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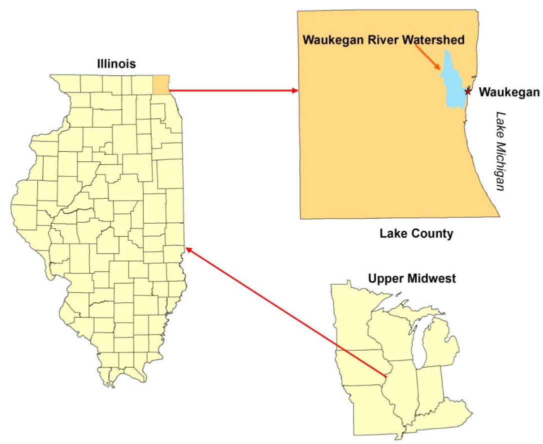

Figure 1. Location of the Waukegan River watershed.

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PROJECT SPOTLIGHT

Waukegan River Illinois National Nonpoint Source Monitoring Program Project

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Introduction

The Waukegan River watershed is located in Lake County, Illinois about 56.3 km (35 mi) north of Chicago (Figure 1). The watershed is 20 km (5 mi) long and has a drainage area of 2,994 ha (7,397 ac), with major land uses consisting of single and multi-family dwellings (35 %), transportation infrastructure (24 %), and public and private open space (12%) (Table 1).

The Waukegan River descends from 222 m (728 ft) in the headwaters to 177 m (581 ft) above mean sea level (msl). The river discharges into Lake Michigan approximately 1.8 km (1.12 mi) from the city's Lake Michigan water intake located just east of downtown Waukegan. The Waukegan River watershed receives a mean annual precipitation of 834 mm (32.8 in) and has a mean annual temperature of 8.8 °C (47.8 °F) (Midwestern Regional Climate Center 2009).

Soils in the watershed are dominated by Hydrologic Soils Group C (low permeability) covering 66% of the watershed and Hydrologic Soils Group B (medium permeability) covering 32% of the

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watershed. Group C soils have wetland and marsh areas covering 2.3% of the watershed area. The presence of hydric soils indicates that 15% of the watershed was once occupied by wetlands (Kabbes Engineering, Inc. and Geosyntec Consultants 2007). Original wetland and marsh areas were also recorded in Plat surveys of 1839 (Federal Township Plats of Illinois 1804-1891) (Figure 2). The original wetland and marsh areas have been reduced in acreage by land use conversions from agriculture and urbanization over the past 170 years.

EDITOR'S NOTE

In this issue of *NWQEP NOTES*, we continue our series on National Nonpoint Source Monitoring Program (NMP) projects that have been completed and have documented improvements in water quality due to implementation of best management practices (BMPs).

For the majority of cities in the United States, urban sprawl occurred prior to current stormwater runoff control regulations. Such is the case with the City of Waukegan, IL (just north of Chicago) — 80% of which lies within the Waukegan River watershed. Flashy stormwater runoff rates, high stormwater pollutant loads, reduced summer base flows, leaking sanitary sewer pipes, and concrete armored channels have lead to severe degradation of streams.

The Waukegan River watershed NMP project focused on stream naturalization through bank stabilization and aquatic habitat enhancement. Biological and habitat monitoring was conducted over a 12-year period before and after implementation of restoration practices. Results indicate that streambank stabilization structures reduced erosion and improved instream habitat. However, biological diversity only improved with the addition of instream riffle and pool habitat structures. The authors note that sustaining biological diversity in restored streams requires a comprehensive approach that not only includes bank, channel and habitat improvements, but addresses all potential sources of impairment in the watershed.

As always, please feel free to contact me with your ideas, suggestions, and possible contributions to this newsletter.

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Table 1. Land use of the Waukegan River watershed.

Land Use	Area (ha)	%
Agricultural	2.8	0.1
Disturbed Land	56.3	1.9
Forest and Grassland	200.7	6.7
Government and Institutional	181.7	6.0
Industrial	82.7	2.8
Multi-Family	68.7	2.3
Office	0.5	0.0
Public and Private Open Space	353.2	11.8
Retail/Commercial	195.1	6.5
Single Family	978.1	32.7
Transportation	729.2	24.4
Utility and Waste Facilities	65.4	2.2
Water	11.5	0.4
Wetlands	67.6	2.2
TOTAL	2993.5	100

Source: Lake County Illinois Planning, Building and Development 2000; Kabbes Engineering, Inc. and Geosyntec Consultants 2007

The Waukegan River watershed is largely urbanized, with over 80% of the City of Waukegan within the watershed boundaries (Figure 3). After the City of Waukegan became the county seat in 1841, the population began to grow rapidly (Waukegan Historical Society 2009) beginning a long history of urbanization. By 1850 the City of Waukegan was ranked the seventh largest city in the state of Illinois with a population of 2,949 people (U.S. Census Bureau 1850). The 2000 census indicated 87,901 people lived in the City of Waukegan with a density of 1,475 people/km^2 (U.S. Census Bureau 2000). Urban sprawl occurred prior to current requirements for stormwater runoff control. The resulting lack of control over stormwater quantity and quality led to flashy runoff rates and heavy stormwater pollutant loads. Water quality concerns also include cross-connections between sanitary and storm sewers, potential sanitary sewer overflows during wet weather, leaks in piping infrastructure, severe streambank erosion, channel downcutting, and fluvial/hydraulic disequilibration caused by concrete armored channels.

As expected, urbanization has significantly impacted stream biota in the Waukegan River. Fitzpatrick *et al*. (2004) stated in a study of urban influences on aquatic communities that most watersheds with a population greater than 193 people/km^2 had Alternate Index of Biotic Integrity (AIBI) scores less than 40 (fair or poor). Their data set of 193 people/km^2 corresponded to a range of about 10 to 18% urban land in northeastern Illinois and to about 7% total impervious area for Chicago area streams. The State of Illinois has used the Index of Biotic Integrity (IBI) and the AIBI since the mid-1980s (Hite and Bertrand 1989) as principal indicators of stream quality in northeastern Illinois (Dreher 1997). In addition, Macroinvertebrate Biotic Index (MBI) scores, used as an indicator of water quality (Resh and Unzicker 1975), generally increased to 5.0 (fair) or above (poor)

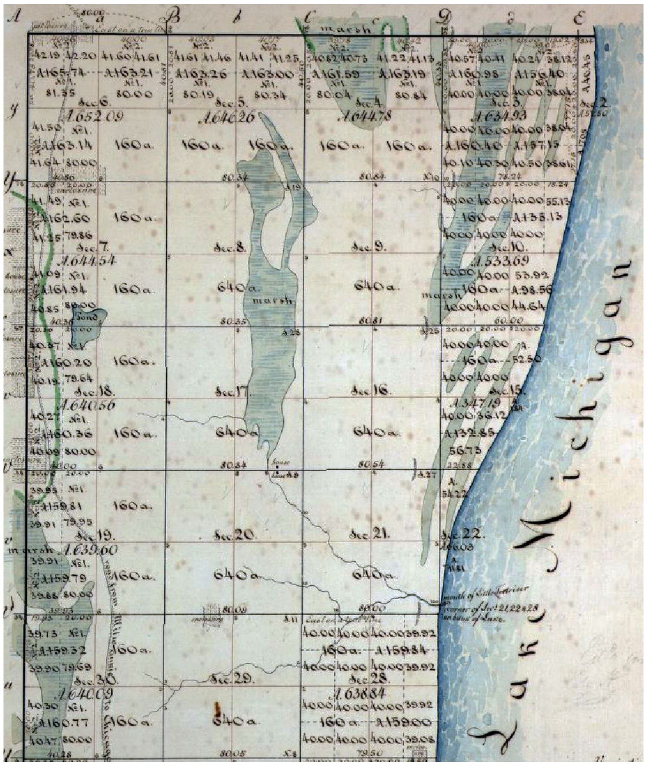

Figure 2. The Waukegan River (formerly the Little Fort River) watershed in 1839 (Federal Township Plats of Illinois 1804-1891).

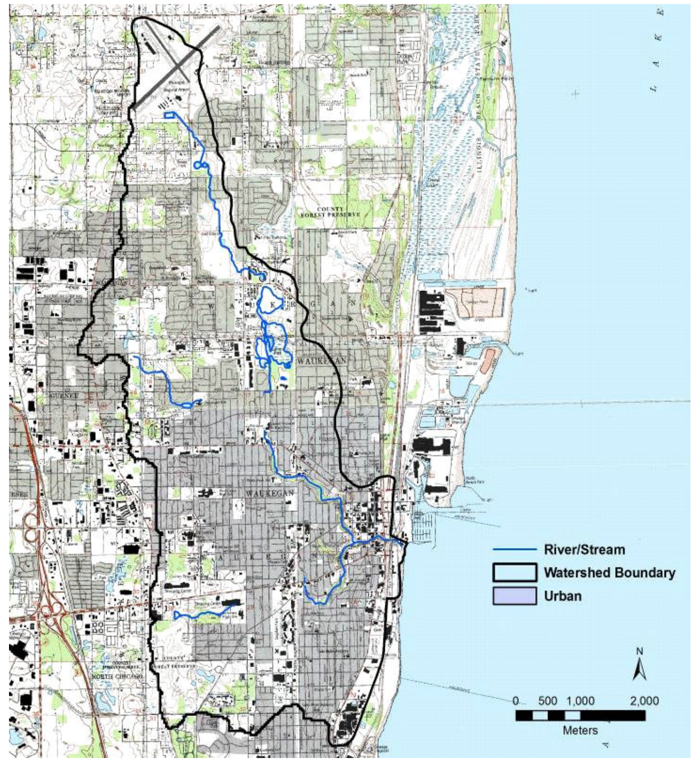

Figure 3. Urban area within the Waukegan River watershed in 1993 (USGS 7.5' quadrangle maps—Libertyville, Wadsworth, Waukegan and Zion).

for streams with greater than 10% urban land (Fitzpatrick *et al*. 2004). This implies that watersheds with a high percent of urban land will have poorer water quality.

In 1990 the Waukegan Park District experienced infrastructure damage from extreme storm events (Figures 4 and 5). As a result, in 1992 the Illinois State Water Survey (ISWS) was asked to adapt and apply previously demonstrated stream habitat enhancement and stabilization practices to stream bank erosion sites in Washington and Powell Parks.

Stream Restoration for the Waukegan River Section 319 National Monitoring Program Project

The 1992 stream restoration projects as well as the sampling and restoration project sites for the Waukegan River Section 319 National Monitoring Program were located in Washington and Powell Parks in the City of Waukegan, Illinois (Figure 6). Washington Park is located at the confluence of the

Figure 4. Damaged infrastructure on the South Branch from "flashy" storm events in 1990 in Washington Park.

Figure 5. View upstream at the South Branch erosion site at Washington Park in 1990.

North Branch and the South Branch of the Waukegan River, about one half mile upstream from the river mouth on Lake Michigan, and is situated in an area that represents the most urbanized reach of the river. Powell Park is located on the North Branch one mile from the river mouth and within a residential area.

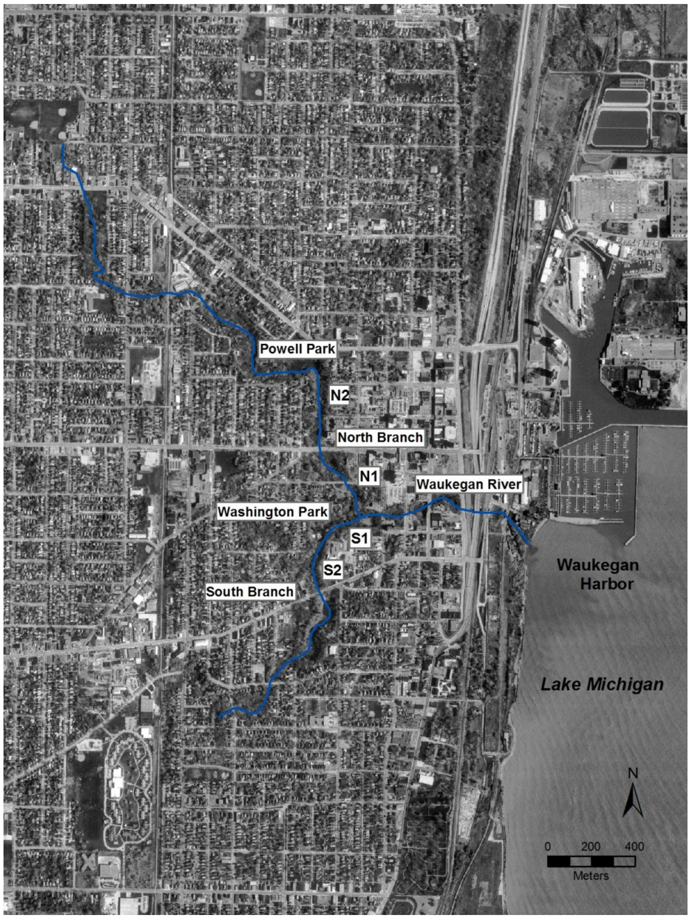

Figure 6. A 1998 aerial shows the location of the sampling stations and project areas established by the ISWS. Station S2 is the control station (non-treated). Stations S1, N1, and N2 are restoration sites (treated).

The core of habitat enhancement included the use of streambank stabilization structures called LUNKERS (Little Underwater Neighborhood Keepers Encompassing Rheotaxic Salmonids) (Vetrano 1988). LUNKERS were originally designed and tested in Wisconsin for improving trout habitat and used as an alternative to single-wing dam deflectors made of logs, wire and rock. In 1982, the first prototype LUNKERS were installed at Spring Coulee Creek in Vernon County, Wisconsin. In 1984, the stream was subjected to a 500-year flash flood. Inspection of the site after the flood event showed only minor damage where a few rocks had moved and some scour of the topsoil occurred.

LUNKERS were installed in Illinois at Franklin Creek State Park (Roseboom *et al.* 1992) where habitat conditions improved and game fish populations increased as a result. LUNKERS were used to stabilize the streambed below the water line and form a base for grasses, dogwoods (*Cornus sericea*), and willows (*Salix exigua Nutt*) on the bank. LUNKERS also improve instream habitat conditions by providing a sanctuary for fish. In Illinois, LUNKERS have been used in targeted areas as habitat for game fish such as smallmouth bass (*Micropterus dolomieu*) and channel catfish (*Ictalurus punctatus).* The Waukegan River is the only known stream in Illinois where non-native salmon enjoyed the use of LUNKERS along with native Illinois fish. Because salmon require specific habitat conditions to spawn (Moyle *et al.* 1995, Hassler 1987) they are rarely found in Illinois streams unless associated with areas that are stocked.

North Branch

On the North Branch of the Waukegan River in Powell Park, a stormwater sewer line was exposed by erosion, increasing the risk of contaminating the stream and limiting the access to downstream park areas (Station N2), (EPA Station QC-02). In May, 1992 LUNKERS were constructed and installed along the bank at N2. These LUNKERS were made from recycled plastic lumber to prevent deterioration during low summer flows. The upper and lower ends of the LUNKERS were stabilized with A-jacks, stone, and vegetation (e.g., Figure 7). After one year of growth, the sheer vertical face of the eroding streambank was stable and the dogwoods and wetland plants were already thriving (Figure 8).

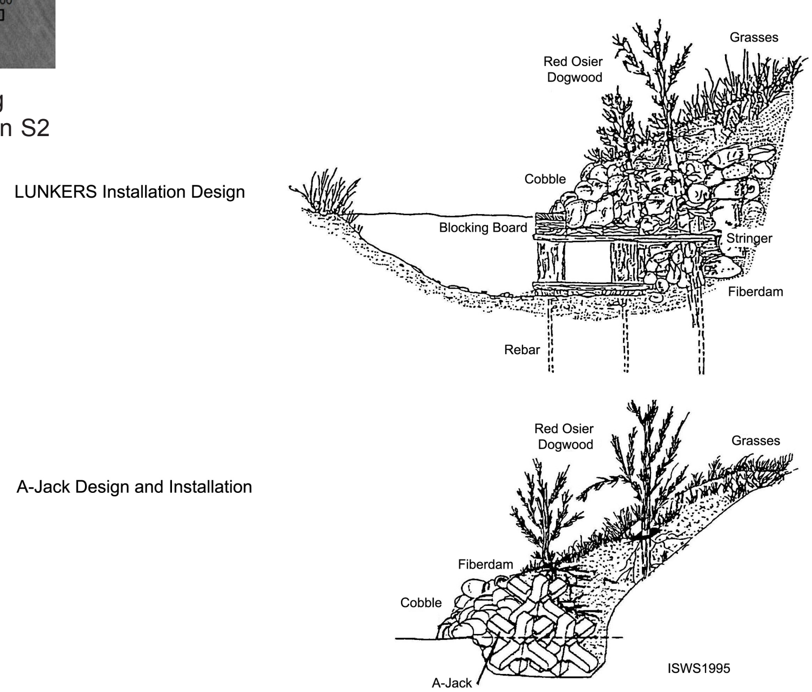

Figure 7. LUNKERS and A-Jack designs.

Figure 8. Stream restoration at station N2 shows pre-restoration conditions in 1991 (photo on left), mid-restoration in 1992 (middle photo), and post-restoration in 1993 (photo on right).

Figure 9. Stream restoration applied at station N1 before restoration in 1991 (photo on left), during construction in 1992 (middle photo), and post-restoration in 1993 (photo on right).

In September 1992, the Waukegan Public Works Department and the Park District built and installed wooden LUNKERS at an erosion site along North Branch at Washington Park designated as station N1 (EPA Station QC-03) (Figures 6 and 9). Just downstream of this site the network of the city's major sewer lines connected before entering the sewage treatment plant. Stream channel stability issues were of concern in this area because of the need to protect the piping system from erosion. Oak LUNKERS were used here because the base of the stream bank needed protection, the stream is wider in this area and the base and higher flows would be deeper. LUNKERS in this segment and station N1 would remain under water and oak species do not deteriorate under water as fast as many other species available. The oak LUNKERS followed the curve of the channel and were secured with rebar. A-jacks, stone, and soil were then placed on the LUNKERS. Cut stone was then laid over the re-worked embankment soil above the LUNKERS and small willow stock was planted between the stone joints. Vertical bank sections were sloped to a 1 to 1 grade. The lower edge of the sloped bank was sprigged with prairie cord grass and bulrush while the upper bank was planted with grasses and red osier dogwood. The upper bank also received an excelsior blanket to promote rapid seed germination. By October 1992, the riparian vegetation exhibited substantial growth greatly reinforcing the bank soil.

During 1993, Waukegan experienced a series of flood events, with the greatest flow occurring when 102 mm (4.0 in) of rain fell in one hour in July 1993. Rapid runoff quickly flooded low areas with the greatest floodwater velocities occurring in the lower end of the Waukegan River in Washington Park, where runoff was concentrated.

The N1 site was submerged by a major flood during in 1993 (Figure 10). Biotechnical bank stabilization effectively protected the parklands from erosion at both project sites on the North Branch.

Even with the success of the streambank stabilization efforts at station N1 and N2, the fish population was limited because of the lack of high quality instream habitat such as cobble substrates and consistently deeper pools. During high stream flows, larger game fish could be found within the sites where LUNKERS were installed but during the summer and fall seasons, the water in the stream was too shallow for game fish, even in the meander pools. In the summer season, low stream flows significantly stress fish communities and contribute to a general reduction in the quality and availability of stream habitat conditions (Bertrand *et al.* 1996 – Biological Stream Characterization (BSC) Work Group, Hite and Bertrand 1989). Urban watersheds tend to have large areas of impervious surface that reduce stormwater infiltration and dry weather (usually summer) base flows. More specifically, decreased infiltration also increases low base flow conditions and consequent biotic impacts even during drier weather episodes within seasonally dry periods.

Figure 10. Photo of flooding at station N1 in July of 1993.

South Branch

In 1993, the Illinois Environmental Protection Agency (IEPA) and the United States Environmental Protection Agency (USEPA) Region 5 requested the ISWS to conduct more detailed data collection and stream restoration on the South Branch of the Waukegan River under the auspices of the National Nonpoint Source Monitoring Program (NMP).

The goal was to restore fish habitat in the South Branch of the Waukegan River by applying BMPs and conduct monitoring to evaluate the effectiveness of the restoration efforts. The stream restoration project was evaluated on the basis of channel stability and impacts to instream fish habitat. The South Branch was divided into an upstream untreated reference site designated as station S2 (EPA Station QCA-03) and a severely eroding downstream treatment area designated as station S1 (EPA Station QCA-01). In this setting, water quality characteristics affect both the control (S2) and the rehabilitated station (S1) uniformly. From 1994 through 2006 fish, macroinvertebrates and habitat conditions were sampled at each location during the spring, summer, and fall seasons. The IEPA and ISWS agreed to have the North Branch restoration stations N1 and N2 included in the NMP as additional reference sites (Illinois State Water Survey 1994), so during these same years the North Branch stream site segments were also sampled in the spring, summer, and fall seasons.

In 1994, the streambank at station S1 was eroding rapidly and fish were limited in number by the lack of pool depth in both stream segments being monitored. Fish found at the site consisted of species that are very pollution tolerant. Therefore, biotechnical streambank stabilization techniques (LUNKERS, A-jacks, and bank revegetation identical to the North Branch restoration project) were installed for the purpose of improving habitat and water quality conditions.

The 1994 restoration project work on the South Branch coincided with the time of the Second National Nonpoint Source Monitoring Workshop held in Northbrook, IL. This meeting provided an opportunity for many workshop attendees to participate in both the fish monitoring and restoration project installation (Figure 11).

Starting in 1994 at the downstream end of station S1, over 61m (200 ft) of eroding banks were stabilized with rolls of coconut fiber installed along the toe of the bank and fastened into a shallow trench with rebar. The fiber rolls were then perforated with small willow cuttings. Grass seed and additional willow cuttings were placed on areas of exposed bank. The dogwoods and grass seedlings grew quickly although the willow cuttings had limited growth probably due to the high density of the canopy shadowing the stream reach (White *et al*. 2003). This stream reach was in an early stage of channel evolution. This was consistent with channel evolution models (CEM) that are often used to assess present channel geomorphic conditions and predict future channel adjustment conditions associated with intrinsic channel evolution factors and/or more extrinsic watershed disturbances (see Simon 1989, Simon and Downs 1995, Simon and Rinaldi 2000, US Army Corps of Engineers 1990, Federal Interagency Working Group 1998, White *et al.* 2005, White *et al.* 2006, White and Keefer 2005). The restoration applied through this reach significantly reduced channel erosion consequently reducing sedimentation. Field reconnaissance, site-specific monitoring, and video documentation from 1994 to 2006 indicated that the reach remained stable since 1994.

However, shallow pool depths were still considered to be limiting habitat for stream fisheries during the summer low flows, as was also the case in the North Branch. The stream

Figure 11. Stream restoration at station S1 show pre-restoration conditions before 1991 (photo on left), mid-restoration condition in 1994 (middle photo) and post-restoration conditions in 1995 (photo on right).

channel functioned as a ditch with a uniform streambed lacking a defined pool and riffle pattern. The ditch-like characteristics of the stream limited stream aeration and promoted deposition of fine textured mineral and organic materials in the shallow pools. In January 1996, the Waukegan Park District and the Illinois State Water Survey provided more pool depth by constructing seven rock grade control riffle structures (Newbury weirs) and pools within the South Branch. The locations and height of the riffles were based on designs by Dr. Robert Newbury, a Canadian hydrologist accredited with developing this technique of stream restoration (Newbury and Gaboury 1994, Roseboom *et al*. 1996). The riffle structures started at the confluence with the North Branch (Figure 12). In March 1996, two additional riffles were constructed in the North Branch upstream of the confluence at station N1.

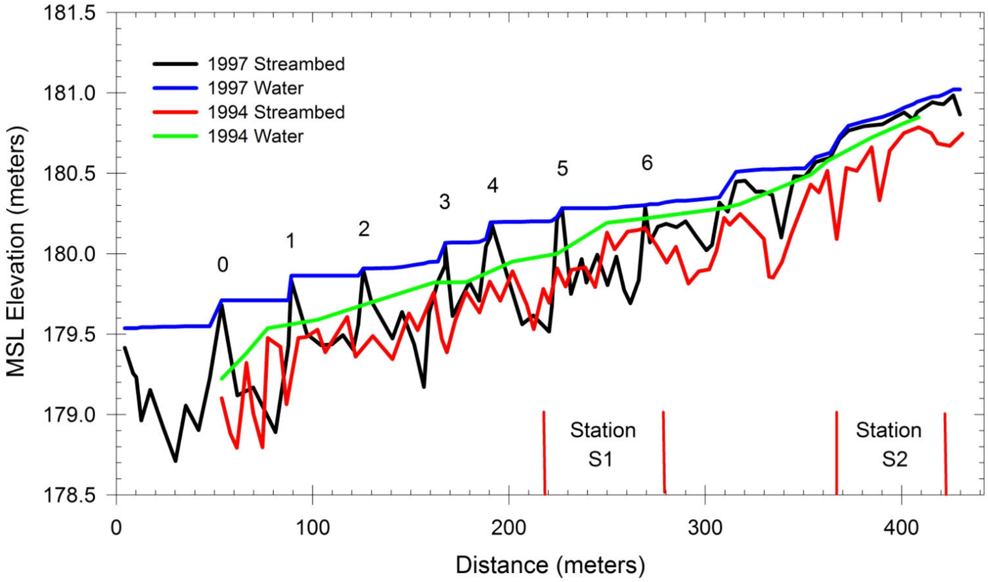

Figure 12. The profile of the South Branch of the Waukegan River showing riffle locations (below the numbers along the profile) after construction of riffles in January of 1996. The vertical red bars indicate the extent and location of the monitoring stations. The 1997 water level line (blue) shows the pool depth is higher than the water depth in 1994 (green line). Both surveys were conducted during base flow.

The overall riffle project design relies on discharge estimates, channel profile and cross-section surveys, and observation of substrate types as explained by Newbury and Gaboury (1994). The riffle itself uses a line of large crest stones that forms a foundation and helps control the pool elevation. The crest stone is "keyed" 3 to 4.5 m (10 to 15 ft) into the streambank. Where bank heights and stream widths exceed the reach of equipment, the "key" is laid into a ramp excavated by heavy equipment. As crest stone is being added, smaller stone is packed around and upstream of the crest forming a front face and a back face (or "tail") on the downstream side of the crest stone. Laying the crest in front of the excavator builds a support base for the excavator to cross the stream and reach the other side. While the excavator works its way across the stream, the front face is created at a 4:1 slope and tail at a 20:1 slope (Figure 13). Elevations are set on the crest stones located at the center of flow. Once the bank opposite the ramp has been "keyed," a "shoulder" is built over the crest stone to help form a V-shaped cross-section at a 4:1 slope. The equipment operator then finishes the slope on the tail and extends the shoulder in accordance with design specifications. Large boulders similar to the crest stones are placed around the tail to agitate the flow to create hydraulic diversity, add roughness, and provide a place for fish to rest as they navigate super-critical flows coming down the tail of the riffle (see Newbury and Gaboury 1994 for an explanation of hydraulic flow conditions

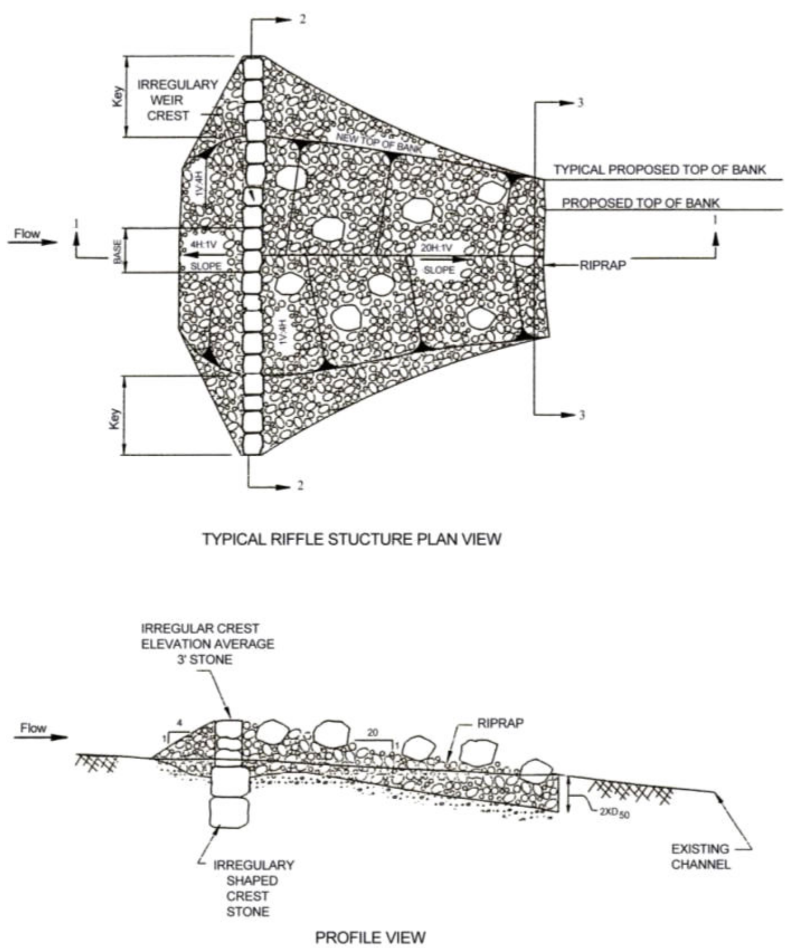

Figure 13. A typical design of a riffle structure, modified by ISWS from original work by Newbury and Gaboury (1994).

associated with riffles). After the tail is completed, the shoulder is built up the slope of the tail and along the bank. As the excavator exits back up the ramp, the final shoulder is completed and the ramp is then filled while reforming the remainder of the bank area. During this entire process, trucks or a track loader feeds a constant supply of rock over the bank to the excavator. The work area is then cleaned of excess rock, leveled, seeded and mulched. Figure 14 shows an upstream view of riffle 3 and 4 in May 2006.

Figure 14. Upstream view of riffle 3 and 4 on the South Branch in May 2006. The staff gage at the right of the picture measures up to 2 m (6.7 ft).

Monitoring Methods

Biological responses are measured using metrics that provide the Index of Biological Integrity (IBI), allowing the development of a biological stream site characterization score. The IBI, a metric that considers a variety of attributes of lotic fish communities, has been used by stream biologists from the Illinois DNR and the Illinois EPA since 1984 (Hite and Bertrand 1989). These agencies along with specialists from the Illinois Natural History Survey formed the Biological Stream Characterization Work Group which reviewed 12 IBI metrics used to evaluate streams based on Illinois statewide stream fisheries data (Bertrand *et al.* 1996). The 12 metrics encompass trophic condition, fish abundance, and condition of fish communities (Karr *et al.* 1986, Hite and Bertrand 1989). The index accounts for changes in species richness, where Fausch *et al*. 1984 described scoring criteria, and allows comparison of fish community composition with maximum known values for similar sized streams in the state. Stream size is described by the standard stream order classification (Strahler 1957).

Fish Community Sampling

Each monitoring station consisted of a single pool and associated upstream and downstream riffles. The stations ranged from 36.6m to 62m (120 to 200 ft) in length. Blocking seines positioned at both the upper and lower ends of the riffles isolated the reach during sampling periods. Fish were collected using a backpack electrofishing unit that stuns fish bringing them to the surface. The fish survey crew included the shocker operator and a single “netter” to collect the stunned fish. Electrofishing normally requires 10-15 minutes depending upon habitat and pool depth. Time was accurately recorded to calculate the catch per unit effort. Larger fish were identified on site and returned to the stream. Smaller fish were stored in 95% ethanol and identified at a later date by Illinois DNR fishery biologists. Fish species were identified and individual fish were examined for disease and physical condition.

Macroinvertebrate Surveys

Aquatic macroinvertebrates, as defined by Weber (1973), are invertebrates large enough to be seen by the naked eye and retained on a U.S. Standard 30 (0.595 mm) sieve. Macroinvertebrates spend at least part of their life cycle within or upon aquatic substrates. Invertebrates included in this group are typically annelids, crustaceans, aquatic insects, and mollusks (Isom 1978) and are commonly useful in water quality monitoring as indicator species (Resh and Unzicker 1975). At each sampling station, substrates were sampled at three locations with a Hess bottom sampler and a 500-micron net. The screened material was removed from the Hess sampler and the invertebrates were picked from the screened materials, preserved in 95% ethanol, and identified to genus level later in the laboratory. Macroinvertebrate data were analyzed by examining community attributes such as community structure, taxa richness, and use of the Macroinvertebrate Biotic Index (MBI) (Hite and Bertrand 1989). Interpretation of available data relied heavily on MBI assessment data that provide summation or average tolerance values that are assigned to each taxon collected and weighted by its abundance. The values are used as surrogate information to discern an organism’s tolerance to pollution. Low values indicate high water quality (for example, a rural Franklin Creek LUNKERS project had an MBI of 5.5) (Roseboom et al. 1992). High MBI values indicate degraded water quality. The index has a scale ranging from 0-11 rather than the 0-5 scale proposed by Hilsenhoff (1977, 1982) for Wisconsin streams (Hite and Bertrand 1989).

Instream Habitat Monitoring

Instream habitat monitoring followed Illinois EPA Potential Index of Biological Integrity (PIBI) guidelines outlined in the Biological Stream Characterization (BSC) (Hite and Bertrand 1989). Variables used to develop the PIBI scores are the same used to develop IBI scores. Regression analysis of habitat data generated by Illinois EPA/Illinois DNR Cooperative Intensive Basin surveys found the percent of silt-mud substrate, the percent claypan substrate, the percent pool habitat, and the mean stream width accounted for the greatest variance in IBI values. For typical Illinois streams, the PIBI values will range from 35 to 50 for third- to sixth-order streams using Strahler's (1957) stream order classification system. Smaller streams typically have lower PIBI values. This result is similar to IBI values for smaller streams because smaller streams have fewer species and less abundance than larger streams with similar habitat.

The PIBI was developed from data generated by the wadable stream transect methodology (IEPA 1987, 1994). The transect assessment procedures used in the IEPA's wadable streams method used in conjunction with Illinois EPA/Illinois DNR Cooperative Intensive Basin surveys, special studies, or appropriate elements of the Biological Stream Characterization (BSC) effort combine the habitat assessment approach published by Gorman and Karr (1978). Additional metrics important to stream quality (e.g., pool/riffle development, instream cover, and shading) (IEPA 1987, 1994) are also used to score the PIBI.

The Waukegan River PIBI assessment process used the wadable transect methodology where sampling stations were divided into 10 segments of equal length using 11 transects to collect habitat data. Variables of habitat data included stream width, stream depth, streambed substrate (defined as the mixture of particles comprising the streambed (Bovee 1982, Lane 1947); instream cover (features where fish can hide under or behind (Bovee 1982); percentage of riffles, pools, and runs (Platts *et al.* 1983, Keller and Melhorn 1978); shade canopy; and base flow stream discharge. Stream width, stream depth and bottom substrates were determined by direct measurement at each of the 11 transects. The extent of shade canopy, pool, riffle, and run were recorded at each of the 10 stream segments. Stream discharge was measured at 30.5 cm (1 ft) intervals along one transect within each sampling station. Discharge measurement methods followed established USGS procedures and guidelines (Buchanan and Somers 1969).

Sondes (Shipboard Oceanography Network Data Environment) are devices for testing physical conditions and often used in remote or underwater locations. For the Waukegan River project Sondes were installed at stations S1 and N1, with the help of Lake County Health Department, to record temperature, conductivity, pH, and dissolved oxygen ((DO). They were used to record data from June 2003 through October 2006 with the exception of the winter (November through April).

Monitoring Results and Discussion

South Branch

Monitoring data collected in 1994 (pre-LUNKER construction) and 1995 (post-LUNKER construction) revealed that after LUNKER construction there was an increase in the total number of fish and a more consistent number of fish species at downstream station S1 compared to data from the upstream control area at S2 (Figure 15). Based on these data alone the increase in the fish population and diversity suggested that "stream health" improved after LUNKERS were constructed. At downstream station S1, the seasonal average percent of cobble in the streambed increased after installing the riffle and pool structures and the seasonal average percent of gravel in the streambed decreased. Untreated station S2 exhibited a higher percent of gravel substrates overall with an increase in cobble substrate percentages from 1998 through 2002. The seasonal average percent of sand and silt substrates increased slightly at station S1 remaining consistent for the period while station S2 had varying percentages all below 20% over the period. The seasonal average percent of claypan substrate was minimal at both stations (Figure 16).

A deeply incised tributary at the upstream end of station S2 is believed to be a major source of substrate material accumulating at station S2. Fluctuation in percent of cobble in the substrate at station S2 may be caused by deposition of sediment from the tributary along with exposure of a cobble substrate by repeated scouring and deposition of gravels and additional finer textured sediment at this station. Clearly the substrate of the stream segment changes as the system dynamically adjusts to efficiently transport materials.

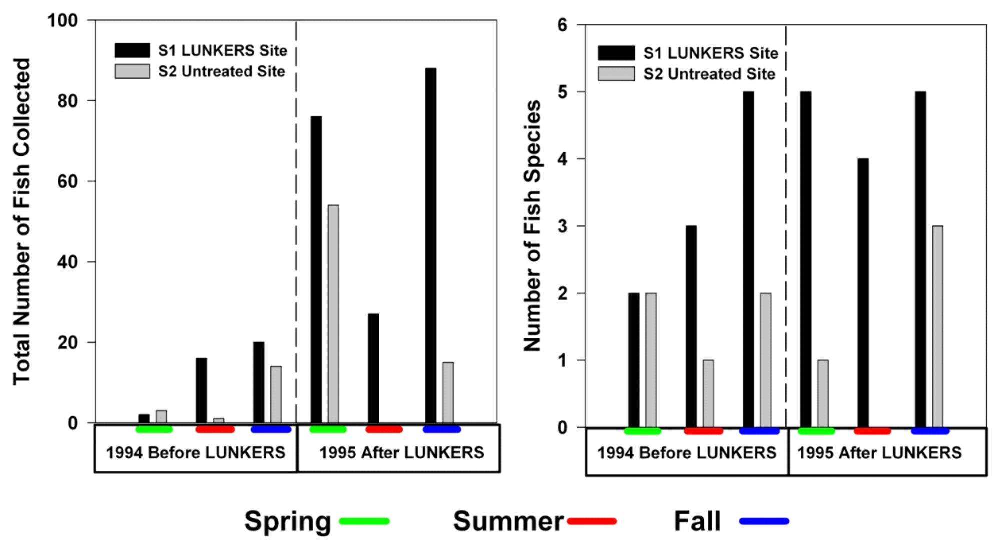

Figure 15. Comparison of diversity and abundance of fish at stations S1 and S2 prior to and one year after construction of LUNKERS installed in 1994.

At station S2, the annual average depth (average of the seasons and of the period) was only 58mm (2.3 in) at all eleven cross-sections during the entire monitoring period. Figure 12 shows evidence of the streambed filling at station S2 between 1994 and 1997. Figure 17 shows an upstream view of the station S2 untreated control area. The formation of stream bars in the center of the channel at station S2 is typical of stream segments elsewhere that are hydraulically adjusting to transport a heavier bedload. As a result of streambed aggradation, the channel widened and eroded around the right bank footbridge abutment. Repairs performed by the Waukegan Park District at the abutments of the footbridge and on the upstream right bank required using rock to armor the streambank. It is possible that some of this rock may have added cobble to the assessed reach but not all cobble came from this source. Analysis of the habitat transect data from 1995 to 2006 at station S2 indicated a 23% annual average increase in average width of the water line when compared to 1994 data (Figure 18). In addition, the 1994 percent average pool area at station S2 decreased from 23.4% to an annual average of 2.5% from 1995 through 2006. From 1994 to 2006 the average pool area at this control station decreased by 89% (Figure 19).

In contrast, station S1 had a 37% annual average increase in the mean water width over the period from 1995 to 2006 in comparison to that of 1994. Mean depth increased by an average of 62% annually. The annual average mean depth was 23.1 cm (9.1 in) (Figure 18) over the 1995 to 2006 period.

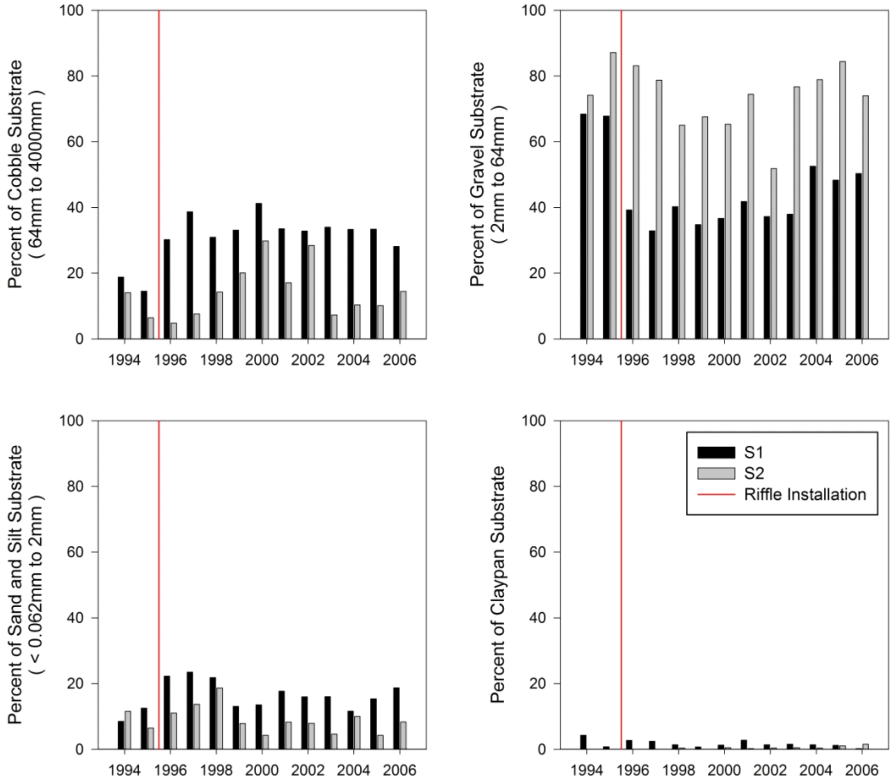

Figure 16. Seasonal average comparison of cobble, gravel, sand, silt, and claypan substrates at stations S1 and S2 before and after construction of riffles and pools in January 1996.

Figure 17. Looking upstream at station S2 in 2004 where the pool depth remains insufficient.

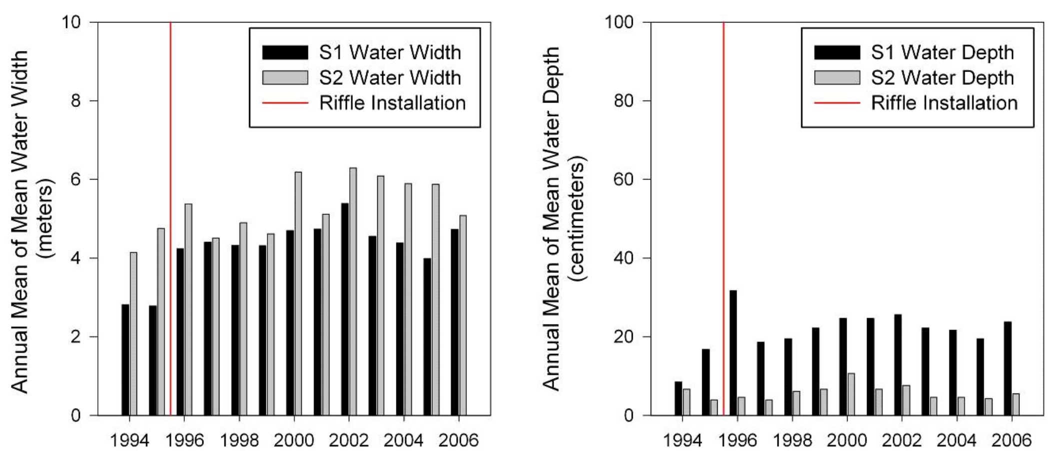

Figure 18. Mean of Spring, Summer, and Fall mean cross-section data (width of water line and water depth) for stations S1 and S2.

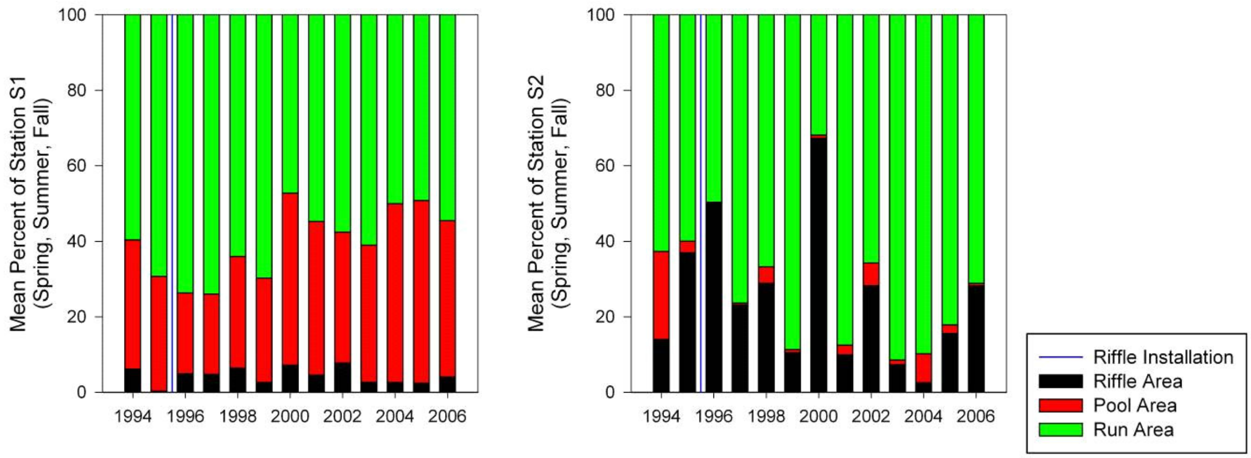

Figure 19. Mean of Spring, Summer, and Fall of riffle, pool and run areas for stations S1 and S2.

North Branch

At station N1, the seasonal average percent sand/silt was the highest compared with all other stations with an annual average of 33%. The percent of sand/silt at N1 decreased after 1997 while the percent of gravel and cobble substrates increased due to the installation in 1996 of riffle and pool structures and bank armoring. Station N1 had an annual average of 40% gravel substrates during the monitoring period from 1994 through 2006 and an annual average of 21% cobble substrates from 1995 through 2006. This is a 58% increase in comparison to the 8.9% gravel bed composition in 1994.

Station N2 had an annual average of 40% cobble substrates with an increase in the seasonal average occurring during 2005 and 2006 due to streambed armoring conducted at that time by the City of Waukegan. At N2, the substrate averaged 36% gravel from 1995 through 2006, a 35% decrease compared to 1994, when gravel comprised 55% of the substrate. The seasonal average percent sand/silt at station N2 was less than 20% over the monitoring period. The seasonal average percent of claypan substrate was minimal at both stations during the monitoring period, with station N1 showing a slight decrease after 2002. Though minimal, station N2 had the highest annual average claypan substrate at 5% when compared to all other stations (Figure 20).

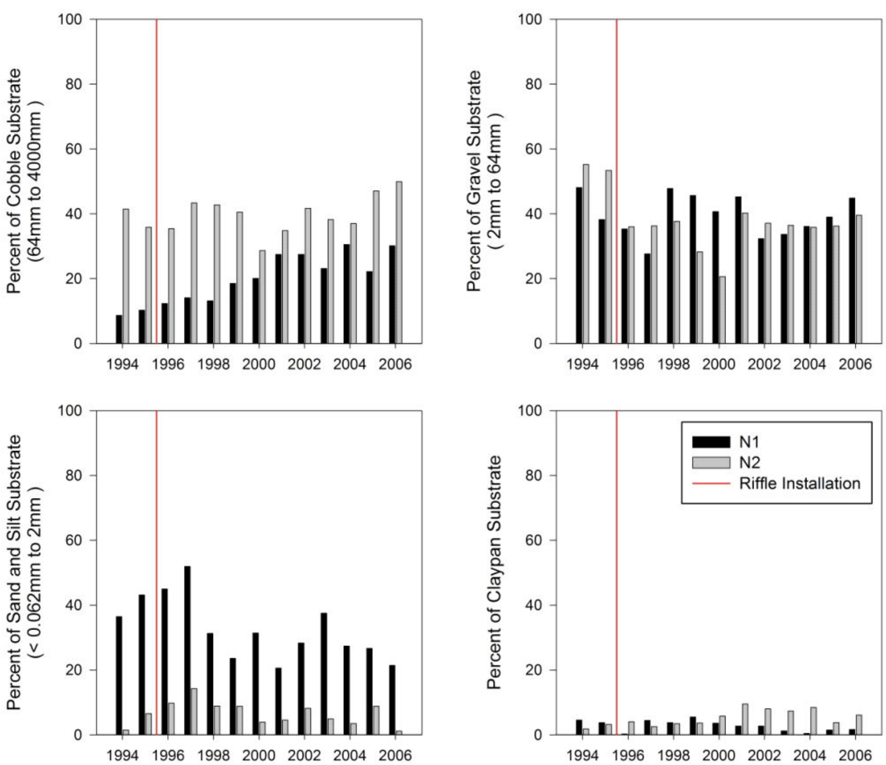

Figure 20. Seasonal average comparison of cobble, gravel, sand, silt, and claypan substrate at stations N1 and N2 before and after construction of Newbury Weirs in 1996.

Analysis of the cross-section habitat data showed the mean water width at station N1 increased annually by an average of 35% compared to 1994. At station N1 the annual average of mean water depth was 22.2 cm (8.7 in) in 1994. Station N2 had an annual average mean depth of 14.3 cm (5.6 in.) and an annual mean water width of 4.3m (14 ft). This represents an increase of 36% over the 2.7m (9 ft) 1994 data (Figure 21).

At station N1 the annual mean pool area was 39% over 1994 to 2006. The annual mean percent pool area at station N2 was 41% in 1994 and only 27% in 2006 reflecting an overall decrease of 34% during this period. The annual mean percent pool area at station N2 over the period 1994 to 2006 was 24% (Figure 22).

Fish and Biological Assessment Results

Pools and cobbled riffle habitat areas were the most valuable instream habitat features in the study area. Increased pool depth and

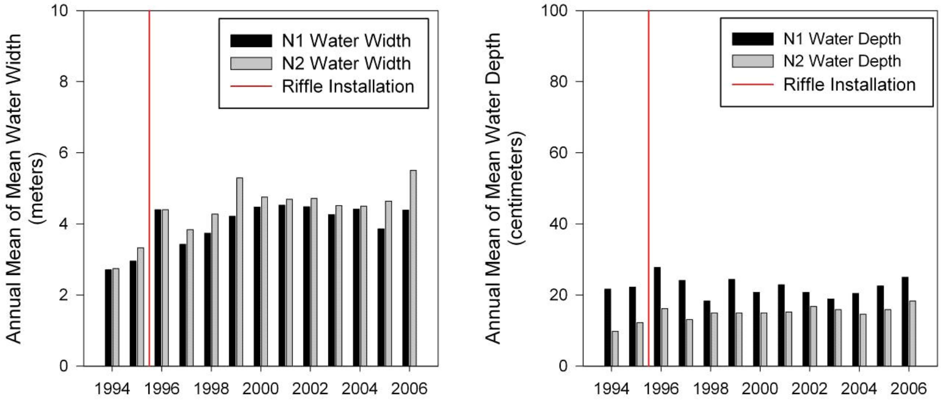

Figure 21. Mean of Spring, Summer, and Fall mean cross-section data (width of water line and water depth) for stations N1 and N2.

cobble riffle habitat at station S1 provided improved habitat and species diversity in 1996 as compared to the sampling years 1994 and 1995 (Figure 23). The specific Newbury Weir riffle design served particularly well to maintain the increased pool depth in the restored area. The deeper pools provided refuge for fish during summer low flows while the upstream reference site (S2) remained extremely shallow and continued to fill with gravel. The long back slope of the riffles at station S1 offered rocky cobble substrate, more turbulence, and additional habitats for fish species as well as the aquatic insects on which they feed. The improved habitat conditions are also responsible for increased numbers of fish species. Bacteria and microflora thriving on the cobbles in the riffles transform ammonia and other soluble nutrients into needed organic material. The air bubbles in the riffle's turbulent water provided oxygen and substrate scour enhancing microbial benefits. The natural geochemical nutrient transformation process in any watershed is very important in maintaining or enhancing stream health and is rarely performing in an optimal fashion in uniformly graded streambeds or modified urban streams.

The Waukegan River was typical of most streams in that it lacked instream habitat. The combination of biotechnical bank stabilization and creation of functioning riffle and pools in the North and South Branch provided necessary additional habitats and promoted healthy fish populations. In 1997, the restored segments of the stream channel in the North and South Branches were stable and well vegetated. The red osier dogwoods were thriving and monitoring at stations S1 and N1 found that the deeper pools and rock riffles functionally persisted.

Biological sampling since 1994 indicated that the abundance of fish and increased number of fish species in the South Branch had improved following the construction of LUNKERS and Newbury weir design for riffle and pools. At the restoration sites S1, N1 and N2, the IBI rose sharply from a limited aquatic resource into the moderate category after construction of the riffles in 1996 (Figure 23). Sampling dates where no fish were discovered were assigned the lowest possible score of 12 (Pescitelli, personal communication). The annual average (average of the seasons and of the period) IBI scores for stations N1 and S1 were in the limited category at 28. Station N2 had an annual average score of 25 and station S2 had an annual average of 21 placing both stations in the limited category. Both N1 and S1 where LUNKERS and Newbury weir riffle and pools were applied averaged higher IBI scores, greater fish numbers, and more fish species than the untreated control at S2 or the N2 bank armored site for the entire period despite all stations averaging in the limited category. An annual average of all the stations throughout the monitoring seasons and throughout the entire monitoring period was 25 (limited). These average scores fall in line with Fitzpatrick *et al*. (2004) where data showed that streams with a high population density had low AIBI scores. Fitzpatrick *et al*. (2005) also described that streams with 40% of the watershed in urban land use tended to have IBI scores below 30. As would be expected, the low IBI scores found in the Waukegan River corroborate these finding and corroborate other studies in

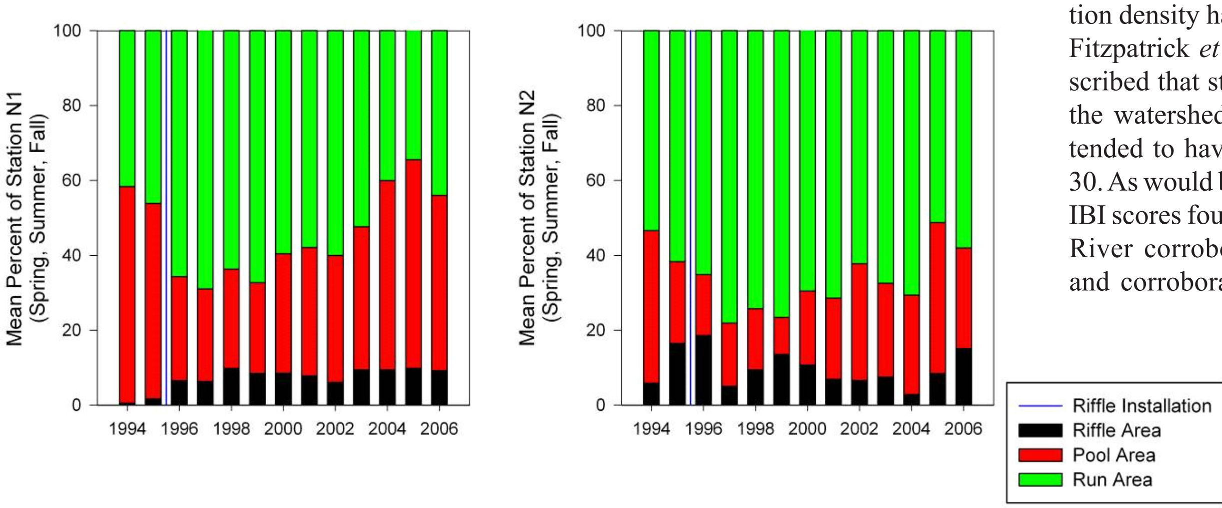

Figure 22. Mean of Spring, Summer, Fall of riffle, pool and run area for stations N1 and N2.

watersheds with relatively high population densities.

Fish kills were documented in the South Branch in 1998 and 1999. The fish kills were observed during very low flow conditions when turbidity was minimal. Fish kills were not observed during sampling after 1999. After 1996, peak IBI scores continued to decline at S1, N1 and N2. Tolerant fish species dominated the fish population at all four stations which factored in to drive down the IBI scores. The mottled sculpin (*Cottus bairdii*) was the only intolerant species caught during the entire period making up less than 1% of the total catch. Threespine Stickleback (Gasterosteus aculeatus) had the highest overall percent of species with intermediate tolerance and Coho salmon (Oncorhynchus kisutch) had the second highest overall percent of species with intermediate tolerance. Coho salmon is a non-native species which occurs at this site because of annual spring stocking of Lake Michigan. Since 1976, approximately 14.7 million salmonids had been stocked annually into Lake Michigan. This figure includes annual stocking of 100,000 Coho salmon in the Waukegan Harbor (Robillard 2009). Eighty percent of the Coho salmon recorded overall were caught during the spring sampling period. Table 2 shows the percent of the total catch of fish species for each station over the thirteen-year period.

Macroinvertebrate Biotic Index (MBI) scores indicated a poor stream condition in the North and South Branches following a pattern similar to the IBI scores (Figure 24). Though the annual average at station S1 scored 7.2 (fair), some individual scores at S1 and S2 on the South Branch were calculated to be in the very poor stream condition category. Station S2 had MBI scores that indicated a fair stream condition after restoration that occurred in 1996 persisting up to 2001 when the scores began to move back down reflecting poor stream condition.

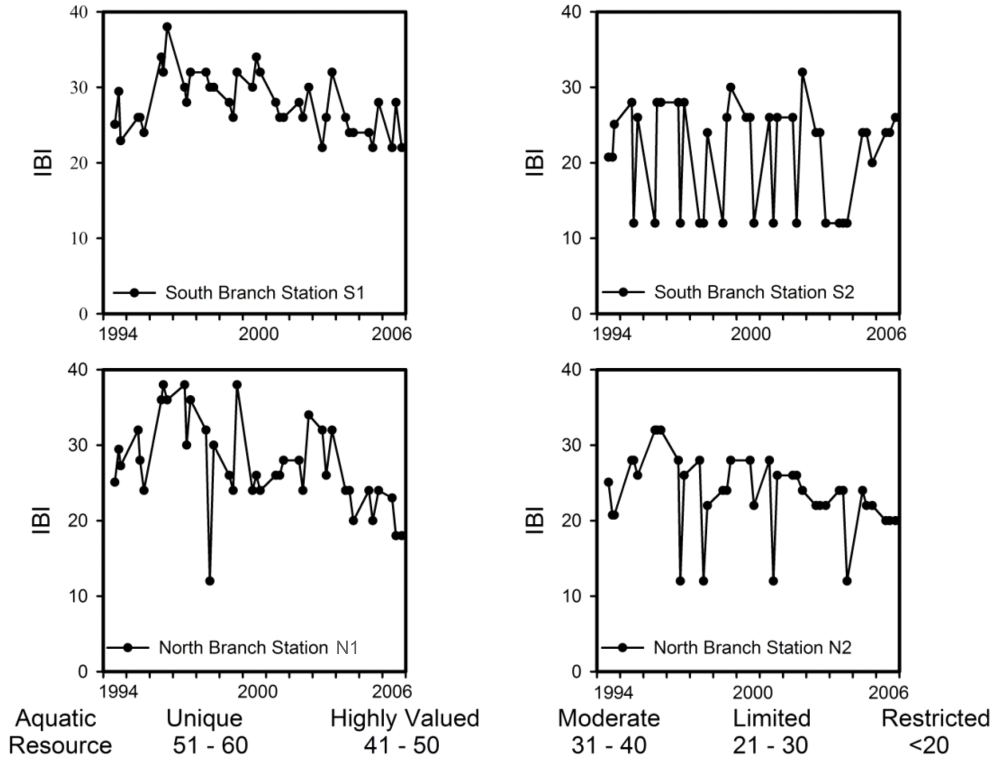

Figure 23. IBI scores from monitoring stations in the Waukegan River.

Table 2. Percent of total fish recorded from monitoring of Waukegan River stations from 1994 to 2006.

Fish Species	Tolerance	Native Status	Station S1	Station S2	Station N1	Station N2
Common Name (Scientific Name)			%	%	%	%
Green Sunfish (*Lepomis cyanellus*)	Tolerant	Native	38.0	13.4	15.2	48.8
Mosquitofish (*Gambusia affinis*)	Tolerant	Native	8.4	37.6	1.6	0.5
Threespine Stickleback (*Gasterosteus aculeatus*)	Intermediate	Non-Native	12.2	31.1	43.5	1.2
Fathead Minnow (*Pimephales promelas*)	Tolerant	Native	12.8	8.7	7.5	9.2
White Sucker (*Catostomas commersoni*)	Tolerant	Native	8.5	2.2	6.4	23.7
Goldfish (*Carassius auratus*)	Tolerant	Non-Native	0.9	0.0	0.9	3.7
Bluegill (*Lepomis macrochirus*)	Tolerant	Native	1.5	0.2	4.6	2.9
Coho Salmon (*Oncorhynchus kisutch*)	Intermediate	Non-Native	0.9	4.3	1.5	2.5
Longnose Dace (*Rhinicthys cataractae*)	Intermediate	Native	4.0	0.2	1.6	0.0
Largemouth Bass (*Micropterus salmoides*)	Tolerant	Native	3.5	0.7	1.6	0.0
Golden Shiner (*Notemigonus crysoleucas*)	Tolerant	Native	2.4	0.7	1.6	0.0
Carp (*Cyprinus carpio*)	Tolerant	Non-Native	1.8	0.0	1.1	1.9
Number of remaining species <1% & percent			(12) 5.1%	(3) 0.9%	(13) 12.9%	(8) 5.6%

Station S2 had the highest annual average score of 7.5 and remained in the fair category, although on the borderline of poor. The station N1 restoration site also had MBI scores in the fair stream condition category from 1995 through 2001 (during and after stream restoration) when the scores then began to slightly drop to a poor stream condition. The annual average MBI score at station N1 was 6.9 (fair). Station N2 maintained higher scores indicating better quality throughout the project period with the exception of 2004 and 2006 when scores exhibited poor stream conditions. The annual average MBI score at station N2 was 6.6, also in the fair category.

Pollution-tolerant taxa such as Chironomidae (bloodworms or midge fly larvae), Oligochaeta (aquatic earthworms), and Caecidotea (pillbugs or sowbugs) dominated the overall population of collected species (Table 3). The average taxa richness for the thirteen-year period at stations N2, N1, and S2 was 8 (poor) while station S1 averaged a 10 (fair). An overall average of the EPT (Ephemeroptera + Plecoptera + Trichoptera) taxa richness for stations N1 and N2 were in a fair category with a score of 3 where 23% of the 39 sampled dates at station N1 fell into the fair, good, or excellent categories and 13% of the sampled dates at station N2 were in the fair, good, or excellent categories. The remaining percents fell into the poor or very poor category. At stations S1 and S2 the overall average EPT taxa richness score was less than 1 (very poor). Approximately 8% of the sampled dates at both stations fell into the fair, good or excellent categories.

Review of the functional feeding designations of species collected at sites S1, S2, N1, and N2 from 1994 through 2006 revealed that gatherer/collectors averaged 87% of the populations from all stations, 6% were predators, and 4% were scrapers. The remaining 3% included filter/collectors, omnivores, and shredders. Generalists, such as collectors and filterers, have a broader range of acceptable food materials than specialists (scrapers, piercers, and shredders), and thus are more tolerant to pollution that might alter availability of certain food (Cummins and Klug 1979).

All stations remained within the moderate to highly valued category as indicated by PIBI scores (Figure 25). The PIBI scores climbed slightly throughout the period at treated station S1. Station N1 also climbed slightly probably because of the decrease in percent of silt-mud. The untreated station S2 stayed fairly consistent over the monitoring period. Project scores from bank armored station N2 also remained fairly consistent.

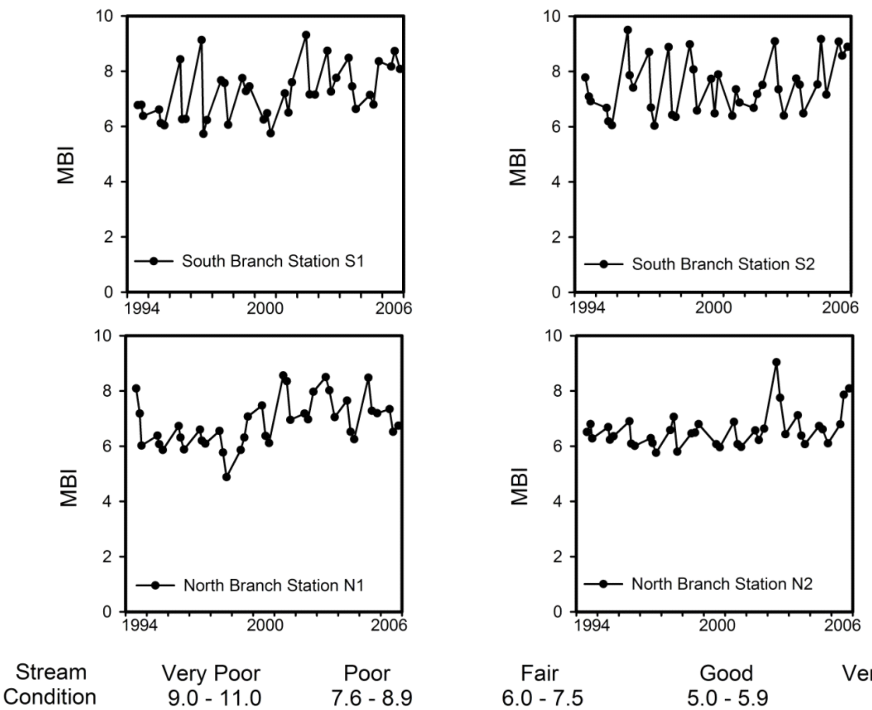

Figure 24. MBI scores from monitoring stations in Waukegan River.

Table 3. Percent of the total macroinvertebrates sampled during the project period (1994-2006) in Waukegan River.

Taxon	Functional Feeding	Tolerance	Station S1	Station S2	Station N1	Station N2
			%	%	%	%
Chironomidae	Gatherer/Collector	6	39.29	37.12	24.42	24.17
OLIGOCHAETA	Gatherer/Collector	10	30.02	27.83	16.35	9.00
Caecidotea intermedius	Gatherer/Collector	6	4.57	1.67	35.83	25.42
Caecidotea	Gatherer/Collector	6	9.30	15.82	12.16	29.17
Physella	Scraper	9	4.42	6.46	1.76	3.23
Erpobdellidae	Predator	8	3.48	2.55	2.76	2.13
Gammarus	Omnivore	3	0.89	0.41	3.19	1.91
Glossiphoniidae	Predator	8	0.76	1.01	0.83	1.85
Ischnura	Predator	6	2.08	1.34	0.05	0.01
Crangonyx	Gatherer/Collector	4	0.03	0.68	0.39	0.94
TURBELLARIA	Predator	6	0.41	1.29	0.03	0.49
Hydropsyche	Filter/Collector	5	0.19	0.22	0.74	0.70
Number of remaining taxa & percent		--	(55) 4.56	(45) 3.60	(25) 1.49	(30) 0.98

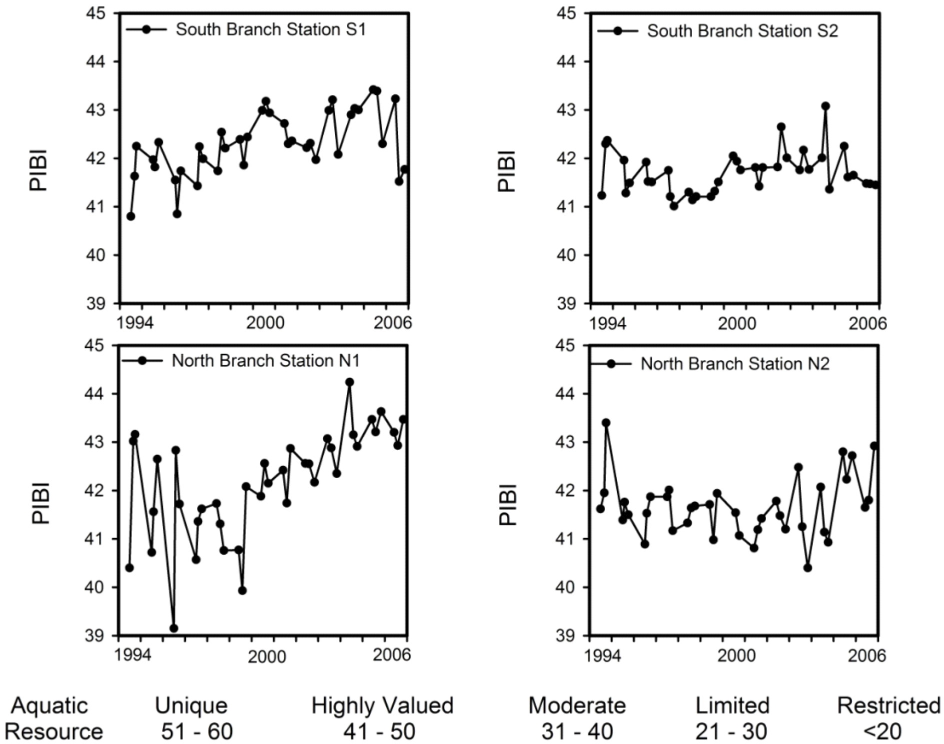

Figure 25. PIBI scores from monitoring stations in Waukegan River.

This site exhibited an increase in the percent of claypan substrate driven by local scouring which affected the scores. The annual average PIBI score was 42 at all stations, remaining in the highly valued aquatic resource category.

Funding was not available to monitor nutrients in the river. However, data collection beginning in 2003 from sondes recorded temperature, conductivity, pH, and dissolved oxygen (DO) at stations S1 and N1. The sonde data and other field observations indicated that the Waukegan River is highly eutrophic. Extensive periphyton growth was routinely observed during onsite vists when technicians were exchanging monitoring equipment (Pfister, personal communication). Dissolved oxygen data indicated that, at times, the DO levels dropped below the Illinois Pollution Control Board 5 mg/l DO limit for aquatic life and did so for long periods during the summer months. Illicit sewer hookups were discovered during a 2006 stream survey. Disharges in situations like this can contribute to elevated fecal coliform levels (Kabbes Engineering, Inc. and Geosyntec Consultants 2007), eutrophication, and perhaps other water quality impairments.

Conclusions

The Waukegan River Illinois National Nonpoint Source Monitoring Program Project demonstrated that biotechnical streambank stabilization helped reduce erosion and provided additional water quality and instream habitat benefits. Evidence continues to suggest that Newbury weir riffle and pool design structures successfully mimic natural pool and riffles sequences and increase instream habitat and biodiversity. In addition to enhancing habitat and biodiversity, pool and riffle structures effectively reduce streambed and streambank erosion and improve stream stability and aeration.

Overall, the project clearly showed that naturalization of stream channel morphology and enhancement of habitat does improve biological diversity, at least temporarily, but sustaining biological diversity is not necessarily achievable by those efforts alone. Often, more comprehensive conservation efforts are required to address other systemic problems relating more specifically to water quality impairments associated with development and water and sewer management operations, hydrologic alterations and discharge extremes, and reduction of summer base flow.

It is clear that in the case of the Waukegan River watershed, there is a need to update sewage and stormwater infrastructure and maintenance operations as well as adopting comprehensive plans and management ordinances that implement and enforce alternative conservation practices to infiltrate and treat stormwater. Habitat enhancements, naturalization of hydrologic regimes, and reduction of current sources of water quality impairments are essential components of comprehensive watershed management plans. These problems need to be addressed with innovative, environmentally sound practices if biologically sustainable floral and faunal communities and other value-added natural watershed amenities are to be sufficiently available to elevate overall quality of life for citizens who live, work, and "play" in a watershed (White *et al*. 2006).

Although the local restoration efforts applied in the Waukegan River failed to overcome the impact of water quality degradation from the watershed, the study was a success by defining issues more clearly and drawing attention to the importance of addressing the watershed in its entirety. Efforts to take positive action throughout the watershed came to life when, in 2005, a Waukegan River watershed planning initiative began. At that time a local advisory group began facilitating more comprehensive watershed planning with local stakeholders and eventually developed a comprehensive watershed plan. This plan included the selection of a watershed coordinator, formation of stakeholder and technical planning committees, stakeholder workshops, watershed data evaluation and resource inventory, and a proposed Action Plan to improve water quality and to identify and reduce pollutants while protecting, restoring and enhancing the natural habitat and aesthetics.

The Waukegan River watershed planning effort brought together the general public, governmental entities, local businesses, educational institutions and homeowners in the watershed to improve the quality of life for their community. The result of the present planning efforts was the creation of a contemporary Waukegan River Watershed Plan in December 2007 with input from all the involved stakeholders.

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INFORMATION

EPA Releases First-Ever Baseline Study of U.S. Lakes

EPA released its most comprehensive study of the nation's lakes to date. The draft study, which rated the condition of 56 percent of the lakes in the UnitedStates as good and the remainder as fair or poor, marked the first time EPA and its partners used a nationally consistent approach to survey the ecological and water quality of lakes. A total of 1,028 lakes were randomly sampled during 2007 by states, tribes and EPA.

The National Lakes Assessment reveals that the remaining lakes are in fair or poor condition. Degraded lakeshore habitat, rated "poor" in 36 percent of lakes, was the most significant of the problems assessed. Removal of trees and shrubs and construction of docks, marinas, homes and other structures along shorelines all contribute to degraded lakeshore habitat. Nitrogen and phosphorous are found at high levels in 20 percent of lakes. Excess levels of these nutrients contribute to algae blooms, weed growth, reduced water clarity, and other lake problems.

The survey included a comparison to a subset of lakes with wastewater impacts that were sampled in the 1970s. It finds that 75 percent show either improvements or no change in phosphorus levels. This suggests that the nation's investments in wastewater treatment and other pollution control activities are working despite population increases across the country.

The results of this study describe the target population of the nation's lakes as a whole and are not applicable to a particular lake.

The draft study can be viewed at http://www.epa.gov/lakessurvey.

EPA Study Reveals Widespread Contamination of Fish in U.S. Lakes and Reservoirs

A new EPA study shows concentrations of toxic chemicals in fish tissue from lakes and reservoirs in nearly all 50 U.S. states. For the first time, EPA is able to estimate the percentage of lakes and reservoirs nationwide that have fish containing potentially harmful levels of chemicals such as mercury and PCBs.

The data showed mercury concentrations in game fish exceeding EPA's recommended levels at 49 percent of lakes and reservoirs nationwide, and polychlorinated biphenyls (PCBs) in game fish at levels of potential concern at 17 percent of lakes and reservoirs. These findings are based on a comprehensive national study using more data on levels of contamination in fish tissue than any previous study.

EPA is conducting other statistically based national aquatic surveys that include assessment of fish contamination, such as the National Rivers and Streams Assessment and the National Coastal Assessment. Sampling for the National Rivers and Streams Assessment is underway, and results from this two-year study are expected to be available in 2011. Collection of fish samples for the National Coastal Assessment will begin in 2010.

More information: http://www.epa.gov/waterscience/fishstudy

More information on local fish advisories: http://www.epa.gov/waterscience/fish/states.htm

Search EPA's Section 319 Nonpoint Source Grants Database

EPA's Nonpoint Source Grants Reporting and Tracking System (GRTS) is the primary tool for management and oversight of state Nonpoint Source (NPS) Management Programs under Section 319 of the Clean Water Act. EPA recently added new tools to the GRTS database to enable the public to search for information about NPS pollution control projects.

One way to search the database is to perform a criteria-based query. This method is best for finding 319 projects that meet certain conditions; for example, NPS projects that implement a Total Maximum Daily Load to control mine waste, or projects implementing best management practices for waters polluted by urban runoff. To search for projects, visit http://iaspub.epa.gov/grts/projects.

Another new search tool is the interactive map, which enables browsing for project information by watershed. Use the find, pan, and zoom buttons to navigate to the location of interest, and the 319 projects will appear, summarized by watershed. At a regional scale, projects are displayed by subbasins (8-digit hydrologic units), and at a local scale, by subwatersheds (12-digit hydrologic units). Check out the GRTS Map Viewer at http://iaspub.epa.gov/grts/map.

For more information on GRTS, please visit http://www.epa.gov/nps/grts, or contact Santina Wortman at wortman.santina@epa.gov.

EPA Launches TMDL Program Results Analysis Web Site

EPA has developed a new Web site to communicate information about Total Maximum Daily Load (TMDL) Program results to technically specialized audiences, including TMDL developers, state water programs, academia, other federal agency programs, and EPA water quality staff. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. The TMDL Program Results Analysis Project is a multi-year effort directed at measuring and analyzing programmatic and environmental results of the program.

The Web site provides a Clean Water Act Impaired Waters Program Pipeline navigation feature, fact sheets, EPA reports and Web sites, EPA grantee reports and Web sites, publications, and datasets related to this effort. The TMDL Program Results Analysis Web site is available at http://www.epa.gov/owow/tmdl/results.

EPA Launches "TMDLs at Work" Web Site

EPA has released a new Web site which provides a collection of stories to inform and educate stakeholders about the benefits of developing pollution reduction budgets, or total maximum daily loads (TMDLs), to protect and restore water quality. The site provides both *sound byte* (one to two pages) and *technical* (four to five pages) fact sheets, representative of TMDLs prepared by states around the country. These fact sheets illustrate how stakeholders can get involved in identifying and cleaning up polluted waters that do not meet their state's water quality standards. The fact sheets also give real-life examples of benefits citizens can enjoy from a cleaned-up waterbody, including enhancements to recreation or better quality drinking water supplies. The collection of "TMDLs at Work" stories may be updated or expanded annually.

The "TMDLs at Work" Web site is available at http://www.epa.gov/owow/tmdl/tmdlsatwork/.

Center for Watershed Protection Updates National Pollutant Removal Performance Database

The Center for Watershed Protection has updated its National Pollutant Removal Performance Database, Ver. 2, published in 2000, to include an additional 27 studies published through 2006. The updated database was statistically analyzed to derive the median and quartile removal values for each major group of stormwater BMPs. The brief technical paper presents the data as box and whisker plots for the various pollutants found in stormwater runoff. This Pollutant Removal Database Report (V.3) is now available for direct free download as a PDF from the Center website: http://www.cwp.org

EPA Releases Guidance to Help Federal Facilities Better Manage Stormwater

EPA has issued guidance to help federal agencies minimize the impact of federal development projects on nearby water bodies. The guidance is being issued in response to a change in law and an Executive Order which calls upon all federal agencies to lead by example to address a wide range of environmental issues, including stormwater runoff.

EPA worked closely with other federal agencies to develop this document, which provides background information, key definitions, case studies and guidance on meeting the new requirements of the Energy Independence and Security Act of 2007.

Under the new requirements, federal agencies must minimize stormwater runoff from federal development projects to protect water resources. Federal agencies can comply using a variety of stormwater management practices often referred to as *green infrastructure* or *low impact development* practices, including reducing impervious surfaces, using vegetative practices, using porous pavements and installing green roofs.

More information on the guidance can be found at http://www.epa.gov/owow/nps/lid/section438/.

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Production of NWQEP NOTES is funded through U.S. Environmental Protection Agency (EPA). Project Officer: Tom Davenport, Office of Wetlands, Oceans, and Watersheds, EPA. 77 W. Jackson St., Chicago, IL 60604. Website: http://www.epa.gov/OWOW/NPS

MEETINGS

Meeting Announcements — 2010

April

2010 International Low Impact Development Conference: Redefining Water in the City: April 11-14, 2010, San Francisco, CA. View conference website at http://content.asce.org/conferences/lid10/

Seventh National Monitoring Conference: Monitoring from the Summit to the Sea: April 25-29, 2010, Denver, CO. Sponsored by the National Water Quality Monitoring Council. View conference website at http://acwi.gov/monitoring/conference/2010/. See highlight on Page 22 of this newsletter for more information.

May

World Environmental & Water Resources Congress 2010: Challenges of Change: May 16-20, 2010, Providence, RI. View conference website at http://content.asce.org/conferences/ewri2010/courses.html

June

Maintaining Permeable Interlocking Concrete Pavement: A Hands-On Demonstration: June 4, 2010, Monterey, CA. View conference website at http://www.bae.ncsu.edu/stormwater/training/permeable _pavement.html

Bioretention Summit: Ask the Researcher: June 29-30, 2010, Raleigh, NC. View conference website at: http://www.bae.ncsu.edu/stormwater/training/bioretention_summit.html

July

GEER 2010: Greater Everglades Ecosystem Restoration Planning, Policy and Science Meeting: The Greater Everglades: A Living Laboratory of Change: July 12-16, 2010, Naples, FL. View conference website at http://www.conference.ifas.ufl.edu/GEER2010

Bioretention Summit: Ask the Researcher: July 15-16, 2010, Annapolis, MD. Visit conference website at http://www.bae.ncsu.edu/stormwater/training/bioretention_summit.html

10th International Conference on Precision Agriculture, July 18-21, 2010, Denver, CO. Visit conference website at http://icpaonline.org/

August

StormCon: the North American Surface Water Quality 9th Annual Conference & Exposition: August 1 - 5, 2010, San Antonio, TX. Visit conference website at http://www.StormCon.com

2010 AWRA Summer Specialty Conference: International Specialty Conference & 8th Caribbean Island Water Resources Congress on Tropical Hydrology & Sustainable Water Resources in a Changing Climate: August 20-September 1, 2010, Puerto Rico. View conference website at http://awra.org/meetings/PR2010/

November

2010 AWRA Annual Water Resources Conference: November 1-4, 2010, Philadelphia, PA. View conference website at http://awra.org/meetings/Philadelphia2010/index.shtml

TMDL 2010: Watershed Management to Improve Water Quality: November 14-17, 2010. Baltimore, MD. View conference website at http://www.asabe.org/meetings/tmdl2010/index.htm

Stream Restoration in the Southeast: Connecting Communities with Ecosystems: November 15-18, 2010, Raleigh, NC. View conference website at http://www.ncsu.edu/srp/conference.html

Meeting Announcements — 2011

January

2011 Land Grant and Sea Grant National Water Conference: January 31 - February 1, 2011, Washington, DC. View conference website at http://www.soil.ncsu.edu/training/training.php

May

American Ecological and Engineering Society Annual Meeting: May 20-26, 2011. Asheville, NC. View conference website at http:www.bae.ncsu.edu/workshops

August

4th National Conference on Ecosystem Restoration (NCER): August 1-5, 2011, Baltimore, MD. Visit conference website at http://www.conference.ifas.ufl.edu/NCER2011

September

2011 LID Green Infrastructure Congress: Greening the Urban Environment: September (dates to be announced), Philadelphia, PA. Three great conferences combined in one location: 19th National NPS MonitoringWorkshop, EWRI LID Conference, Pennsylvania Stormwater Symposium.

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The NCSU Water Quality Group publications list and order form can be downloaded at
http://www.ncsu.edu/waterquality/issues/pub_order.html

Call for Papers

18th National NPS Monitoring Workshop
Monitoring and Evaluation Workshop for Great Lakes Restoration Initiative

November 16-18, 2010 – Milwaukee, Wisconsin

The Annual Nonpoint Source (NPS) Monitoring Workshop is an important forum for sharing information and improving communication for controlling and monitoring NPS pollution issues and projects. The focus of the 18 th National Workshop is on nutrients and what lessons we have learned that can be factored into the projects funded under the Great Lakes Restoration Initiative (GLRI).

A number of technical workshops and interactive learning sessions will be offered to build knowledge and skills, transfer technology and promote innovative evaluation/documentation techniques. Technical workshops include Utilizing Social Indicators in Watershed Management Projects, Transforming Data into Information and Enhancing State Nutrient Reduction Strategies.

Specific topics that will be highlighted include:

- Controlled Drainage Practices for Agricultural
- Innovative Agricultural Conservation and Management Practices
- TMDL and Watershed Management Plan Implementation
- Section 6217 NPS Efforts
- Urban NPS / Stormwater Management
- NPS pollution and Great Lakes aquifers
- Integrating social indicators monitoring with environmental monitoring
- Monitoring the impacts of agricultural drainage management
- Innovative monitoring in agricultural and urban landscapes
- Monitoring for decision making
- Detecting change in water quality from BMP implementation
- Presenting monitoring data to the public
- Riparian area, Wetland Restoration and stream protection/restoration

Submit abstracts and biography to June 4, 2010:
Liz.Hiett@tetratech.com (phone: 703-385-6000)

Workshop Queries:
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