and lingering, thick accumulations of fine depositional substrates likely means considerable time for full recovery. The presence of much better habitats just upstream and occasional deposit of coarse tills along the upper mainstem and within the impoundment should benefit future recovery. Removal of the Churchill Woods dam means that fish passage in the East Branch is largely unimpeded except for the West Lake dam in the extreme upper mainstem (RM 23.8). Other gabion and weir-type structures located further downstream do not maintain permanent impoundments and allow fish passage during certain flow conditions.

QHEI scores in the 18 river mile stretch of the lower East Branch between Churchill Woods and the mouth were generally similar or somewhat lower than in 2007 (Figure 35). Overall, median scores remained in the fair range but declined an average of five points per site, from 57 to 52. The specific reasons for the decline vary by site, but include siltier substrates and different flow conditions that influenced the habitat features (e.g., shoreline, vegetation) available to boat sampling transects. The lower 18 miles of the East Branch, while largely unimpounded, consists mostly of pools and runs rarely interrupted by riffle habitats. In fact, riffles were absent from 10 of 14 sampling stations in this lower reach in 2011.

E. Branch DuPage River Tributaries

Tributary habitats show a more marked decline than the mainstem since 2007 as a majority of comparable sites dropped from the good to the fair quality range (Figure 33). An approximate 9 point drop in median scores coincided with the loss of numerous, Good Quality Habitat Attributes and subsequent increases in Moderate Influence Modified Attributes (Figure 34). Loss of good quality attributes outpaced gains by 3:1 while modified attributes increased by an

average 1.5 per site. Lost attributes were most reflective of increased site embeddedness, riffle embeddedness, and a loss of coarse substrates and deep pools.

The greatest change in QHEI was a 24-point drop recorded at Armitage Ditch (EB 22) a small, modified channel lined with rock gabions. Field observations from fish and macroinvertebrate collections suggest recent channelization activity, armoring, and riparian removal, possible reasons for the decline.

St. Joseph Creek RM 1.0 experienced an almost 20-point decline (from 68.5 to 49.0) which was attributable to much poorer substrate conditions (more silt and embeddedness) and poorer instream cover. The substrate score declining from 16 to four and the cover score declined from 15 to eight. Declines of that magnitude are usually related to severe upstream silt/sediment loads or direct habitat manipulation but can also be influenced by severe differences in flow during sample collection.

The 22nd Street Tributary (EB 17) dropped 16.5 points between surveys, from fully capable of supporting warmwater communities (QHEI=71) to marginally capable (QHEI=54.5). In contrast, stable, good quality habitats were maintained in Glencrest Creek, Willoway Brook, Prentiss Creek (2011 sampling only) and, to a lesser degree, Rott Creek and portions of St. Joseph Creek. Based on the most recent results, degraded stream habitat, habitats with minimal function beyond water conveyance, were encountered in four tributaries: Army Trail Creek, Armitage Ditch, Lacey Creek, and the Trib. to E. Br. DuPage River (2011 sampling only). The Trib. to E. Br. DuPage River is less than one square mile in drainage and flow was severely intermittent during the summer.

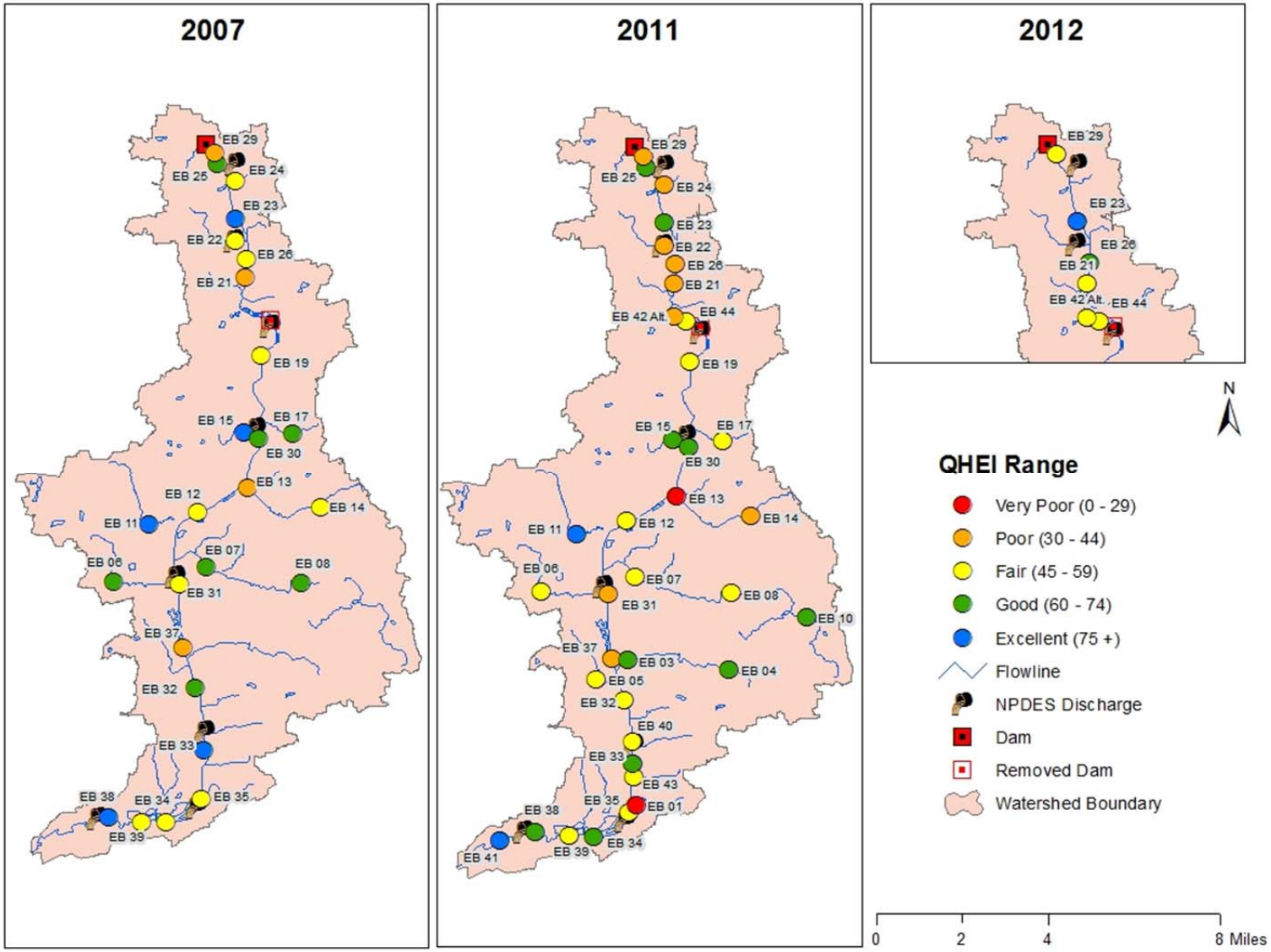


Figure 32. QHEI scores and ranges from East Branch DuPage River fish sampling sites in 2007, 2011 and 2012 (upper mainstem only).

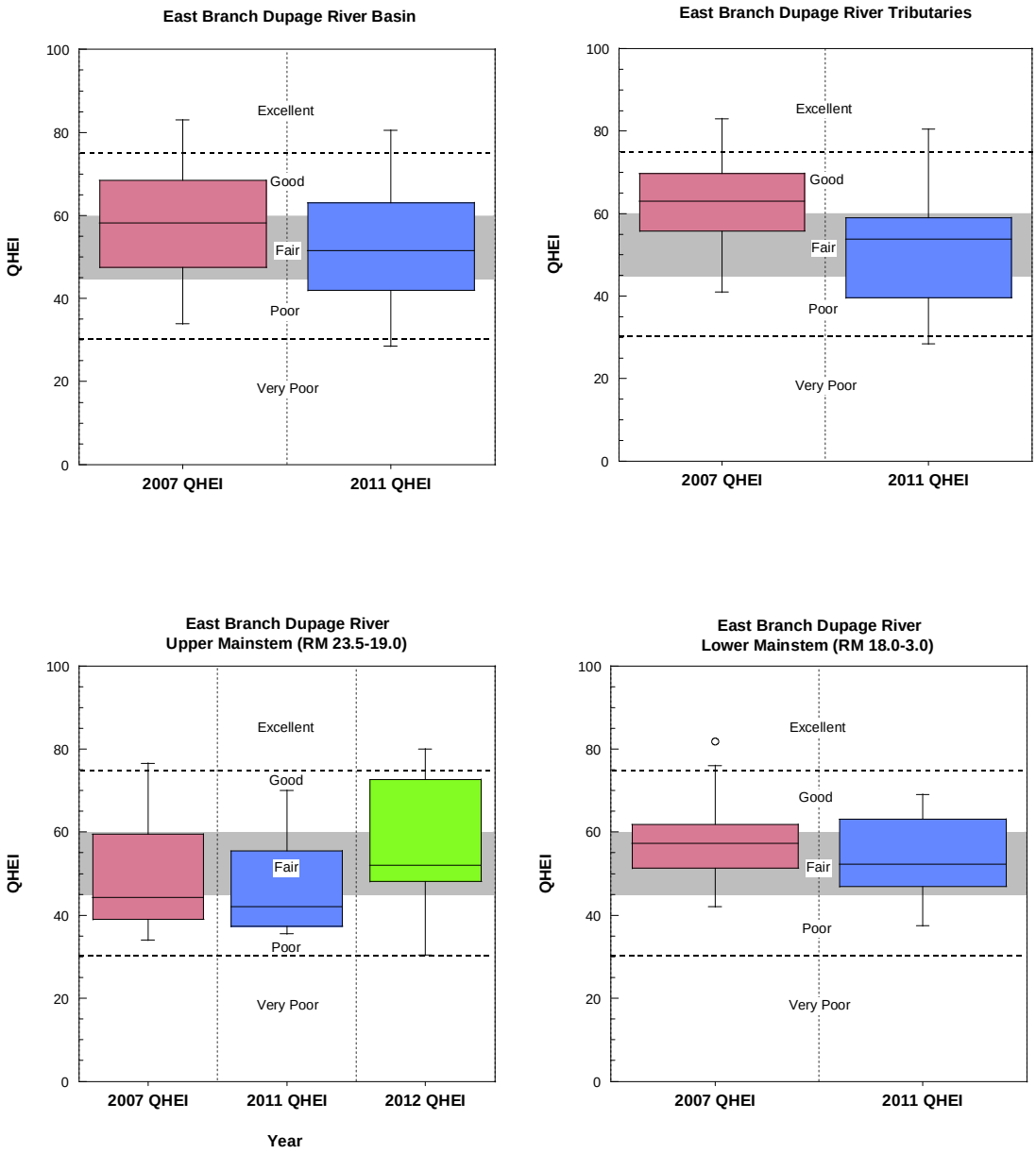


Figure 33. Box and whisker plots of QHEI scores at comparable sites from the E. Branch DuPage River study area in 2007 (salmon), 2011 (blue), and 2012 (green-upper East Branch only). Results are displayed by basin (upper left), tributaries (upper right), upper mainstem (lower left) and lower mainstem (lower right). Sampling in 2012 (lower left plot) was conducted to assess removal of the Churchill Woods dam (RM 18.7).

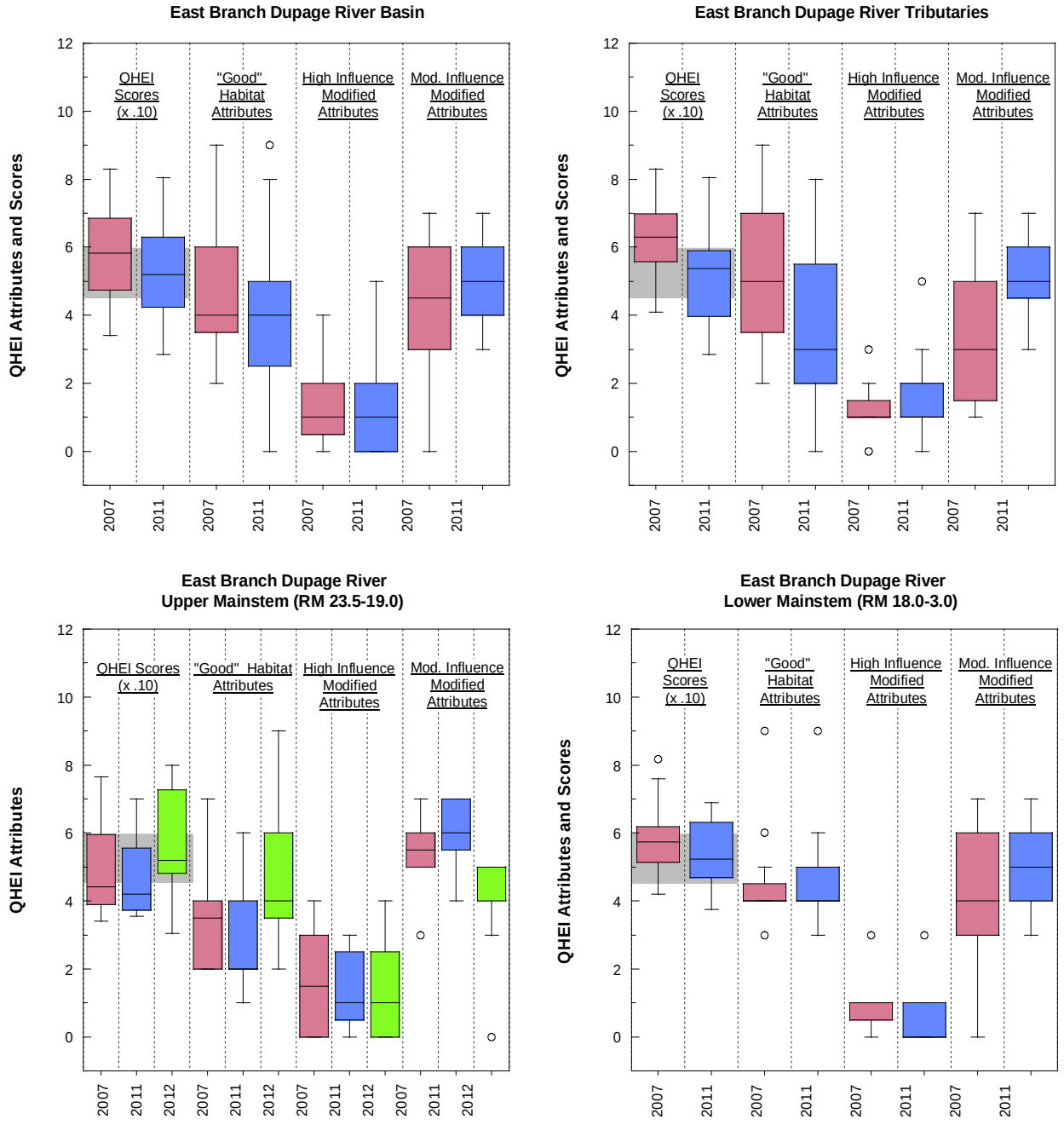


Figure 34. Box and whisker plots of QHEI score (x.10) and selected QHEI habitat attributes at comparable sites from the E. Branch DuPage River study area in 2007 (salmon), 2011 (blue), and 2012 (green- upper East Branch only). Results are displayed by basin (upper left), tributaries (upper right), upper mainstem (lower left) and lower mainstem (lower right). Sampling in 2012 (lower left plot) was conducted to assess removal of the Churchill Woods dam (RM 18.7). "Good" Habitat attributes are closely associated with natural, high quality stream channels. In contrast, "High" and "Moderate Influence Modified Attributes" are strongly associated with modified channels; "High Influence" attributes are the most negatively influential to biological quality.

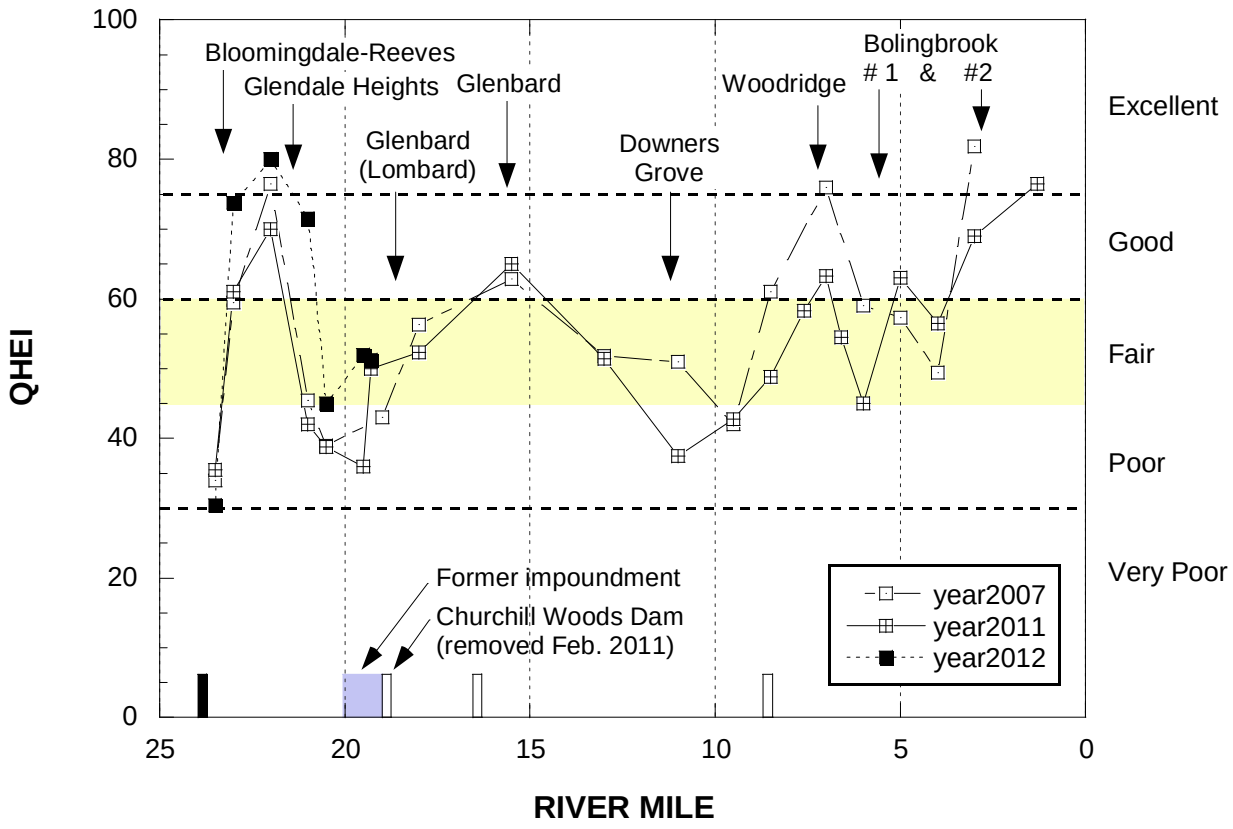


Figure 35. Qualitative Habitat Evaluation Index (QHEI) scores for the E. Branch DuPage River in 2011-12 and 2007 in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). The shaded region depicts the range of QHEI scores where habitat quality is marginal and limiting to aquatic life. QHEI scores less than 45 are typical of highly modified channels.

Table 12. Qualitative Habitat Evaluation Index (QHEI) scores showing Good and Modified Habitat attributes at sites in the E. Branch DuPage River study area during 2011-12. Additional sampling the upper East Branch in 2012 further assessed removal of the former Churchill Woods dam (RM 18.7).

Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	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 Embeddness	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 Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95- 951 - Army Trail Creek																																			
EB 24	2007	0.25	**54**	13.07		■			■	■	■	■	■		6				●		1	●				●						●	●	4	1.4	0.71
	2011	0.25	**43.5**	13.07	■					■					2		●			●	2		●			●	●			●	●		●	6	0.43	2.33
95-952 - Armitage Ditch (trib to E. Branch DuPage)																																			
EB 22	2007	0.5	**57.5**	38.5		■				■			■		3	●		●			2		●			●				●	●	●		5	0.67	1.5
	2011	0.5	**33.3**	38.5									■		1	●		●	●		3		●			●				●	●	●		5	0.33	3
95-953 - Glencrest Creek																																			
EB 15	2007	0.5	**79.3**	20.75	■	■		■	■	■	■	■	■	■	9						0		●											1	5	0.2
	2011	0.5	**65.8**	20.7	■	■		■	■	■	■				6					●	1		●								●	●		3	1.75	0.57
95-954 - Lacey Creek																																			
EB 14	2007	2	**44.8**	9.68		■				■					2	●			●	●	3		●			●	●			●	●	●	●	7	0.38	2.67
	2011	2	**35.8**	9.68	■					■					2		●			●	2		●			●	●	●		●	●	●		7	0.38	2.67
EB 13	2007	0.25	**41**	8.02						■			■		2	●	●	●			3		●			●				●	●		●	5	0.5	2
	2011	0.25	**28.5**	8.02											0	●	●	●	●	●	5		●			●				●	●		●	5	0.17	6
95-955 - Willoway Brook																																			
EB 11	2007	1	**83**	5.47		■		■	■	■	■	■	■	■	8						0	●												1	4.5	0.22
	2011	1	**80.5**	5.47	■	■		■	■	■	■	■	■		8						0		●		●							●		3	2.25	0.44

Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	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 Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95-956 - 22nd St. trib to E. Branch DuPage River																																				
EB 17	2007	1	**71**	40.5		■		■		■	■	■	■	■	7	●					1						●							1	4	0.25
	2011	1	**54.5**	40.5	■	■		■	■	■	■				6					●	1		●			●					●	●		4	1.4	0.71
95-957 - Rott Creek																																				
EB 06	2007	2	**63**	4.6		■		■		■	■	■	■	■	7	●					1		●				●							2	2.67	0.38
	2011	2	**55**	4.6		■		■		■	■		■		5						0	●	●			●	●				●	●		6	0.86	1.17
95-980 - E. Branch DuPage River																																				
EB 29	2007	23.5	**34**	9.96						■			■		2	●	●		●		3		●		●	●	●			●	●		●	7	0.38	2.67
	2011	23.5	**35.5**	9.96						■			■		2		●				1	●	●			●	●			●	●	●		7	0.38	2.67
	2012	23.5	30.5	9.96						■			■		2	●	●	●	●		4		●			●				●	●		●	5	0.50	2.00
EB 25	2007	23	**59.5**	9.96		■				■	■		■		4		●				1	●	●			●	●				●	●		6	0.71	1.4
	2011	23	**61**	9.96		■				■	■		■		4						0	●	●			●	●				●	●		6	0.71	1.4
	2012	23	73.8	9.96		■		■		■	■	■	■	■	7						0	●					●			●				3	2.00	0.50
EB 23	2007	22	**76.5**	5.12	■	■		■	■	■	■		■		7						0		●								●	●		3	2	0.5
	2011	22	**70**	5.12		■		■	■	■	■		■		6						0	●	●								●	●		4	1.4	0.71
	2012	22	80	5.12	■	■		■	■	■	■	■	■	■	9						0													0	10.0	0.10
EB 26	2007	21	**45.5**	4.58		■				■	■		■		4	●	●				2		●			●	●				●		●	5	0.83	1.2
	2011	21	**42**	4.58						■			■		2		●				1	●	●			●	●			●	●	●		7	0.38	2.67
	2012	21	71.5	4.58		■		■		■	■		■		5						0	●	●				●				●	●		5	1.00	1.00

Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	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 Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
EB 21	2007	20.5	**39**	8.11						■			■		2	●	●	●	●		4		●			●				●	●		●	5	0.5	2
	2011	20.5	**38.8**	8.11									■		1		●	●	●		3	●	●			●	●			●	●		●	7	0.25	4
	2012	20.5	45	8.11		■				■			■		3	●	●	●			3		●			●				●	●		●	5	0.67	1.50
Churchill Woods dam pool (removed Feb., 2011)																																			
EB 42 Alt.	2011	19.5	**36**	2.72						■			■		2	●	●		●		3		●			●	●			●	●	●		6	0.43	2.33
	2012	19.5	52	2.72		■			■	■			■		4	●					1		●			●				●	●	●		5	0.83	1.20
EB 44	2011	19.3	**50**	13.15					■	■			■	■	4		●		●		2	●	●			●				●	●			5	0.83	1.2
	2012	19.3	51.3	13.20					■	■			■	■	4		●		●		2	●	●			●				●	●			5	0.83	1.20
EB 36	2007	19	**43**	2.11		■				■			■		3						0		●			●	●			●	●		●	6	0.57	1.75
EB 19	2007	18	**55.3**	2.11						■	■		■	■	4		●				1	●	●			●	●			●	●			6	0.71	1.4
	2007	18	**57.3**	2.11						■	■	■	■	■	5		●				1	●	●			●	●							4	1.2	0.83
	2011	18	**52.3**	2.11		■				■	■		■		4				●		1	●	●			●	●				●	●		6	0.71	1.4
EB 30	2007	15.5	**62.8**	3.29		■				■	■		■		4						0	●	●			●	●				●	●		6	0.71	1.4
	2011	15.5	**65**	3.29		■		■		■	■		■		5						0	●	●				●				●	●		5	1	1
EB 12	2007	13	**51.8**	5.55		■				■	■		■		4		●				1	●	●			●	●			●	●		●	7	0.63	1.6
	2011	13	**51.5**	4.47		■				■			■		3						0	●	●			●	●			●	●	●		7	0.5	2
EB 31	2007	11	**51**	3.55		■				■	■		■		4	●		●	●		3					●					●		●	3	1.25	0.8
	2011	11	**37.5**	3.55		■					■	■	■		4	●		●	●		3					●		●				●		3	1.25	0.8
EB 37	2007	9.5	**42**	3.55		■					■	■	■		4	●		●	●		3					●		●					●	3	1.25	0.8
	2011	9.5	**42.8**	3.55		■				■	■		■		4	●		●	●		3		●			●					●	●		4	1	1

Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	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 Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
EB 32	2007	8.5	**61**	3.17		■				■	■		■		4	●					1					●	●				●	●		4	1	1
	2011	8.5	**48.8**	3.17		■				■	■		■		4						0	●	●			●	●				●	●		6	0.71	1.4
EB 40	2011	7.6	**58.3**	3.78		■					■	■	■		4				●		1	●	●			●	●				●	●		6	0.71	1.4
EB 33	2007	7	**76**	3.17		■		■		■	■	■	■		6						0	●					●					●		3	1.75	0.57
	2011	7	**63.3**	3.7		■				■	■		■		4						0	●	●			●	●				●	●		6	0.71	1.4
EB 43	2011	6.6	**54.5**	3.64		■				■	■		■		4						0	●				●	●				●	●		5	0.83	1.2
EB 35	2007	6	**59**	1.86		■				■	■		■		4		●				1	●	●			●	●				●	●		6	0.71	1.4
	2011	6	**45**	1.86						■	■		■		3		●				1	●	●			●	●				●	●		6	0.57	1.75
EB 34	2007	5	**57.3**	1.86	■				■	■	■		■		5		●				1		●			●					●		●	4	1.2	0.83
	2011	5	**63**	1.86	■	■			■	■	■		■		6		●				1		●			●					●	●		4	1.4	0.71
EB 39	2007	4	**49.5**	1.86						■	■		■		3		●				1	●	●			●	●				●		●	6	0.57	1.75
	2011	4	**56.5**	1.86	■				■	■	■		■		5						0		●			●					●	●		4	1.2	0.83
EB 38	2007	3	**81.8**	1.86	■	■		■	■	■	■	■	■	■	9						0													0	10	0.1
	2011	3	**69**	1.86	■	■		■	■	■	■	■	■	■	9						0		●								●	●		3	2.5	0.4
EB 41	2011	1.3	**76.5**	2.36	■	■			■	■	■	■	■		7						0					●					●	●		3	2	0.5
95-986 - Prentiss Creek																																			
EB 04	2011	3.8	**62**	11.53		■		■	■	■	■				5					●	1	●									●	●		3	1.5	0.67
EB 03	2011	1.1	**68.5**	17.88		■	■	■		■	■		■	■	7						0	●				●	●				●			4	1.6	0.63

Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	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 Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Poor Habitat Attributes	Ration of Poor (High) to Good	Ration of Poor (All) to Good
95-987 - St. Joseph Creek																																			
EB 10	2007	6	**52**	19.6		■				■			■		3	●		●	●		3		●			●	●			●	●	●	●	7	1.0	2.75
	2011	6	**63**	19.6		■		■		■	■				4					●	1	●				●	●				●	●		5	0.83	1.2
EB 08	2007	4	**59.5**	3.78		■			■	■			■		4				●		1	●	●			●				●	●	●		6	0.71	1.4
	2011	4	**53.8**	3.78		■				■			■		3				●		1	●	●			●	●			●	●	●		7	0.5	2
EB 07	2007	1	**68.5**	6.48		■				■		■	■	■	5	●					1					●	●			●				3	1.5	0.67
	2011	1	**49**	6.48							■		■		2			●	●		2		●			●	●				●	●		5	0.67	1.5
95-988 - Trib. to E. Br. DuPage River																																			
EB 01	2011	0.25	**29**	43.7											0	●	●		●	●	4	●	●			●	●			●	●	●		7	0.13	8
95-989 - Trib to E. Br. DuPage River, #6																																			
EB 05	2011	0.6	**47**	26.6		■			■		■				3				●	●	2	●	●			●					●	●		5	0.67	1.5

E. Branch DuPage River Watershed Biological Assemblages – Macroinvertebrates

Macroinvertebrates from the East Branch watershed were largely in the fair or poor quality ranges with a few lower East Branch sites reaching the good range (Figure 36). Overall, assemblages throughout the study area were predominated by facultative and tolerant organisms most often associated with elevated nutrients, dissolved solids, and low D.O. Many of these same organisms are common to sluggish, impounded, or wetland habitats containing muck or silt substrates. Few sensitive taxa were encountered and the limited numbers of distinct EPT taxa (16 in the entire watershed) often represented the more facultative or tolerant varieties within each group. No stonefly (Plecoptera) individuals were found in the study area.

Macroinvertebrate trends from 2007 to 2011 included:

1) Mainstem macroinvertebrate assemblages in 2011 were similar to 2007 although most collections from comparable locations reflected lower quality. This pattern was particularly evident in the lower 15.5 miles of the mainstem (Figure 37 and Figure 38) where scores declined by an average of nearly 12 mIBI points. In contrast, upper mainstem mIBIs, particularly within and downstream from the former Churchill Woods dam pool, increased by an average 12 points, from the poor to the fair quality range.

2) The removal of the Churchill Woods dam was a major contributor to improvements in the upper East Branch while habitat alterations coupled with increased nutrient enrichment and elevated levels of dissolved solids were linked to declines in the lower mainstem in 2011.

3) The improving trend in the upper East Branch is noteworthy. Impairments in 2007 in roughly the same reach (i.e., upstream from RM 15.0) were largely attributed to high $cBOD_5$ concentrations emanating from West Lake, Churchill Woods, and a number of small ponds and impoundments adjacent to the mainstem. The 2011 results point to an abatement of nutrient enrichment influences following the removal of one of the largest of these impoundments.

4) Farther downstream, a 12-point decline (from fair to poor quality) occurred at RM 15.5, just downstream from the Glenbard WWTP. The lower quality was evident despite a large percentage of coarse substrates, a physical habitat factor that appeared associated with higher quality mainstem mIBI scores (Figure 39).

5) An average 18.4-point decline occurred at RMs 9.5 and 8.5, located approximately 2-3 miles downstream from the Downers Grove WWTP. Substrate conditions were a potential factor as the declines also mirrored a reduction in coarse substrates (Figure 39). However, substrate conditions in 2011 were largely replicated during the 2007 survey when assemblage performance was substantially better. The pattern of decline suggests worsened water quality conditions in 2011, possibly related to a D.O. sag zone.

A similar trend of longitudinal decline was observed in the fish assemblage within this same reach.

6) The Woodridge WWTP is located near RM 7.3. Declines in biological performance beginning downstream from the WWTP in 2007 prompted additional sampling immediately upstream (RM 7.6) in 2011. The bracketing sites in 2011 revealed good quality macroinvertebrates upstream (mIBI = 53 at RM 7.6) and a 25 point decline immediately downstream (mIBI = 28.3 at RM 7.0). Reductions in the percentage of mayflies, scrapers, and EPT taxa, lower EPT taxa richness, and increases in the percentage of enrichment tolerant sludge worms (Oligochaeta) and blackflies (*Simulium*) mirrored the reduction in water quality. While a greater abundance of coarse substrates upstream may partially explain the differences, the results still suggest an overriding water quality impact downstream from the discharge given the sheer magnitude of the mIBI decline.

7) A 34-point decline (from good to almost poor quality) occurred at RM 3.0 between 2007 and 2011. At this time, there are no obvious explanations for the observed decline.

E. Branch DuPage River Tributaries

As in 2007, all 2011 East Branch tributaries had mIBI scores in the poor or fair narrative ranges (Figure 36; Table 1). While mIBI scores from comparable stations suggest a slight improvement over the much more degraded condition of small drainage sites in 2007 (Figure 37), overall changes in narrative condition were minimal. An exception to this trend was Armitage Ditch, a 2.2 sq. mi. drainage that experienced an over 20-point increase in mIBI, from the lower poor to solidly fair narrative range. Increases in percent EPT, scrapers, and total taxa reflected improved assemblage condition. Surprisingly, field observations described the station as recently channelized with the installation of rock gabions, bank armoring, and riparian removal. Since much of the stream channel was culverted directly upstream from the site in the 1990s, urban runoff and water quality conditions may be having a greater influence on community health than variation in habitat condition.

Three tributaries were sampled in 2011 for the first time and all were poor (Prentiss Creek RM 3.8, Trib. to E. Br. DuPage) or fair (Prentiss Creek RM 1.1, Trib. to E. Br. DuPage #6). The Trib. to E. Br. DuPage was extremely small (0.8 sq. mi. drainage area) with muck substrates and intermittent flows. The upper Prentiss Creek mIBI score (5.8 at RM 3.8) was the lowest of any site sampled in the East Branch study area. However, macroinvertebrate field sampling forms note that collections were made under “flooded” conditions. Under more typical, summer base flows, the sampling site may well be dry or intermittent. Photos of interstitial flows nearly 3 miles downstream at RM 1.1 would tend to confirm this assertion.

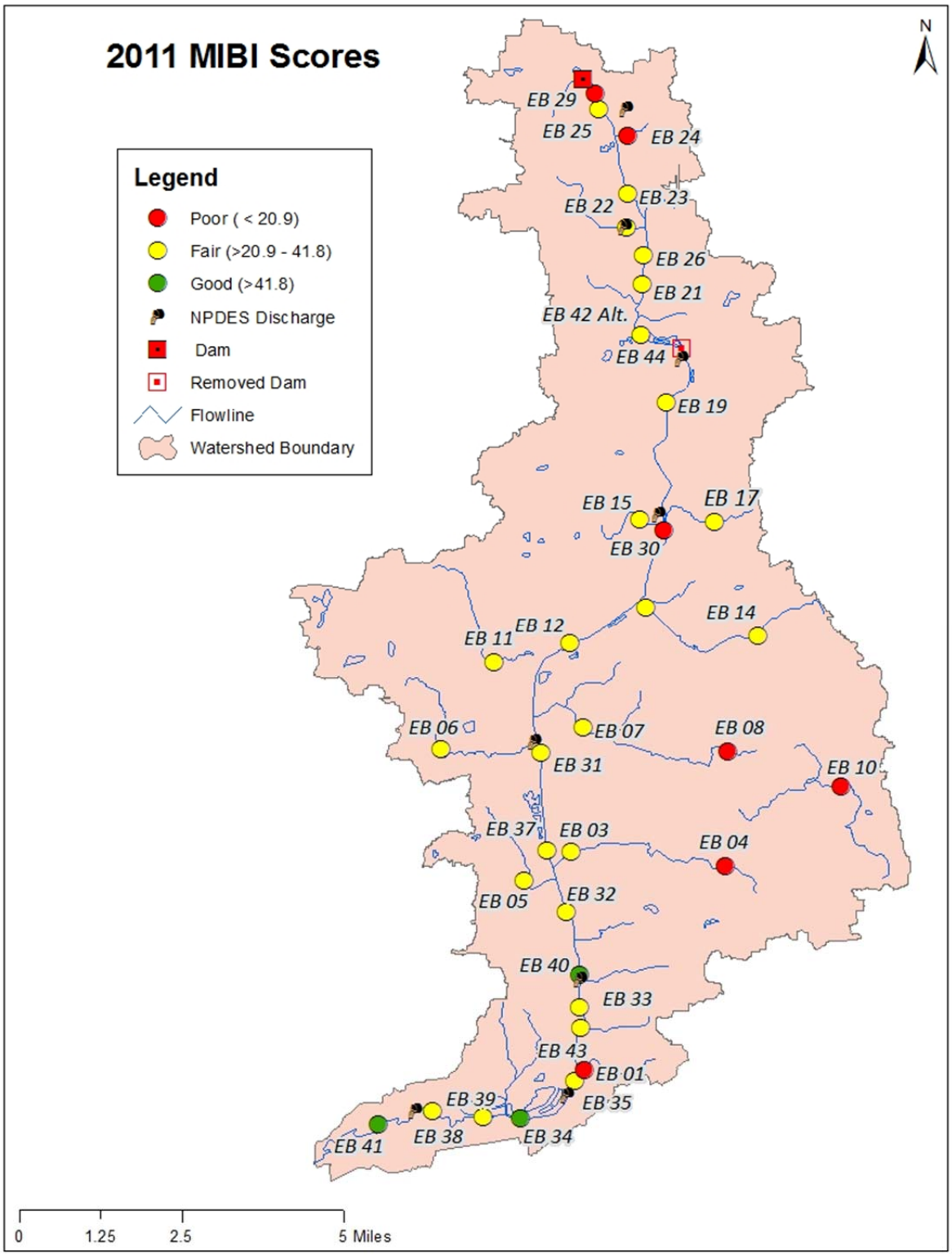


Figure 36. Macroinvertebrate IBI (mIBI) scores from 2011 in the E. Branch DuPage River study area rated by Illinois EPA narrative ranges. Square symbols denote dams and outfalls denote WWTP locations.

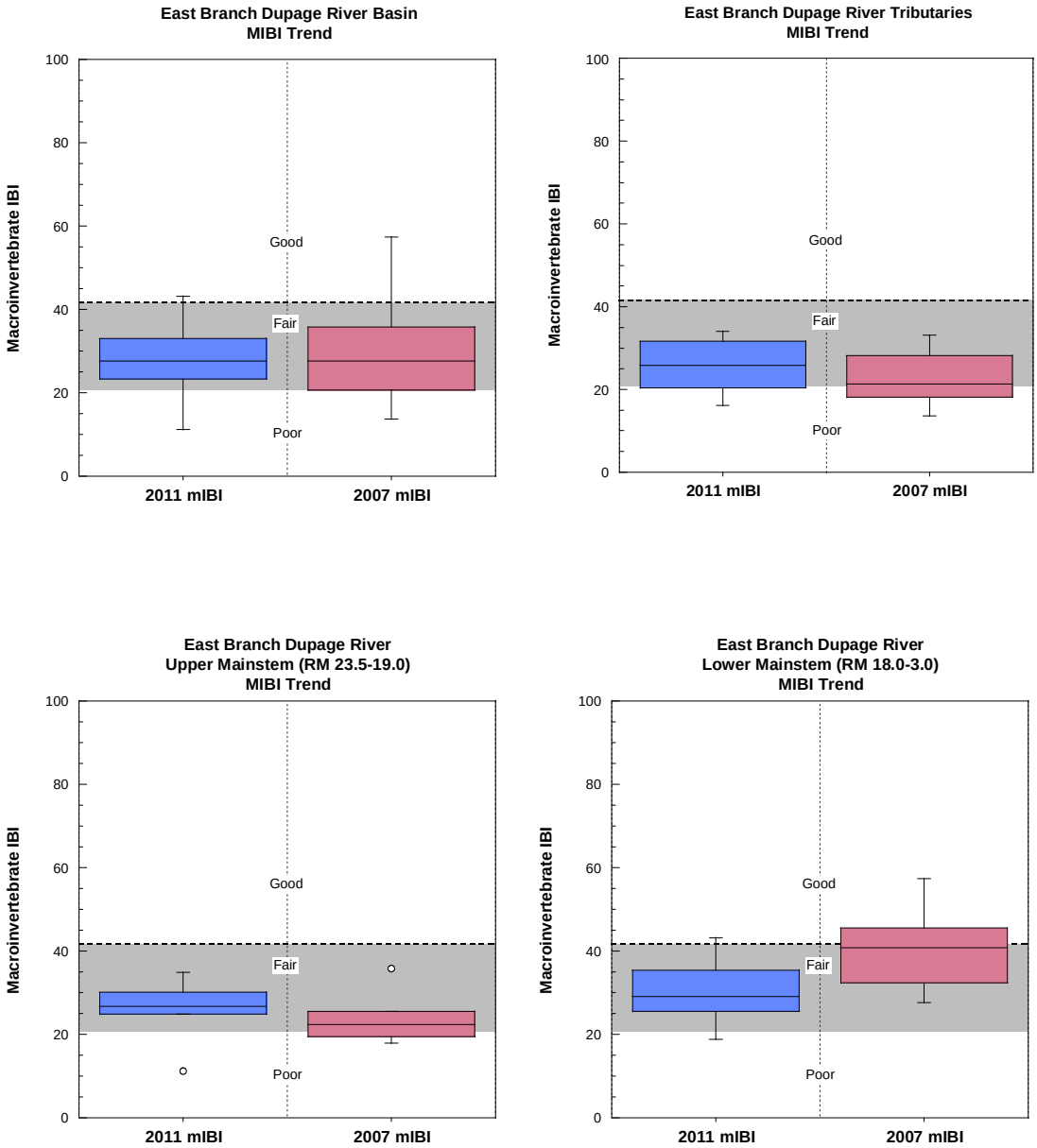
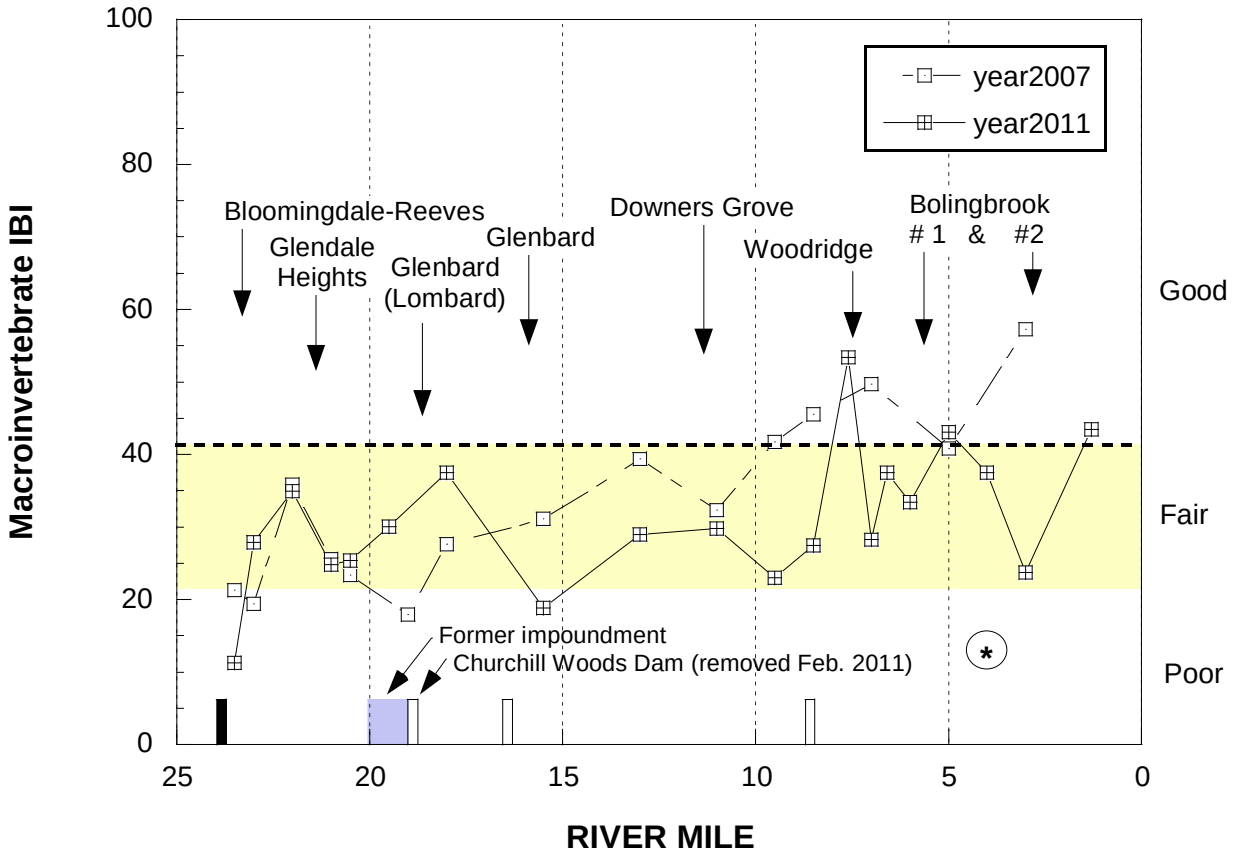


Figure 37. Box and whisker plots of mIBI scores and trends at comparable sites from the E. Branch DuPage River study area in 2007 (salmon) and 2011 (blue). Scores displayed are broken down by basin (upper left), tributaries (upper right), upper East Branch mainstem (lower left) and lower East Branch mainstem (lower right). Note: The Churchill Woods dam (East Branch RM 18.7) was removed in February 2011.



* RM 4.0 sample from 2007 was invalidated and is not displayed due to excessive stream depth and poor sampling efficiency.

Figure 38. Macroinvertebrate IBI scores for samples collected from the E. Branch DuPage River, 2011 and 2007 in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). The shaded region demarcates the "fair" narrative range.

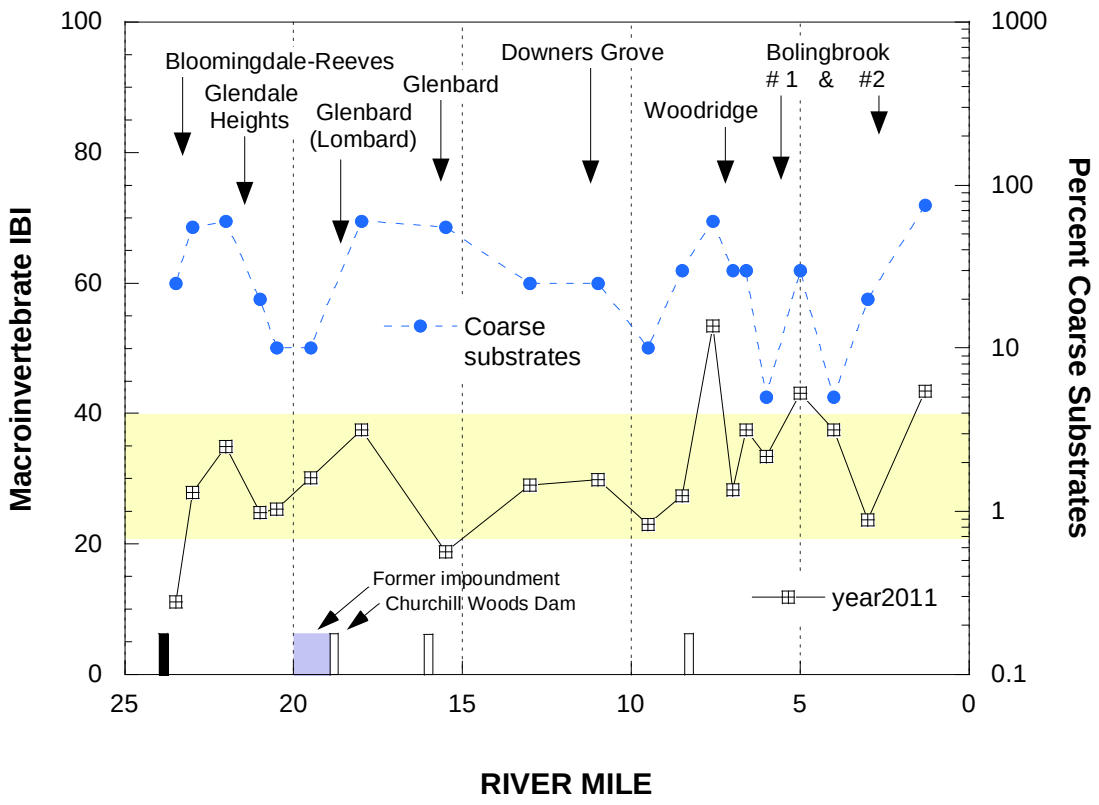


Figure 39. Macroinvertebrate IBI scores and percentages of coarse substrates (gravels and cobbles) from 2011 E. Branch DuPage River samples sites in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). The shaded region demarcates the "fair" narrative range.

E. Branch DuPage River Watershed Biological Assemblages – Fish

Fish assemblage condition in the lower DuPage River watershed in 2012 ranged from poor to fair (Figure 40). Prior to removal of the Churchill Woods dam, East Branch fish assemblages upstream from the dam were essentially that of a pond, predominated by sunfish, bullheads, golden shiner, and mosquito fish. Downstream from the dam, the assemblage reflected more lotic, stream-like conditions and populations of sand shiner, johnny darter, hornyhead chub, and rock bass were present. In the two years following the dam removal, eight new species have been recorded upstream (Table 13) and a number of other populations have expanded their ranges. For example, johnny darter were absent above the dam, but have now been found at six sites in 16 sample passes between RMs 23.0 and 19.3. Sand shiner were found at only two upper mainstem sites in 2007 (in three samples), but are now found at all 7 sites between RMs 19.3 and 23.5 (18 samples). Besides the expansion of these species populations, fIBI scores have also positively followed the dam removal and improved habitat features (Figure 41 and Figure 42).

Table 13. Fish species collected downstream of the Churchill Dam and not upstream, fish species collected upstream of the dam in 2011 and 2012 after the removal of the dam, and fish species collected upstream of the dam prior to 2011, but not collected after the removal.

Fish Species Collected Downstream and Not Upstream	Fish Species Collected Upstream Only After Dam Removal	Fish Species Collected Upstream Only Before Dam Removal
golden redhorse	*quillback carpsucker*	*western mosquitofish*
shorthead redhorse	*river carpsucker*	*central mudminnow*
lake chubsucker	*hornyhead chub*	
striped shiner	*blackstripe topminnow*	
common shiner	*channel catfish*	
bullhead minnow	*goldfish*	
stonecat madtom	*pumpkinseed*	
tadpole madtom	*johnny darter*	
rockbass		

Lower East Branch fish communities downstream from the Churchill Woods dam have not maintained the improvements in quality documented upstream. All comparable sites from the lower 18 river miles of the mainstem had lower fIBI scores than in 2007 (Figure 41 and Figure 42). Upstream to downstream trends in this reach were remarkably similar between surveys but the 2011 results showed a persistent decline in quality. Of particular concern, the declining trend in the lower seven river miles, first noted below the Woodridge and Bolingbrook WWTPs in 2007, continued in 2011. This gradual, upstream to downstream pattern of decline and recovery suggests a classic D.O. sag as excess nutrients and organic wastes are assimilated downstream from their inputs. Unfortunately, continuous D.O. measurements were unavailable for this reach such that this specific phenomenon has not been chemically confirmed. Compared to 2007, water quality impacts in 2011 were exacerbated by persistently elevated concentrations of nutrients and dissolved solids along the effluent dominated mainstem.

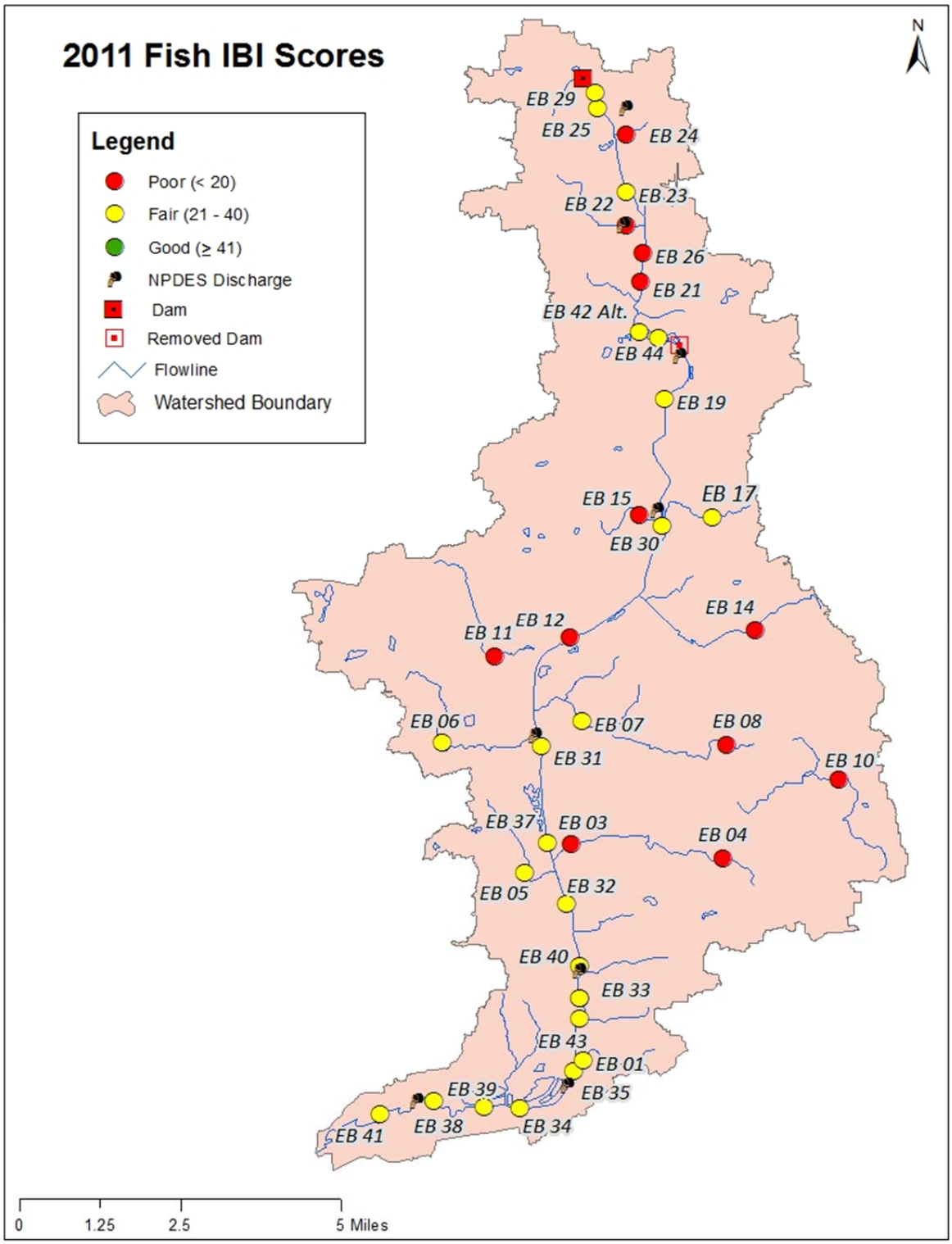


Figure 40. Fish IBI (fIBI) scores from 2011 in the E. Branch DuPage River study area rated by Illinois EPA narrative ranges. Square symbols denote dams and outfalls denote WWTP locations.

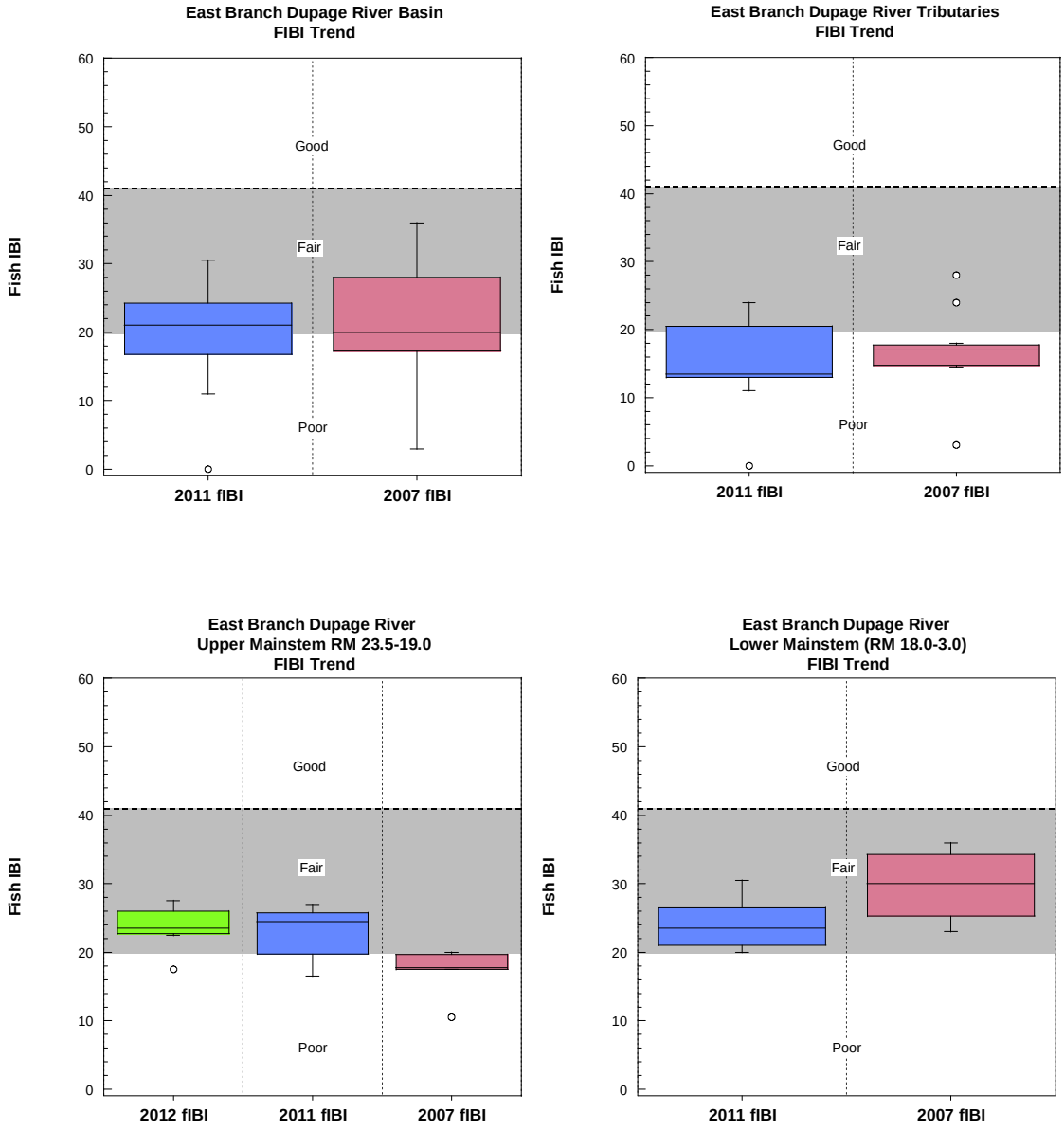


Figure 41. Box and whisker plots of fIBI scores and trends at comparable sites from the E. Branch DuPage River study area in 2007 (salmon), 2011 (blue), and 2012 (green - upper East Branch only). Scores displayed are broken down by basin (upper left), tributaries (upper right), upper East Branch mainstem (lower left) and lower East Branch mainstem (lower right). Additional upper mainstem sampling in 2012 (lower left plot) assessed removal of the Churchill Woods dam (RM 18.7).

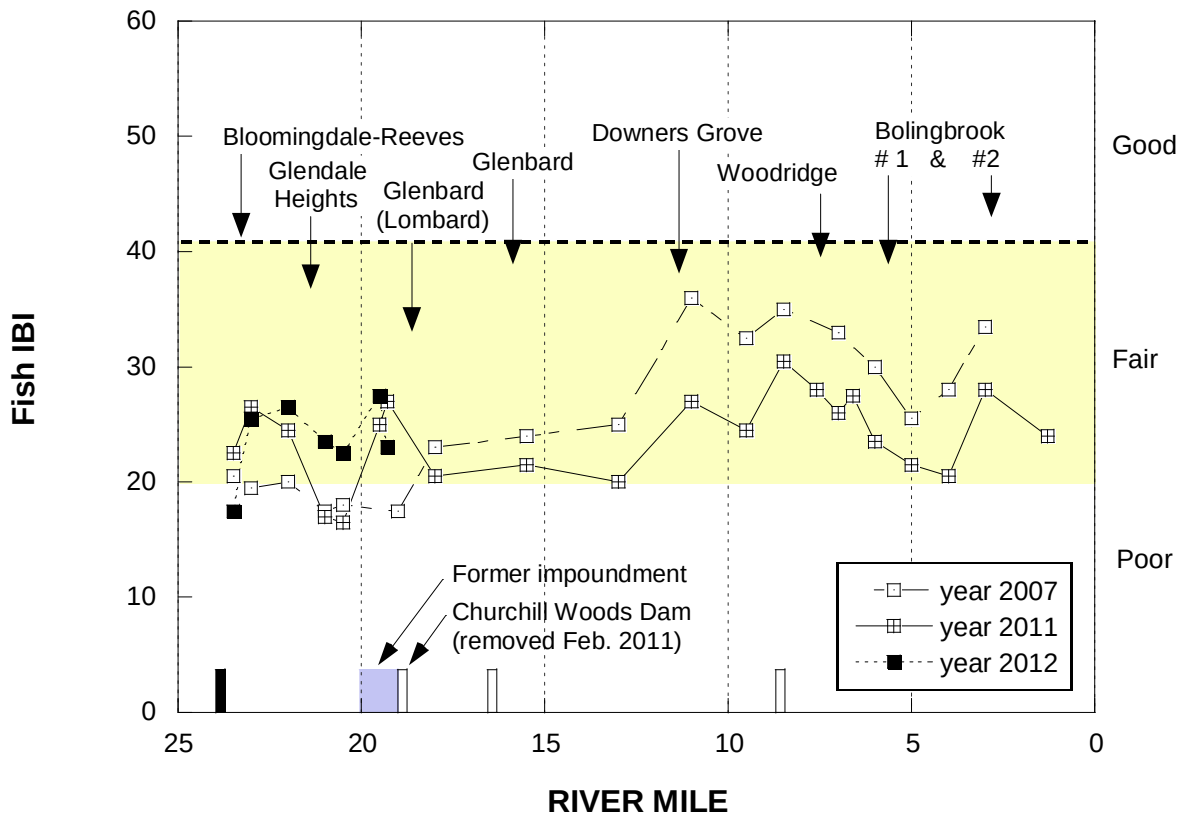


Figure 42. Fish IBI scores for samples collected from the E. Branch DuPage River, 2011-12 and 2007 in relation to municipal WWTP discharges. Bars along the x-axis depict mainstem dams or weirs (only black bars impede fish passage). The shaded region demarcates the "fair" narrative range.

Longitudinal Patterns in Fish Assemblage Condition along the E. Branch DuPage River

Fish assemblages in the East Branch mainstem showed a general decline between 2007 and 2011 based on fIBI scores (see Figure 42). An exception was an increasing trend in assemblage condition beginning in 2011 and continuing in 2012 following removal of the Churchill Woods Dam (discussed on page 77). Herein we examine the upstream to downstream trends in specific key fIBI metrics to more fully understand the changes that have occurred between surveys. Fish species richness generally increased from upstream to downstream in 2007, whereas in 2011 species richness declined, on average, in the lower half of the river compared to 2007 (Figure 43). Some of this is related to generally higher species richness in the upstream reaches during 2011, but the larger influence was the decline in species richness in the lower reaches. In the upper reach, the maximum species richness values occurred during 2012 that resulted from improved connectivity with downstream reaches following the removal of the Churchill Woods dam in 2011.

Figure 44 is a plot of sunfish species richness and benthic invertivore species, both fIBI metrics, vs. river mile in 2007, 2011, and 2012. There was an increasing trend in the richness of both sunfish and benthic invertivore species in 2007 than during 2011, largely because of high maximum species richness values at downstream sites.

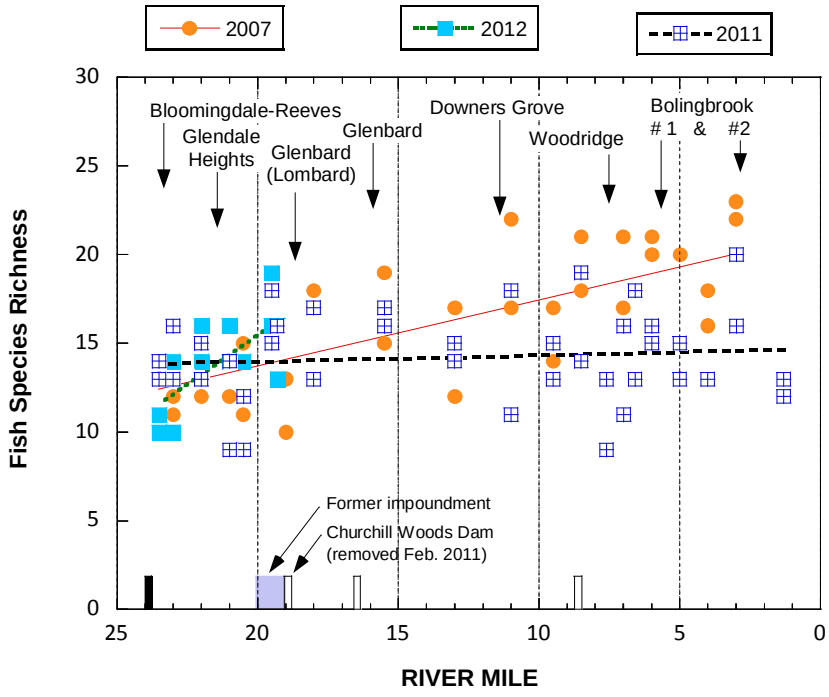


Figure 43. Total fish species richness vs. river mile plotted by sampling year and sampling pass on the E. Branch DuPage River. Regression lines represent linear trends through the data points.

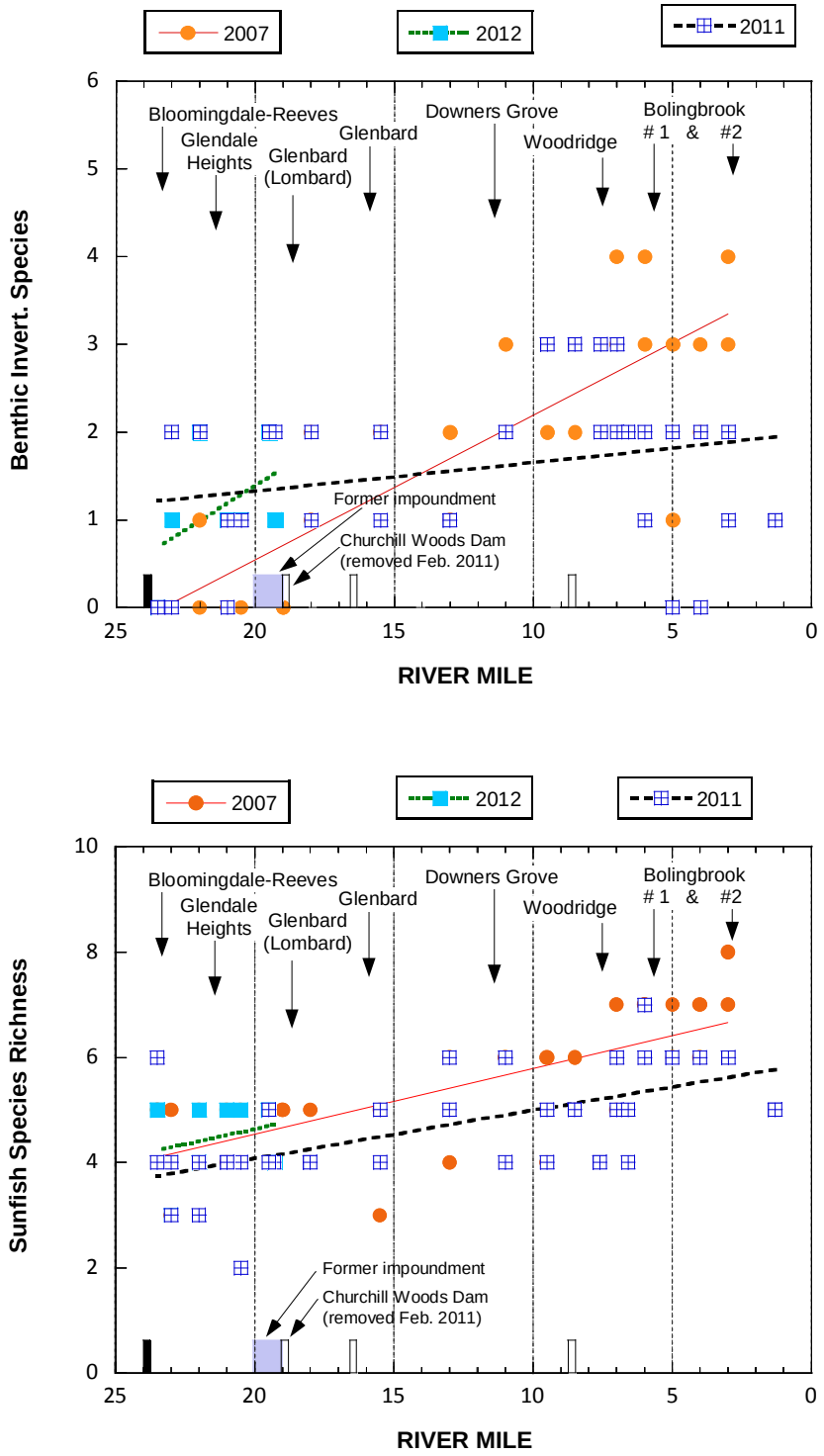


Figure 44. Benthic invertivore and sunfish species richness vs. river mile plotted by sampling year and sampling pass on the E. Branch DuPage River. Regression lines represent linear trends through the data points.

The fIBI proportional metrics, such as the percentage of fish as generalist feeders, was greatest particularly in downstream reaches during 2011 (Figure 45). This is a negative metric with high values indicating more degraded conditions. This matches the pattern of increased nutrient enrichment from nitrates and phosphorus in the lower reaches of the East Branch. Conversely, the percent of individuals as mineral-spawners, species that require clean gravel and cobble substrates for spawning, declined downstream except at the downstream-most sites that were not sampled in 2007 (Figure 46). These species are deterred by siltation and embeddedness from sands and fine gravels that is associated with upland erosion from runoff and bank erosion. There is a similar decline in the richness of benthic invertivore species (fewer downstream in 2007 vs. 2011) which are also generally associated with coarse substrates (see Figure 44). Thus, fish metric responses generally support the notion of a decline in the downstream reaches between 2007 and 2011 and an improvement in upstream reaches in 2012 with the removal of the Churchill Woods dam.

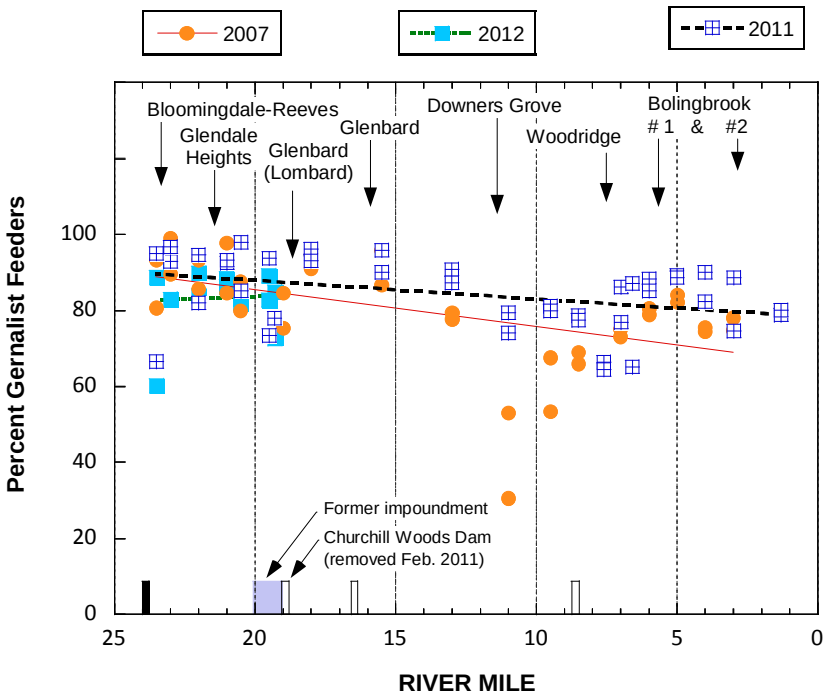


Figure 45. Percent generalist feeders vs. river mile plotted by sampling year and sampling pass on the E.Branch DuPage River. Regression lines represent linear trends through the data points.

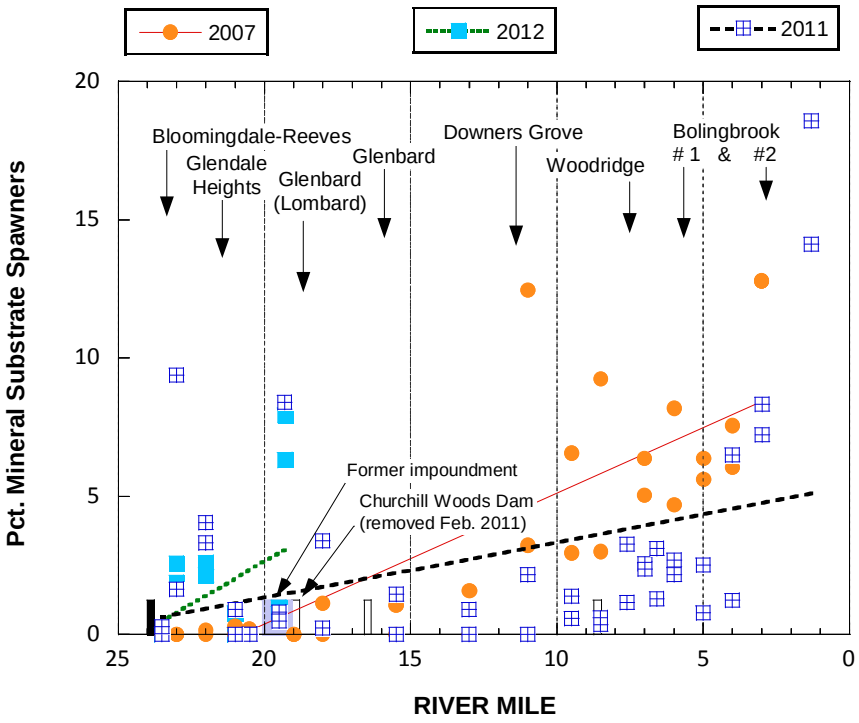


Figure 46. Percent mineral substrate spawners (top) river mile plotted by sampling year and sampling pass on the E. Branch DuPage River. Regression lines represent linear trends through the data points.

DELT anomalies trends in the East Branch mainstem were relatively similar between surveys and not particularly elevated except for some isolated, higher percentages found in one 2007 pass and a steeper, upward trend in the lower reach as the East Branch neared its confluence with the DuPage River (Figure 47). DELTs were elevated at the new sites added in the lower mainstem in 2011. Taken together the increase in DELTs at the most downstream sites may well reflect the suggested adverse effects to the D.O. regime.

E. Branch DuPage River Tributaries

Fish IBI scores from tributary sites were very similar to 2007 and continue to reflect mostly poor to marginally fair quality (Figure 41). Pollution tolerant populations, or those characteristic of lakes and ponds, frequently dominated the tributary sites and included green sunfish, bluegill, black and yellow bullhead, fathead minnow, white sucker, and common carp. In contrast, intolerant species were almost entirely absent.

In 2007, lower Lacey Creek and St. Joseph Creek were of a somewhat higher quality and appeared augmented by populations from the East Branch mainstem. However, by 2011 the Lacey Creek fIBI declined from fair (fIBI = 24) to virtually fishless (fIBI = 0); only two species (common carp and yellow bullhead) were found in 2011 compared to 18 species in 2007 (see

photo below). Lower St. Joseph Creek fIBIs were in the lower fair range in both 2007 and 2011 and conditions were largely unchanged between surveys.

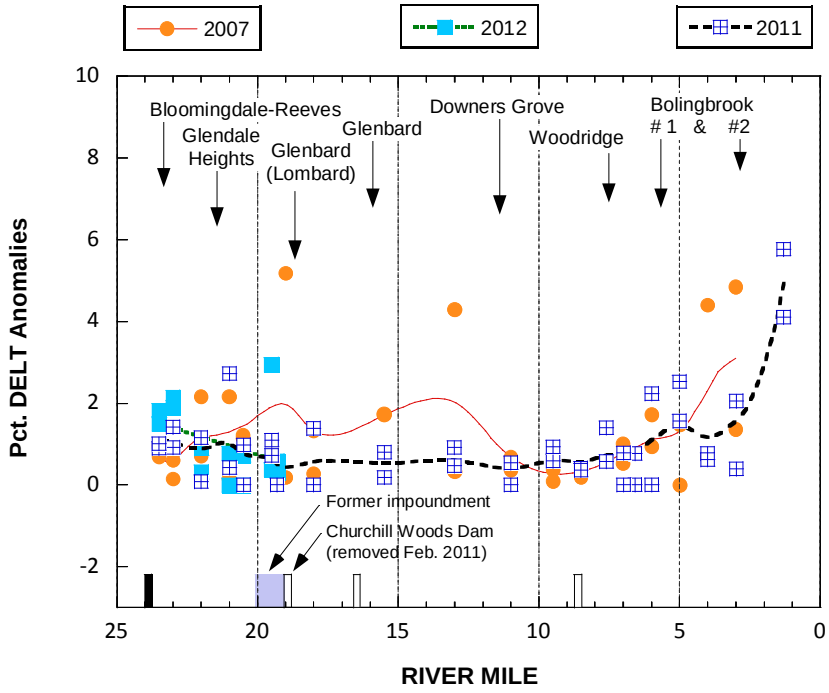


Figure 47. Percent DELT anomalies trends vs. river mile plotted by sampling year and sampling pass on the E. Branch DuPage River. Regression lines represent linear trends through the data points.

EB13 – Lacey Creek

DISCUSSION

Biological assemblages, physical habitat, and chemical water quality conditions remain significantly impaired throughout much of the E. Branch DuPage River study area. Biological assemblages were rated in poor to fair condition (in accordance with Illinois EPA methods) at almost all locations sampled in 2011. No fIBI values met the IEPA good quality threshold and good macroinvertebrate IBIs were limited to only three of 36 sites.

Habitat degradation and channel alteration was particularly severe in the tributaries and small drainages (<5 sq. mi.) that were dominated by extensive suburban land uses and the attendant chemical and physical stressors. Elevated chloride and TDS levels, likely remnants of winter road salt applications, were also characteristic of these smaller drainages.

Biological performance fared somewhat better in the larger East Branch mainstem, but river flows were dominated by a series of large municipal WWTPs. The discharges, which stretch from the headwaters to the mouth, resulted in elevated nutrients, chlorides, dissolved solids and subsequently low D.O. levels downstream. An improving trend was noted in the upper mainstem in 2011 and 2012 following the elimination of the Churchill Woods dam impoundment, but this trend was reversed in the lower mainstem in 2011 where excessive nutrient enrichment and elevated dissolved solids contributed to persistently lower water quality than in 2007.

Both the 2007 and 2011 surveys showed significant impairment, degraded habitats, and nutrient enriched water quality conditions. Still, there were noticeable differences between the two surveys including:

1) A more pronounced elevation in nutrient levels between mainstem and tributary sites in 2011 (see Figure 28). This was evident not only in elevated concentrations of nutrients, but also in wider swings in diel D.O. as evidenced by extremely high daytime values in 2011.

2) A nearly order of magnitude increase in nitrate-N concentrations in the East Brach mainstem, primarily related to point source discharges. Continued elevated phosphorus levels and persistently low mainstem diurnal dissolved oxygen levels continued, particularly in the lower half of the river.

3) A further increase in the already elevated levels of TDS and chlorides throughout the watershed likely related to increased applications of winter road salt in 2007-2010 and that were not diluted by point source discharges.

4) Consistent declines in both fish and macroinvertebrate performance since 2007 in the East Branch mainstem, particularly within the lower 15-18 river miles and downstream from specific point source discharges.

5) In contrast to the lower mainstem, improvements in habitat quality and biological performance in portions of the upper mainstem following removal of the Churchill Woods dam.

6) The 2011 survey results increasingly indicate point source discharges are the major source of nutrients as opposed to nonpoint source runoff from the surrounding suburban landscape.

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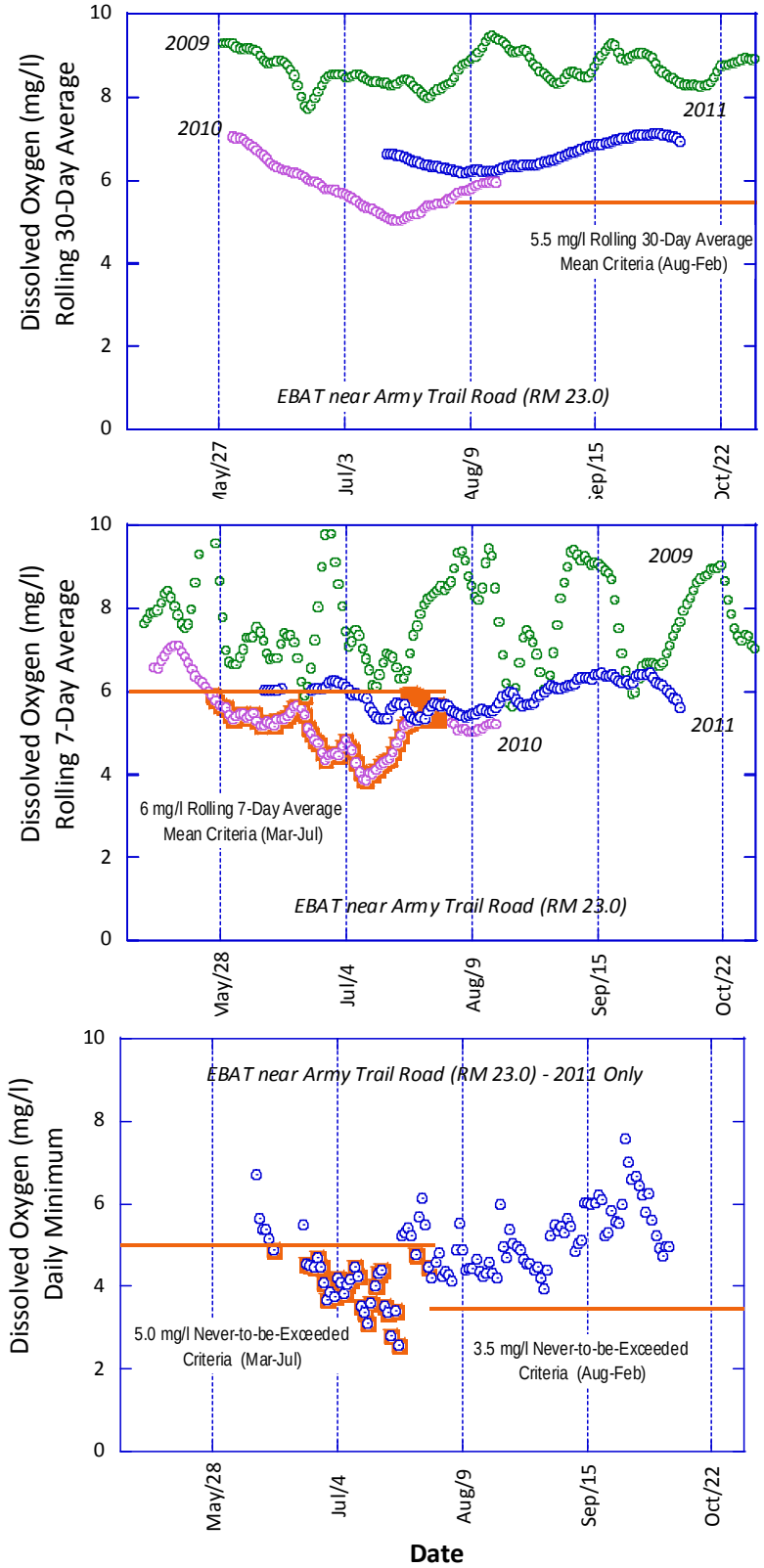
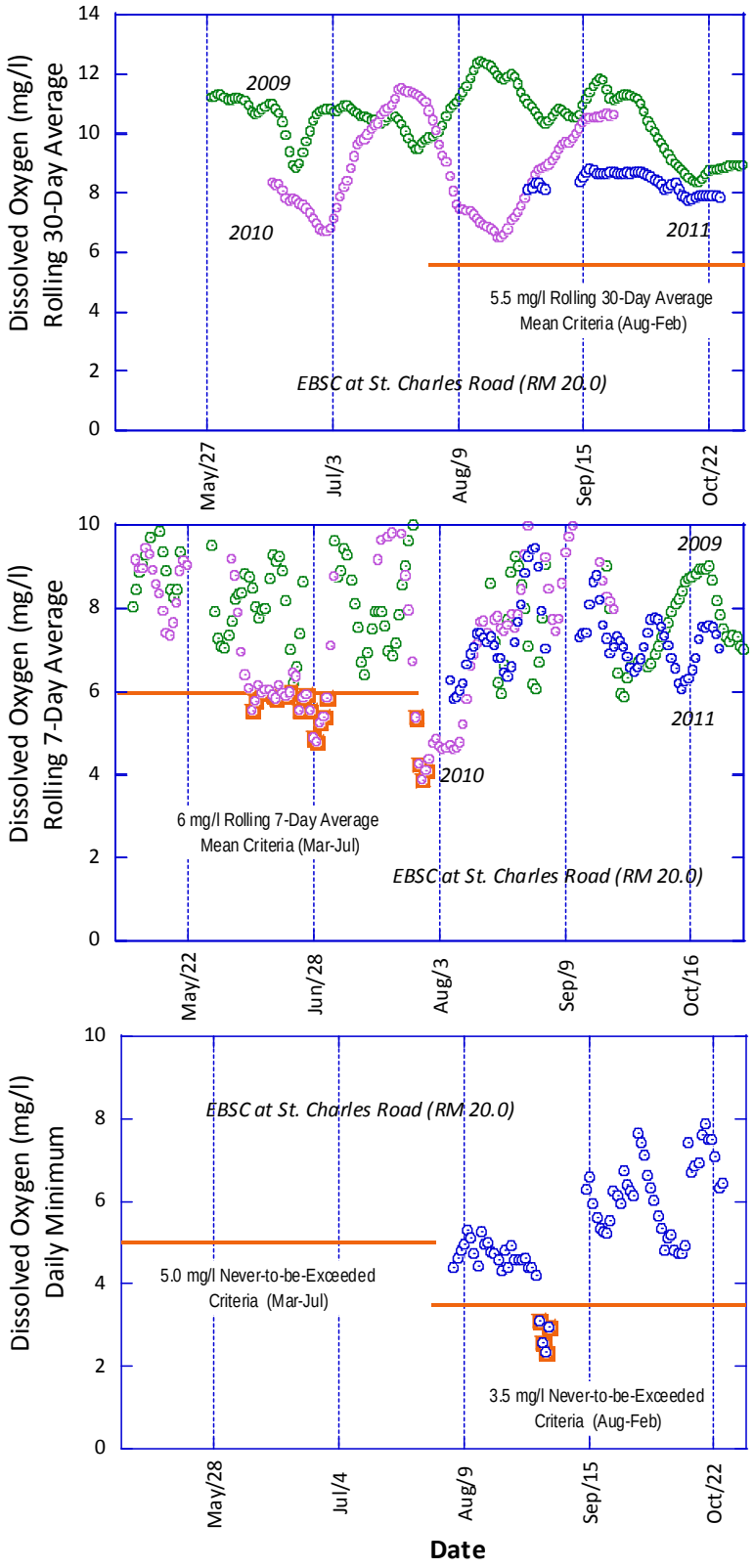
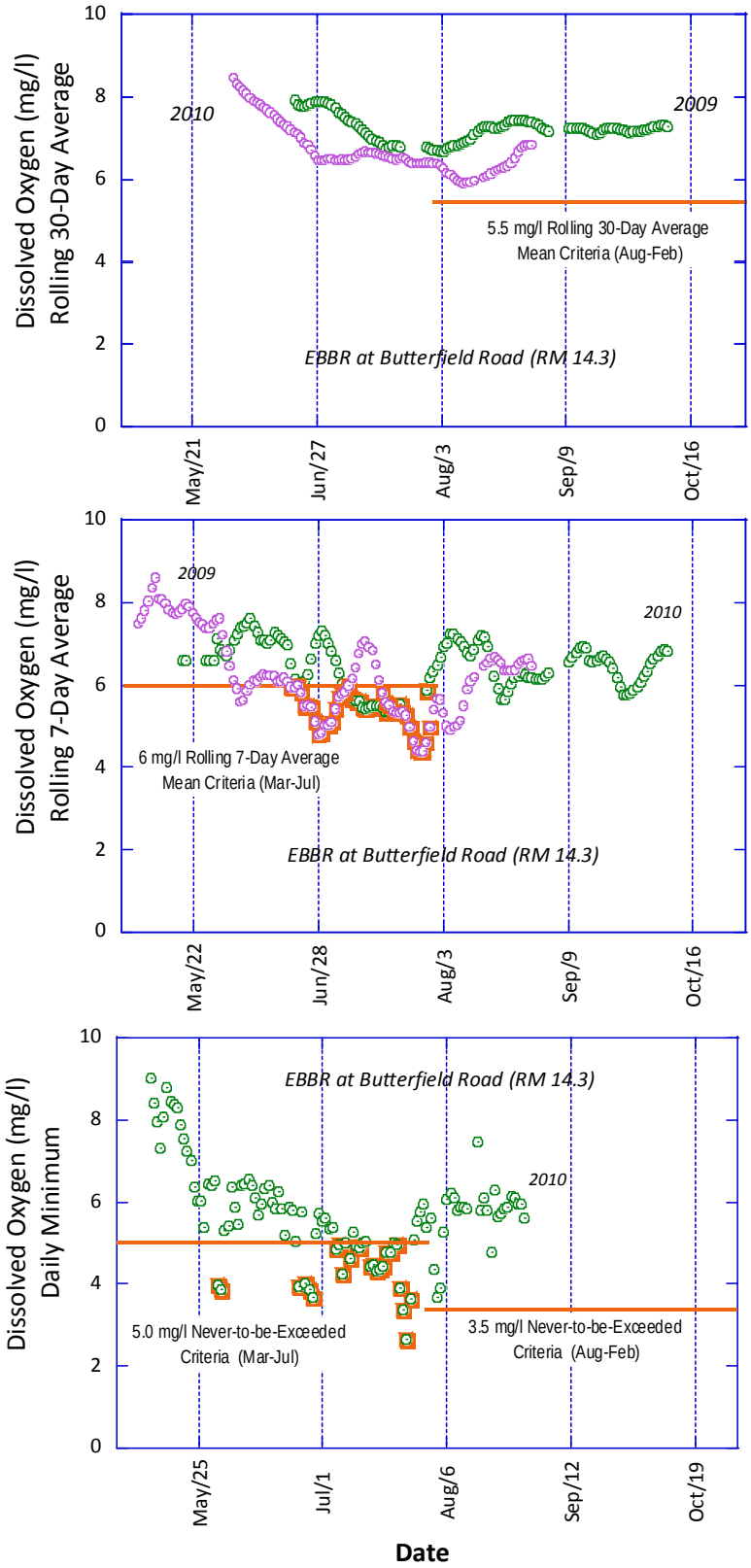
APPENDIX A. Plots of continuous dissolved oxygen profiles from selected sites on the East Branch DuPage River during 2009-2011. East Branch monitor stations were located at EBAT near Army Trail Road (RM 23.0), EBSC at St. Charles Road (RM 20.0), EBHL at Hidden Lake (RM 14.0) and EBHR at Hobson Road (RM 8.4).



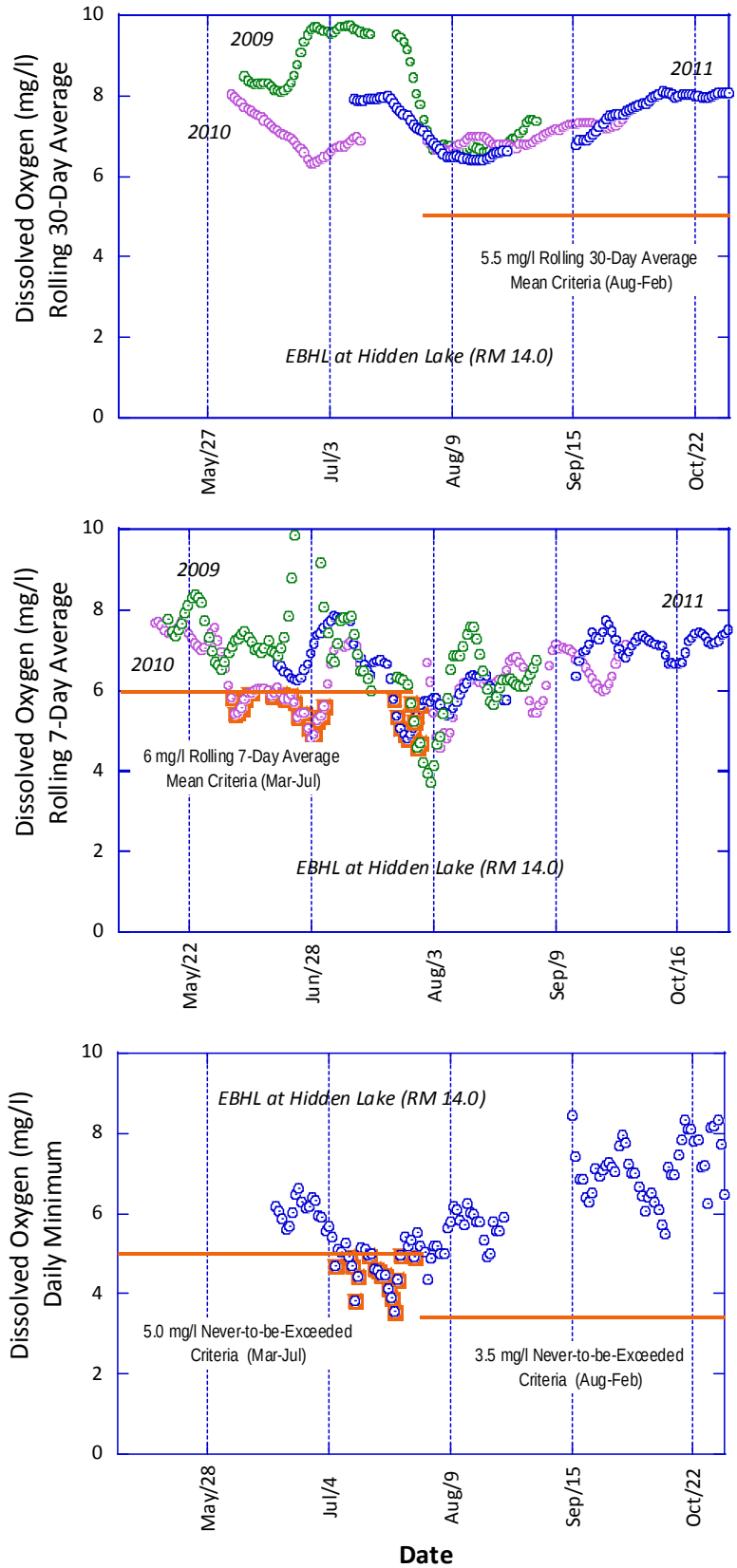
Appendix Figure A-1. Plots of continuous dissolved oxygen profiles including the rolling 30-day average (top), rolling 7-day average (middle) and the daily minimum (bottom) site EBAT near Army Trail Road (RM 23.0) on the East Branch DuPage River. , EBSC at St. Charles Road (RM 20.0), EBHL at Hidden Lake (RM 14.0) and EBHR at Hobson Road (RM 8.4).



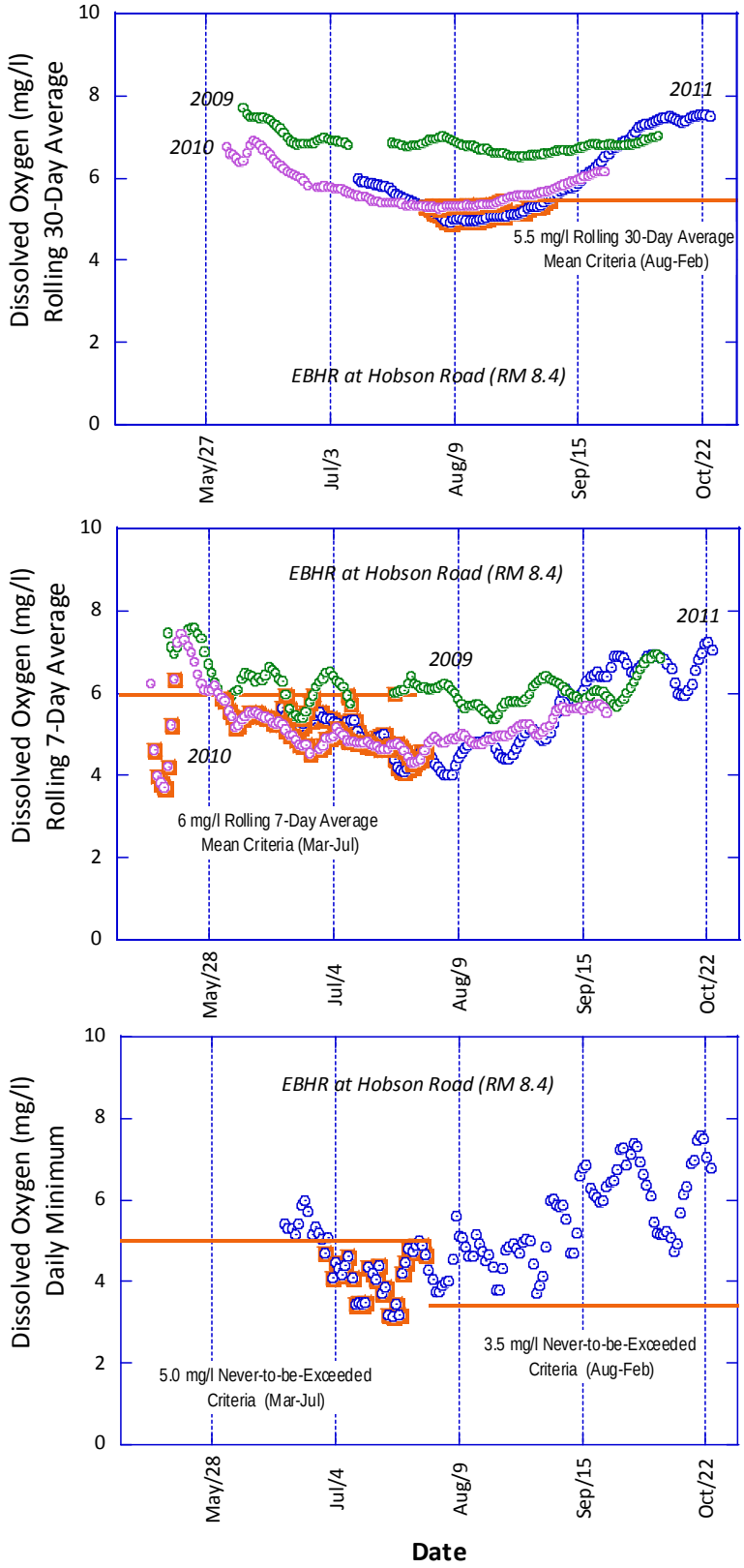
Appendix Figure A-2. Plots of continuous dissolved oxygen profiles including the rolling 30-day average (top), rolling 7-day average (middle) and the daily minimum (bottom) at site EBSC at St. Charles Road (RM 20.0).



Appendix Figure A-3. Plots of continuous dissolved oxygen profiles including the rolling 30-day average (top), rolling 7-day average (middle) and the daily minimum (bottom) at site EBBR at Butterfield Road on the East Branch DuPage River.



Appendix Figure A-4. Plots of continuous dissolved oxygen profiles including the rolling 30-day average (top), rolling 7-day average (middle) and the daily minimum (bottom) at site EBHL at Hidden Lakes on the East Branch DuPage River.



Appendix Figure A-5. Plots of continuous dissolved oxygen profiles including the rolling 30-day average (top), rolling 7-day average (middle) and the daily minimum (bottom) at EBHR at Hobson Road on the East Branch DuPage River.