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# 2012 Biological and Water Quality Study of the Lower DuPage River Watershed

Will and DuPage Counties, Illinois

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*Cover photo: A flathead catfish from the Lower DuPage River,  
downstream from the 135<sup>th</sup> Street Bridge at RM 21.5 (Station  
DP11).*



# **2012 Biological and Water Quality Study of the Lower DuPage River Watershed**

**Will and DuPage Counties, Illinois**

Final Report

Technical Report MBI/2014-03-01

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Prepared for:

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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 Lower DuPage River watershed represents a defined watershed of approximately 81 square miles in drainage area that has a complex mix of overlapping stressors and sources in a developed suburban landscape. This assessment is a follow-up to a fish survey of the DuPage River performed in 2007 (MBI file data). Previous surveys and 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 Lower 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) establish the first baseline assessment of the Lower DuPage River watershed to serve as a basis for tracking and understanding changes through time that could 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 assessment made herein is directly comparable to those accomplished in East and West Branches of the DuPage River between 2006 and 2012, such that trends in status can be examined, and causes and sources of impairment can be confirmed, appended, or removed. This study contains a summary of major findings and recommendations for future monitoring, follow-up investigations, and any immediate actions that may be needed to resolve readily diagnosed impairments. It was not the role of this study to identify specific remedial actions on a site specific or watershed basis. However, the baseline data established by this study contributes to a process termed the Integrated Priority System (IPS; MBI 2010) that was developed for the upper DuPage watersheds to help determine and prioritize restoration projects.

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### INTRODUCTION

A biological and water quality study of the Lower DuPage River and selected tributaries was conducted in 2012 to assess aquatic life condition status, identify proximate stressors, and examine chemical/ physical water quality and biological condition relative to publicly owned treatment works and other potential sources of stress and impact. The 2012 survey data were also used to assess trends relative to a baseline fish and habitat survey of the mainstem conducted in 2007. These unpublished results from 2007 are located in MBI data files.

Data analyses and site selection for the 168 sq. mi. Lower DuPage watershed was originally organized by geometric survey design which displayed chemical and biological results by drainage area categories within 5, 11, 21, 42, 84, and 168 sq. mi. geometric panels. Additional sites that targeted discharges of specific interest or that filled gaps left by the geometric design in the mainstem were also included. MBI has employed a similar survey design in the East and West Branch DuPage Rivers and Salt Creek during the period 2006-2012 (MBI 2008, 2013). However, in the Lower DuPage, stream sizes were clustered at the extremes of the range of geometric panels such that 90% of tributary sites were <12 sq. mi and all mainstem sites exceeded 200 sq. mi. For this reason, discussion of the results was simplified following a *mainstem* and *headwater tributary* stratification. A single tributary site that exceeded 20 sq. mi. was discussed separately.

### SUMMARY

Biological assemblages in the Lower DuPage River watershed were rated in poor to good condition in accordance with Illinois EPA methods (Table 1; Figure 2). Small tributaries were of poorest quality and reflected the most direct impacts associated with urban runoff and, in the case of Rock Run Creek, a municipal WWTP discharge. In fact, no stream site draining less than 20 sq. mi. has fully attained the Illinois biological thresholds within the entire DuPage River basin or the adjacent Salt Creek watershed since these assessments were initiated in 2006 (see Figure 19). Fish assemblages reflected the most pronounced impacts as performance was no better than the fair range. Macroinvertebrates are not as consistently impaired as fish, but rarely exhibited good quality with only 6.7% of samples (n= 208) in the good range. Habitat degradation was not limiting at all headwaters sites with biological impacts occurring despite QHEI scores from 54% of headwater sites >55, a level of quality consistent with general warmwater habitat potential. The basic importance of habitat to biological potential is supported by the fact that all the macroinvertebrate sites that were rated as good had QHEI scores >50 (Figure 19), particularly when headwater streams in the West Branch of the DuPage

River watershed are included. The cumulative results reflect a consistent inability of small drainages in the DuPage River basin as a whole to support general warmwater assemblages. Impairments appear primarily related to urban land use and likely include a combination of chemical and physical factors such as the physical effects of flashy flows, chemical contaminants delivered by “first-flush” runoff events, habitat alteration by impoundments, retention basins and other barriers to fish movement, legacy effects of habitat modifications, unknown toxicity, elevated chlorides resulting from road salt applications, and undocumented spills.

In contrast to the smaller drainages, biological performance in the DuPage River mainstem was mostly in the fair or lower good ranges. Impairment in the upper mainstem generally mirrored the condition of the East and West Branches as nutrient enrichment related to municipal point sources and elevated levels of chlorides and dissolved solids persisted well downstream. Gradual downstream recovery trends were negated by the Channahon Dam impoundment at RMs 2.5 and 1.3. Full attainment occurred immediately downstream from the dam and immediately prior to the confluence with the Des Plaines River. The fIBI and mIBI values are the highest recorded in the entire DuPage River basin.

The declining trend in mainstem fIBI values between 2007 and 2012 (particularly in the upper half of the DuPage mainstem) mirrors a declining trend observed in the lower East Branch DuPage River between 2007 and 2011 (MBI 2013). East Branch declines were coincidental with increased nutrient levels and higher diel D.O. swings observed in 2011; WWTP effluent comprised 98% of the lower mainstem flow in the late summer months. The similarity in the magnitude of decline between the upper mainstem and lower East Branch lends support to the notion that the tributary affected the mainstem.

In addition to lingering impacts from upstream, the 2012 DuPage River results suggest that legacy habitat alteration (channelization), point source inputs, and the severance of connectivity with the Des Plaines River by the Channahon Dam possibly act in a synergistic manner to deter higher biological performance. For example, a long stretch of historically modified habitat and a series of mainstem WWTP discharges are located between the Naperville WWTP (RM 26.65) and Hammel Woods low-head dam (RM 10.6). Throughout this approximate 15 mile reach, the DuPage River is mostly pooled or sluggish with an abundance of aquatic macrophytes (Figure 1); the river



*Figure 1. Lush macrophyte growth at Lower DuPage River RM 21.6.*

channel is poorly developed and lacks sinuosity. Impairment in this sluggish reach was most pronounced in an approximate 9 mile section between the Naperville and Joliet WWTPs (RMs 26-17.7) as both fish and macroinvertebrates were in the fair range and fIBI scores were the lowest in the mainstem (excluding the Channahon dam impoundment). The combination of excessive nutrients and suboptimal habitats, particularly during low flow conditions (i.e., 2.5 times lower in 2012 than 2007), likely exacerbated these impacts. However, based on chemical sampling and, with the possible exception of the Naperville WWTP, the impact of mainstem point source influences appeared secondary to upstream sources. Also, despite physical habitat limitations, QHEI scores reflected at least marginally good quality habitat (mean QHEI = 64.5) and should be adequate to support warmwater assemblages.

Another influence on mainstem fish assemblages are the impoundments formed immediately upstream from the Hammel Woods (RM 10.6) Channahon (RM 1.05) low head dams. In addition to the elimination of riverine habitat within each pool, the structures are permanent barriers to fish movement, as evidenced by differences in fish species richness between the upstream and downstream reaches (see Table 11). Analysis of fish sampling results indicate the Channahon Dam is especially effective at precluding several species from re-entering the DuPage basin from the Lower DesPlaines River and suggests the barriers may well contribute to lower fIBI scores upstream (see Figure 30). While not considered entirely responsible for the observed impairments, the dams may be an important contributing factor. For this reason, “migration barriers” was included as a cause of impairment at affected sites where the “fair” fIBI scores nearly reached the criterion (Table 1).

The results of the 2012 survey largely confirmed the conclusions of the 2011 Lower DuPage River Basin Watershed Plan Final Technical Report (The Conservation Foundation 2011). The Technical Report found that point source discharges were responsible for the large majority of nutrient (nitrates, phosphorus) loadings in the watershed while nonpoint sources were the primary source of chloride (from road salt), sediment (agriculture), and fecal coliform (sewage infrastructure). The 2012 survey results support similar conclusions as the highest nutrient levels were found downstream from point sources (including those located on the East and West Branches) while chlorides were particularly elevated in headwater tributaries. In addition, the Crest Hill WWTP on Rock Run Creek was a major source of ammonia and phosphorus and contributed to severe biological impairment.

Nonpoint source loading and land use maps from the Technical Report and Figure 5 reveal a well-defined section of undeveloped land in the Spring Brook Creek headwaters that delivers consistently low loadings of urban runoff parameters. The section corresponds to the 1,834 acre Springbrook Prairie, an Illinois Natural Areas Inventory site, and sampling site LD24, which had the highest quality habitat and biological performance among the tributaries. Some of the lowest nutrient and urban parameter concentrations in the 2012 survey were found in Spring Creek, which drains mostly agricultural lands in the extreme western edge of the Lower DuPage watershed. Unfortunately, biological communities reflected over-riding impacts in the creek due to intermittent flow and channelization. The Technical Report predicts increased loadings

of chlorides and subsequent decreases in nonpoint sediment runoff with the anticipated residential build-out of the watershed and the subsequent loss of agricultural lands.

One Lily Cache Creek sampling site at RM 6.3 (LD15) was not sampled biologically due to stream desiccation. However, the stream was free-flowing at two other Lily Cache sites located miles up and downstream. The de-watered site was surrounded by active and historic gravel mines, perhaps an indication of an underlying sand lens or a localized disruption of the stream hydrology by mining. Given its relatively large drainage (21.4 sq. mi.), a simple lack of rainfall or small stream size should not account for the complete lack of flow.

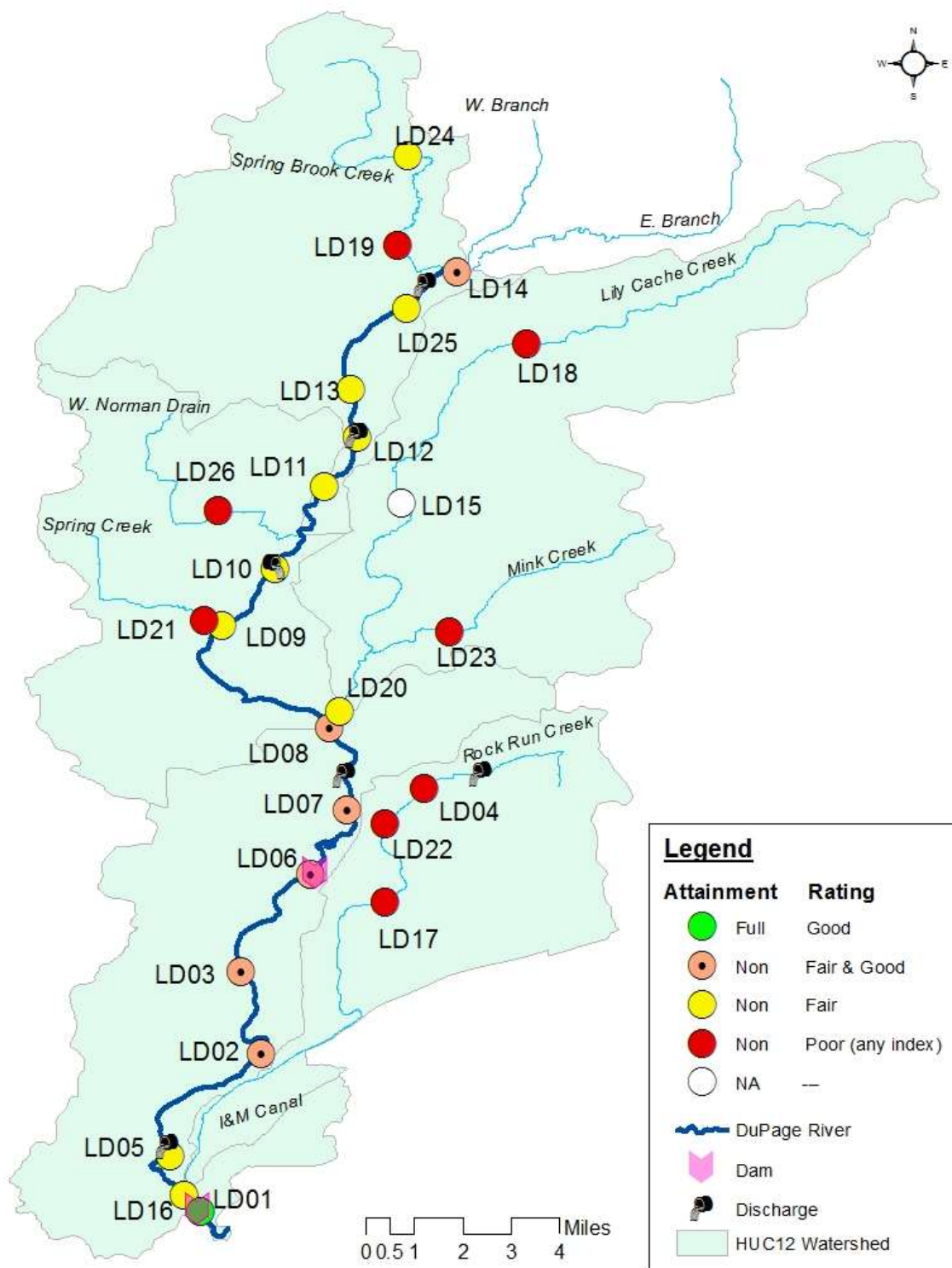


Figure 2. Aquatic life use attainment map for Lower DuPage River watershed biological sampling sites in 2012. Non-attainment status based on biological performance in the fair and good range is noted with "Orange Dot" circles, the fair range with "Yellow" circles and "Red" circles note non-attainment with poor performance.



*Table 1. Status of aquatic life use support for stream segments sampled in the Lower DuPage River watershed study area in 2012. All sites with one or more fair or poor index scores are in Non-attainment and categorized as follows: 1) sites with any poor biological performance [i.e., Non (Poor)] are shaded in red and poor scores are underlined; fair quality sites [i.e., Non (Fair)] are shaded in yellow; fair to good quality sites [i.e., Non (Fair/Good)] are shaded in orange and the “good” scores are **bold**; good quality sites (Full attainment) are shaded in green. MBI assigned causes associated with impaired fIBI and/or mIBIs are compared to previously IEPA assigned causes.*

River (95-Code #)	River Mile	DA (sq. mi)	IL fIBI	MLwb	IL mIBI	QHEI	Attainment Status	MBI Associated Causes	fIBI 2007
Site ID									
<b>DuPage River (95-666)</b>									
LD14	27.3	212.0	31.5	8.17	<b>45.14</b>	88.5	Non (F/G)	TDS/Chloride, nutrients, D.O	--
LD25	26.0	219.0	32.5	7.31	36.90	80.0	Non (Fair)	TDS/Chloride, nutrients, D.O, (Dst. Naperville WWTP)	--
LD13	23.8	230.0	27.5	6.67	39.94	62.0	Non (Fair)	TDS/Chloride, nutrients, D.O, Habitat Alt.	37
LD12	22.7	235.0	26.0	6.34	30.00	57.0	Non (Fair)	TDS/Chloride, nutrients, TKN, D.O, Habitat Alt., (Dst. Bolingbrook WWTP)	32
LD11	21.5	240.0	26.5	7.63	38.36	68.0	Non (Fair)	TDS/Chloride, nutrients, D.O, Habitat Alt.	30
LD10	19.2	253.0	26.5	7.36	39.52	62.5	Non (Fair)	TDS/Chloride, nutrients, D.O, Habitat Alt. (Dst. Plainfield WWTP)	30
LD09	17.7	260.0	29.0	7.43	39.79	59.0	Non (Fair)	TDS/Chloride, nutrients, D.O, Habitat Alt.	32
LD08	14.2	318.0	37.5	8.53	<b>46.36</b>	<b>65.0</b>	Non (F/G)	TDS/Chloride, nutrients, D.O, Habitat Alt., Migration barrier	31
LD07	12.2	325.0	32.5	7.65	<b>46.67</b>	<b>63.0</b>	Non (F/G)	TDS/Chloride, nutrients, D.O, Habitat Alt., Migration barrier (Dst. Joliet WWTP)	34
LD06	10.4	332.0	40.5	8.28	<b>54.20</b>	75.0	Non (F/G)	TDS/Chloride, nutrients, D.O, Migration barrier	<b>42</b>
LD03	7.8	340.0	38.5	8.26	<b>48.08</b>	76.0	Non (F/G)	TDS/Chloride, nutrients, D.O, Migration barrier	--
LD02	5.5	345.0	37.0	8.43	<b>62.28</b>	84.0	Non (F/G)	TDS/Chloride, nutrients, D.O, Migration barrier	--
LD05	2.5	357.0	27.0	7.23	40.29	68.3	Non (Fair)	TDS/Chloride, nutrients, D.O, Flow Alt. (impoundment)	37
LD16	1.3	368.0	20.5	6.17	--	41.5	[Non <sup>a</sup> ] (Fair)	Habitat Alt., TDS/Chloride, nutrients, D.O., Flow Alt. (impoundment)	--
LD01	0.8	376.2	<b>52.0</b>	10.53	<b>46.45</b>	86.5	Full (Good)		<b>58</b>

River (95-Code #)	River Mile	DA (sq. mi)	IL fIBI	MIwb	IL mIBI	QHEI	Attainment Status	MBI Associated Causes	fIBI 2007
Site ID									
<b>West Norman Drain (95-661)</b>									
LD26	2.2	6.2	<u>16.0</u>	--	30.68	67.0	Non (Poor)	TDS/Chloride, nutrients	--
<b>Mink Creek (95-662)</b>									
LD23	1.8	8.8	<u>16.0</u>	--	<b>41.94</b>	53.5	Non (Poor)	TDS/Chloride, Habitat Alt.	--
<b>Spring Creek (95-663)</b>									
LD21	0.5	5.3	<u>18.0</u>	--	33.41	48.0	Non (Poor)	Flow Alt. (intermittent), habitat alt., nutrients (agriculture)	--
<b>Spring Brook Creek (95-664)</b>									
LD24	4.5	8.9	26.0	--	<b>59.55</b>	82.0	Non (F/G)	TDS/Chloride, nutrients	--
LD19	1.2	12.3	<u>19.0</u>	--	24.56	72.5	Non (Poor)	NH3, TDS/Chloride, nutrients	
<b>Rock Run Creek (95-665)</b>									
LD04	6.5	4.9	<u>11.0</u>	--	<u>5.42</u>	32.0	Non (Poor)	NH3, TKN, TDS/Chloride, nutrients, habitat Alt., (Dst. Cresthill WWTP)	--
LD22	5.4	5.5	<u>12.0</u>	--	<u>10.64</u>	36.0	Non (Poor)	NH3, TKN, TDS/Chloride, nutrients, habitat Alt.,	--
LD17	3.5	10.6	<u>17.0</u>	--	21.39	70.0	Non (Poor)	NH3, TDS/Chloride, nutrients	--
<b>Lily Cache Creek (95-668)</b>									
LD18	10.9	11.1	<u>13.0</u>	--	26.13	54.0	Non (Poor)	TDS/Chloride, nutrients, Habitat Alt.	--
LD15	6.3	21.4	--	--	--	--	Non	Flow Alteration (stream de-watering); not sampled	--
LD20	0.2	46.0	29.0	5.85	32.44	65.3	Non (Fair)	TDS/Chloride, nutrients	--

a [Attainment status] based on one organism group is displayed in brackets.

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 3) 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 succeeding level, as one moves upstream, decreases geometrically. While the entire DuPage River basin is 353 sq. mi., the section of the Lower DuPage watershed accounts for 168 sq. mi. (Conservation Foundation 2011). Subdividing this section resulted in six levels of drainage area, starting at 168 sq. mi., and continuing through drainage area panels of 84, 42, 21, 11 and 5 sq. mi., the smallest drainage area sampled. 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 26 sampling sites. One Lily Cash Creek site at RM 6.4 was dry and not sampled during the survey.

Each 2012 site was sampled for fish, stream habitat, macroinvertebrates and water quality, except for macroinvertebrates in the lower Channahon dam pool (LD16/ RM 1.3) and biological and habitat sampling in Lily Cache Creek RM 6.3 (LD 15) due to stream desiccation. 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.), pH and water temperature. Water column metals (Ca, Cd, Cu, Fe, Mg, Pb and Zn) were included at 26 locations. Continuous D.O. monitoring was limited to two sensors in the upper mainstem that bracket the Naperville WWTP at approximately river miles 27 and 26.

### ***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, 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<sup>1</sup> 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

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<sup>1</sup> [http://www.drscw.org/reports/DuPage.QAPP\\_AppendixE.07.03.2006.pdf](http://www.drscw.org/reports/DuPage.QAPP_AppendixE.07.03.2006.pdf)

*Table 2. Biological sampling sites in the Lower DuPage River watershed study area, 2012. Chemical sampling was also conducted at each site but may have been from slightly different river miles (see lists in Table 7 or Table 8).*

Site ID	[River Code 95-x ] - River	River Mile	Latitude/Longitude	Description
LD14	[-666] - DuPage River	27.3	41.701220, -88.15102	Upstream Naperville WWTP
LD25	[-666] - DuPage River	26.0	41.690520, -88.16622	Upstream Naperville Road
LD13	[-666] - DuPage River	23.8	41.666330, -88.18291	Upstream 119th Street
LD12	[-666] - DuPage River	22.7	41.652050, -88.18099	Upstream 127th Street
LD11	[-666] - DuPage River	21.5	41.637180, -88.19077	Downstream 135 <sup>th</sup> Street
LD10	[-666] - DuPage River	19.2	41.612570, -88.20555	Upstream Rt 126 bridge
LD09	[-666] - DuPage River	17.7	41.595740, -88.22119	Upstream Renwick Rd bridge
LD08	[-666] - DuPage River	14.2	41.565380, -88.18916	Caton Farm Rd, dst. Joliet WWTP
LD07	[-666] - DuPage River	12.2	41.540530, -88.18402	Ust. Black Rd, dst. Joliet WWTP
LD06	[-666] - DuPage River	10.4	41.521450, -88.19507	Dst. dam at Hammel Woods
LD03	[-666] - DuPage River	7.8	41.492360, -88.21564	South of Mound Road
LD02	[-666] - DuPage River	5.5	41.467950, -88.20959	Shepley Rd along Canal Road
LD05	[-666] - DuPage River	2.5	41.437460, -88.23685	Ust. Hwy 6, dst. Minooka WWTP
LD16	[-666] - DuPage River	1.3	41.425800, -88.23264	Hwy 6 bridge, impoundment
LD01	[-666] - DuPage River	0.8	41.420610, -88.22757	Channahon Parkway State Park, dst. Channahon dam
LD26	[-661] - W. Norman Drain	2.20	41.630110, -88.22234	Ust. Hwy 30/Lincoln Dr
LD23	[-662] - Mink Creek	1.80	41.594010, -88.15345	Dst. Old Renwick Trail Road
LD21	[-663] - Spring Creek	0.50	41.597190, -88.22653	Mather Woods foot bridge
LD24	[-664] - Spring Brook Cr	4.5	41.735900, -88.16571	Dst. Book Rd
LD19	[-664] - Spring Brook Cr	1.2	41.709200, -88.16875	Dst. 95th Street
LD18	[-668] - Lily Cache Creek	10.9	41.679740, -88.13026	Dst. Weber Rd @ foot bridge
LD04	[-665] - Rock Run Creek	6.50	41.547040, -88.16081	Ust. Essington Rd
LD22	[-665] - Rock Run Creek	5.40	41.536590, -88.17275	Ust. Black Rd
LD17	[-665] - Rock Run Creek	3.50	41.513020, -88.17262	Dst. McDonough Street
LD15	[-668] - Lily Cache Creek	6.3	41.632360, -88.16757	Dst. East Main Street
LD20	[-668] - Lily Cache Creek	0.2	41.570090, -88.18614	Ust. Lily Cache Rd

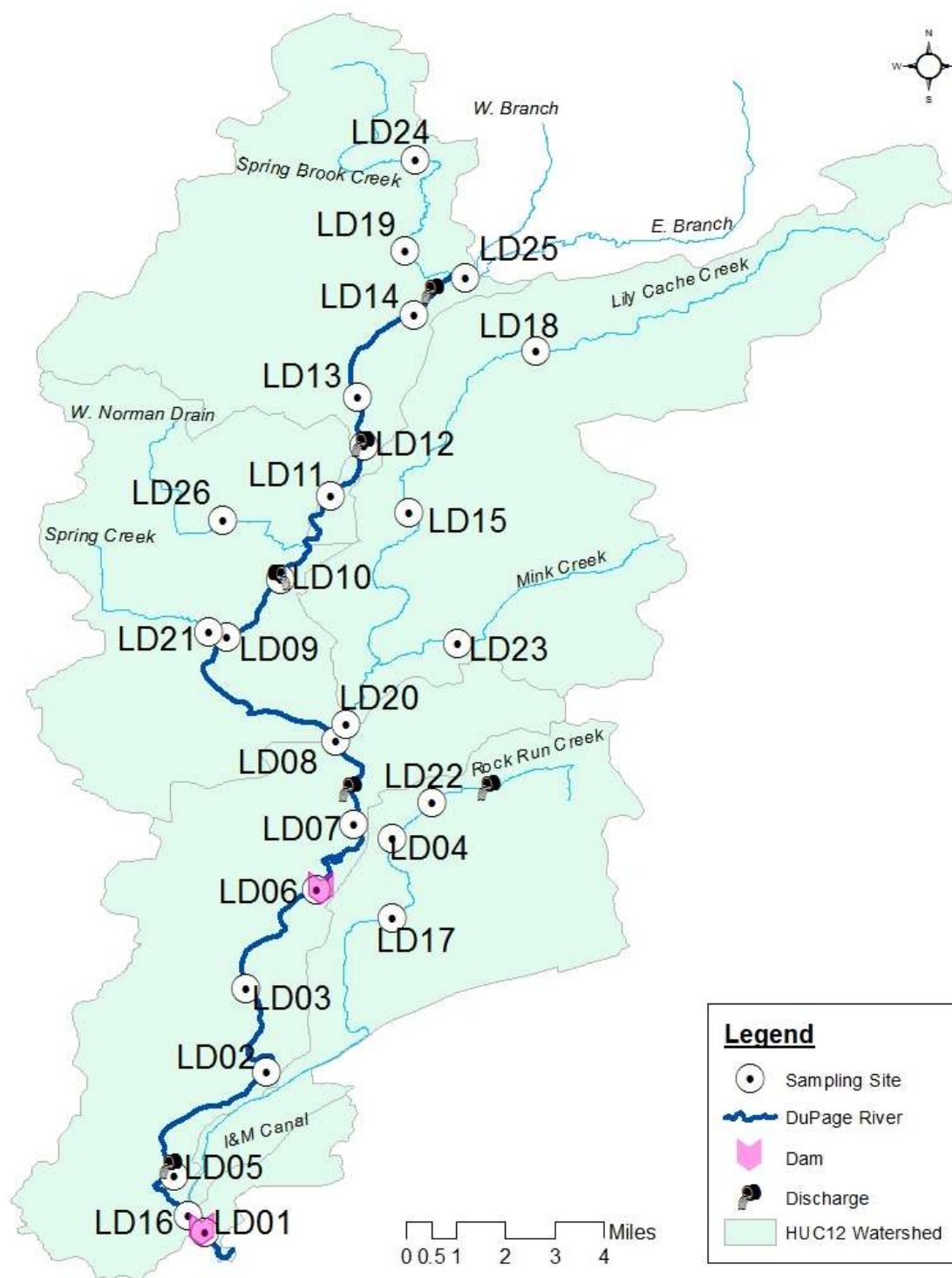


Figure 3. Sampling locations (white dots with associated “LD” station numbers), WWTP discharges (outfall symbols), and significant mainstem dam impoundments (dam symbols) in the Lower DuPage River watershed study area, June-Oct., 2012.

zone or bank zone throughout the entire sampling reach, 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, reasonably accurate estimates of the bottom-zone and bank-zone habitat types are unlikely; thus, the multi-habitat method is not applicable.

Multi-habitat samples were field preserved in 10% formalin. Upon delivery to the MBI lab in Hilliard, OH, the preserved samples were then transferred to 70% ethyl alcohol. Laboratory procedures generally followed the IEPA (2005) methodology. For the multi-habitat method, this requires the production of a 300-organism subsample from a gridded tray following a scan and pre-pick of large and/or rare taxa. Taxonomic resolution was performed at the lowest practicable resolution for the common macroinvertebrate assemblage groups such as mayflies, stoneflies, caddisflies, midges, and crustaceans. This goes beyond the genus level requirement of IEPA (2005); however, calculation of the macroinvertebrate IBI followed IEPA methods in using genera as the lowest level of taxonomy for mBI 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 in the project QAPP (MBI 2006b). Sampling distance was measured with a GPS unit or laser range finder. Sampling locations were delineated using the GPS mechanism and indexed to latitude/longitude and UTM coordinates at the beginning, end, and mid-point of each site. The location of each sampling site was indexed by river mile (using river mile zero as the mouth of each stream). Sampling was conducted during a June 15-October 15 seasonal index period.

Samples from each site were processed by enumerating and recording weights by species and by life stage (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 the Fishes of Illinois (Smith 1979) and updates available through the Illinois Natural History Survey (INHS). Vouchers were deposited and verified at The Ohio State University Museum of Biodiversity (OSUMB).

### ***Habitat***

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995; Ohio EPA 2006b) and as recently modified by MBI for specific attributes. Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic 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 on the basis of environmental results. A tiered approach that links the results of administrative actions with true environmental measures was employed by our analyses. This integrated approach is outlined in Figure 4 and includes a hierarchical continuum, from administrative to true environmental indicators.

The six “levels” of indicators include:

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

In this process, the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental “results” (level 6). An example is the aggregate effect of billions of dollars spent on water pollution control since the early 1970s that have been determined with quantifiable measures



## Completing the Cycle of WQ Management: Assessing and Guiding Management Actions with Integrated Environmental Assessment

### Indicator Levels

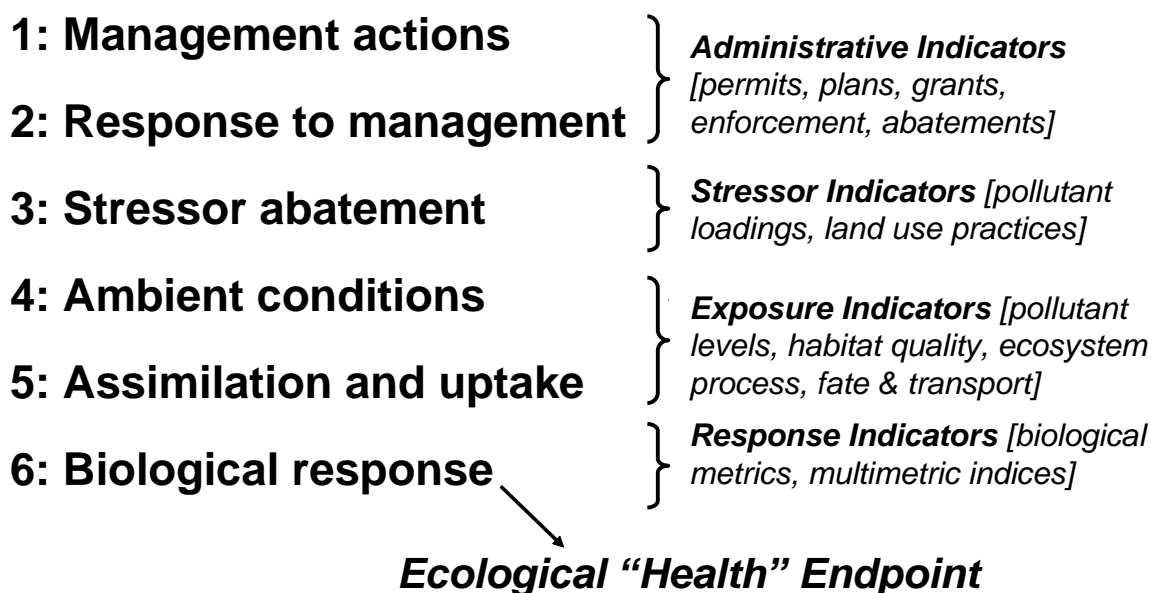


Figure 4. Hierarchy of administrative and environmental indicators that can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995) and further enhanced by Karr and Yoder (2004).

of environmental condition (Yoder et al. 2005). Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers. Each provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of 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 stressor and exposure principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Illinois Water Resource Inventory (305[b] report), the Illinois Nonpoint Source Assessment, and other technical products.

***Illinois Water Quality Standards: Designated Aquatic Life Uses***

The Illinois Water Quality Standards (WQS; IL Part 303.204-206) consist of designated uses and chemical criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad categories, aquatic life and non-aquatic life uses. Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each use. The system of use designations employed in the Illinois WQS constitutes a general approach in that one or two levels of protection are provided and extended to all water bodies regardless of size or position in the landscape. In applications of state WQS to the management of water resource issues in rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality assessments. In addition, an emphasis on protecting for aquatic life generally results in water quality suitable for all other uses.

Aquatic life use support for a water body in Illinois is determined by examining all available biological and water quality information. Where information exists for both fish and macroinvertebrate indicators, and both indicators demonstrate full support, the water body is considered in full support independent of the water chemistry results. Where information for both biological indicators exists, and one indicator suggests full support while the other shows moderate impairment, a use decision of full support can be made if the water chemistry data show no indication of impairment. Where one biological indicator is severely impaired, non-support is demonstrated. If information for only one biological indicator exists, water chemistry information is used to inform the use support decision in that a biological result of full support can be overridden if the water chemistry results clearly demonstrate impairment. However, in the Lower DuPage River survey biological data was available for each site.

### STUDY AREA DESCRIPTION

The DuPage River is formed by the confluence of the East and West Branch DuPage Rivers near the northern border of Will County in Naperville. The mainstem runs approximately 28 lineal miles with a drop of 121 feet before entering the DesPlaines River near Channahon in the I&M Canal State Park. Mean flow, measured at the USGS gage at U.S. Rt. 52 in Shorewood (station 05540500) between 2002 and 2012 was 527.5 cubic feet per second (cfs).

The entire DuPage River basin drains a total of 353 square miles, the largest tributary of the DesPlaines River. The upper watershed (*i.e.*, the East and West Branches) includes 185 square miles of highly urbanized land, which exerts a great influence on water quality conditions downstream. The Lower DuPage River watershed includes an additional 168 square miles of mostly urban land and some rural/agricultural land situated in northwestern Will County and small parts of DuPage and Grundy counties (Table 3; Figure 5). The lower mainstem has two major tributaries (Spring Brook Creek and Lily Cache) five minor tributaries (Rock Run, Norman Drain, Spring Creek, Wolf Creek plus the I&M Canal) as well as several small un-named tributaries. The lower watershed includes all or part of 13 communities; five publicly owned treatment plants discharge treated effluent to the Lower DuPage mainstem between RMs 26.65 and 2.65 while the Crest Hill West WWTP discharges to the headwaters of Rock Run Creek at RM 7.65.

*Table 3. Land uses types by area and percent for the Lower 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	Lower DuPage River Watershed	
	Area (acres)	Area (percent)
Residential	34,951	32.44
Commercial and Services	4,338	4.03
Institutional	2,916	2.71
Industrial, Warehousing, and Wholesale Trade	5,596	5.19
Transportation, Communication and Utilities	2,848	2.64
<b>Sub Total non-Residential Urban</b>	<b>50,649</b>	<b>47.01</b>
Agricultural Land	28,786	26.72
Open Space	8,771	8.14
Vacant, Wetlands, or Under Construction	15,871	14.73
Water	3,652	3.39
<b>Totals</b>	<b>107,729</b>	<b>99.99</b>

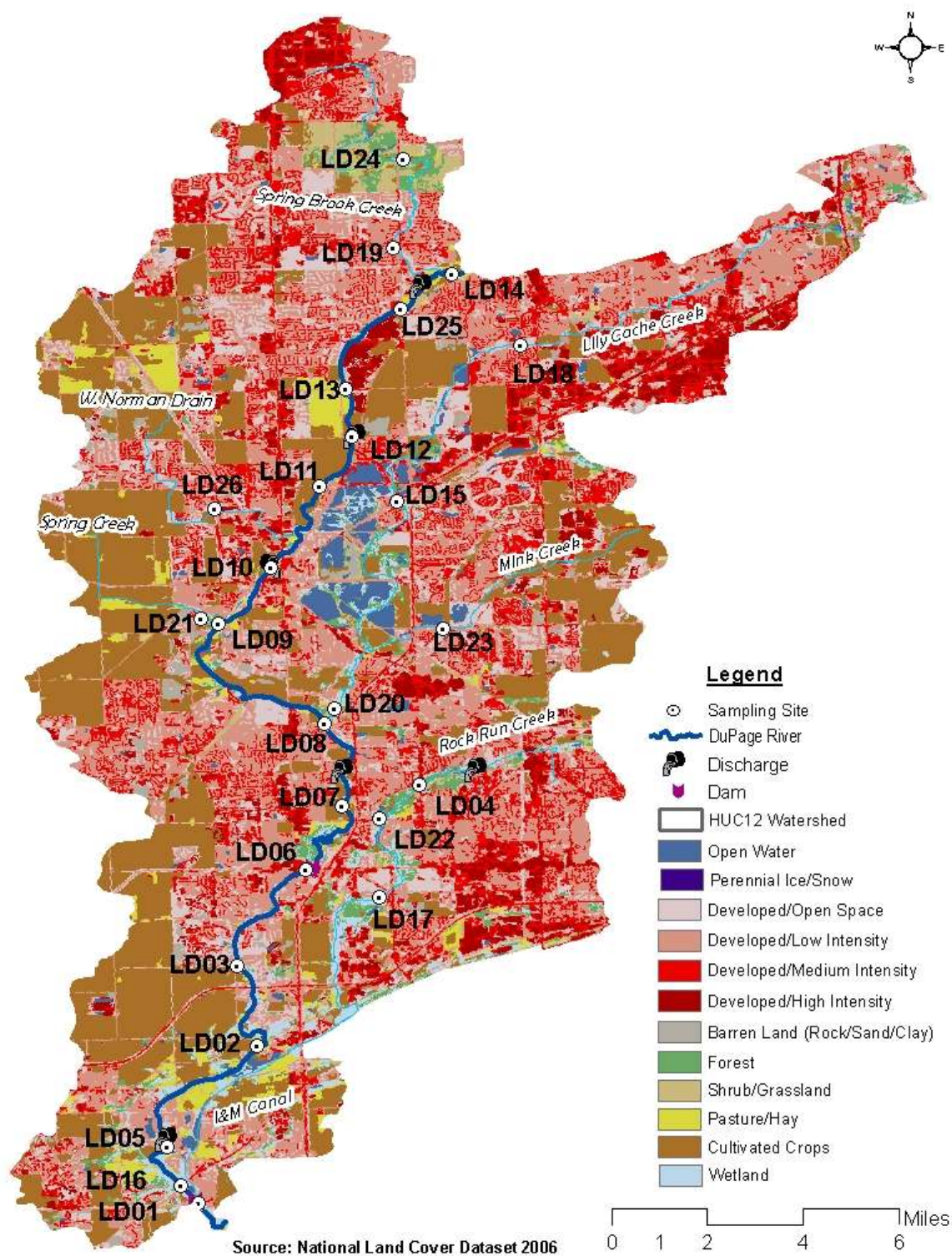


Figure 5. Land use types in the Lower DuPage River watershed based on 2006 National Land Cover Dataset (NLCD). <http://www.mrlc.gov/nlcd2006.php>

### **Lower DuPage River Dams**

A summary of the dams on the DuPage River in 2011 appears in Table 4.

*Table 4. Known dams or bed control structures on the DuPage River.*

<b>Dam Name</b>	<b>Affected Waterway</b>	<b>River Mile</b>	<b>Impoundment Size (acres)</b>	<b>Impedes Fish Passage</b>
a) Hammel Woods Dam	DuPage River	10.6	5.2	Y
b) Channahon Dam	DuPage River	1.1	75	Y

Detailed descriptions of each dam follows:

**Hammel Woods Dam:** The Hammel Woods Dam is owned by the Forest Preserve District of Will County (FPDDC) and located within their Hammel Woods Forest Preserve in Shorewood, IL. Spanning the river at River Mile 10.6, the dam is about 300 feet upstream from the IL Route 52 Bridge over the river.

The dam is a run of the river structure constructed of quarried limestone with a concrete foundation. Original construction plans of the dam are not available. The dam is a straight, broad crest weir 110 feet across with a total height of about 4 feet and a hydraulic height of 2.3 feet (from spillway crest to tailwater elevation under average flow conditions).

The impoundment created by the Hammel Woods Dam is approximately 1600 feet in length. The surface area of the impoundment is about 5.2 acres. The FPDWC owns the property on either side of the dam as well as the riverbanks within the impoundment. (Adapted from: *Assessments Of The Impacts Of Dams On The Dupage River; Section 4 – Hammel Woods Dam, 2003*)

**Channahon Dam:** The Channahon Dam is the first dam on the DuPage River, located 1.1 miles from the DuPage confluence with the Des Plaines River in the I&M Canal State Park in Channahon. The 9-foot high dam has effectively disconnected the DuPage River from the Des Plaines River, from a biological standpoint. The impoundment behind this dam extends upstream 4.1 miles and covers an area of 75 acres. The environment within the impoundment is characterized as a deep and slow-moving channel with little or no flow diversity and silty deposits over a rocky substrate. These conditions have resulted in a poor macroinvertebrate population and relatively low fish diversity. (Adapted from: *Assessments Of The Impacts Of Dams On The Dupage River, 2003*)

In 1996, the dam was breached under extremely high flood conditions but the damaged structure was fully rebuilt and the impoundment was restored by 1998. MBI sampling in 2007 and 2012 suggests limited migration (or persistence) of new fish populations upstream from the dam during that brief period of unrestricted flow (see Table 11).

### Point Source Discharges

Eighteen permitted point sources were identified within the Lower DuPage River watershed, but only six have significant loadings and pollutants of concern. Design flows and locations of each discharger are listed in Table 5 and design flows and estimated annual loadings of total nitrogen and phosphorus are illustrated in Figure 6. The Naperville-Springbrook WRC is the largest contributor to flow and loadings and is located about a mile downstream from the confluence with the East and West Branches of the DuPage River.

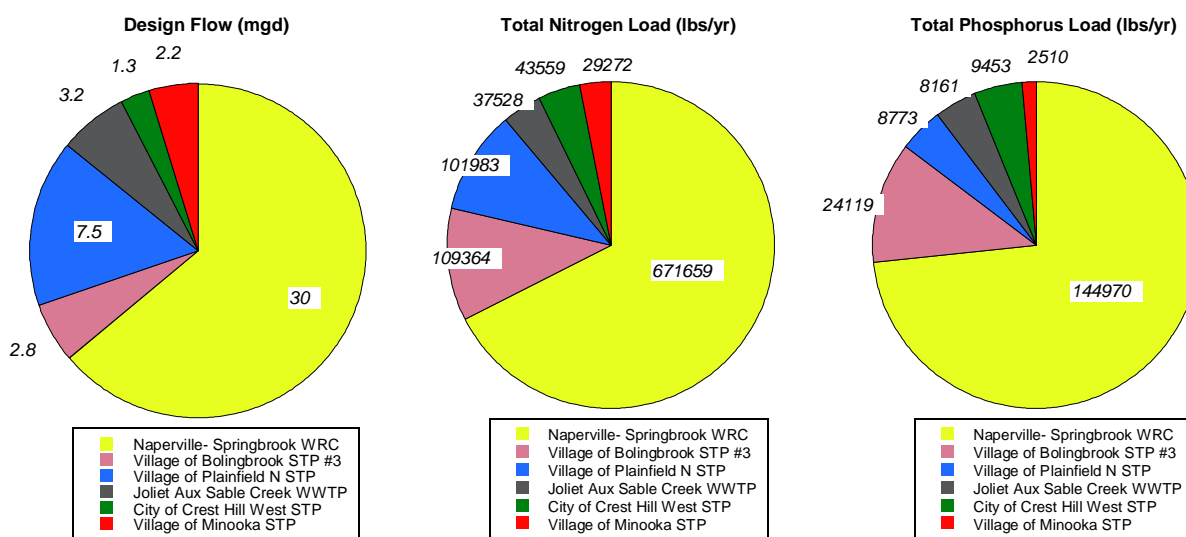


Figure 6. Relative contribution to point source flow, and nitrogen and phosphorus loadings in the Lower DuPage River by six WWTPs. Data from The Conservation Foundation (2011).

Point source discharges in the East and West Branches of the DuPage River make flow in these rivers effluent dominated and, as a product of upstream flow, the Lower DuPage River is similarly effluent dominated. For example, during September 2007, effluent composed approximately 76 percent of the flow in the East Branch of the DuPage River. Contributions from effluent diminish, however, with distance downstream with later dischargers a smaller percentage of stream flow compared to the major contributors in the East and West Branch. Based on wasteload allocations conducted in the Lower DuPage River Watershed Plan (The Conservation Foundation 2011) point sources are the major contributors to loadings of nitrogen and phosphorus. Unlike nonpoint sources, that typically discharge during high flow events, point source loading persists at all flows and can have significant influences on aquatic life, particularly during periods of low flow.

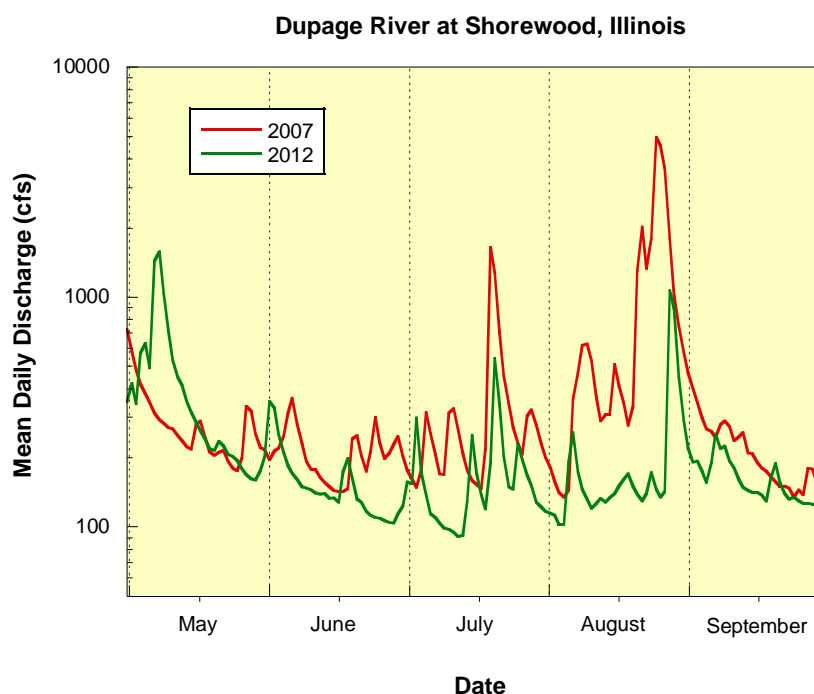


**Table 5. Municipal wastewater treatment plants located in the Lower DuPage River watershed.**  
*ADF = average design flow in million gallons per day (mgd); MDF = maximum design flow (mgd).*

NPDES	Name	ADF (mgd)	MDF (mgd)	Receiving Stream/ (~RM)	Latitude	Longitude
IL0034061	Naperville-Spring Brook WRC	30	55.13	L. DuPage R. (26.65)	41.7000	-88.163333
IL0069744	Bolingbrook STP #3	2.8	7.0	L. DuPage R. (22.85)	41.566176	-88.189756
IL0074373	Plainfield N STP	7.5	15.0	L. DuPage R. (19.40)	41.616667	-88.208333
IL0076414	Joliet Aux Sable Cr. WWTP	3.2	7.8	L. DuPage R. (13.10)	41.546944	-88.183333
IL0021121	City of Crest Hill West STP	1.3	3.0	Rock Run Cr. (7.65)	41.551667	-88.141667
IL0055913	Village of Minooka STP	2.2	5.8	L. DuPage R. (2.65)	41.438333	-88.236944

### **Lower DuPage River flow Conditions**

Measured at the USGS DuPage River gage in Shorewood, mainstem peak and daily average flows were substantially higher on 2007 fish sampling survey than in 2012. With the exception of the month of May, average monthly flows were 2.5 times higher in June through September 2007 than in 2012, particularly in August and between mid-June and mid-July (Figure 7).



**Figure 7. Flow hydrographs for the Lower DuPage River near Shorewood, IL (USGS station # 05540500) from May through September, 2007 and 2012.**

## RESULTS

### ***Lower DuPage River Watershed - Chemical Water Quality***

As noted in the point source discharge section (see page 19), stream flow in the DuPage River is a product of the effluent dominated flows of the East and West Branches during the summer months. As such, its water quality is highly influenced by the concentrations and composition of chemical constituents in the effluent as well as runoff from the urban and developed land cover in the watershed. Water quality samples collected in 2011 during the late summer through early fall low-flow period suggest that the quality of treated effluent, with respect to regulated parameters (i.e., cBOD5, TSS, NH3), was generally good. Effluents did not result directly in exceedences of water quality standards for these parameters.

Exceedences of chemical water quality criteria are listed in Table 6. Mainstem continuous monitor data were limited to two sensors in the upper mainstem that bracket the Naperville WWTP. Dissolved oxygen measurements listed in Table 6 are simply values of concern because they are below 5 mg/l; the frequency of sampling was not sufficient to declare them actual violations. In the DuPage mainstem, the only issues of concern related to water quality criteria were low dissolved oxygen values and slightly elevated pH values, suggesting nutrient enrichment and algal stimulation effects from high nitrate and total phosphorus concentrations. The elevated nutrients largely originated from point sources in the East and West Branches.

Mean concentrations of ammonia NH<sub>3</sub>-N in the mainstem were consistently below the 0.15 mg/l level threshold associated with degraded biological assemblages found in the IPS Study (Figure 8, bottom). In fact, most median values were below the 0.05 mg/l detection limit. Elevated ammonia concentrations are symptomatic of poorly or untreated sewage, and these very low concentrations are indicative of efficient WWTP performance. Ammonia concentrations in the East and West Branches did exceed the 0.15 mg/l threshold during 2011 and 2012, but diminished in the Lower DuPage. Means in the East and West Branches (Figure 8, top) were influenced by occasional high values that were likely diluted by the other Branch downstream from their confluence, resulting in lower mean values in the Lower DuPage mainstem. Additional mainstem point source discharges did not increase ammonia levels.

Nitrate values were highly elevated throughout the mainstem length but were highest at its source, immediately downstream from the East and West Branches (Figure 9, top). Mainstem concentrations declined by about half between its source (avg. 12.5 mg/l at RM 27.3) and the mouth (avg. 6.0 mg/l at RM 0.8) but remained consistently elevated (Figure 9, bottom). A series of 5 municipal WWTPs between RMs 26.65 and 2.65 may help sustain the high nitrate levels but downstream concentrations rarely increased. Results reflect the highly enriched character of the Lower DuPage, which is heavily influenced by its effluent, dominated Branches. The sharp increase in East Branch nitrates between 2007 and 2011 was considered a byproduct of improved nitrification at many of the large WWTPs in the basin.



*Table 6. Chemical parameter concentrations (mg/l) in violation<sup>a</sup> of Illinois water quality standards in chemical grab samples from the Lower DuPage River watershed, 2012.*

Site ID	Basin	Stream	River Mile	Exceedence or Parameter of Interest
<b>DuPage River</b>				
LD14	95	666	27.40	D.O. (4.20)
LD25	95	666	26.10	
LD13	95	666	23.90	D.O. (4.68), (4.62)
LD12	95	666	22.80	D.O. (3.88)
LD11	95	666	21.60	D.O. (3.52)
LD10	95	666	19.20	
LD09	95	666	17.60	
LD08	95	666	14.30	D.O. (4.20)
LD07	95	666	12.00	pH (9.08)
LD06	95	666	10.50	
LD03	95	666	7.90	pH (9.02)
LD02	95	666	5.60	pH (9.02), (9.04), (9.14)
LD05	95	666	2.60	D.O. (4.95)
LD16	95	666	1.40	D.O. (4.12); pH (9.04)
LD01	95	666	0.90	pH (9.18)
<b>West Norman Drain</b>				
LD26	95	661	2.20	
<b>Mink Creek</b>				
LD23	95	662	1.80	
<b>Spring Creek</b>				
LD21	95	663	0.50	
<b>Spring Brook Creek</b>				
LD24	95	664	4.50	Diss. Solids (2491.25)
LD19	95	664	1.20	D.O. (4.80), (4.16)
<b>Rock Run Creek</b>				
LD04	95	665	6.60	D.O. (2.72), (2.50), (3.40), (3.05); Diss. Solids (3663.43); NH3 (5.46), (4.98), (4.56), (5.38), (2.34), (3.02)
LD22	95	665	5.40	Diss. Solids (2978.00); NH3 (6.37)
LD17	95	665	3.50	D.O. (3.29), (3.66), (2.66); Diss. Solids (2412.20); NH3 (3.69), (3.22), (4.76), (4.96)
<b>Lily Cache Creek</b>				
LD18	95	668	10.90	Temp C (34.1); pH (9.04)
LD15	95	668	6.30	
LD20	95	668	0.05	

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

On the nitrate plot, the orange dashed line represents the upper range of the US EPA Ecoregion VI target concentration; mean values are all above this value in the DuPage River. About 64% of the load of nitrate in the Lower DuPage originates from point source discharges (Conservation Foundation 2011).

Like nitrates, total phosphorus concentrations in the Lower DuPage River were highly elevated throughout its length (Figure 10). Highest concentrations were found immediately downstream from the East and West Branch confluence (1.7 at RM 27.4) and immediately downstream from the Naperville WWTP (1.9 at RM 26.6). Concentrations gradually declined from upstream to downstream but were still highly elevated and above 1.0 at the mouth (1.04 mg/l). Like nitrates, elevated phosphorus concentrations were sustained downstream from mainstem WWTPs but experienced minimal increase (avg. + 0.084 mg/l). Illinois targets for total phosphorus (0.763 mg/L) represents the upper range of the US EPA Ecoregion VI target concentration for total phosphorus. About 71% of the load of total phosphorus in the Lower DuPage River watershed originates from point source discharges (Conservation Foundation 2011).

TKN is a measure of organic nitrogen and ammonia in a waterbody and typically provides a strong signal of organic enrichment. There are no criteria for TKN in Illinois, but elevated levels of TKN above background levels can be used to infer significant enrichment. A TKN background level based on aggregated ecoregions (Nutrient Ecoregion VI) for the Corn Belt is estimated at 0.65 mg/l. Values in the East and West Branch exceed this concentrations although most site on the DuPage River mainstem are near this ecoregion level of 0.65 mg/l (Figure 11).

BOD levels, a measure of biological oxygen demand follows a similar pattern to TKN with higher levels in the East and West Branch and lower concentrations, including fewer high maximum values in the DuPage River mainstem (Figure 12). A similar pattern with total suspended solids (higher in the East Branch and West Branch compared to Lower DuPage) occurred as well (Figure 13).

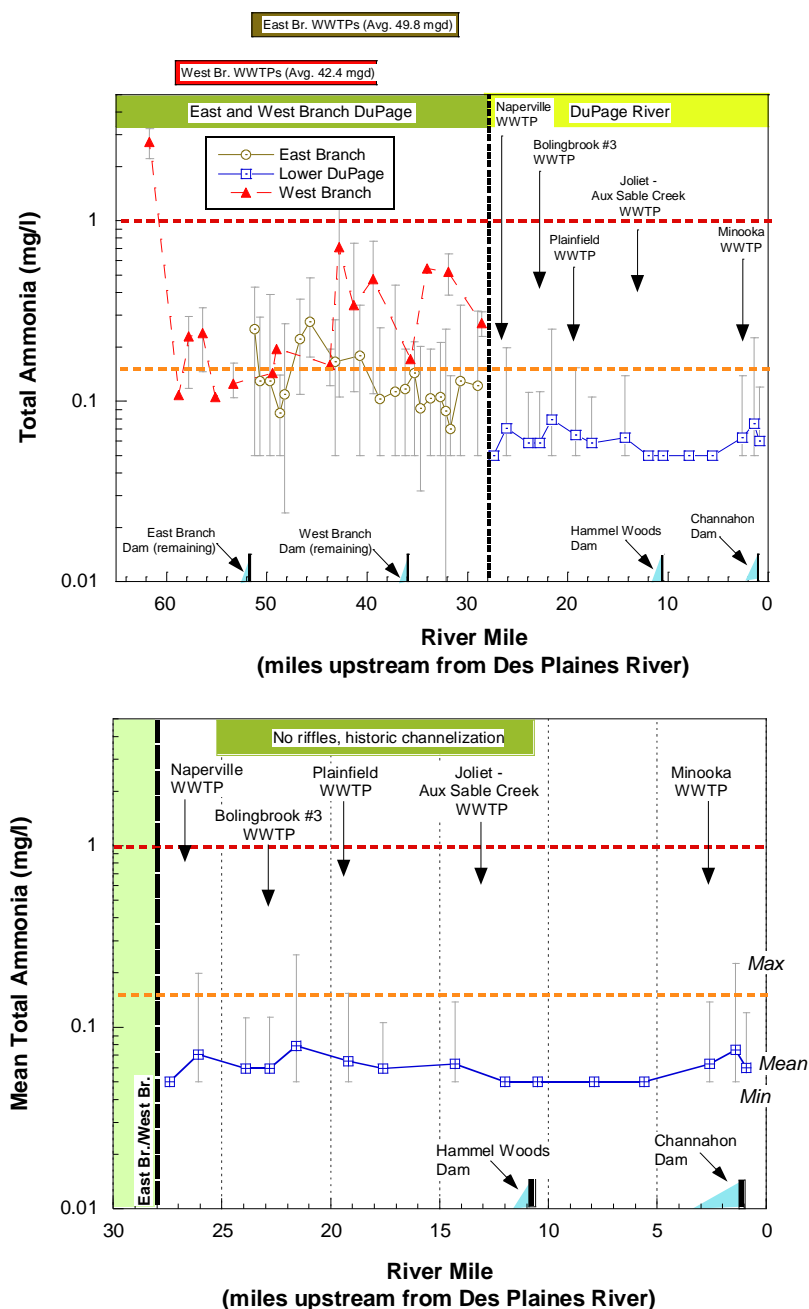


Figure 8. Mean concentrations of ammonia nitrogen in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The upper dashed red line represents a threshold concentration beyond which toxicity is likely while the lower dashed orange line (0.15 mg/l) correlated with impaired biota in the IPS study.

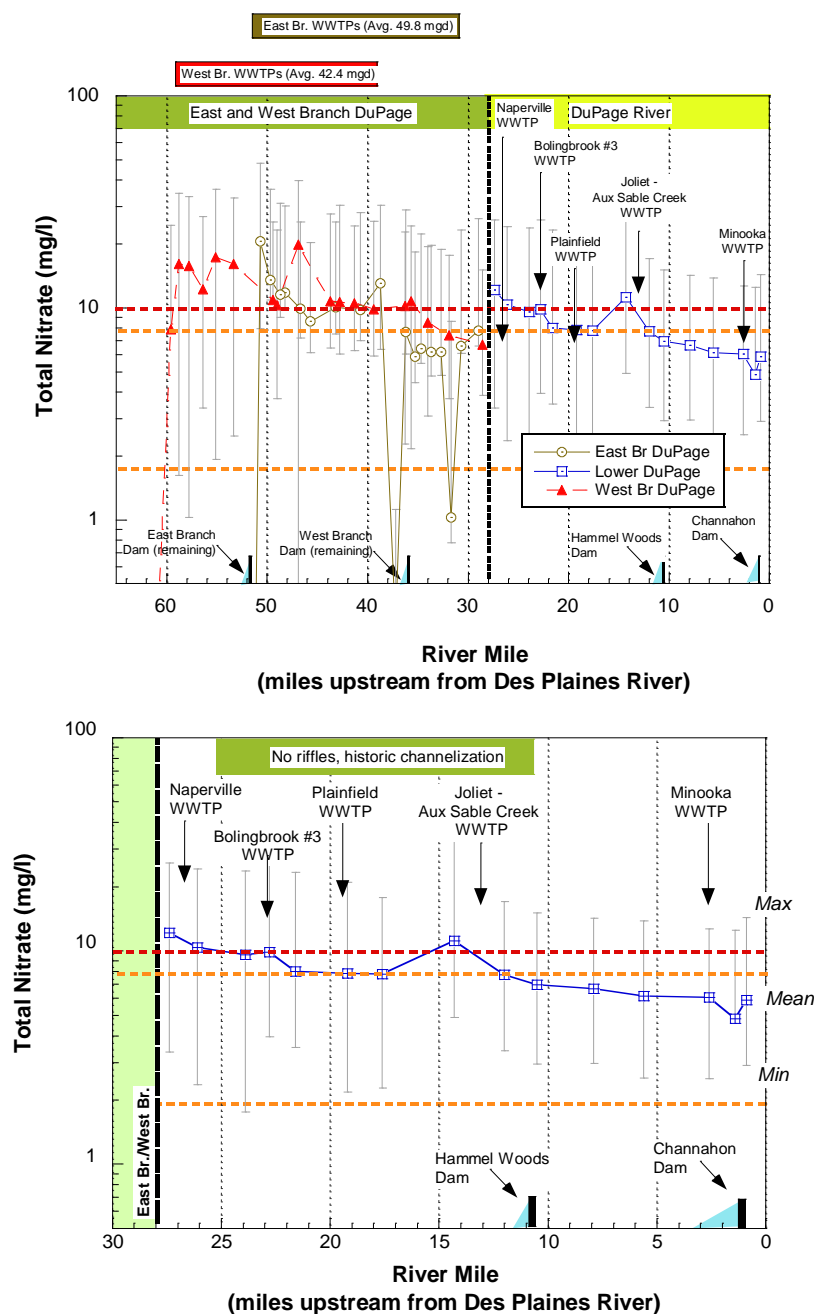


Figure 9. Mean concentrations of total nitrate in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. 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).

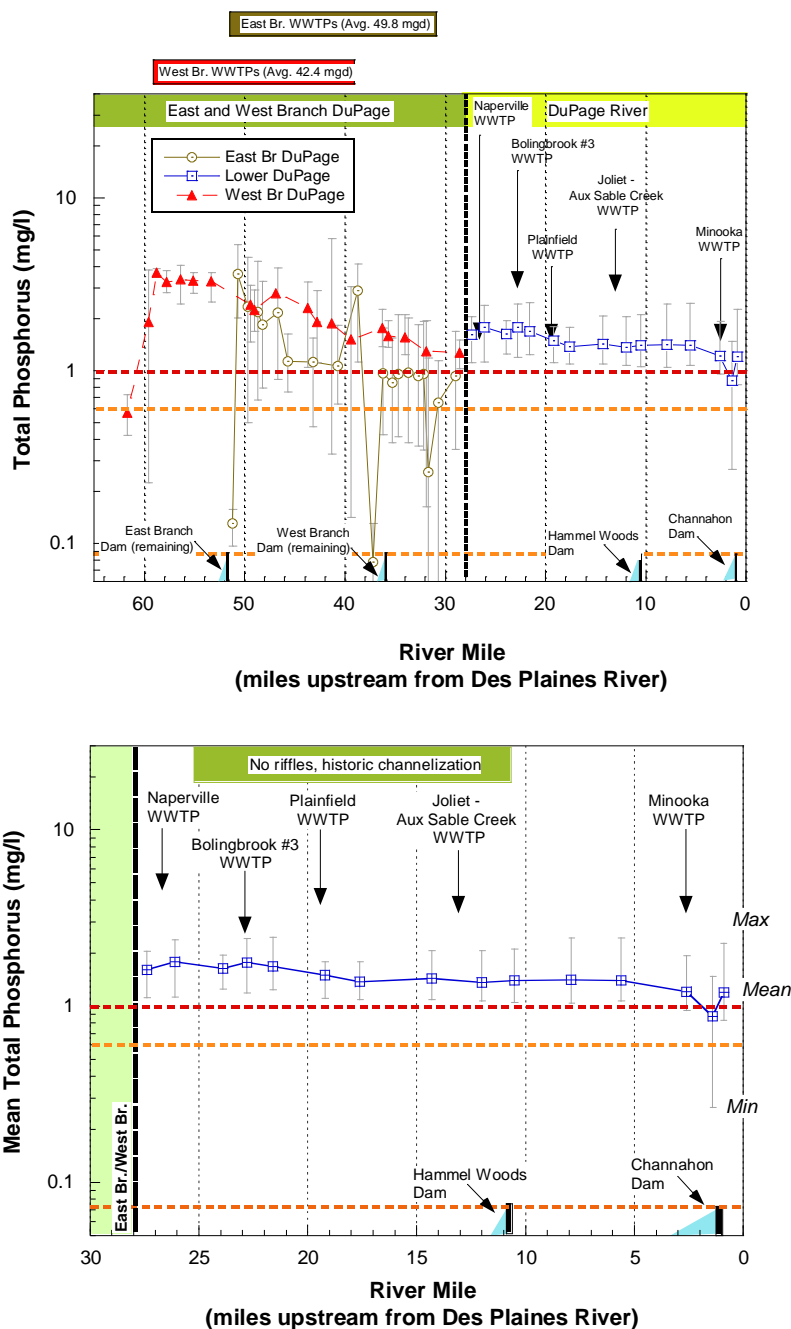


Figure 10. Mean concentration of total phosphorus in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values, and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The orange dashed lines represent target total phosphorus concentrations for USEPA Ecoregion 54 (0.072 mg/l) and the middle to high range of US EPA nutrient Ecoregion VI (0.61 mg/l). The red dashed line (1.0 mg/l) represents a threshold concentration beyond which toxicity is likely.

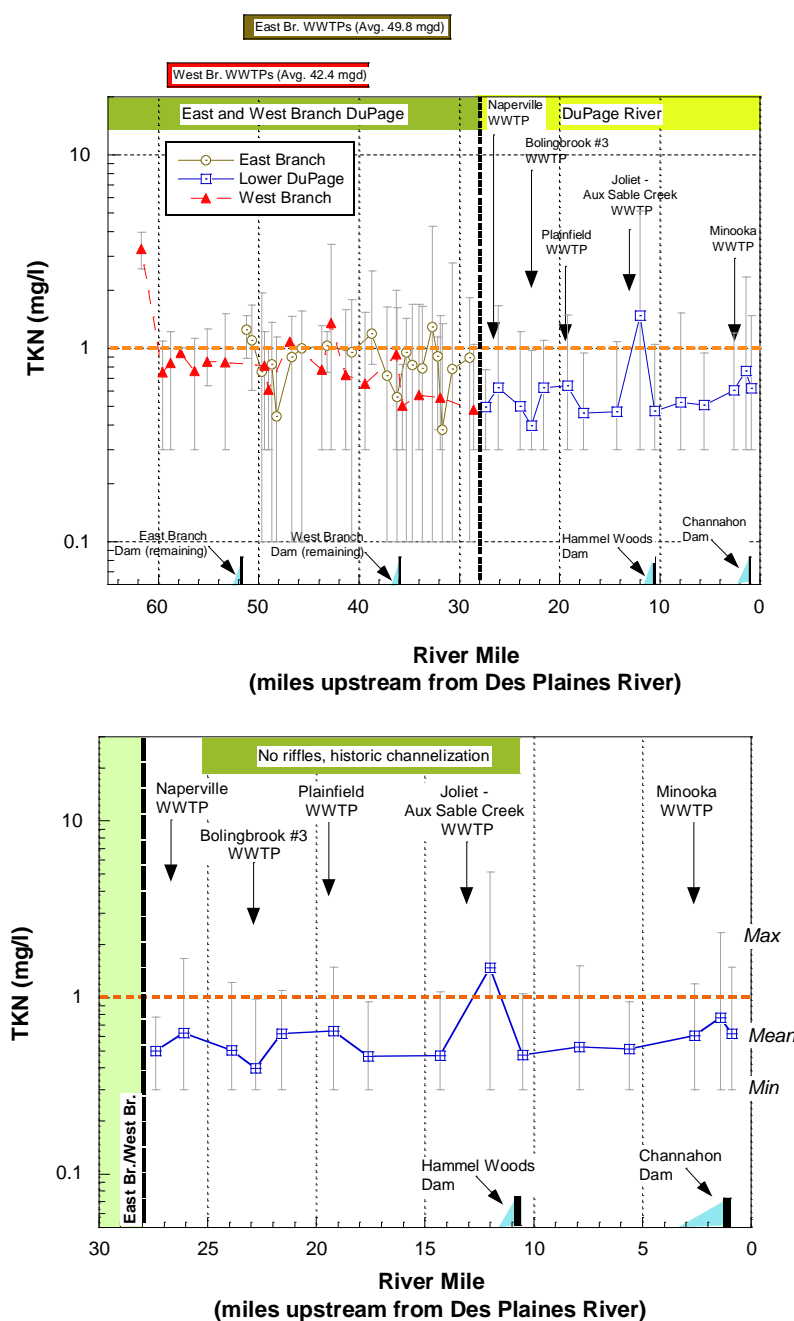


Figure 11. Mean concentration of total Kjeldahl nitrogen in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The dashed line in each plot represents the IPS TKN aquatic life target level.

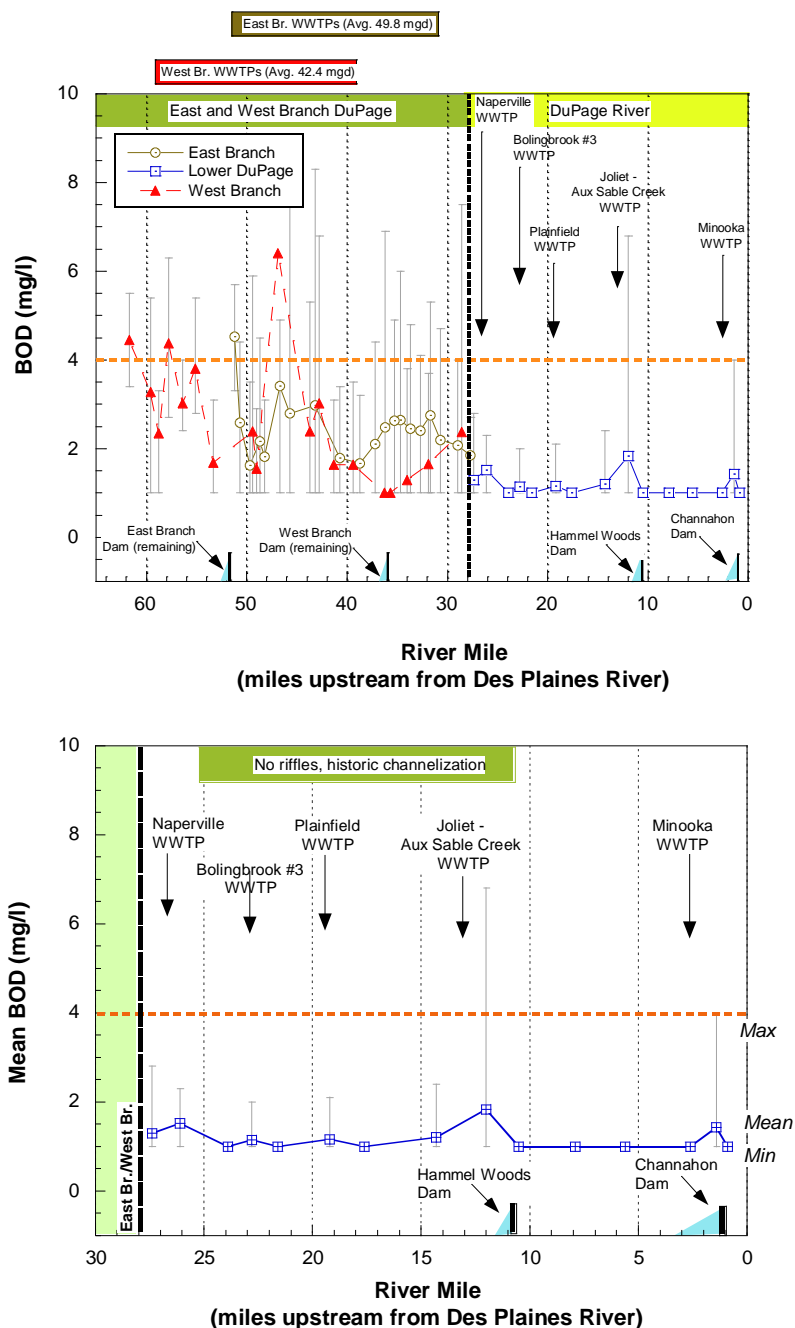


Figure 12. Mean concentration of 5-day biological oxygen demand (BOD) in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The dashed line in each plot (4 mg/l) represents the upper limit of concentrations typical of unpolluted waters in the Midwest (McNeeley et al. 1979).

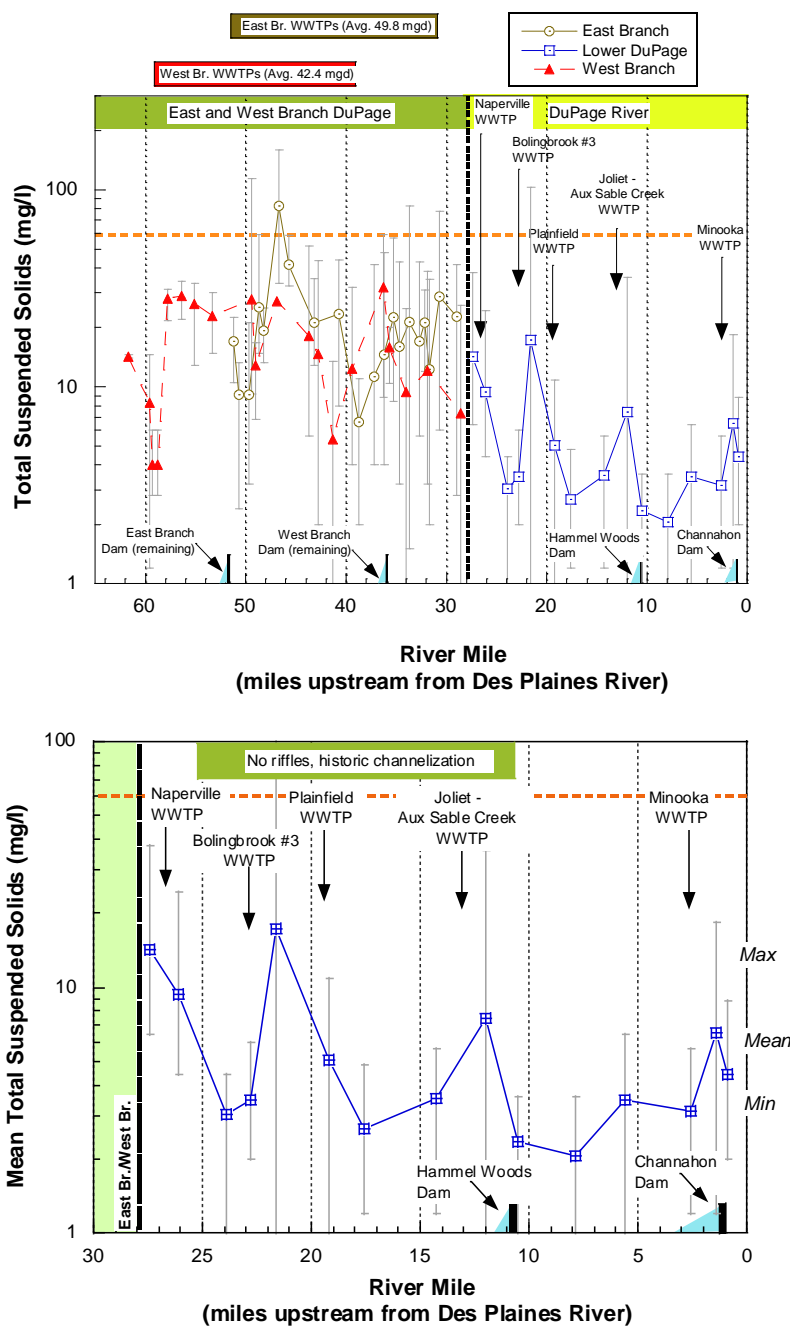


Figure 13. Concentrations of total suspended solids in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The dashed line in each plot represents the upper limit of concentrations typical of unpolluted waters in the Midwest.



***Nutrient Conditions in the Lower DuPage River Watershed***

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

In Illinois, as in other states, efforts are underway to derive nutrient water quality criteria for aquatic life. The U.S. EPA Inspector General (IG) concluded that the U.S. EPA, with regard to nutrient criteria, failed to adequately monitor and measure progress and “would consider promulgating numeric nutrient standards for a State if it had not substantially completed adopting numeric nutrient criteria in accordance with its plan by the end of 2004. (US EPA 2009).” The IG concluded that US EPA failed to sanction states who had not made progress and provided Illinois as an example because of Illinois EPA’s “apparent belief that it did not need numeric nutrient criteria” (USEPA 2009). In this section of the report, we present data from sites exceeding nutrient thresholds that represent regional reference conditions and are associated with excessive export of nutrients.

Table 7 lists four nutrient enrichment parameters in relation to various benchmarks that have been established to associate nutrients concentrations with impaired aquatic life. For aquatic life in Illinois, Illinois EPA derived targets for nitrates and other parameters without existing numeric criteria by using . . . “a statistically derived numeric value or a field observation may be used to identify potential causes of aquatic life use impairment”. For example, for total phosphorus and suspended solids, a numeric threshold based on an 85<sup>th</sup> percentile value is used as a cause guideline; this threshold value is derived from all available data from water years 1978 through 1996, at Ambient Water Quality Monitoring Network sites.”

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

*Table 7. Median concentrations of key nutrient parameters including total ammonia, nitrate, TKN, and phosphorus in the Lower DuPage River watershed in 2012. Shading represents exceedences of various criteria or thresholds for nutrient parameters (see footnotes).*

Site ID	River Mile	Drainage Area (sq. mi)	Ammonia <sup>1</sup> (mg/l)	Nitrate <sup>2,3,4</sup> (mg/l)	TKN <sup>5</sup> (mg/l)	Phosphorus <sup>6,7,8</sup> (mg/l)
<b>DuPage River (95-666)</b>						
LD14	27.40	212.0	0.050	12.500	0.470	1.710
LD25	26.10	219.0	0.050	10.000	0.300	1.920
LD13	23.90	230.0	0.050	9.330	0.300	1.570
LD12	22.80	235.0	0.050	9.510	0.300	1.780
LD11	21.60	240.0	0.050	6.840	0.700	1.570
LD10	19.20	253.0	0.050	6.980	0.620	1.570
LD09	17.60	260.0	0.050	8.210	0.300	1.400
LD08	14.30	318.0	0.050	8.380	0.300	1.250
LD07	12.00	325.0	0.050	8.040	1.030	1.330
LD06	10.50	332.0	0.050	7.330	0.300	1.280
LD03	7.90	340.0	0.050	7.160	0.300	1.300
LD02	5.60	345.0	0.050	6.430	0.300	1.230
LD05	2.60	357.0	0.050	6.440	0.300	1.150
LD16	1.40	368.0	0.050	6.520	0.300	0.920
LD01	0.90	376.2	0.050	6.000	0.300	1.040
<b>West Norman Drain (95-661)</b>						
LD26	2.20	6.2	0.100	0.470	0.860	0.110
<b>Mink Creek (95-662)</b>						
LD23	1.80	8.8	0.050	0.080	0.300	0.040
<b>Spring Creek (95-663)</b>						
LD21	0.50	5.3	0.050	0.120	0.470	0.170
<b>Spring Brook Creek (95-664)</b>						
LD24	4.50	8.9	0.050	0.060	0.300	0.110
LD19	1.20	12.3	0.450	0.300	0.960	0.240
<b>Rock Run Creek (95-665)</b>						
LD04	6.60	4.9	4.770	0.030	4.750	0.870
LD22	5.40	5.5	3.690	0.030	4.470	1.230
LD17	3.50	10.6	0.260	0.050	1.270	1.500
<b>Lily Cache Creek (95-668)</b>						
LD18	10.90	11.1	0.050	0.030	1.260	0.160
LD15	6.30	21.4	0.050	0.060	0.300	0.130
LD20	0.05	46.0	0.050	4.420	0.300	0.960
<sup>1</sup> MBI IPS ammonia aquatic life target level (0.15 mg/l) <sup>2</sup> US EPA Ecoregion 54 reference target for nitrate (1.798 mg/l) <sup>3</sup> 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) <sup>4</sup> Illinois water quality criteria for nitrate (10.0 mg/l)						

<sup>5</sup>IPS TKN aquatic life target level (1.0 mg/l)

<sup>6</sup>US EPA Ecoregion 54 reference target for total phosphorus (0.072 mg/l)

<sup>7</sup>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)

<sup>8</sup>Suggested protective effluent limit for total phosphorus (1.0 mg/l)

The enriched condition of the DuPage River is illustrated in Table 7, Figure 9, and Figure 10 as phosphorus and nitrate levels were highly elevated throughout its length. Concentrations were particularly high near the mainstem source, immediately downstream from the East and West Branches (RM27.3) and immediately downstream from the Naperville WWTP (RM 26.6). Nitrates exceeded the 10 mg/l criterion in the upper reach before gradually declining to about 6 mg/l near the mouth. Phosphorus also experienced gradual, upstream to downstream declines but remained almost entirely above 1.0 mg/l from headwaters to mouth. Additional contributions from WWTPs along the DuPage mainstem may play a part in maintaining the enriched conditions but most parameters experienced minimal change downstream from the discharges. Median ammonia concentrations were below detection throughout the DuPage River, an indication of efficient wastewater treatment, although some individual samples were occasionally higher (see Figure 8).

### ***Lower DuPage River Watershed Tributaries***

Phosphorus was consistently elevated in almost all Lower DuPage watershed tributaries. Highest concentrations were found in the three Rock Run Creek sites located downstream from the Crest Hill WWTP (mean = 1.2 mg/l); in contrast, the eight remaining tributary sites averaged 0.24 mg/l. Mink Creek RM 1.8 was the only tributary site that did not have elevated nutrient concentrations. While Mink Creek still drains an urban or suburban landscape, upstream development in the watershed tended to be set back from the floodplain as a golf course and undeveloped sections of fields buffered much of the channel.

Nitrates were not rated as elevated in any of the Lower DuPage River tributaries. Rock Run Creek was unique among tributary sites due to high ammonia, TKN, and phosphorus concentrations and its effluent-dominated water quality characteristics.

### ***Sources of Nutrients***

Figure 14 illustrates concentrations of nitrate and total phosphorus in mainstem of the DuPage River vs. the tributaries in the Lower DuPage during 2012. Both nitrate and total phosphorus were substantially higher in the mainstem vs. the tributaries, a consequence of the point source origin of the mainstem nutrients. This is also supported by the effluent dominance of the flows in the East and West Branches of the DuPage Rivers, which can approach 98% during low flow periods (MBI 2013) and which makes up the majority of flow in the DuPage River. This was supported by the nonpoint source modeling study in the Lower DuPage River watershed plan (Conservation Foundation 2011). Tributary enrichment, particularly for phosphorus is still higher than “reference” levels, but much lower than mainstem concentrations (Table 7).

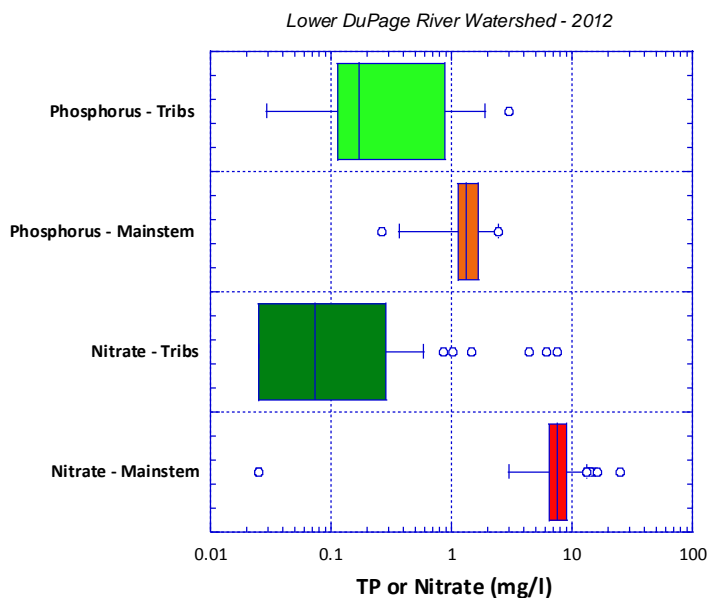
### ***Dissolved Materials in Urban Runoff***

Urban runoff, with its typically high concentration of dissolved constituents, can become limiting when concentrations reach toxic thresholds. Of particular concern in Northern climates in urban areas with high road density is the concentration of chlorides from nonpoint sources such as of road salt application and from point sources with loadings from water softener salts. Table 8 displays a series of dissolved materials, nutrients and metals often associated with urban runoff and highlights concentrations in excess of applicable reference targets.

Work in Illinois and elsewhere has identified the increasing salinization of surface and groundwater from

increase loadings of chlorides over time. The Illinois EPA conducted a total chloride TMDL in 2004 (CH2MHill 2004) and identified road salt and WWTP effluents as two key sources in this watershed. Kelly et al. (2012) has demonstrated the recent increase in chloride concentrations in the Chicago area correlated with a pattern of increasing road salt applications, particularly over the past 20 years. Kelly et al. (2012) also identified a strong, steady increasing trend in chlorides in the Illinois River at Peoria where the median increased from about 20 mg/l in 1947 to nearly 100 mg/l in 2004 with high values in the 1940s of less than 40 and spikes in 2003 of greater than 300. Even higher values occur in small urban streams well above the 500 mg/l water quality criterion as evidenced by recent data from the E. and W. Branch DuPage watersheds.

Rather than a simple runoff and export mode of effect, chlorides and similar salt constituents accumulate in groundwater (Kelly 2008), soils, and land surfaces adjacent to the streams. Seasonal sampling in studies have shown that high summer concentrations are typically well correlated with acute concentrations during late winter and spring time periods (Kaushal et al. 2005) shows a group of parameters associated with urban runoff. The highlighted variables are values that exceed the IPS derived thresholds (total chloride, TKN) or statewide reference levels from similar Ohio waters (conductivity, TDS, TSS, metals; Ohio EPA 1999). Metals (primarily Zn) were slightly elevated at sites close to the confluence of the East and West Branch and at one site on Lily Cache Creek). Mainstem metals were generally lower at sites further downstream. For chloride, IPS threshold values for fish and macroinvertebrates (112 and 141 mg/l, respectively) are lower than the Illinois aquatic life water quality criterion (500 mg/l). These IPS thresholds were regularly exceeded at sites in the Lower DuPage watershed and during earlier



*Figure 14. Box and whisker plot concentrations of total phosphorus (mg/l) and nitrate (mg/l) in the Dupage River vs. the tributaries of the Lower Dupage River watershed during 2012.*

surveys in the East Branch and West Branch DuPage River watersheds (MBI 2008, 2013). Levels of chloride and conductivity, a surrogate for chloride and other dissolved materials, were also elevated in the Lower DuPage and were higher in the East Branch in 2011 when compared to 2007 (MBI 2013).

Increased chloride and conductivity levels in the East Branch followed several years of high snowfall between 2007 and 2010 (Figure 15).

Within the Lower DuPage River watershed, nonpoint source modeling results demonstrated that 98.7% of chloride loading arises from non-point sources and a relatively minor percent of the loading originated from point sources (The Conservation

Foundation 2011). This analysis did not include distinguishing point vs. nonpoint origins in the upstream East and West Branches but, given the developed nature of these watersheds, it is likely still dominated by nonpoint sources at December-March high flows. At base flows the contribution of chloride and TDS from point sources may be relatively larger because of the effluent dominance of upstream point sources in these rivers (Figure 16; Figure 17); however, recent sampling of effluent chloride levels by DRSCW indicated a majority of effluents had a moderating effect on receiving stream concentrations. Regardless, the thresholds generated by the IPS reflect a correlation between summer chloride concentrations and biological effects and do not necessarily reflect the concentration where or when toxic effects occur. Actual concentrations that result in adverse effects on fish and invertebrates likely occur during peak runoff events in late winter and spring when values may approach or exceed the 230 mg/l US EPA recommended chronic criteria or the 500 mg/l Illinois criteria. The quantile regression thresholds are likely more meaningful in the tributaries where these concentrations are likely stronger signals for acute chloride levels. Work in New England (Kaushal et al. 2005) and Minnesota (Novotny et al. 2008) identify that chlorides are accumulating in watersheds and that there is a strong association between winter and summer concentrations. Novotny et al. (2008) identify that about 78% of road salt applied in a Minnesota watershed was accumulating in a given year and contributing to gradually increasing baseline (summer) chloride concentration. High levels of chloride during summer in the tributaries (all except Spring Creek) indicates late winter and early spring chloride levels are likely much higher during runoff events and likely contributes to the extent of impairment in headwater streams.

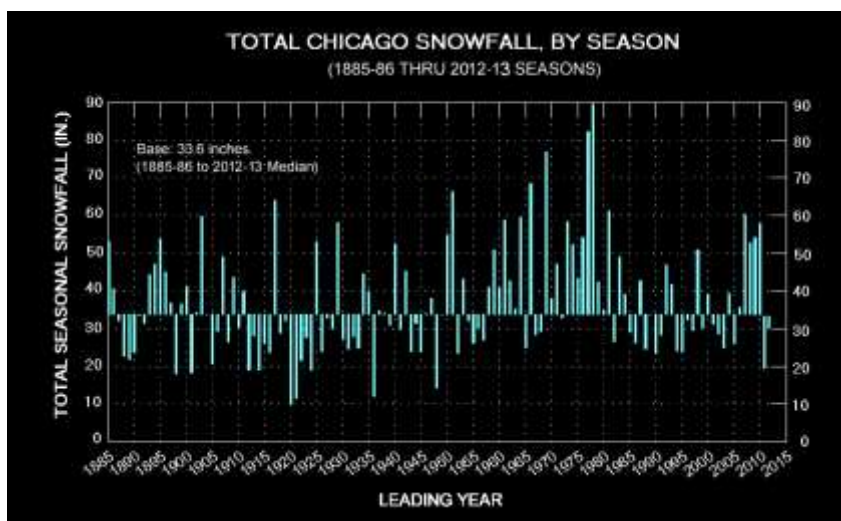


Figure 15. Total seasonal snowfall in inches in Chicago by year. Data from ClimateStations.com:

<http://www.climatestations.com/wp-content/uploads/2013/05/chisnow.gif>

Table 8. Urban parameter sampling results in the Lower DuPage River watershed, summer 2012. Values above applicable reference targets are highlighted in yellow.

Site ID	River Mile	Conductivity <sup>a</sup> (umhos/cm)		Total Dissolved Solids (mg/l)		Total Chloride (mg/l)		TKN (mg/l)		Total Suspended Solids		Metals above Targets <sup>b</sup> (Value)
		Median	Target	Median	Target	Median	Target	Median	Target	Median	Target	(Cu, Pb, Zn)
DuPage River (95-666)												
LD14	27.40	936	610	624	463	173	112	0.470	1	8.6	24.75	Zn (17.1)
LD25	26.10	948	610	582	463	162	112	0.300	1	6.8	24.75	Cu (6.07); Zn (19.6)
LD13	23.90	963	610	638	463	184	112	0.300	1	4	24.75	
LD12	22.80	962	610	622	463	183	112	0.300	1	2.8	24.75	
LD11	21.60	938	610	596	463	174	112	0.700	1	2.4	24.75	Zn (19.9)
LD10	19.20	923	610	560	463	166	112	0.620	1	5.2	24.75	Zn (16.8)
LD09	17.60	940	610	593	463	180	112	0.300	1	2.4	24.75	
LD08	14.30	889	726	566	505	169	112	0.300	1	3.2	39	
LD07	12.00	924	726	606	505	178	112	1.030	1	4	39	
LD06	10.50	868	726	584	505	178	112	0.300	1	2.4	39	
LD03	7.90	873	726	590	505	178	112	0.300	1	2	39	
LD02	5.60	865	726	602	505	178	112	0.300	1	2.8	39	
LD05	2.60	993	726	580	505	176	112	0.300	1	3.2	39	
LD16	1.40	971	726	608	505	176	112	0.300	1	4	39	
LD01	0.90	962	726	592	505	185	112	0.300	1	3.2	39	
West Norman Drain (95-661)												
LD26	2.20	850	600	578	443	129	112	0.860	1	8.4	16	
Mink Creek (95-662)												
LD23	1.80	822	600	588	443	143	112	0.300	1	4	16	
Spring Creek (95-663)												
LD21	0.50	558	600	331	443	57.9	112	0.470	1	2.4	16	
Spring Brook Creek (95-664)												
LD24	4.50	980	600	768	443	334	112	0.300	1	8.4	16	
LD19	1.20	928	600	637	443	238	112	0.960	1	4.8	16	
Rock Run Creek (95-665)												
LD04	6.60	1707	600	638	443	290	112	4.750	1	4.8	16	
LD22	5.40	1649	600	586	443	377	112	4.470	1	10	16	

Site ID	River Mile	Conductivity <sup>a</sup> (umhos/cm)		Total Dissolved Solids (mg/l)		Total Chloride (mg/l)		TKN (mg/l)		Total Suspended Solids		Metals above Targets <sup>b</sup> (Value) (Cu, Pb, Zn)
		Median	Target	Median	Target	Median	Target	Median	Target	Median	Target	
LD17	3.50	1339	600	656	443	197	112	1.270	1	18	16	
<b>Lily Cache Creek (95-668)</b>												
LD18	10.90	883	600	486	443	206	112	1.260	1	16.4	16	
LD15	6.30	Dry/NA	610	516	463	202	112	0.300	1	1.8	24.75	Zn (38.2)
LD20	0.05	784	610	560	463	170	112	0.300	1	3.6	24.75	

<sup>a</sup> Note: conductivity listings above are from field measurements during fish sampling.

<sup>b</sup> Note: target for Cu = 5 ug/l; Pb = 3 ug/l; Zn 15 ug/l.

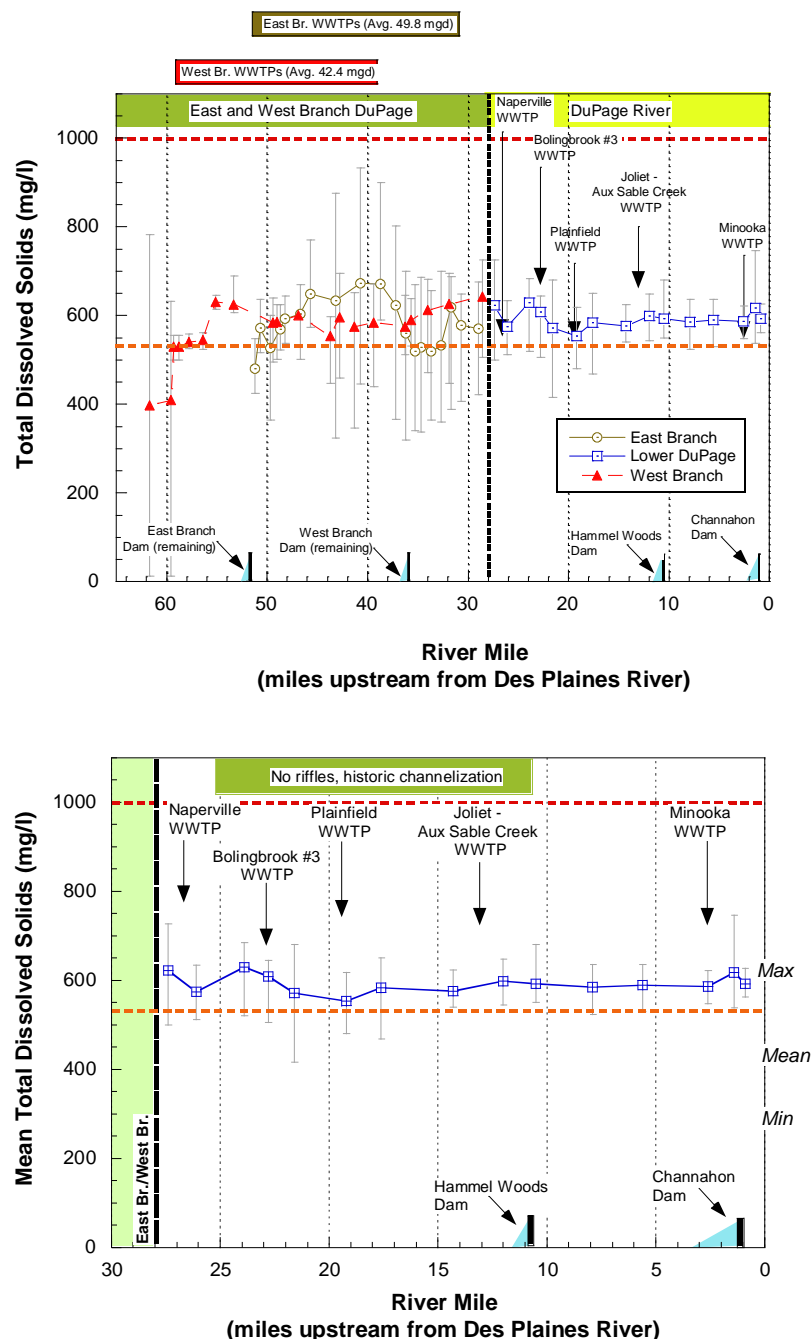


Figure 16. Mean concentrations of total dissolved solids in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. Orange dashed lines represent the 75<sup>th</sup> percentile TDS level for small rivers in Ohio and the red dashed line is the existing Illinois water quality criterion for TDS (1000 mg/l).



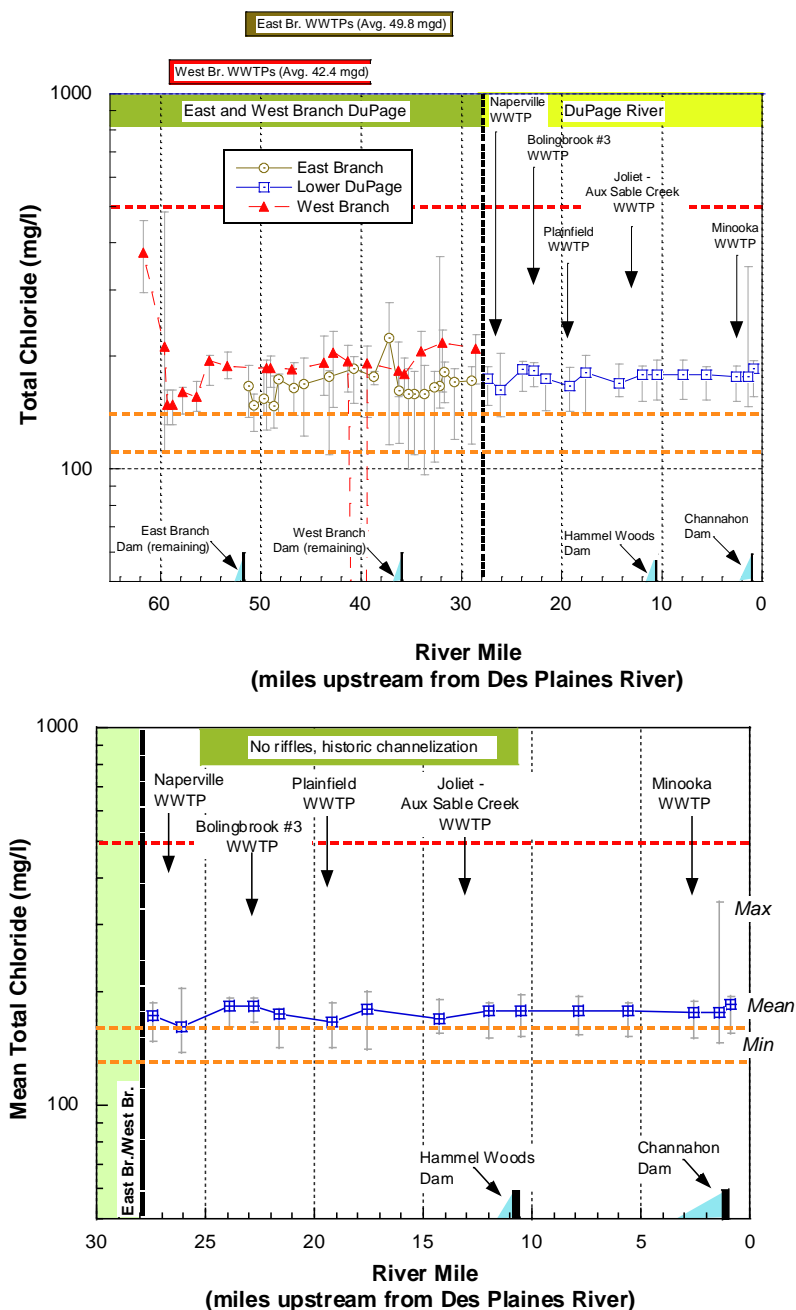


Figure 17. Mean concentrations of total chloride in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Grey error bars delineate maximum and minimum values and the approximate locations of municipal WWTP discharges are noted. Bars along the x-axis show locations of existing dams. The upper, red dashed line represents the existing Illinois water quality criteria (500 mg/l); the lower orange dashed lines show IPS quantile regression thresholds for the fBI (141 mg/l) and mBI (112 mg/l) .

***Lower DuPage River Watershed Sediment Chemistry Results***

Sediment samples were analyzed for heavy metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides at seven sites in the Lower DuPage River mainstem in October of 2012 and were evaluated against guidelines compiled by McDonald et al. (2000) and the Ontario Ministry of Environment (1993) that list ranges of contaminant values by probable toxicity to aquatic life (Table 9). Specifically, threshold effects levels (TEL) are those where toxicity is initially apparent, and likely to affect only the most sensitive organisms. Probable effects levels (PEL) are those where toxicity is likely to be observed over a range of organisms.

The frequency of detection of sediment compounds was consistent among sites and likely reflects contributions from sources upstream (*i.e.*, the East and West Branches). The compounds detected were primarily metals (11-12 out of 13 parameters tested) and PAHs (10-11 of 16 compounds tested). No PCB compounds were detected and only a single pesticide. The detection of metals and PAHs is consistent with runoff from roads and other urban and industrial landscapes.

Threshold effects levels for polycyclic aromatic hydrocarbons (PAHs) were exceeded for 4-8 compounds across Lower DuPage River sites and the Probable Effect Level was only exceeded for a single compound at all but the downstream most site (Table 9). PAHs result from the incomplete combustion of gasoline, a major component of coal-tar based asphalt sealants (Mahler et al 2012) and are a component of stormwater in urban areas.

Threshold effects levels for metals were exceeded for 4-6 compounds at all sites in 2012, but there were no PEL exceedences at any site (Table 9). Metals can also originate from urban runoff from roads and highways or from industrial and municipal sources. There were no elevated PCBs and Pesticide exceedences of the TEL any site in the Lower DuPage River in 2012 (Table 9).

**Table 9.** Number of metals, polychlorinated biphenyls (PCBs), pesticides and polycyclic aromatic hydrocarbons (PAHs) detections found in sediment samples collected from the Lower DuPage River in 2012 having concentrations that exceed threshold effects levels (TEL) or probable effect levels (PEL) listed in McDonald et al. (2000) or Ontario Ministry of Environment (1993). Key: T – tested; D – detected.

Site ID	RM	All Parameters		Metals		PCBs		Pest./ Other		PAHs		Metals		PCBs		Pest./ Other		PAHs		Parameters > TEL Benchmark (Value, mg/l)	Parameters > PEL Benchmark (Value, mg/l)
		T	D	T	D	T	D	T	D	T	D	T	P	T	P	T	P	T	P		
LD01	0.90	103	22	13	11	6	0	68	1	16	10	4	0	0	0	0	0	5	0	Copper (50.50); Manganese (845.00); Nickel (18.90); Zinc (163.00); Benzo(k)fluoranthene (539.00); Benzo(a)pyrene (940.00); Indeno(1,2,3-cd)pyrene (873.00); Phenanthrene (420.00); Benzo(a)anthracene (509.00)	
LD03	7.90	103	22	13	11	6	0	68	1	16	10	4	0	0	0	0	0	8	1	Copper (41.10); Manganese (840.00); Nickel (18.90); Zinc (134.00); Benzo(k)fluoranthene (407.00); Benzo(a)pyrene (710.00); Chrysene (707.00); Indeno(1,2,3-cd)pyrene (588.00); Phenanthrene (308.00); Pyrene (934.00);	Benzo(g,h,i) perylene (744.00)
LD05	2.60	103	22	13	11	6	0	68	1	16	10	5	0	0	0	0	0	8	1	Chromium (32.70); Copper (45.60); Manganese (861.00); Nickel (23.10); Zinc (155.00); Benzo(k)fluoranthene (367.00); Benzo(a)pyrene (625.00); Chrysene (654.00); Indeno(1,2,3-cd)pyrene (592.00); Phenanthrene (282.00); Pyrene (919.00);	Benzo(g,h,i) perylene (682.00)
LD07	12.00	103	22	13	11	6	0	68	1	16	10	5	0	0	0	0	0	5	1	Chromium (28.60); Copper (56.30); Manganese (660.00); Nickel (20.40); Zinc (162.00); Benzo(k)fluoranthene (620.00); Indeno(1,2,3-cd)pyrene (895.00); Phenanthrene (504.00); Benzo(a)anthracene (660.00)	Benzo(g,h,i) perylene (982.00)
LD09	17.60	104	23	14	12	6	0	68	1	16	10	5	0	0	0	0	0	5	1	Chromium (28.20); Copper (54.30); Manganese (817.00); Nickel (20.50); Zinc (169.00); Benzo(k)fluoranthene (583.00); Indeno(1,2,3-cd)pyrene (844.00); Phenanthrene (463.00); Benzo(a)anthracene (601.00)	Benzo(g,h,i) perylene (958.00)
LD14	27.40	104	24	14	12	6	0	68	1	16	11	4	0	0	0	0	0	4	1	Copper (57.80); Manganese (591.00); Nickel (19.50); Zinc (168.00); Benzo(k)fluoranthene (863.00); Phenanthrene (743.00); Benzo(a)anthracene (904.00);	Dibenzo(a,h) anthracene (240.00)
LD25	26.10	103	23	13	11	6	0	68	1	16	11	6	0	0	0	0	0	4	1	Chromium (29.30); Copper (57.60); Lead (31.30); Manganese (950.00); Nickel (22.40); Zinc (182.00); Benzo(k)fluoranthene (879.00); Phenanthrene (720.00); Benzo(a)anthracene (872.00);	Dibenzo(a,h) anthracene (235.00)

### ***Lower 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. QHEI scores and physical habitat attributes were recorded for sites in the DuPage River watershed where biological sampling occurred (Table 10).

DuPage River habitat quality varied by location but was adequate to support warmwater communities throughout most of its 27.8-mile length (see Figure 20; Figure 21). Variations in habitat were also strongly associated with variation in mainstem fIBI scores in both 2012 and a previous, 2007 survey (Figure 18). QHEI scores ranged from exceptional near its source (88.5 at RM 27.3) to fair in the Channahon dam pool (41.5 at RM 1.3). Excluding the dam pool, QHEI scores averaged 71.1, reflecting habitats fully capable of supporting diverse warmwater fish assemblages.

Extreme upper mainstem habitats were clearly exceptional, but declined

to the lower good range over an approximate 14 mile reach between the Naperville WWTP and the Hammel

Woods low-head dam (~ RMs 25-10.6). Compared to upstream, this long, sluggish and historically channelized reach was characterized by pooled or pool/run habitats, higher levels of siltation, finer substrates, lower sinuosity and development, and an abundance of aquatic macrophytes. Moderate influence modified attributes increased markedly and conversely, good attributes declined through the same reach (Table 10). However, no High Influence modified attributes were noted and the river habitats maintained marginal but adequate quality for warmwater habitat attainment.

Further downstream, QHEI scores improved immediately downstream from both the Hammel Woods and Channahon low head dams. It is not unusual to find localized, higher quality habitats below dams as the structures often act as sediment sinks, resulting in reduced siltation downstream. In addition, dams are often sited at abrupt breaks in stream gradient so strong, relatively clean riffle habitats are found in the tailwater reaches. Enhanced D.O. levels are also a common phenomenon immediately below the cascades and riffles.

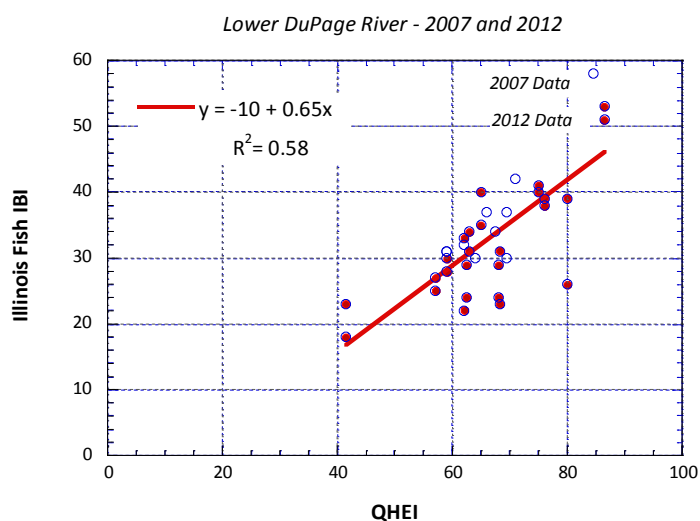


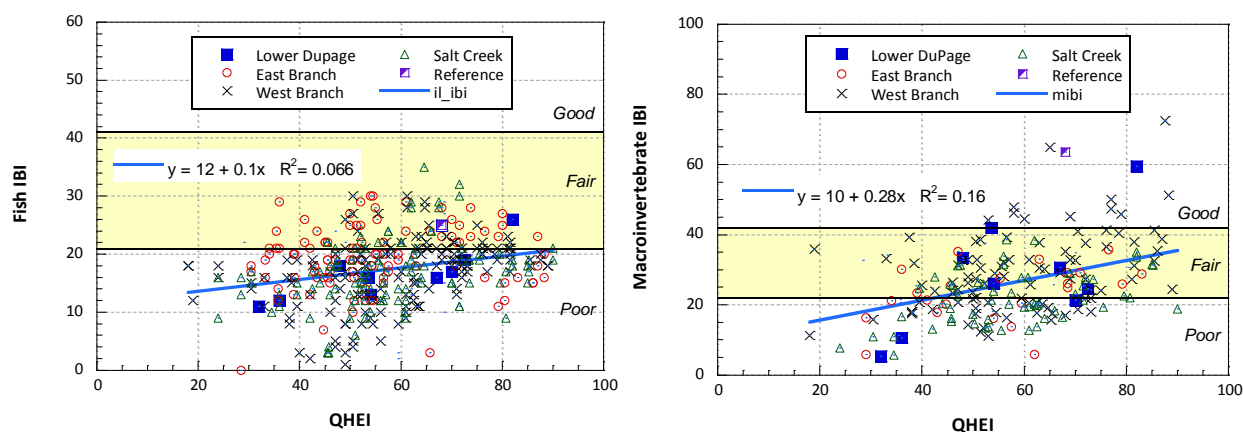
Figure 18. Plot of QHEI vs. fIBI for mainstem sites in the Dupage River during 2007 and 2012.

Lower DuPage QHEI scores at remaining, non-impounded sites were also higher than in the long sluggish reach of the upper mainstem. Compared to upstream, sites included riffle habitats, substrates were coarser and channel morphology, while not considered “natural”, appeared largely recovered from any historical modification. Lowest quality mainstem habitat was found immediately behind the Channahon dam (QHEI = 41.5). Monotonous, pooled habitats, fine, depositional substrates of muck and detritus, and an abundance of channel features associated with lentic, rather than lotic habitats, contributed to the low score.

### **Lower DuPage River Watershed headwater ( $\leq 20$ sq. mi.) and Wadeable Sites**

Nearly all the small tributaries sampled in the DuPage River were considered headwaters (catchments  $\leq 20$  sq. mi) with exception of two sites on Lily Cache Creek. Habitat quality in Lower DuPage River tributaries varied substantially from *poor* in sites with extensive, maintained channels, to excellent in upper Spring Brook Creek, situated within an Illinois Natural Areas Inventory site. Spring Brook Creek had the largest proportion of undeveloped land remaining in the watershed (Figure 5).

Unfortunately, biological condition in Lower DuPage tributaries was universally impaired, regardless of habitat quality (see Table 1). Besides the Lower DuPage tributaries, the relative lack of correlation between habitat quality and biological performance was observed at small tributary sites throughout the DuPage, and nearby Salt Creek watersheds (Figure 19). Within this pool of sites, no headwater fish scored above fair and only a handful of macroinvertebrates have reached the good range. Adequate habitat quality is clearly a “prerequisite” for attaining general use goals. However, factors associated with urban development and runoff is clearly limiting headwater sites where habitat is otherwise adequate to support a warmwater aquatic life use. The suite of stressors in small urban streams shown to be important to aquatic life impairment includes alteration of natural flow regimes, dissolved constituents (e.g., chlorides and total dissolved solids), nutrients, and sedimentation. In some cases, toxicants association with road runoff and industrial and commercial development (e.g., metals, organic chemicals)



can also accumulate in sediments.

Figure 19. Plots of QHEI vs. Fish IBI (left) and Macroinvertebrate IBI (right) for headwater sites ( $< 20$  Sq. mi.) sampled between 2006 and 2012 in the Lower DuPage, East Br., and West Br. DuPage Rivers, Salt Creek, and reference sites located in adjacent watersheds.

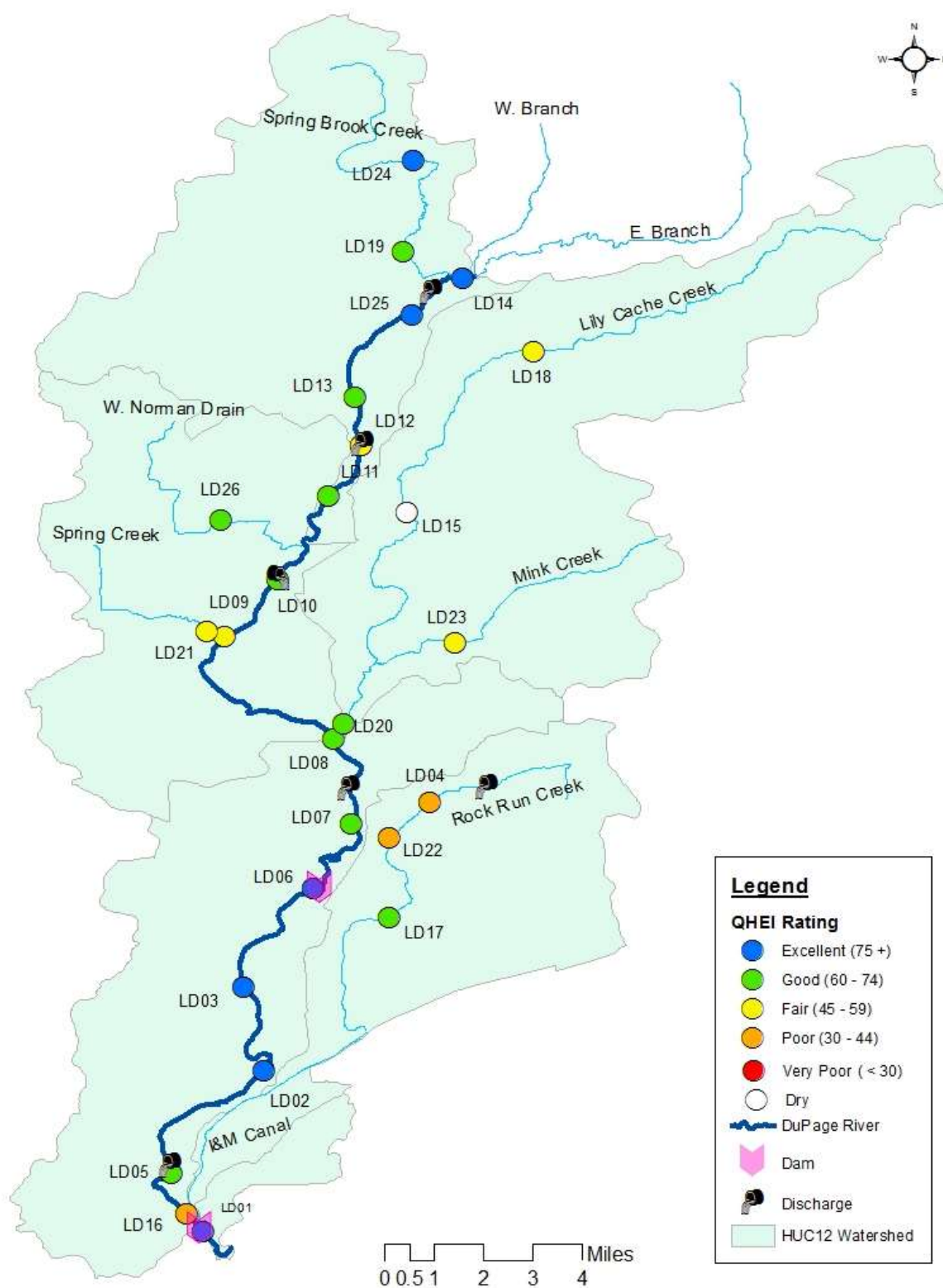


Figure 20. Lower DuPage River watershed QHEI scores in 2012 mapped by narrative range. Square symbols denote dams and discharge pipes denote WWTP locations.

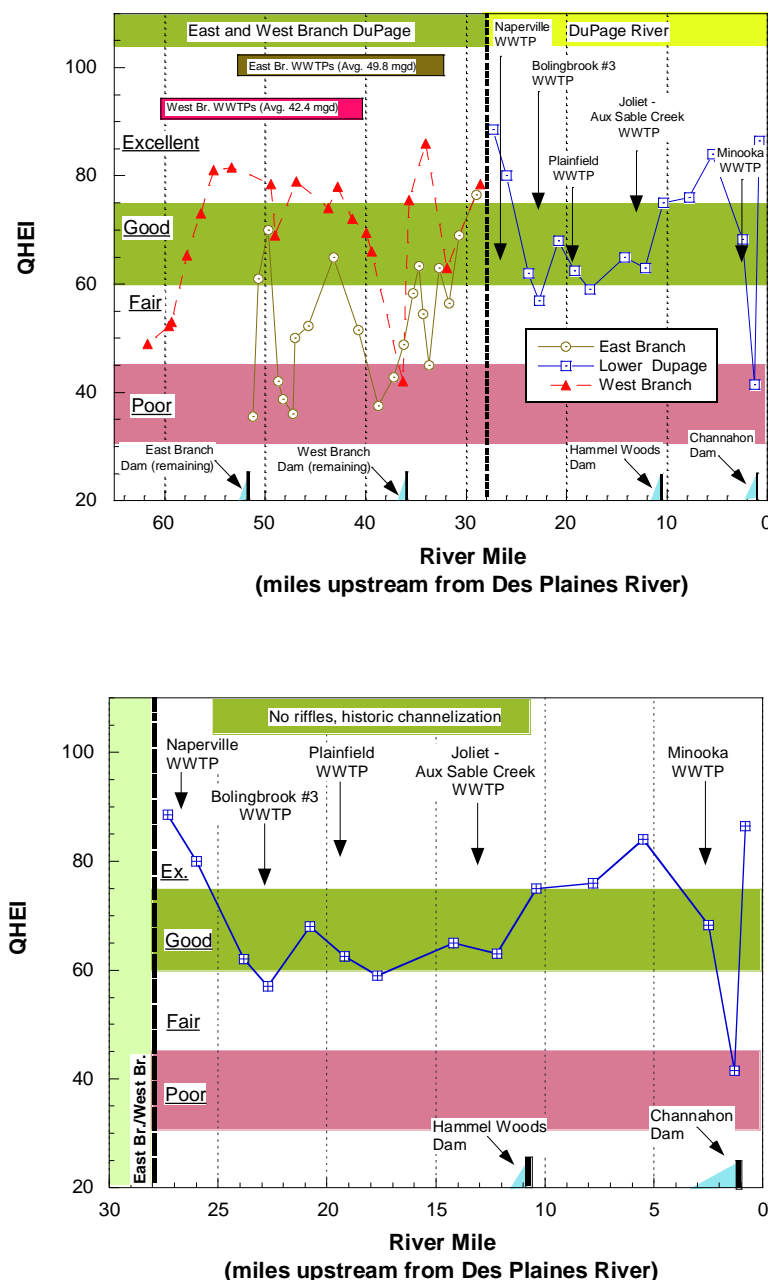


Figure 21. Qualitative Habitat Evaluation Index (QHEI) scores for the Lower DuPage River and its branches in 2011-12 (top) and the Lower DuPage River alone in 2012 (bottom) in relation to municipal WWTPs and existing low head dams (noted by bars adjoining the x-axis). The green shaded region depicts the range scores where habitat quality is good while the red shade indicates habitat is poor and limiting to aquatic life. QHEI scores less than 45 are typical of highly modified channels or dam pools.

Table 10. Qualitative Habitat Evaluation Index (QHEI) scores showing Good and Modified Habitat attributes at sites in the Lower DuPage River watershed during 2007 and 2012.

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
Dupage River (95-666) - 2007																																				
IS-1	2007	23.8	69.5	4.01	■	■				■		■	■		5						0		●	●			●	●			●		6	0.86	1.17	
IS 2	2007	22.7	62.0	4.01	■	■				■		■	■	■	6						0	●	●	●			●	●			●		6	1.00	1.00	
IS 3	2007	21.5	69.5	4.01	■	■				■		■	■	■	6						0		●	●	●			●	●			●		5	1.17	0.86
IS-4	2007	19.2	64.0	4.01	■	■				■		■	■	■	6						0	●	●	●			●	●			●		7	0.88	1.14	
IS 5	2007	18	66.8	4.17	■	■				■		■	■	■	6						0		●	●			●	●			●		5	1.17	0.86	
IS 6	2007	14.2	59.0	2.93	■	■				■		■	■		5			●			1	●		●		●			●	●			5	1.00	1.00	
IS 7	2007	12.2	67.5	6.62		■		■		■		■	■	■	6						0	●		●			●			●				4	1.40	0.71
IS-8	2007	10.4	71.0	5.26		■		■		■	■	■	■	■	7			●			1	●		●										2	2.67	0.38
IS-09	2007	2.5	66.0	2.5		■			■	■		■	■	■	6						0	●	●	●		●			●					5	1.17	0.86
IS-10	2007	0.8	84.5	2.5	■	■		■	■	■	■	■	■	■	9						0			●										1	5.00	0.20
Dupage River (95-666) – 2012																																				
LD14	2012	26.6	88.5	4.9	■	■		■	■	■	■	■	■	■	9						0													0	10.0	0.10
LD25	2012	26	80.0	4.9	■	■			■	■	■	■	■	■	8						0					●								1	4.50	0.22
LD13	2012	23.8	62.0	5		■				■			■		3						0	●	●	●		●	●			●	●	●		8	0.44	2.25

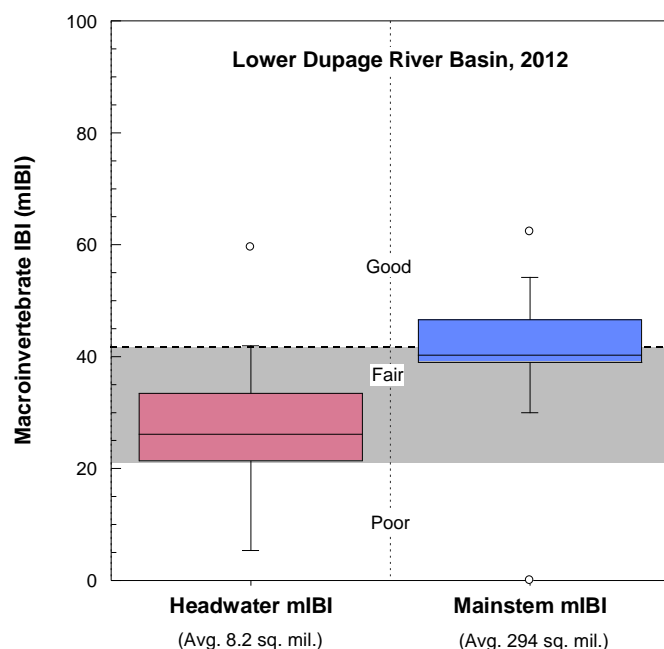


Site ID	Year	River Mile	QHEI	Gradient (ft/mi)	Good Habitat Attributes										High Influence Modified Attributes				Moderate Influence Modified Attributes										Ratios								
					No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive 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	
DuPage River (95-666) – 2012 (continued)																																					
LD12	2012	22.7	57.0	5.1		■				■			■		3				●			1	●	●	●		●			●	●		●	7	0.50	2.00	
LD11	2012	21.5	68.0	5.1		■				■		■	■	■	5						●	0	●		●		●		●				5	1.00	1.00		
LD10	2012	19.2	62.5	5		■				■	■	■	■		5						0	●	●	●	●		●	●					●	6	0.86	1.17	
LD09	2012	17.7	59.0	4.9		■				■			■		3						0	●	●	●	●		●	●				●	8	0.44	2.25		
LD08	2012	14.2	65.0	4.8		■				■	■	■	■		5						0	●	●	●	●				●			●	6	0.86	1.17		
LD07	2012	12.2	63.0	4.5		■				■	■	■	■		5						0	●	●	●		●	●					●	5	1.00	1.00		
LD06	2012	10.4	75.0	4.4	■	■			■	■	■	■	■	■	9						0			●	●								2	3.33	0.30		
LD03	2012	7.8	76.0	4.2	■	■			■	■	■	■	■	■	9						0												0	10.0	0.10		
LD05	2012	2.5	68.3	4.1		■				■	■	■		■	5						0	●	●	●		●			●	●	●		7	0.75	1.33		
LD16	2012	1.3	41.5	4.1						■			■		2		●	●			2			●		●			●	●		●	6	0.43	2.33		
LD01	2012	0.8	86.5	4.2	■	■			■	■	■		■	■	8						0				●			●					2	3.00	0.33		
LD02	2012	0.5	84.0	4.1	■	■			■	■	■	■	■	■	9						0												0	10.0	0.10		
West Norman Drain – [95-661]																																					
LD26	2012	2.2	67.0	14.9	■	■			■	■	■		■		7					●	1		●						●				2	2.67	0.38		
Mink Creek – [95-662]																																					
LD23	2012	1.8	53.5	10.8	■	■			■	■	■				5		●			●	2		●						●	●	●		4	1.20	0.83		
Spring Creek – [95-663]																																					
LD21	2012	0.5	48.0	14.3	■				■						2		●		●	●	3		●			●			●	●		●	5	0.50	2.00		

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	
Spring Brook Creek – [95-664]																																					
LD24	2012	4.5	82.0	5.1	■	■		■	■	■		■	■	■	8						0							●				1	4.50	0.22			
LD19	2012	1.2	72.5	6.1	■	■		■	■	■		■	■	■	8						0							●				1	4.50	0.22			
Rock Run Creek – [95-665]																																					
LD04	2012	6.5	32.0	1						■			■		2		●		●		2	●	●			●	●		●	●		●	7	0.38	2.67		
LD22	2012	5.4	36.0	15.1	■				■						2		●		●	●	3		●			●	●		●	●		●	5	0.50	2.00		
LD17	2012	3.5	70.0	8.8	■	■		■	■	■				■	6					●	1		●				●	●				3	1.75	0.57			
Lily Cache Creek – [95-668]																																					
LD18	2012	10.9	54.0	11.8		■				■		■	■		4			●			1	●				●	●		●			●	4	0.40	1.2		
LD20	2012	6.3	--	--																													Dry – not sampled				
LD20	2012	0.2	65.3	8.3	■	■			■	■			■		5					0		●				●		●	●		●	5	0.17	1.0			

### **Lower DuPage River Watershed Biological Communities – Macroinvertebrates**

Macroinvertebrate communities were not sampled from the Lower DuPage watershed prior to 2012. Mainstem community health fell consistently in the good and upper fair ranges while conditions in the headwater tributaries was more variable, ranging from low poor to good (Figure 22; Figure 23). Overall, communities throughout much of the study area were predominated by facultative or tolerant populations often associated chemically with elevated nutrients, dissolved solids, and low dissolved oxygen. Many of these same taxa are also common to sluggish or impounded habitats. Few sensitive varieties were encountered and the limited numbers of distinct EPT taxa (20 in the entire Lower DuPage watershed) often represented the more facultative or tolerant ranges within each group. No stonefly (Plecoptera) individuals were found in the watershed. Differences in quality between mainstem and tributary sites was noticeable as 85% of the watershed EPT taxa were found at the 14 mainstem sites while only 50% were found in 11 tributary sites.



**Figure 22.** Box and whisker plots of mIBI scores from the DuPage River mainstem and headwater tributaries (<20 sq. mi.).

condition for about nine additional river miles (RMs 26.0-17.7). Improvement to the good range at RM 14.2 may also be considered illusory as the increase in mIBI largely resulted from an increased percentage of scrapers (a positive metric) but the increase was almost entirely attributed to the very tolerant snail genus *Physella*, which does not signify improved quality.

This middle mainstem reach is characterized as sluggish with mostly pooled or run habitats, an absence of riffles and abundance of macrophytes. In fact, the lowest mIBI score at RM 22.7 (30) coincided with the highest percentage of macrophytes in sample jabs (90%) and an absence of coarse substrates (Figure 25). Nutrient tolerant flatworms, oligochaetes, midges, and snails

Macroinvertebrates from the upper DuPage River reflected enriched conditions but were of good quality and exceeded criteria at RM 27.3, immediately downstream from the East Branch and West Branch confluence (Figure 24). Sampling results were in-line with 2011 and 2012 mIBI scores at the mouths of the East and West Branches, which had largely recovered from upstream impacts and exceeded criteria immediately prior to the mainstem. Habitat quality at all three sites was consistently exceptional and included strong riffle habitats with coarse substrates.

mIBI scores initially declined to the fair range downstream from the Naperville WWTP (mIBI=36.9 at RM 26.0) and remained in a persistently fair/upper fair

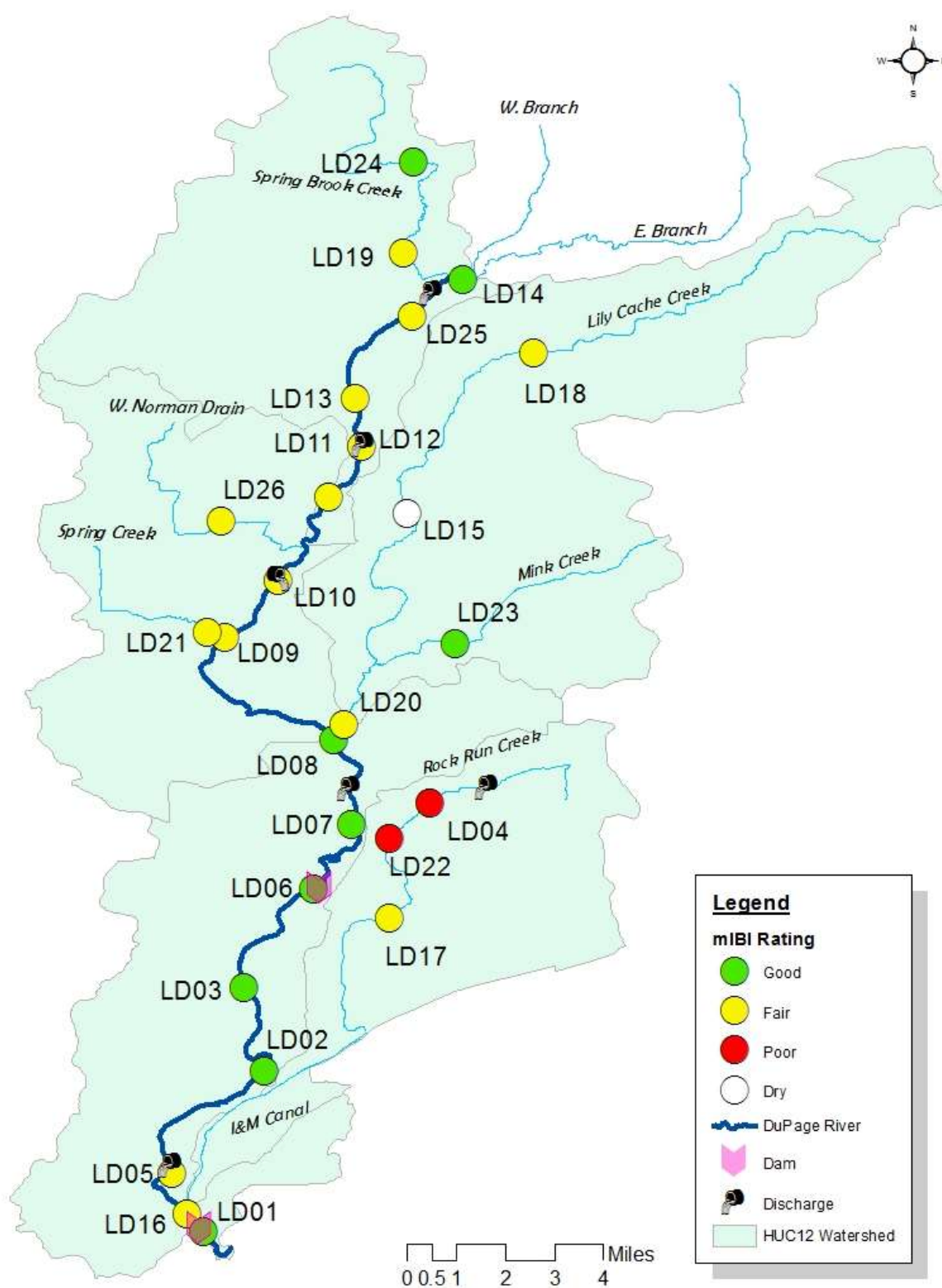


Figure 23. Lower DuPage River watershed mIBI scores in 2012 mapped by Illinois EPA narrative ranges. Square symbols denote dams and discharge pipes denote WWTP locations.

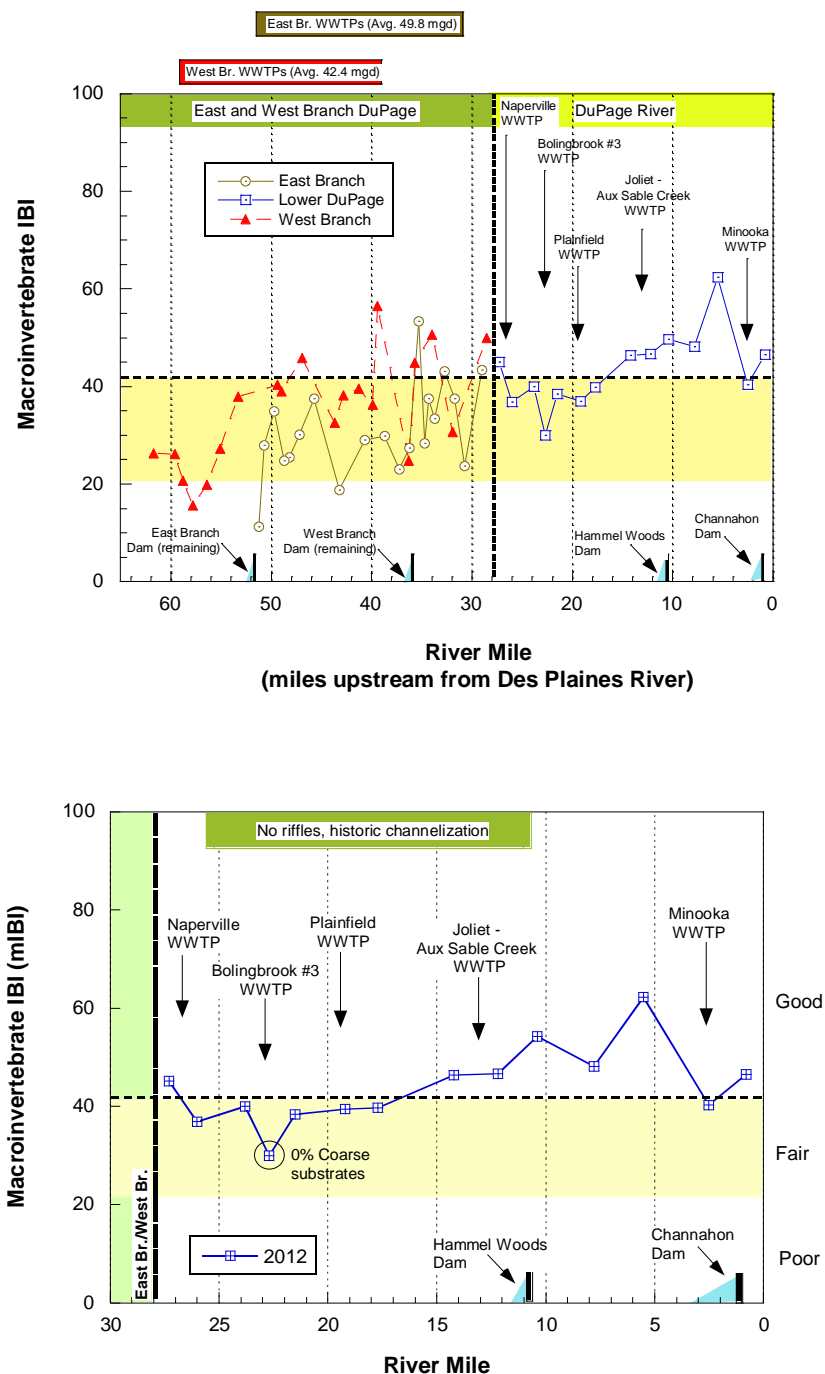


Figure 24. Macroinvertebrate Index of Biotic Integrity (mIBI) scores for the Lower DuPage River and its branches in 2011-12 (top) and the Lower DuPage River alone in 2012 (bottom) in relation to municipal WWTPs and existing low head dams (noted by bars adjoining the x-axis). The shaded region demarcates the “fair” narrative range.

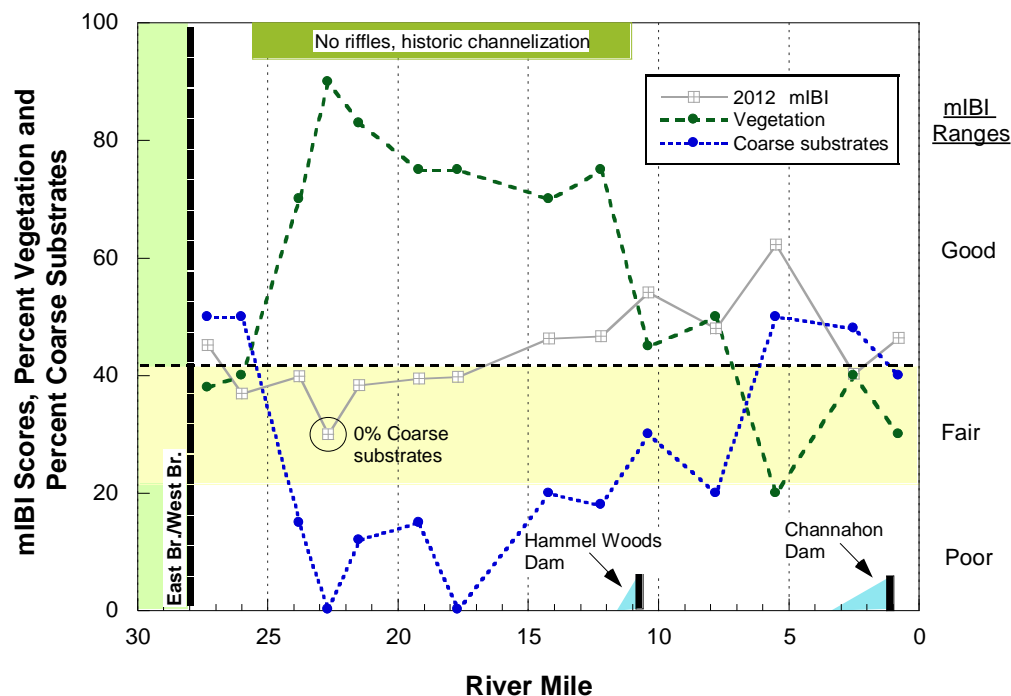


Figure 25. Macroinvertebrate IBI (mIBI) scores and percentages of vegetation and coarse substrates (gravels and cobbles) from Lower DuPage River sample sites in 2012. Low head dams are noted by bars adjoining the x-axis. The shaded region demarcates the “fair” narrative range.

were among the more common populations in the reach while *Hyaella azteca*, an amphipod often associated with pooled habitats and submergent vegetation, was often abundant. Numerous *Tricorythodes*, a facultative mayfly genus associated with slower currents was also common. Since the decline in mIBIs coincided with significant changes in habitat quality, it is difficult to discern the potential effect of the Naperville WWTP, or other mainstem discharges, on downstream performance. Still, communities throughout the upper and middle DuPage mainstem could be characterized as enriched and of generally marginal quality.

Outside of the influence of the Channahon Dam impoundment at station RM 2.5, highest quality mainstem macroinvertebrates were found at free-flowing river and tailwater sites between the Hammel Woods low-head dam and the mouth (RM 10.5-0.8). Unlike the sluggish reach upstream, most sites had strong riffle/run habitats with coarse substrates. A pollution sensitive caddisfly genus, *Protophila* (Family Glossosomatidae) was collected between the dams at station RMs 10.4-5.5, underscoring the higher quality nature of the reach.

#### **Lower DuPage River Tributaries - Macroinvertebrates**

The quality of DuPage River tributary communities was quite variable, ranging from the lower Poor to Good narrative ranges (Table 1). In small, headwater drainages, index scores reflected fair to poor quality (mean mIBI = 21.7) at seven of nine sites in Rock Run Creek, West Norman Drain, Spring Creek, Lily Cash Creek (RM 11.2) and Spring Brook Creek (RM 1.4). The impaired

communities were often characterized by low EPT and intolerant taxa richness and an abundance of pollution tolerant taxa, particularly sludge worms (Oligochaeta). Poorest macroinvertebrates were found in Rock Run Creek, downstream from the Crest Hill West WWTP.

Among impaired tributaries, Spring Creek was unique in that the watershed drainage was primarily agricultural, not urban. However, the stream was channelized and stream flow was intermittent during sampling. As a result, the sample zone was comprised of isolated pools with substrates composed of fine muck and sand. The fair quality community (mIBI=33.41) was predominated by the riffle beetles (facultative) sludgeworms (tolerant), and the moderately tolerant midge species, *Clinotanypus pinguis*, which inhabits soft sediments.

In contrast to the seven degraded tributaries, Mink Creek RM 1.8 and Spring Brook Creek RM 4.8 exceeded criteria and reflected good quality. While not remarkably different in composition, oligochaete abundance was much lower at these good quality sites compared to other tributaries. Intolerant taxa richness and percentage of EPT taxa was also higher at the Mink and Spring Brook sites.

Throughout the Lower DuPage watershed, residential development comprised a significant portion of the upstream drainage in both impaired and good quality watersheds (Figure 5). However, both Mink Creek and upper Spring Brook Creek tended to have channels that are more natural and wide, relatively undisturbed floodplain features upstream. In upper Spring Brook, the natural floodplain is part of the 1,834 acre Springbrook Prairie, an Illinois Natural Areas Inventory site and an extensive stream remaindering project was conducted in 2007. In upper Mink Creek, a golf course and large tracts of undeveloped old fields and new fields were located immediately upstream. Macroinvertebrates appeared to benefit from the increased buffering between the channels and adjacent development. Examination of aerial maps also found that storm retention basins or impoundments were often situated between the creeks and residences, possibly reducing the impact of direct runoff events and interrupting delivery of fine silts.

Lily Cache Creek RM 0.2 was the only Lower DuPage River tributary with drainage greater than 20 sq. mi. Macroinvertebrate performance in this 46 sq. mi. suburban stream was fair (mIBI=32.4) but in line with impaired urban headwater streams in the survey area. A second Lily Cache Creek site at RM 6.3 also had drainage over 20 square miles but the channel was dry and not sampled.

### Lower DuPage River Watershed Biological Communities – Fish

Fish assemblage condition in the lower DuPage River watershed in 2012 ranged from poor to good (Figure 26, Figure 27). Mainstem fish were previously sampled by MBI in 2007 but tributary communities were not sampled prior to 2012. During each survey, mainstem community health has been in the fair range except for falling into the poor range in the Channahon dam pool and reaching the good range on two occasions in the Hammel Woods and Channahon dam tailwaters. In contrast, conditions in the tributaries were almost entirely in the poor range (Figure 26).

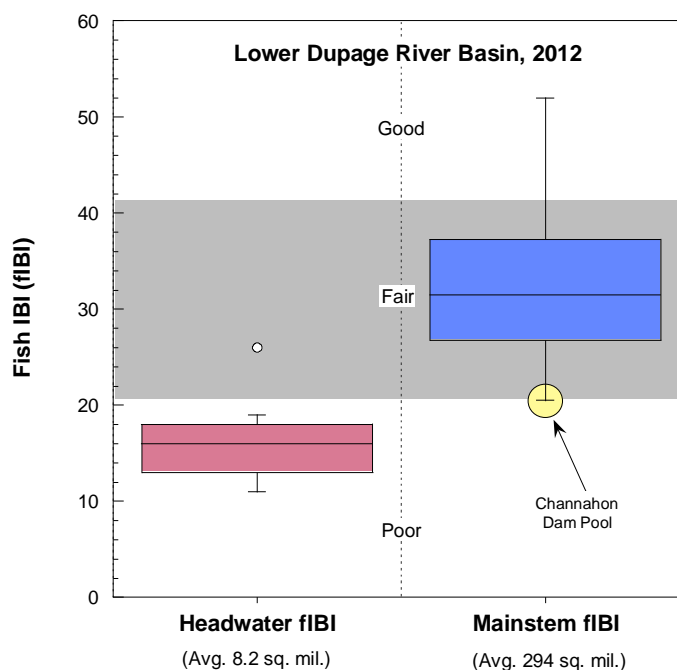


Figure 26. Box and whisker plots of fIBI scores from the Lower DuPage River mainstem and headwater tributaries (<20 sq. mi.).

Longitudinal patterns in fish assemblage condition generally reflect variations in stream habitat as measured by the QHEI (Figure 28). However, absolute assemblage condition (e.g., compared to reference expectations) is also influenced by upstream nutrient loadings, high dissolved constituents such as chloride and the presence of the Channahon dam, which not only impounds the river, but also restricts movement of fish from the very lowest mile of the DuPage River and the Des Plaines River to which it confluences. The declining fIBI scores between 2007 and 2012, particularly in the upper and middle reaches of the mainstem (Figure 29), mirrors a declines of similar magnitude in the East Branch DuPage River between 2007 and 2011. East Branch declines were largely attributed to excessive nutrient loadings from point sources and the trend in the Lower DuPage fish suggest the influence extended downstream.

### Influence of Dams on the Illinois Fish IBI

During the 2007 and 2012 surveys, there were nineteen fish species and one hybrid found only downstream from the Channahon dam). While a few of these species are more strongly associated with the larger Des Plaines River, many would be expected to inhabit the DuPage River mainstem and move into the West and East Branches if flow was unrestricted. This is particularly true of the redhorse species and most minnow and darter species that are currently restricted to the lowest reach. Based on the data from 2007-2012 it does not appear that the short-term breach of the Channahon dam in 1996 was sufficient to establish viable populations of these species upstream from the dam. Many of these species (e.g., redhorse) exhibit seasonal movements characterized by migrations to and from larger waters. Even if small populations exist upstream from the dam, maintaining larger, robust populations are likely dependent on permanent connectivity with downstream reaches. MBI's sampling results are in



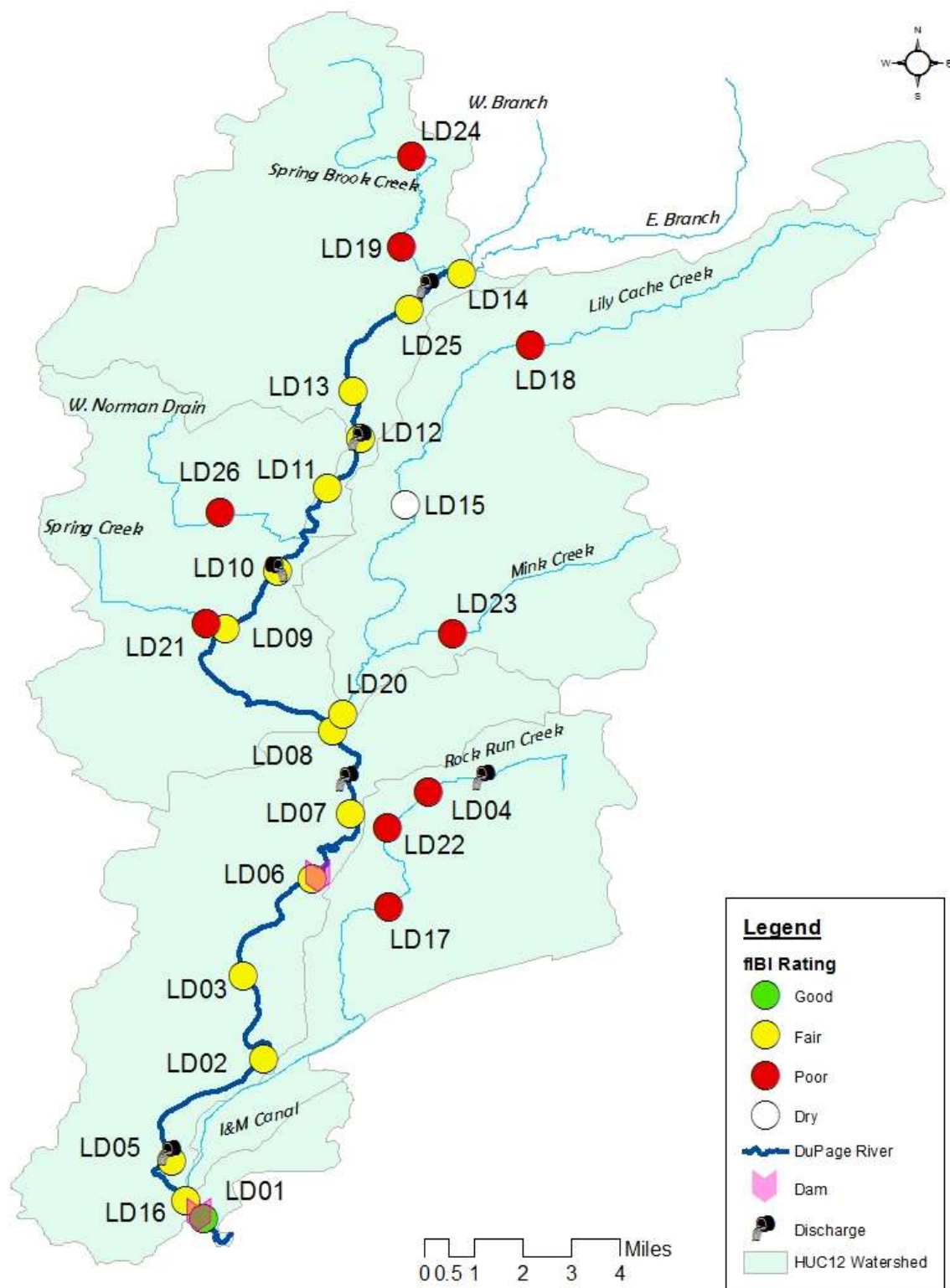


Figure 27. Lower DuPage River watershed fIBI scores in 2012 mapped by Illinois EPA narrative range. Square symbols denote dams and discharge pipes denote WWTP locations.

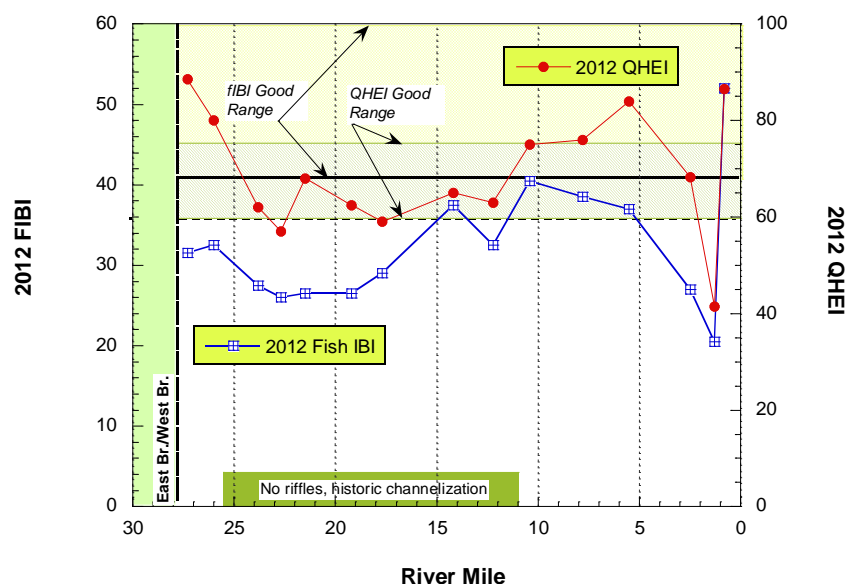


Figure 28. Fish IBI and QHEI scores from the Lower DuPage River, 2012.

line with 2007 IDNR monitoring of the DuPage mainstem and their conclusion that the dams were significant obstructions to fish dispersal (Conservation Foundation, 2003b).

When examining the effects of dams on FIBI scores, it is necessary to examine the individual metrics of the index. The Illinois IBI has 10 metrics, of which six are based on “species-richness” measures (i.e., total native species, sunfish species,

sucker species, minnow species, intolerant species and benthic invertivore species) and four are proportional “condition” metrics (i.e., percent as generalist feeders, mineral spawners, tolerant individuals and specialized benthic invertivores). Figure 30 displays a box and whisker plot of the score for each metric (0-6) in the DuPage River upstream (top) and downstream (bottom) from the Channahon Dam.

To distinguish potential water quality or habitat influences from loss of connectivity, one would expect strong trophic impacts to be evident in the proportional metrics. In contrast, loss of connectivity (alone) would be independent of certain trophic metrics and show more signal in the loss of species richness metrics. In the DuPage, total species richness, sucker species, intolerant species, minnow species and benthic invertivore species were depressed above the Channahon Dam while most proportional metrics (tolerants, generalists, mineral spawners) scored well upstream from the dam (usually 4-6). The sunfish richness metric scored well both upstream and downstream from the Channahon Dam (Figure 31) but sunfish are a group that generally can form resident populations in small streams and rivers. The only proportional metric that underperformed upstream from the Channahon Dam was the specialized benthic invertivores (see Figure 33, bottom); however, examinations of the species that comprise this metric include many species excluded by the dam (redhorse and darters). Downstream from the dam this metric scored a six during all sampling events in 2007 and 2012.

Variation in the fish IBI upstream from the dam shows a relationship with habitat quality, as measured by the QHEI, as well as a longitudinal response of decreasing percent generalists and tolerant species from upstream to downstream. Interruptions in this pattern occur within dam pools and in reaches of poorer habitat. In these areas, nutrient impacts may be magnified by the combination of inputs from upstream sources and reduced channel complexity. The relative low levels of total suspended solids relative to nutrient concentrations (nitrate and total

phosphorus) may be related to a relatively quick export of nutrients to the Des Plaines and Illinois Rivers. Extensive growths of aquatic plants may be partly related to the high nutrient concentrations and low turbidity. In some cases, aquatic plants have been shown to inhibit algal growth as well (Ervin 2003).

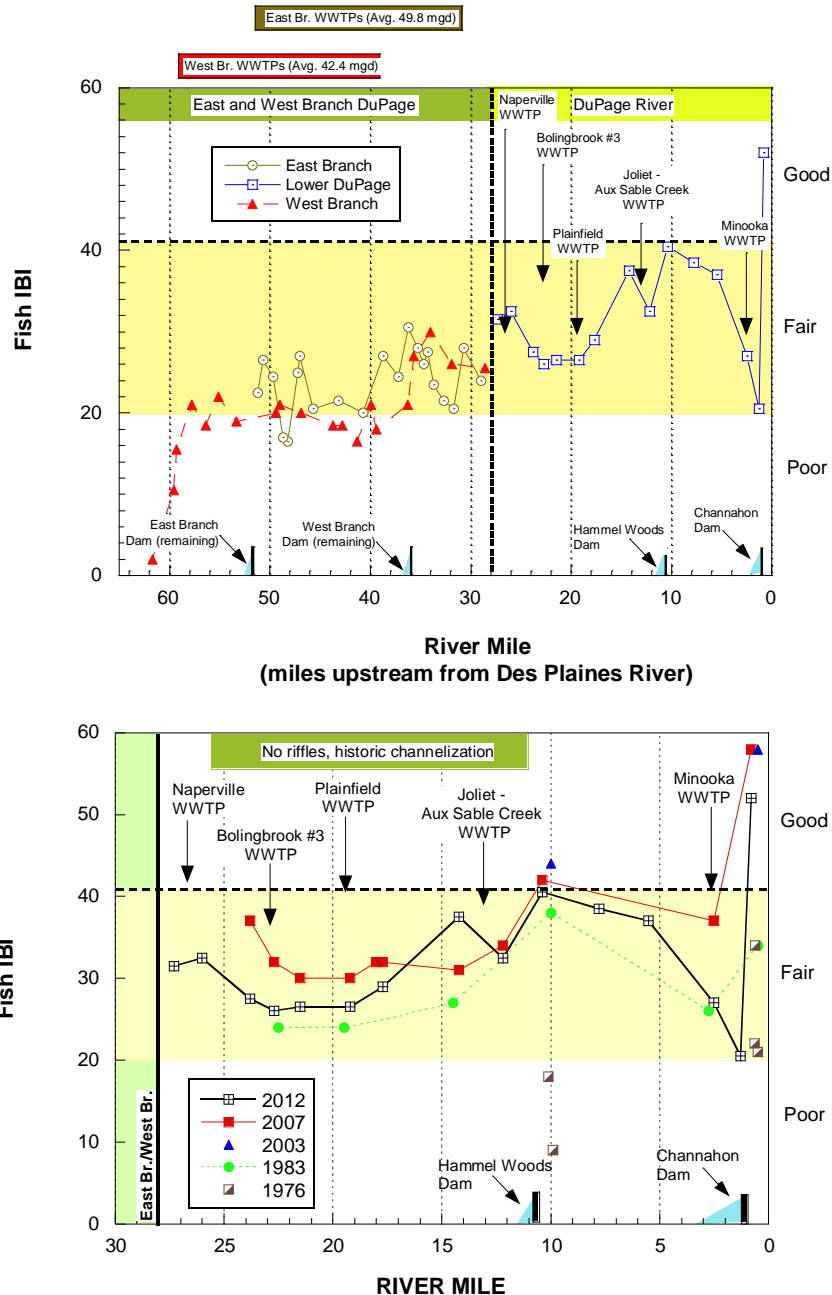


Figure 29. Fish Index of Biotic Integrity (fIBI) scores for the Lower DuPage River and its branches in 2011-12 (top) and the Lower DuPage River alone (bottom), from 2012-1976, in relation to municipal WWTPs and existing low head dams (noted by bars adjoining the x-axis). The shaded region demarcates the “fair” narrative range.

*Table 11. Fish species collected from three segments of the Lower DuPage River in 2007 and 2012: 1) Downstream Channahon Dam, 2) upstream Channahon Dam but downstream Hammel Woods dam, and 3) upstream Hammel Woods Dam. Species highlighted in yellow were only found downstream from the Channahon Dam and those in blue found upstream from the Channahon Dam, but not upstream from the Hammel Woods dam.*

Family Code	Species Code	Common Name	Latin Name	Downstream Channahon Dam	Upstream Channahon & Dst Hammel Woods Dam	Upstream Hammel Woods Dam
10	004	LONGNOSE GAR	<i>Lepisosteus osseus</i>	X		
20	003	GIZZARD SHAD	<i>Dorosoma cepedianum</i>	X	X	X
34	001	CENTRAL MUDMINNOW	<i>Umbra limi</i>		X	
37	001	GRASS PICKEREL	<i>Esox americanus vermiculatus</i>	X		
40	004	SMALLMOUTH BUFFALO	<i>Ictiobus bubalus</i>	X		
40	005	QUILLBACK CARPSUCKER	<i>Carpionodes cyprinus</i>	X	X	X
40	006	RIVER CARPSUCKER	<i>Carpionodes carpio carpio</i>	X	X	X
40	008	SILVER REDHORSE	<i>Moxostoma anisurum</i>	X		
40	009	BLACK REDHORSE	<i>Moxostoma duquesnei</i>	X		
40	010	GOLDEN REDHORSE	<i>Moxostoma erythrurum</i>	X	X	X
40	011	SHORTHEAD REDHORSE	<i>Moxostoma macrolepidotum</i>	X	X	X
40	013	RIVER REDHORSE	<i>Moxostoma carinatum</i>	X		
40	015	NORTHERN HOG SUCKER	<i>Hypentelium nigricans</i>	X	X	X
40	016	WHITE SUCKER	<i>Catostomus commersoni</i>	X	X	X
43	001	COMMON CARP	<i>Cyprinus carpio</i>	X	X	X
43	002	GOLDFISH	<i>Carassius auratus</i>	X	X	X
43	003	GOLDEN SHINER	<i>Notemigonus crysoleucas</i>	X	X	X
43	004	HORNHEAD CHUB	<i>Nocomis biguttatus</i>	X	X	X
43	013	CREEK CHUB	<i>Semotilus atromaculatus</i>	X	X	X
43	015	SUCKERMOUTH MINNOW	<i>Phenacobius mirabilis</i>	X		
43	020	EMERALD SHINER	<i>Notropis atherinoides</i>	X		
43	023	REDFIN SHINER	<i>Lythrurus umbratilis</i>	X	X	X
43	025	STRIPED SHINER	<i>Luxilus chrysocephalus</i>	X	X	X
43	026	COMMON SHINER	<i>Luxilus cornutus</i>			X
43	028	SPOTTAIL SHINER	<i>Notropis hudsonius</i>	X		
43	032	SPOTFIN SHINER	<i>Cyprinella spiloptera</i>	X	X	X
43	033	BIGMOUTH SHINER	<i>Notropis dorsalis</i>	X	X	X
43	034	SAND SHINER	<i>Notropis stramineus</i>	X	X	X
43	035	MIMIC SHINER	<i>Notropis volucellus</i>	X		
43	041	BULLHEAD MINNOW	<i>Pimephales vigilax</i>	X		

Family Code	Species Code	Common Name	Latin Name	Downstream Channahon Dam	Upstream Channahon & Dst Hammel Woods Dam	Upstream Hammel Woods Dam
43	042	FATHEAD MINNOW	Pimephales promelas	X	X	X
43	043	BLUNTNOSE MINNOW	Pimephales notatus	X	X	X
43	044	CENTRAL STONEROLLER	Campostoma anomalum	X	X	X
43	045	COMMON CARP X GOLDFISH	HYBRID	X	X	X
43	048	RED SHINER	<i>Cyprinella lutrensis</i>	X		
47	002	CHANNEL CATFISH	Ictalurus punctatus	X	X	X
47	004	YELLOW BULLHEAD	Ameiurus natalis	X	X	X
47	006	BLACK BULLHEAD	Ameiurus melas		X	X
47	007	FLATHEAD CATFISH	Pylodictis olivaris	X	X	X
47	008	STONECAT MADTOM	Noturus flavus	X	X	X
47	013	TADPOLE MADTOM	Noturus gyrinus	X	X	X
54	002	BLACKSTRIPE TOPMINNOW	Fundulus notatus	X	X	X
57	001	WESTERN MOSQUITOFISH	Gambusia affinis	X		X
70	001	BROOK SILVERSIDE	<i>Labidesthes sicculus</i>	X		
74	001	WHITE BASS	<i>Morone chrysops</i>	X		
74	005	STR. BASS X WH. BASS	HYBRID	X		
77	001	WHITE CRAPPIE	Pomoxis annularis			X
77	002	BLACK CRAPPIE	Pomoxis nigromaculatus	X	X	X
77	003	ROCK BASS	Ambloplites rupestris	X	X	X
77	004	SMALLMOUTH BASS	Micropterus dolomieu	X	X	X
77	006	LARGEMOUTH BASS	Micropterus salmoides	X	X	X
77	008	GREEN SUNFISH	Lepomis cyanellus	X	X	X
77	009	BLUEGILL SUNFISH	Lepomis macrochirus	X	X	X
77	010	ORANGESPOTTED SUNFISH	Lepomis humilis	X		X
77	011	LONGEAR SUNFISH	Lepomis megalotis	X	X	X
77	012	REDEAR SUNFISH	Lepomis microlophus		X	X
77	013	PUMPKINSEED SUNFISH	Lepomis gibbosus	X	X	
80	002	WALLEYE	<i>Sander vitreus</i>	X		
80	003	YELLOW PERCH	Perca flavescens		X	X
80	005	BLACKSIDE DARTER	Percina maculata	X		
80	007	SLENDERHEAD DARTER	Percina phoxocephala	X		
80	011	LOGPERCH	Percina caprodes	X	X	
80	014	JOHNNY DARTER	Etheostoma nigrum	X	X	X
80	016	BANDED DARTER	Etheostoma zonale	X	X	
85	001	FRESHWATER DRUM	Aplodinotus grunniens	X		
87	001	ROUND GOBY	Neogobius melanostomus	X		
				19 species found only dst. dam	3 additional species only dst. dam	42 total species

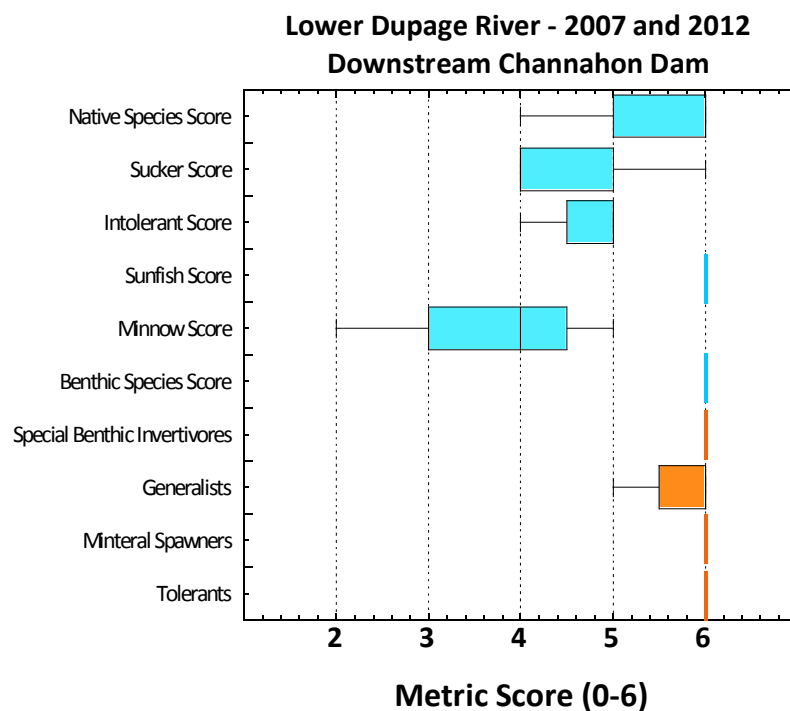
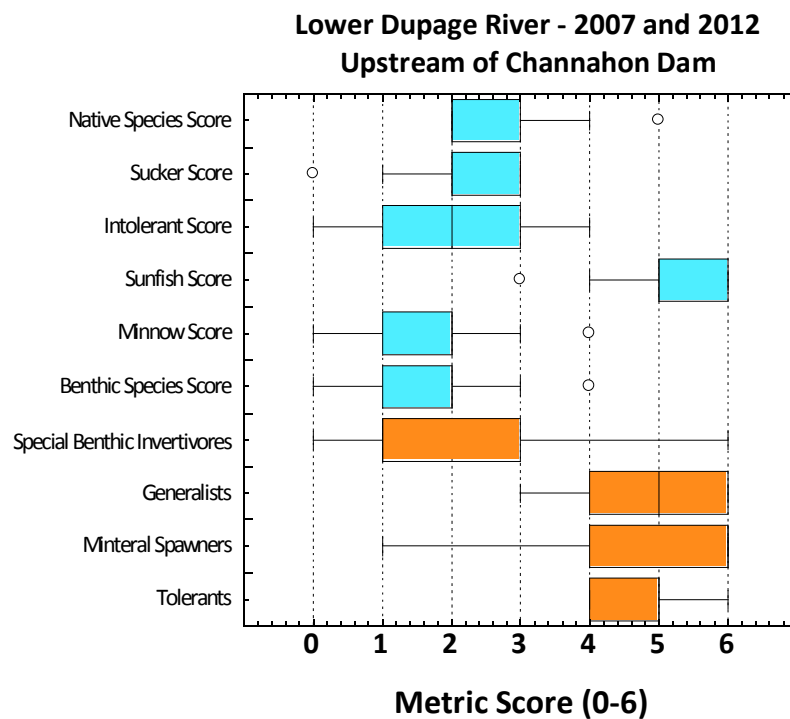


Figure 30. Box and whisker plots of fBI proportional metric scores (0-6) in the Lower DuPage River upstream from the Channahon Dam (top) and downstream from the Channahon Dam (bottom); data from 2007 and 2012.

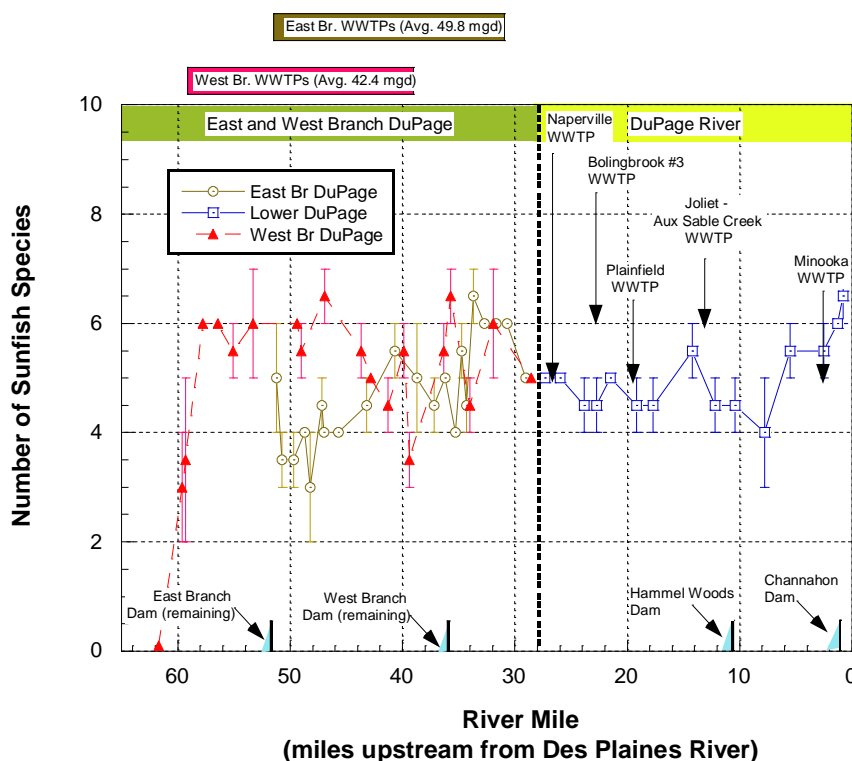


Figure 31. Number of sunfish species found vs. river mile for fish assemblages in the lower DuPage River and its branches (2011-2012).

### Longitudinal Trends in fIBI Metric Values

Although proportional metrics of the fIBI generally scored at four or higher, there is meaningful variation in these scores along the length the DuPage River and comparison to trends in the East and West Branches of the DuPage River. For example, generalists feeders usually scored low (metric scores of 1-3) in the East Branch and West Branch DuPage River, but performed better in the Lower DuPage (metric scores of 4-6) (Figure 32). Within the DuPage River, variation generally matches variation in habitat quality with lower proportion of generalists at sites with highest quality habitats, and higher proportions of generalists at sites with poorer habitats or in dam pools. A similar pattern was evident for mineral spawners (Figure 33, top) and slightly different and weaker patterns for tolerants (Figure 33, middle) and specialized benthic invertivores (Figure 33, bottom).

### Longitudinal Patterns in the MIwb

The Index of well-being (MIwb) is a composite fish index that includes measure of diversity based on abundance and biomass as well as log-weighted factors related to the total biomass and abundance at a site. It ranges from zero to approximately 12, but a value of 8.0 would be a reasonable expectation score for a river such as the Lower DuPage.

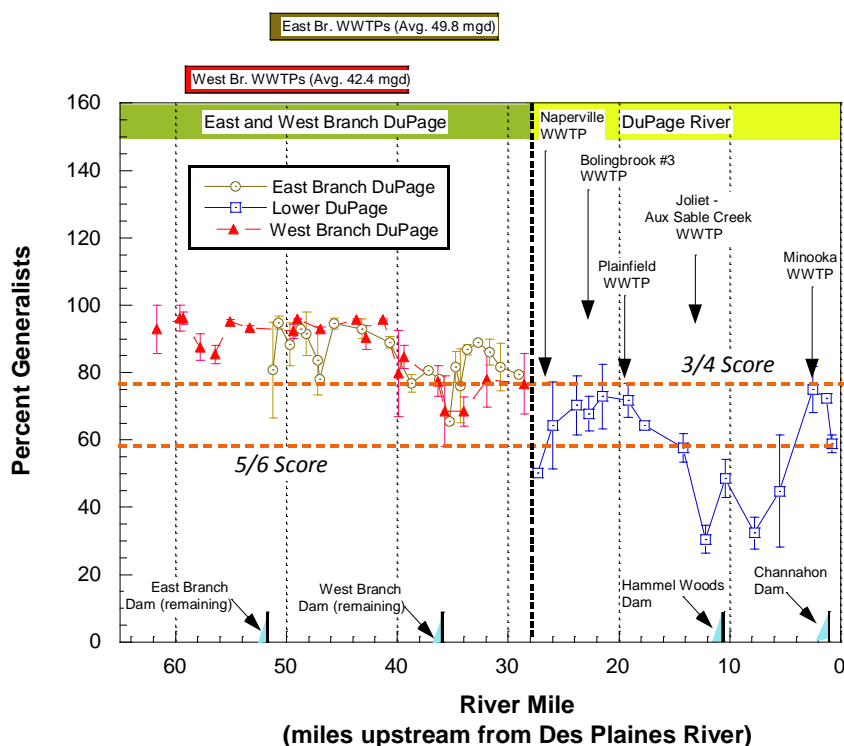


Figure 32. Plot of percent generalists vs. river mile for fish assemblages in the Lower DuPage River and its branches (2011-2012). Dashed lines represent scoring breaks of the percent generalist metric for IBI Region 3.

The East Branch and West Branch both show values that represent a lowering of diversity and biomass likely related to the point source impacts and enrichment identified in these rivers (Figure 34 - top). The Lower DuPage reflects a pattern where sites with good habitat reach a score of 8, but where habitat is less diverse or in dam pools where nutrient impacts likely magnified scores are below the threshold of 8.0 and in some case are approaching a 6.0 (Figure 34 - bottom). Such between 6.0 and 8.0 value would be considered fair and impaired relative to expected values. Values much less than a 6.0 are typically considered poor. The MIwb stressor signal is consistent with that observed in the IBI and several of its metrics.

### Summary

The general trend of low performance among species richness metrics and comparatively higher performance in proportional metrics upstream from the DuPage River dams does not entirely eliminate water quality or habitat as factors in the quality of fish communities. However, the data do suggest the barriers play a significant role, in concert with habitat and water quality, in fish assemblage condition. The results point to all three factors influencing mainstem community performance but the exact proportion or ranking of each is difficult to discern. Overall, results point to a moderately degraded and enriched stretch of river experiencing both physical habitat and structural limitations associated with historical channelization and anthropogenic sources.



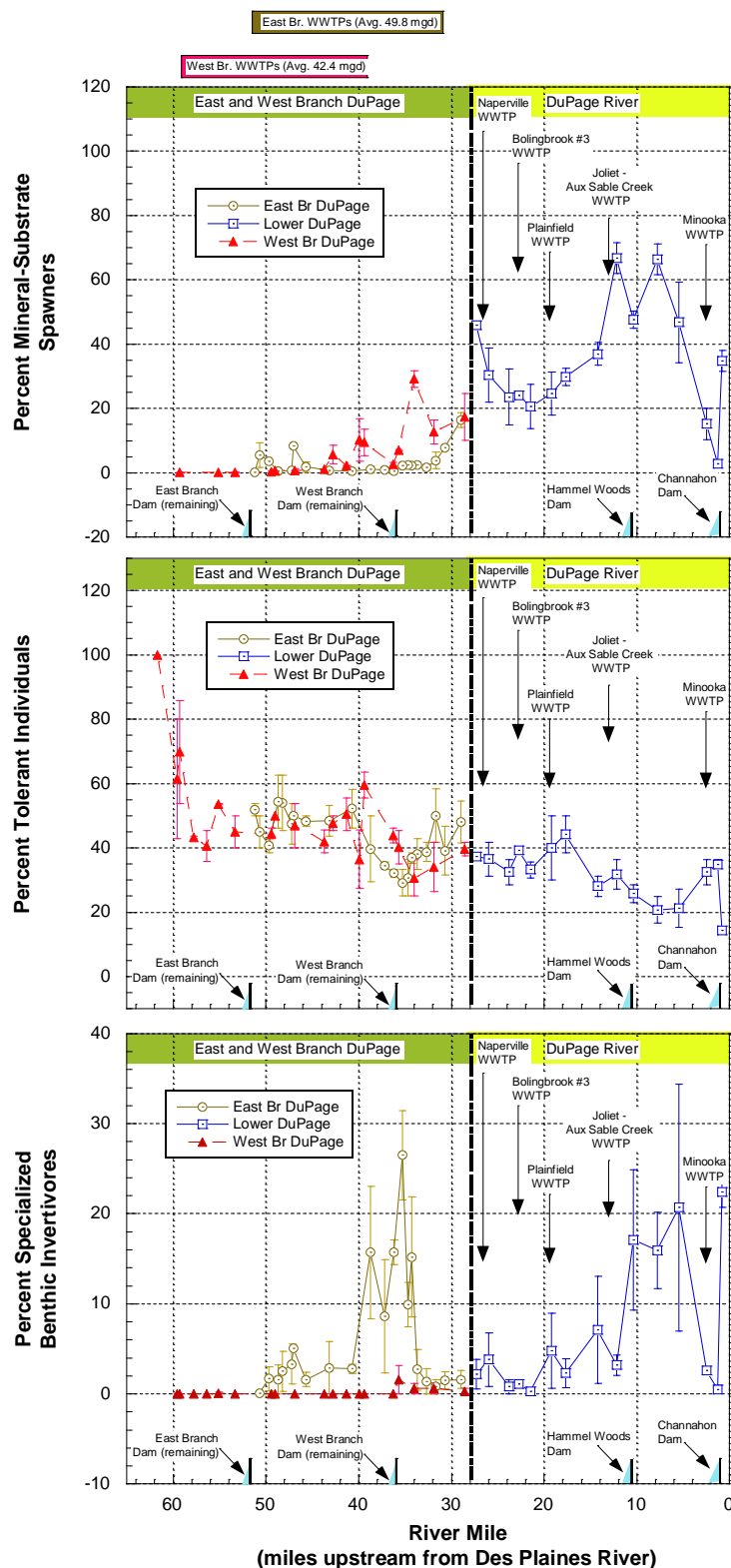


Figure 33. Plot of percent mineral spawners (top), tolerants (middle) and specialized benthic invertivores (bottom) vs. river mile for fish assemblages in the in the Lower DuPage River and its branches (2011-2012).

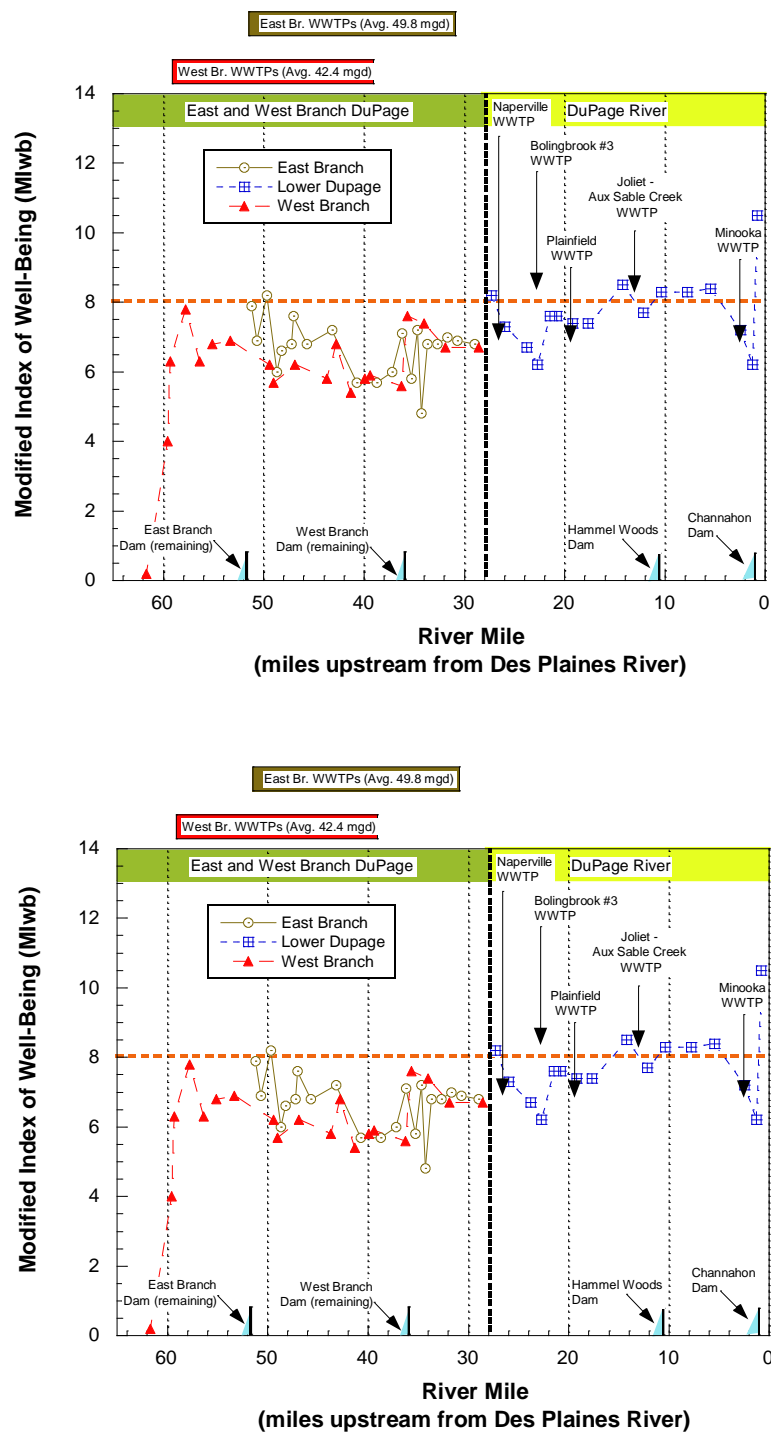


Figure 34. Mean Modified Index of well-being (MIwb) in the Lower DuPage River and its branches (top panel) and the Lower DuPage River alone (bottom panel). Approximate discharge locations of municipal WWTPs along the mainstems are noted. Bars along the x-axis note locations of existing dams. The dashed orange line represents a general threshold between good and fair ranges of the MIwb.

***Lower DuPage River Tributaries - Fish*****Headwater Tributaries (<20 sq. mi.)**

Although we have fish assemblage in the fair to good range at most mainstem DuPage River locations, fish index scores in headwater tributaries (< 20 sq. mi) were near universally rated as poor (see Figure 26). As discussed in the habitat section, some of these sites had poor habitat that likely contributed to the impairment of the fish assemblages. However, habitat conditions at many other impaired sites were more than adequate to support warmwater communities. In these instances, causes of impairment are likely to result from alterations of the natural flow regime and chemical impacts including dissolved parameters such as chlorides and TDS, nutrients. In some cases, impairment may result from toxicants in runoff, such as heavy metals, that can accumulate in sediments.

**Wading Tributaries (>20 sq. mi.)**

Lily Cache Creek near the mouth (RM 0.2) was the only tributary site sampled in the lower DuPage watershed with drainage greater than 20 sq. miles. The quality of the fish assemblage was fair but that performance was better than the poor conditions found at most headwater sites. Lily Cache Creek at RM 6.3 also had drainage over 20 square miles but the channel was dry and site was not sampled.

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