Assessing Progress
on the 1997 Integrated Management Plan
for the Illinois River Watershed
The University of Illinois’ Prairie Research Institute (PRI) provides objective scientific expertise, data, and applied research to aid decision-making and provide solutions for government, industry, and the people of Illinois. PRI is the home of the state’s five scientific surveys: the Illinois Natural History Survey (INHS), Illinois State Archaeological Survey (ISAS), Illinois State Geological Survey (ISGS), Illinois State Water Survey (ISWS), and Illinois Sustainable Technology Center (ISTC).

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EXECUTIVE SUMMARY

The Illinois River Watershed (IRW) encompasses approximately 44 percent of the land in Illinois. The watershed plays a prominent role in supporting the ecological structure and function of natural resources of the state by providing a habitat for fish and wildlife, giving recreational opportunities, producing fertile floodplain soils, and providing a resource for drinking water to human and animal inhabitants as well as water for irrigation of agricultural lands and industrial uses. Participants in the development of the 1997 Integrated Management Plan (IMP) for the Illinois River Watershed determined that the success of the plan could be measured against these seven objectives:

- Objective 1: Healthy levels of abundance, distribution, and diversity of plant and animal communities.
- Objective 2: Restoration of highly eroded streams: 1 percent by the year 2000; 10 percent by the year 2010.
- Objective 3: In all stream segments, the attainment of water quality standards and, every 10 years, a 10 percent improvement in the Index for Biotic Integrity (a state index of biodiversity related to water quality).
- Objective 4: Reduction of the river’s deviation from the natural hydrograph (volume, depth, and duration of water flows).
- Objective 5: For floods with 2-5 year frequencies, reduction of peak flows to the river by 2-3 percent.
- Objective 6: A viable economy that enhances the ecological value of the watershed through high-quality job creation.
- Objective 7: A measurable reduction of the amount of sediment entering the Illinois River and its tributaries.

The plan also listed 34 recommendations, some of which included detailed goals on how to achieve these objectives (see Appendix A).

The Office of the Lieutenant Governor asked the University of Illinois’ Prairie Research Institute (PRI) to review and report on the progress that has been made toward these objectives over the past 20 years based on PRI’s data and studies. As home to the state’s five scientific surveys, PRI offers diverse scientific expertise and perspectives and a wealth of long-term data on Illinois’ resources.

Although PRI conducts many monitoring and research studies directly related to these seven objectives, no dedicated funds were set aside by the state in 1997 to achieve those objectives. Since then, however, some progress or monitoring has been conducted with targeted programs, and some has been a side benefit of other programs. This report is an attempt to evaluate the 20-year progress on the objectives based on a compilation of existing PRI data sources, status and trend summaries, and monitoring and research efforts conducted in accordance with PRI’s mission. From this evaluation, PRI has also identified a number of recommendations for future studies of the Illinois River Watershed that would enable a more complete picture of progress in the coming years and expand on the objectives to cover areas of concern not included in the IMP in 1997.
Objective 1: Healthy levels of abundance, distribution, and diversity of plant and animal communities

Since the creation of the 1997 IMP, there have been numerous restoration efforts for backwater lakes, streams, and wetlands. These efforts have resulted in thousands of acres of wetlands being restored and the re-establishment of habitat, leading to increases in waterfowl use-days and increased populations of waterfowl, bird species, native fish species, and other wildlife. For example, bald eagle (*Haliaeetus leucocephalus*) populations along the Illinois River have grown by 50 percent since 2000. Long-term trends indicate that the number and abundance of native fish species have steadily increased. The number of non-native fish species has gone up since 1985, and the abundance of these species has increased since 2000. Numerous ongoing research and management activities addressing the negative impacts of invasive species in the Illinois River need to continue, particularly as new invaders are detected in the system. For example, multiple state and federal agencies are addressing the impacts and risks of Asian carp, while the INHS has recently discovered a new exotic clam in the Illinois River. In addition, there are concerns about the impacts of legacy and new contaminants on native species in parts of the watershed.

Objective 2: Restoration of highly eroded streams: 1 percent by the year 2000; 10 percent by the year 2010

Since the 1997 IMP was adopted, the scientific community has determined that restoration of streams to pre-degradation standards is not feasible. The standard for stream restoration is now stream stability. ISWS and ISGS made some assessments of erosion and stability of stream reaches and tributaries in the Illinois River Watershed between 2000 and 2010, but few restoration activities were initiated. With a reduction in assessment and restoration funding across state and local agencies since then, these assessments and restoration efforts have significantly reduced or ceased. Therefore, it is assumed that stream restoration likely remains below even the 1 percent reduction level set to be achieved by 2000.

Objective 3: In all stream segments, the attainment of water quality standards and, every 10 years, a 10 percent improvement in the Index for Biotic Integrity

The Illinois Environmental Protection Agency (IEPA) has led the water quality standards effort, especially for nutrients, and coordinated the development of the *Illinois Nutrient Loss Reduction Strategy (NLRS)*. A biennial report discusses the first two years of the Illinois NLRS implementation.

The Index of Biotic Integrity (IBI) is a scoring system of biodiversity related to water quality. For the Illinois River Watershed, IBI can be calculated using data from standard fish community assessments conducted throughout the watershed annually. Since 1963, the overall trend for IBI has been increasing throughout the watershed. In the past 20 years, IBI has increased by 51 percent (from 14.5 to 22.0), indicating improvements in the physical, chemical, and biological functioning of the ecosystem.

Other water and sediment contaminants such as polycyclic aromatic hydrocarbons (PAHs—known carcinogens), polychlorinated biphenyls (PCBs), and metals that were already being regulated have shown a dramatic reduction in sediment concentrations since the 1980s (shortly after the national Clean Water Act). These contaminants are persistent environmental pollutants and effective cleanup may
require more than time alone. Furthermore, chloride from road salt, which was not previously considered an issue, has become an emerging contaminant of concern that can impact watershed biodiversity because of its increased use on roadways. Other emerging aquatic contaminants such as pharmaceuticals and personal care products are also becoming a concern because of their potential negative impacts on human and ecosystem health.

Objective 4: Reduction of the river's deviation from the natural hydrograph (volume, depth, and duration of water flows)

The natural streamflow hydrograph of the Illinois River was significantly altered by the construction in the 1900s of the Illinois River Waterway Lock and Dam system and the Chicago River diversion. These actions elicited a major concern that the delicate backwater/riparian ecosystem of the river was compromised by an increased variability in volume, depth, and duration of water flows, particularly in ecologically critical seasons. This is mainly a water management issue that would have to be addressed by the U.S. Army Corps of Engineers, which operates the system. It appears that no research has been conducted on discerning what would constitute a “natural” hydrograph in this “unnatural” system.

Objective 5: For floods with 2-5 year frequencies, reduction of peak flows to the river by 2-3 percent

Analysis of long-term streamflow records by ISWS indicates that present-day flow conditions across most of the Illinois River Watershed are significantly higher than they were in the early and mid-1900s for both average and high flows. These changes coincide with similar increases in mean annual precipitation, which include increases in the frequency of heavy precipitation events. The identified increases in annual maximum flows since 1940 run contrary to Objective 5 to reduce these types of floods. No such decreases in flooding in non-urbanized portions of the Illinois River Watershed have been identified. Moreover, increasing trends could continue if heavy precipitation events become more frequent. Intense urbanization in the Illinois River Watershed, particularly in Northeastern Illinois, could also result in increasing flooding.

Objective 6: A viable economy that enhances the ecological value of the watershed through high-quality job creation

PRI is working with communities in the Illinois River Watershed to aid them in becoming more resilient to flooding, as well as restoring wetlands and introducing sustainable best management practices for businesses, industry, organizations, and local governments.

Objective 7: A measurable reduction of the amount of sediment entering the Illinois River and its tributaries

In 2002, ISWS researchers determined that the average sedimentation rate along the Illinois River ranged from less than 0.1 to 1.9 centimeters per year. A sediment budget for the river was estimated in 2016 using available U.S. Geological Survey suspended sediment load data. Based on the 35-year average, 60 percent of the sediment coming from the Illinois River Watershed is deposited in the river
and its tributaries. Reduction in the sediment load can be achieved by stream stabilization (outlined in Objective 2) and sustainable agricultural and construction practices. ISWS and ISGS are using LiDAR to identify gullies and other landforms that will enable the design and implementation of agricultural best management practices. In addition, hydrologic models are being developed for certain tributary watersheds, as well as for use in calibration of Illinois River Watershed sub-basin models.

Sediment influx (such as agricultural runoff, streambank erosion, transport of silt by tributary streams, and in-system sediment generation by river shoreline erosion) continues to have mainly negative effects on natural and cultural resources in the Illinois River system. Restoring backwater lakes and wetlands can have a dramatic impact on increasing ecosystem health. One restoration technique is the removal of sediments from backwater lakes and side channels that have been losing water capacity for decades. Work over the past 10 years by ISTC’s sediment reuse and Muds to Parks Program determined that sediments from some areas of the Illinois River could provide needed topsoil for distressed properties, such as strip mines and old industrial sites, and also proved highly successful as a soil amendment on sandy farm soils.

**Major Recommendations**

From this evaluation of progress on the 1997 IMP, PRI identified a number of recommendations for future studies of the IRW:

- **Recommendation I:** Establish an inventory of efforts that inform the stewardship of the Illinois River Watershed.
- **Recommendation II:** Maintain existing and create new long-term monitoring programs.
- **Recommendation III:** Restore critical habitats.
- **Recommendation IV:** Reduce the negative impact of non-native species.
- **Recommendation V:** Examine and reduce contaminants.
- **Recommendation VI:** Add an IMP goal to assess groundwater resources and withdrawal impacts on the Illinois River Watershed.
- **Recommendation VII:** Add an IMP goal to implement cultural resources protections and inventory.
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<tbody>
<tr>
<td>BSMP</td>
<td>Benchmark Sediment Monitoring Program</td>
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<td>CP</td>
<td>Comprehensive Plan or the Illinois River Basin Restoration Comprehensive Plan with Integrated Environment Assessment</td>
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<td>CREP</td>
<td>Conservation Reserve Enhancement Program</td>
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<td>GI</td>
<td>Green Infrastructure</td>
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<tr>
<td>IBI</td>
<td>Index of Biotic Integrity or Biotic Integrity</td>
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<td>IDNR</td>
<td>Illinois Department of Natural Resources</td>
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<tr>
<td>IEPA</td>
<td>Illinois Environmental Protection Agency/ILRGWA Illinois River Geomorphic &amp; Watershed Assessment</td>
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<td>INHS</td>
<td>Illinois Natural History Survey</td>
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<td>IRER</td>
<td>Illinois River Ecosystem Restoration</td>
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<td>IRW</td>
<td>Illinois River Watershed</td>
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<td>ISAS</td>
<td>Illinois State Archaeological Survey</td>
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<td>ISGS</td>
<td>Illinois State Geological Survey</td>
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<td>ISTC</td>
<td>Illinois Sustainable Technology Center</td>
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<td>ISWS</td>
<td>Illinois State Water Survey</td>
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<tr>
<td>NLRS</td>
<td>Nutrient Loss Reduction Strategy</td>
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<td>NRCS</td>
<td>Natural Resources Conservation Service (part of USDA)</td>
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<tr>
<td>PAHs</td>
<td>polycyclic aromatic hydrocarbons</td>
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<tr>
<td>PCBs</td>
<td>polychlorinated biphenyls</td>
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<tr>
<td>PPCPs</td>
<td>pharmaceuticals and personal care products</td>
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<td>PRI</td>
<td>Prairie Research Institute</td>
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<td>SDA</td>
<td>Stream Dynamics Assessment</td>
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<td>USACE</td>
<td>U.S. Army Corps of Engineers</td>
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<td>USDA</td>
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<td>USEPA</td>
<td>U.S. Environmental Protection Agency</td>
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INTRODUCTION

The Illinois River Watershed is a complex and unique large river ecosystem that encompasses 44 percent of the land in the state, making it a dominant feature of the Illinois landscape (Figure 1). The Illinois River Watershed plays a prominent role in supporting the ecological structure and function of natural resources of the state by providing habitat for fish and wildlife, supporting recreational opportunities, and producing fertile floodplain soils that enable agricultural communities to thrive. The Illinois River Watershed also provides a resource for drinking water to human and animal inhabitants as well as water for agricultural irrigation and industrial use.

No single program or entity is specifically charged with regular, detailed evaluation and monitoring of progress toward goals and objectives for the 1997 Integrated Management Plan for the Illinois River

Figure 1. The Illinois River Watershed
Watershed (IMP). Multiple programs across PRI, however, do monitor and investigate the status and trends of natural resources across the state and within the Illinois River Watershed specifically. The Long Term Resources Monitoring Program on the Illinois River and the Critical Trends Assessment Program are among the many existing efforts used to aggregate our collective understanding to characterize progress toward the broad vision of improved ecological health and sustainability.

Participants in the development of the IMP determined that the success of this plan could be measured against these seven objectives:

- **Objective 1:** Healthy levels of abundance, distribution, and diversity of plant and animal communities.
- **Objective 2:** Restoration of highly eroded streams: 1 percent by the year 2000; 10 percent by the year 2010.
- **Objective 3:** In all stream segments, the attainment of water quality standards and, every 10 years, a 10 percent improvement in the Index for Biotic Integrity (IBI, a state index of biodiversity related to water quality).
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The plan also listed 34 recommendations, some of which included detailed goals on how to achieve these objectives (see Appendix A).

The Office of the Illinois Lieutenant Governor asked the University of Illinois’ Prairie Research Institute (PRI) to review and report on the progress toward these objectives over the past 20 years based on PRI’s data and studies, as well as any other known sources of information. As home to the state’s five scientific surveys, PRI offers diverse scientific expertise and perspectives and a wealth of long-term data on Illinois’ resources.

To determine the progress made in management of the Illinois River Watershed, PRI convened a response team of expert staff from the five state scientific surveys: Duane Esarey (ISAS), Nancy Holm (ISTC), Laura Keefer (ISWS), Elizabeth Meschewski (ISTC), Andrew Phillips (ISGS), and Jeffrey Stein (INHS). This team coordinated PRI’s response and worked with scientific colleagues throughout the organization to provide a broad view of the status of the Illinois River Watershed by examining data and integrating existing knowledge and expertise amassed by the surveys and others over several decades (detailed in Appendix A).

It is critical to acknowledge that a full, comprehensive evaluation of the ecological status and trends of the entire watershed is a significant endeavor that would require a coordinated multi-year effort leveraging existing capacities and the future potential of the state scientific surveys and their federal, state, and private partners. Some progress or monitoring has been conducted with targeted programs, and some has been a side benefit of other programs. The summary that follows is an attempt to
evaluate progress by aggregating existing PRI data sources, status and trends summaries, and research studies. The progress for each of the seven objectives is discussed in the Evaluation of Progress section below. PRI staff then also identified recommendations for future studies of the Illinois River Watershed that would enable a more complete picture of progress in the coming years and expand on the objectives to cover areas of concern not included in the 1997 IMP.
BACKGROUND: IMP IMPLEMENTATION ACTIVITIES 1997-2007

The 1997 IMP was a major step in organizing interested agencies and parties to agree on problems and possible solutions in the Illinois River Watershed. This launched subsequent efforts to refine and expand the IMP objectives. For example, the U.S. Army Corps of Engineers (USACE) finalized the Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment (CP) in 2007. The CP was the culmination of a multi-year effort through the Illinois River Basin Restoration Authority provided in Section 519 of the Water Resources Development Act (WRDA) in 2000 and the 1970 Flood Control Act. The purpose of the CP was (USACE, 2007):

“[to provide] the vision, goals, objectives, desired future, and identifies the preferred alternative plan to restore the ecological integrity of the Illinois River Basin System. This plan documents the need for and potential scope of the four components called for in Sec 519 (b)(3): a restoration program; a long-term resource monitoring program; a computerized inventory and analysis system; and a program to encourage sediment removal technology, sediment characterization, sediment transport, and beneficial uses of sediment. An implementation framework and criteria are also presented to guide the identification, selection, study and implementation of restoration projects, monitoring and adaptive management activities, and further system investigations.”

The CP was developed by interagency study teams throughout the basin composed of federal, state, and local agencies along with non-governmental organizations and citizen stakeholders. The overarching goals were to (a) identify and address system-wide limiting factors to ecological integrity (structure and function); (b) restore and conserve natural habitat structure and function; (c) establish existing and reference conditions for ecosystem functioning and sustainability against which change can be measured; and (d) monitor and evaluate actions to determine if goals and objectives are being achieved at both the project and system levels. System-limiting factors were identified, each accompanied by a goal to address the limiting factor along with objectives and measures of success. The six goals of the CP were:

1. Reduce sediment delivery to the Illinois River from uplands and tributary channels with the aim of eliminating excessive sediment load;
2. Restore aquatic habitat diversity of side channels and backwaters, including Peoria Lakes, to provide adequate volume and depth for sustaining native fish and wildlife communities;
3. Improve floodplain, riparian, and aquatic habitats and functions;
4. Restore aquatic connectivity on the Illinois River and its tributaries, where appropriate, to restore healthy populations of native species;
5. Naturalize Illinois River and tributary hydrologic regimes and conditions to restore aquatic and riparian habitats; and

Directly and indirectly, these six goals represent many of the same main objectives outlined in the 1997 IMP, with the addition of more refined objectives and, more importantly, measures for observing
impacts. The CP was formulated around various alternative plans with ranges of options to address the system-limiting factors to restore ecosystem structure and function.

It is important to note that the CP was designed to address restoration needs beyond any federal and state agency restoration programs existing at that time. It was expected that the CP would be implemented over the next 50 years by mutual agreement of all parties and was essentially a guide for agency programmatic agendas. The CP was also an effort to organize and coordinate activities across the watershed and allowed agencies to develop a pathway to qualify for federal restoration funding.

A major contribution to the CP by PRI was the creation of the Illinois River Ecosystem Restoration (IRER) - Monitoring and Watershed Assessment Framework (Holtrop and Pegg, 2004). The document was included as Appendix H of the CP and laid out the framework to monitor and measure changes in geomorphic, ecological (aquatic and terrestrial), and hydrology/sediment conditions over the long term for river mainstem, sub-basin, and project-level spatial scales (USACE, 2007). A watershed assessment framework was also recommended after a review of various approaches used across the United States, selecting ones most applicable to the Illinois River Watershed. The intention was that watersheds would be assessed periodically over long periods of time to determine the success of restoration efforts. The key component of the framework was long-term monitoring as the “data provide the foundation for evaluating accomplishment of goals” (Holtrop and Pegg, 2004).

ISGS, ISWS, and INHS assisted the USACE with the CP, and developing the IRER Monitoring Framework can be considered the next steps in the implementation of the 1997 IMP. The follow-through of the CP and Framework then depended on the continued support of agency/organization restoration program efforts. Unfortunately, the interruption of those resources and funding has significantly hampered the continued implementation of the CP and, consequently, the IMP. However, the inherent mission and research efforts of PRI overlap with the IMP and CP objectives and have enabled some of the monitoring and research to continue. These efforts can contribute, in part, to an understanding of the progress made toward the IMP/CP objectives. A summary and discussion of the progress for each IMP objective is given below with additional data and references included in the Appendices.
EVALUATION OF PROGRESS

Objective 1: Healthy levels of abundance, distribution, and diversity of plant and animal communities

Restoring Backwater Lakes and Wetlands: Creating New Habitats

Wetland acreage across Illinois was initially estimated in the National Wetlands Inventory with data collected between 1980 and 1988. An attempt to update this dataset was conducted in 2010 by Ducks Unlimited on a grant sponsored by the Illinois Department of Natural Resources (IDNR). Although specific numbers from this updated inventory are generally considered inaccurate and these data have not been incorporated into the National Wetlands Inventory, statewide trends indicate great increases in open water wetlands and subsequent large decreases in emergent wetlands.

Since 1997, numerous wetland restoration projects have been initiated. These projects, funded by state and federal agencies as well as private groups, have restored thousands of acres of wetlands across the watershed, with significant restored acreage located on river floodplains and commonly planted with native tree species. Clearly, these restored wetlands provide significant wildlife habitat, as well as other wetland functions such as water quality improvement (sediment and nutrient removal and retention), floodwater storage, and shoreline stabilization. However, the extent to which these restored wetlands are helping to mitigate sedimentation and water quality issues in the Illinois River Watershed is not fully understood. PRI scientists have been monitoring restored and created wetlands for the Illinois Department of Transportation, but the success of these mitigation actions is not conclusive. Additional information and research on quantifying the functional contribution of restored wetlands are needed.

Although a detailed accounting of wetlands and backwater habitat restoration is lacking, restoration of backwater lakes and wetlands are likely supportive of stabilizing or positive trends observed in the abundance, diversity, and distribution of plant and animal communities within the Illinois River Watershed. Such habitat improvements in backwater and wetland habitats are reflected in abundant and diverse bird and fish communities, some of which are described in detail below.

Waterfowl Abundance and Use of Wetlands

Large river floodplain systems and their associated wetlands are critical habitats for migrating waterfowl. The Illinois River Watershed, a focal area of the Upper Mississippi River and Great Lakes Joint Venture of the North American Waterfowl Management Plan, has seen significant changes in wetlands composition and extent since the mid-20th century. Alteration and degradation of those habitats since the 1960s has resulted in changes in waterfowl abundance in the Illinois River Watershed. Specifically, an INHS study (Stafford et al., 2010) demonstrated that the size of wetlands and the extent to which wetlands are undisturbed refuges positively correlated with use of these areas by migrating waterfowl. Waterfowl abundance in the Illinois River Watershed (estimated by fall surveys), while variable year to year, has steadily declined since the late 1950s; however, since 1997 abundance has remained relatively stable but variable (Figure 2).

The intent of waterfowl use-day goals set forth through IDNR, the 2005 Illinois Comprehensive Wildlife Conservation Plan and Strategy ver. 1, and the 2015 Implementation Guide to the Illinois Wildlife Action Plan was to achieve and maintain total duck use-days along the Illinois and Mississippi rivers during
autumn migration. The target of 65.2 million use-days corresponds with the combined average total duck abundance along the Illinois and Mississippi rivers commensurate with 1970s levels. These goals assume average weather conditions and continental duck populations at North American Waterfowl Management Plan goals. From 1996 to 2005, duck use-days dwindled to an annual average of 27.3 million or 37.9 million use-days below (58.1 percent) the goal. However, total duck use-days during the most recent 10-year average (2007-2016) were only 47.5 percent below the 1970s goals, and duck use-days during the most recent five-year average (2012-2016) were 43.4 million, only 33.5 percent below target levels. Diving duck (Genera *Aythya*, *Oxyura*, and *Bucephala*) use-days in the 1970s averaged 12.4 million birds during autumn migration along both rivers. Diver populations plummeted to an average of 2.6 million use-days annually between 1996 and 2005. Recently, however, declining duck numbers have recovered to 7.2 million use-days annually during autumn 2012-2016, 41.9 percent below the 1970s numbers. Congruent with progress toward total and diving duck use-day goals since 2005, many wetland rehabilitation and enhancement projects were completed along both rivers, as well as the restoration of three drainage and levee districts along the Illinois River.

Restoration and enhancement projects increase duck use-days twofold: firstly, by increasing the overall number of waterfowl using the Mississippi and Illinois river valleys, and secondly, by increasing the duration of stay among individuals. There is no doubt that a portion of the 16.1 million duck use-day increase since 2005 can be attributed to improved habitat conditions provided through the restoration and enhancement projects. See Goal 4 in Appendix A for more details on waterfowl use of wetlands.

**Bird Abundance**

Examining bird abundance and population trends from 1975 to 2016 within the 17 counties that border the Illinois River can help assess the health of the Illinois River Watershed habitat. Assessments conducted by INHS focused on both wetland species that use the river and associated backwater lakes, such as the bald eagle, double-crested cormorant, and lesser yellowlegs, and floodplain forest species.
that are associated with mature floodplain forests such as the prothonotary warbler and brown creeper (Figure 3).

Population trends of focal bird species within the Illinois River Valley, 1975-2016

Bald Eagle
The bald eagle (*Haliaeetus leucocephalus*) has made a tremendous recovery along the Illinois River. From 1975 to 1985, one eagle was detected on this survey. During the first 25 years of this survey (1975 to 2000), a total of 60 eagles were found, while in 2016 alone, 95 were found. The large increase in eagles can be attributed to the improved water quality of the Illinois River. Today there are likely dozens of eagle nests along the river, and the eagles can often be seen catching fish in the Illinois River. From these results, it is expected that the population of bald eagles along the Illinois River will continue to increase.

Double-crested Cormorant
The double-crested cormorant (*Phalacrocorax auritus*) was once an endangered species in Illinois, but its populations have recovered in a manner similar to the bald eagle. Cormorants are fish-eating birds that breed in colonies (rookeries) along the river. Although they can be seen in the Illinois River, they prefer to forage in the large backwater lakes associated with the Illinois River. It is likely the improvement in water quality and the recovery of the fish community have contributed to the increase in cormorants.

Lesser Yellowlegs
Lesser yellowlegs (*Tringa flavipes*) are a migratory shorebird that only passes through Illinois. This species breeds in the tundra and winters throughout Central and South America. It is likely that the Illinois River Valley provides critical habitat for the species as they migrate both north in the spring and south in the fall. The species can be found in large concentrations in shallow backwater lakes. Although the population trend is generally positive, there is considerable variation year to year.

Prothonotary Warbler
The prothonotary warbler (*Protonotaria citrea*) is a migratory bird that winters in Central America and breeds throughout much of the southeastern United States. This species prefers floodplain forest—the
wetter the better. The increase in population along the Illinois River is likely due to conservation efforts to restore and protect the remaining floodplain forest. Unlike other floodplain forest birds, this species has no specific preference other than having a floodplain forest habitat. Their populations are expected to continue to increase.

**Brown Creeper**

The brown creeper (*Certhia americana*) is a small, cryptic bird that, as its name suggests, creeps up and down trees looking for insects. This species has been rare in Illinois, but one of its strongholds has been the floodplain forests of the Illinois River. Unfortunately, the species has not responded as well as others to the conservation efforts along the river and its populations are decreasing. This species prefers large hardwood trees such as oaks, hickories, and pecans, and there are few locations that still support these trees.

**Fish Communities**

Long-term trends in Illinois River fish communities are best captured in several recent studies by INHS focused on changes over time in four respects: (a) native vs. non-native species richness and abundance; (b) changes in dominant species in the community; (c) changes in the backwater fish community assemblage; and (d) changes in commercial and recreational harvest. Much of the available data used in these studies are the result of investments in long-term monitoring efforts, including the INHS Long Term Electrofishing Program established in 1957.

Beginning with species richness in native and non-native fish species, long-term trends are quite clear. McClelland et al. (2014) demonstrated that the number of native fish species in the Illinois River has steadily increased in the past 60 years. The number of non-native species was relatively stable until 1985, after which time a steady increase has been observed.

As important as species richness is to understanding changes in biodiversity, abundance trends are critical to understanding the ability of the fish community to support recreational and commercial fishing. Beginning in 1976, not long after the passage of the Clean Water Act, native species abundance began to increase while non-native species abundance declined during that time until about 2000, when the arrival of Asian carp changed that trend upward. Furthermore, reductions in the abundance of certain species of Cyprinidae (minnows) resulted in a change in the fish community composition in the Lower Illinois River Basin (Figure 4). These reductions are likely in response to the sudden expansion of non-native Asian carps in the system. Notable declines in the abundance of backwater fishes in the La Grange Reach of the Illinois River over the past two decades were also observed (Anderson, 2017)(Figure 5). The large yearly influx of sediment in the La Grange Reach may be the cause of this decline (See Objective 7 for details on sediment influx).

**Non-native Species in the Illinois River**

Non-native species in the Illinois River are an emergent and persistent threat to the ecological health of the system. The arrival of Asian carp has been a high-profile example of the problems presented by non-native species. In addition, Black carp, which consume juvenile native mussels, have become established in the Mississippi River and appear to have advanced into the Illinois River as far upstream as Peoria. Similarly, the non-native round goby originally appeared in Lake Michigan in the late 1990s and has now been detected downstream in the Illinois River as far south as Peoria. In a very recent example of the
continued threat of non-native species, a new exotic clam was discovered in the Illinois River in 2015 (Tiemann, 2017).

Figure 4. Abundance of native and non-native fish species in 1955-2010

Figure 5. Abundance of backwater fishes in the La Grange Reach of the Illinois River, 1993-2014
Contaminants and Wildlife

Heavily industrialized wetland and river ecosystems were analyzed to see how contaminants have affected wildlife. Important bird species are still living and nesting in contaminated areas, and their bodies contain high levels of contaminants that they pass down to their nestlings (Levengood et al., 2007; Levengood and Schaeffer, 2011; Soucek et al., 2013). Also, some fish species were found to have contaminants that may bioaccumulate and are not safe for human consumption (Levengood and Weicherding, 2002). Furthermore, antibiotic-resistant bacteria are commonly found downstream of wastewater treatment plant effluents (Drury et al., 2013a; Kelly, 2015). (See Goal 4 in the Appendix for a detailed discussion of these findings.)

Objective 2: Restoration of highly eroded streams: 1 percent by the year 2000; 10 percent by the year 2010

Defining Restoration

Unfortunately, the original goal and targets of Objective 2 are unclear, and it is undetermined whether, by addressing highly eroded streams, the goal was to further reduce erosion in general, protect land or infrastructure, reduce downstream sediment loading, or restore habitat to pre-erosion conditions. It appears that any large-scale comprehensive accounting of which tributaries were highly erodible and which were restored does not exist.

This objective may have largely been derived from ISWS research that indicated erosion was the source of 30-40 percent of sediment from eastern watersheds and up to 80 percent from western watersheds (Demissie et al., 1992). The researchers were only able to differentiate the larger tributaries as sediment sources to the Illinois River due to the spatial density of the available data. There was still no inventory of which or how many eroded stream reaches existed, leading to questions about which reaches streams are covered in this objective. However, in 2007 the CP divided the Illinois River Watershed into four “sediment delivery regions” based on the connection between sediment load and landscape characteristics. When the 1997 IMP was being developed, there was discussion in the scientific community as to the meaning of “restoration.” By the time the CP was created 10 years later, there was consensus that degradation was largely caused by long-term changes in land use, land cover, and climate; thus, restoring ecosystems or landscapes to pre-degradation conditions was not an attainable goal since most streams were already degraded. Rather, the goal would be to stabilize and enhance the existing condition. The CP contributors determined that a 20 percent reduction in sediment loads from the existing condition was achievable within 50 years, assuming appropriate funding levels. This reduction target had also been used in the 1998 USDA-IDNR Conservation Reserve Enhancement Program (CREP) for the Illinois River Watershed. PRI continues to perform CREP monitoring (entering the 18th year), and further discussion of those efforts appears later in this section.

Goal 1 of the CP was “Reduce sediment delivery to the Illinois River from upland areas and tributary channels with the aim of eliminating excessive sediment load.” This goal encapsulated Objectives 2 and 7 of the 1997 IMP because they are intimately related. Reductions in sediment delivery, Objective 7, were to be determined by future updates to the ISWS Sediment Budget, with the year 2000 as the baseline (Demissie et al., 2004). (See further information on sediment loading in Objective 7).
Important definitions in the CP were stream “stability” and “excessive” sediment load. In essence, stable streams are those that pass the imposed water and sediment load standards while maintaining their essential configuration over time. Excessive sediment loads are those that either are higher than expected for a given stream condition or contribute to a progressively degrading habitat. Note that those impacts are independent of each other. For example, direct tributaries to the Illinois River in the Peoria area and the Hickory Creek tributary to the Des Plaines River are recognized as highly eroded and in need of restoration; i.e., returning channels and floodplains to functions that support ecosystems in a sustainable state.

Soil loss from streambank erosion and introduction of sediment from tributary streams typically can also degrade embedded cultural resources along stream borders throughout the Illinois River Watershed. At present, cultural resources are largely considered only in terms of obtaining clearance for restoration efforts addressing other resource degradation. (See Recommendations section for new objectives proposed for preserving cultural resources in the Illinois River Watershed).

**Assessment and Restoration Activities Since 1997**

Based on the CP and supported by limited funding from the USACE with IDNR cost-share, ISWS, ISGS, and INHS formed a team in 2005 to assess direct tributaries to the Illinois River near Peoria (Partridge Creek, Senachwine Creek, and Ten Mile Creek) for stream restoration needs. This assessment team used the Illinois River Basin Geomorphic & Watershed Assessment (IRBGWA) and Stream Dynamics Assessment (SDA) methodology to characterize historical and current physical and ecological conditions, changes in land use/cover, as well as construction in channels and in a number of creeks from 2005 to 2010. The assessments showed that geology, land use, historical upland and channel modifications, and climate are key factors in stream channel instability for highly erodible areas. When funding ceased, few restoration activities were initiated because of the limited funding.

The Stream Dynamics Assessment (Phillips et al., 2002; Urban and Rhoads, 2003) evaluated other selected stream reaches across the Illinois River Basin (Blackberry Creek, Farm Creek, Ferson Creek, Kickapoo Creek, Spoon River, McKee Creek, DuPage River, Sugar Creek, South Fork Sangamon, and West Branch DuPage River) for natural responses to changes in landscape use or water and sediment loading since the 1930s, with aerial imagery from the ISGS Historical Aerial Imagery Program as the baseline (See Goal 10 in Appendix A). A wide range of stream responses occurred in terms of meander migration rates or meander cutoff frequencies to changes in stream power, depending on local geology. Many streams exhibited a slow response to land cover changes, in part because of generally low stream slopes and clayey soils. However, streams with steep slopes or sandy soils showed significant channel form changes under “normal” conditions and responded to landscape changes by increased meander migration rates or by cutting new channels. These natural stream responses are important considerations for successful restoration projects.

In addition to the three watersheds studied by the PRI assessment team, several other geomorphic assessments were conducted on streams in the Illinois River Watershed using the IRBGWA protocols identified in the *IRER-Monitoring and Assessment Framework*. These included Indian Creek, Italian-Dago Slough, Prairie Creek, South Kickapoo Creek, Metz Creek, and Deer Plain Creek. Aerial surveys using a helicopter equipped with GPS (global positioning system) were also conducted to observe obvious indicators of unstable areas, such as eroded streambanks (White and Keefer, 2005; White, 2006). The surveys covered 1,749.66 miles within the Illinois River Watershed and were used to inform resource
managers and as a precursor to ILRGWA and SDA studies. (See Goal 10 in Appendix A for detailed information).

Although most of the funding available for assessments and a few restoration studies ended by 2010, some restoration projects still are being implemented by state/local agencies in response to catastrophes, especially for critical infrastructure. For example, the Peoria Park District recently observed rapid channel degradation of the Forest Park watershed. In response, they reconfigured the landscape to include floodwater drop structures and stream channel armoring. However, there is no current basin-wide comprehensive accounting of these types of restoration projects, long-term monitoring of their success, or a specific definition of the goals for sediment reduction. With fairly universal reduction in restoration funding across state and local agencies, it is assumed that as of 2017, stream restoration likely remains below even the 1 percent reduction level set to be achieved by 2000.

Objective 3: In all stream segments, the attainment of water quality standards and, every 10 years, a 10 percent improvement in the Index for Biotic Integrity

Water Quality Standards

The U.S. Environmental Protection Agency (U.S. EPA) 2008 Gulf Hypoxia Action Plan calls for each of the 12 states in the Mississippi River Basin to produce a strategy to reduce the amount of phosphorus and nitrogen delivered to the Gulf of Mexico. Illinois follows the U.S. EPA recommended framework for state plans. The Illinois Environmental Protection Agency (IEPA) has led the effort to establish standards and has coordinated the development of the Illinois Nutrient Loss Reduction Strategy (NLRS) (IEPA, 2015). The strategy calls for eight key components:

1. Extend ongoing regulatory and voluntary efforts;
2. Identify priority watersheds for nutrient reduction efforts;
3. Establish the Nutrient Monitoring Council to coordinate water quality monitoring efforts by government agencies, universities, non-profits, and industry;
4. Establish the Nutrient Science Advisory Committee, a select committee of scientists that will propose statewide or watershed-wide appropriate numeric water quality standards to the Policy Working Group;
5. Form the Agricultural Water Quality Partnership Forum to oversee outreach and education efforts;
6. Establish the Urban Stormwater Working Group to coordinate and improve stormwater programs and education;
7. Lay out strategies for improving collaboration among government, non-profits, and industry; and
8. Define a process for regular review and revision.

A biennial report discusses the first two years of the Illinois NLRS (IEPA, 2017) implementation of nutrient reduction management strategies. The NLRS Nutrient Science Advisory Committee is tasked with developing metrics to be used for establishing standards.
Contaminants

Biodiversity in the watershed is also related to several environmental factors besides nutrients that affect the water quality. These factors include contamination in sediments and water, hydrologic changes, and human influences. Studies conducted on contaminants in river sediments determined that there has been a reduction in contamination since the 1980s (Cahill et al., 2008; detailed in Appendix A, Goal 2). But the contaminants studied, such as polycyclic aromatic hydrocarbons (PAHs, known carcinogens), polychlorinated biphenyls (PCBs), and metals, are persistent environmental pollutants and may require more effective cleanup methods than time alone. In addition, emerging contaminants such as pharmaceutical and personal care products (PPCPs) are negatively affecting water quality (Zheng et al., unpublished; Drury et al., 2013b; Kelly et al., 2015). For example, Kelly et al. (2015) found that bacterial abundance and diversity were decreased and antimicrobial resistant communities were increased downstream of the discharge point of wastewater treatment plants. In addition, other researchers have found that antidepressants bioaccumulate and negatively impact mating behavior and predation (Arnnok et al., 2016) and estrogen compounds are causing feminization of male fish (Iwanowicz et al., 2015; Blazer et al., 2007; Hinck et al., 2009; Bhandari et al., 2015; Kidd et al., 2006).

Furthermore, Panno et al. (2008, 2010) completed a synoptic study of nitrate and chloride in the Illinois River and compared the results to historical data. The trends were not encouraging: Chloride in surface water has steadily increased since the 1940s when road salt was introduced to combat icing on roads. The rate of increase has been ~1 mg/L/a since around 1960, when concentrations at Peoria were about 30 mg/L, with peak concentrations as high as 488 mg/L (Kelly et al., 2012). Groundwater chloride concentrations, and thus baseflow concentrations, are also increasing. Predictions for 2021 are that biota will be significantly affected. In addition, the annual flux is highly variable, but increasing with time. Individual runoff events can introduce toxic levels of chloride, many times the annual mean. Similarly, nitrate concentrations have increased since the introduction of nitrate fertilizers in the 1960s. Wet season inputs appear to be dominated by agricultural field runoff, whereas dry season concentrations are dominated by municipal wastewater effluent (Panno et al., 2007). Cahill (2017; in press) conducted a soil geochemistry mapping project of Illinois soils, and it serves as a geochemical baseline for the Illinois to understand future contaminants in the Illinois River Watershed.

Biotic Integrity

Biotic integrity or Index of Biotic Integrity (IBI) is a scoring system of biodiversity related to water quality. There is no universal standard value for an index for biotic integrity, and developing consistently accurate metrics for a given ecosystem requires rigorous testing to confirm the validity of the index. IBIs are region-specific and require experienced professionals such as those at PRI to provide sufficient quality data to correctly assess a score of a given region such as the Illinois River Watershed.

For the Illinois River Watershed, IBI can be calculated using data from standard fish community assessments conducted throughout the watershed annually. Although sampling has occurred yearly since the late 1960s, each stream segment is not sampled every year, limiting our ability to exhaustively report segment-level trends within this report. Across the entire watershed, nearly 3,000 assessments were conducted from 1963 to 2015, with sampling intensity increasing significantly beginning in 1994.

Since 1963, the overall trend for IBI is increasing throughout the watershed (Figure 6). When the IMP was adopted in 1997, the watershed mean IBI was 14.5 (SE = 1.1); by 2007, that mean IBI value had
increased 23 percent to 18.0 (SE = 0.7). In 2015 (the most recent year with available data), mean watershed IBI was 22.0 (SE = 0.7), representing another 22 percent increase. This simplistic analysis does not consider changes in IBI at the stream segment level, which likely has greater ecological relevance when assessing progress toward the stated goals of the 1997 IMP.

Objective 4: Reduction of the river’s deviation from the natural hydrograph (volume, depth, and duration of water flows)

The natural streamflow hydrograph of the Illinois River was significantly altered by the construction of the Illinois River Waterway Lock and Dam system in the 20th century. This initiative elicited concern that the delicate backwater/riparian ecosystem of the river was compromised now by the increase in the variability of volume, depth, and duration of water flows, especially during ecologically critical seasons. The Comprehensive Plan (Section 3) noted the cyclic nature of the hydrograph prior to hydrologic modifications in the 1900s. Modifications included not on the construction of the lock and dam system on the Illinois River, but also included watershed activities such as urbanization (increases in impervious surfaces, stormwater runoff) and stream channelization. Figure 7 illustrates the dramatic shift in the hydrograph regime. Appendix C of the CP continues to identify many sources of water level management activities throughout the watershed. This is mainly a water management issue that would have to be addressed by the U.S. Army Corps of Engineers, which operates the system. It appears that no research has been done to discern what would constitute a “natural” hydrograph in this “un-natural” system, including any plans to determine optimal water level management activities.
Objective 5: For floods with 2-5 year frequencies, reduction of peak flows to the river by 2-3 percent

Flooding

Analysis of long-term streamflow records by ISWS (Knapp, 2005) indicates that present-day flow conditions across most of the Illinois River Watershed are significantly higher than they were in the early and mid-1900s, for both average flows and high flows. These changes coincide with similar increases in mean annual precipitation, which include increases in the frequency of heavy precipitation events (Kunkel et al., 2013). The changes in high flows are consistent with findings from several other studies, including Archfield et al. (2016). Additionally, McCabe and Wolock (2002) indicate that such changes in streamflows have not been gradual, but rather abrupt or step-wise, occurring around and prior to 1970. Villarini et al. (2011) appear to substantiate this result, as they found no additional increases in flood peaks since 1970.

The identified increases in annual maximum flows since 1940 run contrary to Objective 5 to reduce these types of floods. No such decreases in flooding in non-urbanized portions of the Illinois River Watershed have been identified. Moreover, increasing trends could continue if heavy precipitation events become more frequent. Winters at al. (2015) found that heavy precipitation in Northeastern Illinois (representing tributaries of the Upper Illinois River) has been increasing and may continue to
increase. Intense urbanization in the Illinois River Watershed, particularly in Northeastern Illinois, could also result in increasing flooding (Hejazi and Markus, 2009).

Flood Impacts on Natural and Cultural Resources
Major flood events that cause levee topping/cutting and catastrophic failures or mediated solutions often drastically impact both natural and cultural resources. Byard et al. (2014) have shown that levee overtopping poses a real threat to cropland and buildings in the Illinois River floodplain. Estimated damages could exceed $1.1 billion during one extreme weather event. In another study (Lian et al., 2008) flooding caused by heavy rain in the Lake Calumet region was examined. It was found that large anthropogenic changes to the hydrology had created a bottleneck flow to an undersized culvert that prevented water from leaving the inundated area. This project is detailed in Goal 2 in Appendix A.

In addition, these major flood events release massive quantities of turbulent water onto leveed floodplain surfaces and strip protective layers off shallowly buried cultural resources across large tracts of floodplains as well as excavate deep plunge pools next to levees. See Goal 7 in Appendix A for a discussion on flood crest reduction strategies that need to be implemented.

Tools & Future Directions
LiDAR (Light Detection and Ranging) is a remote sensing method that uses light in the form of a pulsed laser to measure variable distances from the LiDAR instrument to the Earth. LiDAR elevation data provide critical base layers for modeling surface runoff and flood routing. PRI coordinates statewide collection of these data and makes them available to the public at http://clearinghouse.isgs.illinois.edu/data/elevation/illinois-height-modernization-ilhmp-lidar-data.

PRI is collaborating on an Illinois-Indiana Sea Grant-funded project to evaluate opportunities for green infrastructure (GI) based on soil properties, especially of anthropogenic soils. The scientific goal is to enhance gray stormwater infiltration to reduce loading of sewer systems. Increased use of GI is expected to reduce peak flows in storm watersheds, as well as reducing potential direct runoff of wastewater to streams. Mapping and measurement of soil hydraulic properties will be coordinated with the USDA Natural Resources Conservation Service (USDA-NRCS). In addition to reducing peak flows, the GI is expected to enhance local ecology, thus improving quality of life for a secondary economic benefit (Schuler, 2017). The results should support GI planning and implementation across Illinois, especially in highly developed landscapes, potentially lessening flooding in parts of the Illinois River Watershed.

Objective 6: A viable economy that enhances the ecological value of the watershed through high-quality job creation

Community Resiliency
PRI staff and communities in the Illinois River Watershed (specifically Peoria and Ottawa at the time of this publication) are collaborating to improve the sustainability of these communities, which will enhance their viability and help them maintain and increase ecological attributes and enhance economic development. For example, in 2016, ISTC helped Illinois businesses and communities save $1.1 million, 4.98 million gallons of water, and 10.6 million kilowatt hours of energy and reduce carbon dioxide emissions by 9.6 gigatonnes and municipal solid waste by 241 thousand pounds. These efforts are described in Goal 25 in Appendix A.
Objective 7: A measurable reduction of the amount of sediment entering the Illinois River and its tributaries

Sediment History
In the 1980s, research and data collection programs were established to address science-based information needed by natural resource agencies and planners dealing with erosion and sedimentation issues within the Illinois River Watershed and the state. The goal was to establish a baseline and future data at large scales to determine the magnitude and location of sediment problems. This resulted in the:

a) periodic computation of Illinois River Basin sediment budgets (Demissie, Keefer, and Xia, 1992; Demissie et al., 2004; and Demissie, Getahun, and Keefer, 2016);
b) statewide Benchmark Sediment Monitoring Program (Allgire, 2001a, 2001b, 2002; Allgire and Demissie, 1995; Davie, 1988, 1989, 1990); and
c) watershed hydrologic and water quality modeling.

Sediment Loading
In 2002, PRI researchers determined that the average sedimentation rate along the Illinois River ranged from less than 0.1 to 1.9 centimeters per year (Cahill et al., 2008) (see Goal 2 in Appendix A for details). More recently, Demissie et al. (2016) estimated the sediment budget of the Illinois River using available U.S. Geological Survey (USGS) suspended sediment load data. Daily sediment load equations were developed for 17 sediment-monitoring stations using up to 35 years of data, culminating in four regional relationships between annual sediment loads and annual water discharge, which was then used to estimate annual sediment yields of tributaries to the Illinois River. Based on the 35-year average, 60 percent of suspended sediment delivered from the Illinois River watershed is deposited in the Illinois River and its tributaries, with the remaining sediment transported to the Mississippi River. See Goal 10 in Appendix A for details.

The main methods to reduce the sediment load are by stream restoration (outlined in Objective 2) and sustainable agricultural practices. The ISGS is in the middle of a project funded by USDA-NRCS to develop computer code in a supercomputing environment to automatically identify gullies and other landforms in LiDAR landscapes. The results of this project will be useful in precision agriculture (computerized decision-making to optimize planting and application of agricultural chemicals) and for designing and implementing agricultural best management practices.
Sediment & Nutrient Monitoring Program & Watershed Modeling

In 1981, ISWS established the statewide Benchmark Sediment Monitoring Program (BSMP) with 50 monitoring stations around the state. PRI maintains 14 stations with funding from federal, state, local, and not-for-profit organizations to investigate the magnitude and causes of sediment and nutrient loading for their specific resource management issues. Figure 8 illustrates the location of watershed monitoring stations (six of which are in the Illinois River Watershed). More detailed information about the sponsors, locations, monitoring duration, type of data collected, and major watershed can be found in Table 1 in Appendix A under Goal 12.

Figure 8. Location of historical and current ISWS watershed monitoring stations and the ISWS Benchmark Sediment Monitoring Program (BSMP) stations.
In addition to the BSMP stations, since 1999 the USDA-IDNR Conservation Reserve Enhancement Program (CREP) has sponsored monitoring stations for hydrology and sediment and nutrient loading to detect any changes in nutrient and sediment loading due to CREP. The monitoring also contributes to making more accurate assessments and trends of sediment and nutrient delivery to the Illinois River. Historically, sediment and nutrient monitoring stations within the Illinois River Watershed were limited in number and of insufficient duration to monitor long-term trends, especially in smaller watersheds where changes can be observed and quantified more easily than in larger watersheds. Now with nearly 18 years of detailed monitoring data, long-term and seasonal trends in sediment, nutrients, and streamflow can be analyzed. This detailed monitoring data also is being used to develop hydrologic and water quality models for these stations’ watersheds and to calibrate recently developed models for major watersheds of the Illinois River. These models can then be used to evaluate impacts of best management practices and restoration scenarios, including climate variability, on watershed responses, including flow and sediment and nutrient loadings. The scenario evaluations provide resource managers with valuable information about optimal selection and placement of best management practices in the watersheds. With sufficient years of detailed monitoring data available, both the data analyses and modeling are currently in development with results expected later in 2018.

**Beneficial Uses of Excess Sediment**

Restoring backwater lakes and wetlands can have a dramatic impact on increasing ecosystem health. One restoration technique is the removal of sediments from backwater lakes and side channels that have been losing water capacity for decades. Sediment enters the lake when soil is eroded from land throughout the watershed. Through work by ISTC’s sediment reuse and Muds to Parks Program, dredging techniques and alternative uses of the dredged sediments were investigated. Testing and demonstration projects determined that sediments from some areas of the Illinois River could provide needed topsoil for distressed properties such as strip mines and old industrial sites (Marlin, 2002; Machesky et al., 2005). Dredged material also proved highly successful as a soil amendment on sandy soils in Mason County (Figure 9; Ruiz Diaz and Darmody, 2017). These uses enhance land for farming,
development, parks, and other uses. Using Peoria Lake sediment to provide topsoil for the Lakefront Steel Workers Park (Figure 10) in Chicago is the premiere project to date (Marlin and Darmody, 2005). Since the program’s inception, a number of projects have been completed. (See Goal 2 in Appendix A for a detailed discussion of the findings.)

Figure 10. (left) Sediment dredged from Lower Peoria Lake was barged 165 miles to Chicago for use as topsoil. (right) Prairie plants, grass, and trees at the new Steel Workers Park on Chicago’s lakefront grow in sediment-derived topsoil from Lower Peoria Lake.

Sediment Impact on Natural and Cultural Resources

Sediment influx (such as agricultural runoff, streambank erosion, transport of silt by tributary streams, and in-system sediment generation by river shoreline erosion) has both positive and negative effects on natural and cultural resources in the Illinois River system. The effects on wetlands, wildlife, and water quality have been described in earlier sections.

For cultural resources, shoreline erosion in particular is by far the most destructive agent of nonrenewable cultural resources in the Illinois River Watershed. Compared with all other river systems in the midcontinent, archaeological habitations dating to the past 3,500 years are particularly densely distributed upon the low-lying natural levees adjoining the Illinois River shoreline. This is because of the remarkable geomorphological stability of this river in its channel compared with rivers with meandering or braided stream regimes. Archaeological sites, as well as navigational settlement and history sites (such as early towns, landings, and shipwrecks), are often totally buried (and thus preserved) under the deep post-settlement alluvium that plagues the Illinois River and its bottomlands (Bhowmik and Demissie, 1989).

Along the Illinois River shoreline a large number of archaeological sites are steadily being degraded and even destroyed by erosion (Benn et al., 2011a, b). This damage relates to, and is exacerbated by, the erosional widening of the original Illinois River channel caused by the addition of Lake Michigan diversion waters (Bellrose et al., 1983). The effect of wave impact zones induced by wind and traffic (especially recreational traffic) and the artificial elevation of pool levels in relation to original cultural strata in the lock and dam system, make the problem highly variable, chronic, and somewhat intractable, but no less worthy of management efforts (Bhowmik et al., 1982, 1989, 1999; Bhowmik and Soong, 2000). Archaeological sites are progressively exposed and destroyed by landward migration of
beaches and lower scarps of the river shoreline as erosion progresses onto and across the top of the sites’ preserved matrices. Thus, this damage is primarily wave-driven and occurs at normal and low river stages on the lower margins of shoreline and sloping beach exposures. In many cases, the result is steady degradation, which is expressed by sites producing a continuous resupply of recently exposed artifacts (Bhowmik and Soong, 2000; Esarey, 1988; Warren, 1987). A continuing need to understand and address the impacts of bank erosion to water quality, related biological indices, and the structural integrity of the navigation system strongly dovetails with cultural resource management needs as well. Specific effects on cultural resources are discussed under Recommendations.
RECOMMENDATIONS

Recommendation I: Establish an inventory of efforts that inform the stewardship of the Illinois River Watershed

Develop an inventory of projects that have been completed to improve the health of the IRW (for example, projects undertaken to advance IMP and CP goals), including information about the project, funding source, and contact information. This catalog would establish the baseline, help identify successful and unsuccessful projects, and identify research and monitoring data that are needed to continue to assess the IRW.

Recommendation II: Maintain existing and create new long-term monitoring programs

Assessing the health of the Illinois River Watershed is difficult to determine without continuous long-term monitoring programs. These are the specific recommendations for programs of this nature that would help address questions about the Illinois River Watershed:

a. Create an inventory of wetlands that is updated annually to provide valuable information for multifaceted management across the Illinois River Watershed.
b. Expand existing long-term monitoring programs focused on fish and bird communities to include several other important taxa in the Illinois River Watershed. For example, native freshwater mussels, riverine mammals (such as river otters), amphibians, and reptiles all play important ecological roles in the river ecosystem, but we understand little about them and their response to habitat changes.
c. Enhance monitoring and analysis of biotic data across the watershed to provide an accurate assessment of biotic integrity for each stream, as recommended in Objective 3.
d. At minimum, maintain monitoring stations for stream gaging and sediment data to provide better estimates of the sediment trends in the Illinois River Watershed.
e. Increase reservoir/lake sedimentation surveys.
f. Update and make publicly available the ISWS database of sediment surveys conducted in Illinois.
g. Conduct additional research and compile information to assess shoreline stabilization.
h. Develop a quantitative understanding of the geomorphological evolution of streams in the Illinois River Basin and their response to altered sediment supply and hydrology.
i. Establish more studies to accurately assess a water management plan for highly urbanized areas such as the Lake Calumet area. Green infrastructure should be considered as a best management practice.

Recommendation III: Restore critical habitats

The Illinois River Watershed is a vital resource for humans and animals. To improve recreational activities such as fishing for native species, bird watching, and hiking, and ecosystem health, the restoration of critical habitats is necessary. A few specific recommendations are:

a. Restore and preserve habitats for migratory birds such as the yellowlegs.
b. Restore and preserve native wetland hardwood forests for native species such as the creeper.

c. Increase aquatic and terrestrial topographic diversity within the floodplain boundaries including deepened backwaters, elevated areas designed for floodplain hardwoods and islands, different substrates in river bottom habitats (e.g., sand and gravel, hard clay, etc.) by:

d. continuing to investigate and develop dredging and sediment placement techniques;

e. sampling sediment in selected areas and determining its physical and chemical quality; and

f. working with other agencies and the private sector to find beneficial uses for sediment such as providing soil and cover material for areas outside the floodplain.

Recommendation IV: Reduce the negative impact of non-native species

a. Conduct additional research to determine the extent to which the recently identified invasive non-native clam has spread and evaluate its potential ecological impacts.

b. Undertake more research and public education on how non-native species enter the Illinois River Watershed and how they impact the environment.

Recommendation V: Examine and reduce contaminants

a. Develop and implement non-invasive in-situ methods for remediating contaminated river sediments.

b. Examine ways to ensure that discharge effluent to rivers and streams in the Illinois River Watershed matches the river water chemistry of the stream that it discharges to so that the ecosystem is maintained at the same quality downstream of the effluent as it is upstream.

c. Conduct studies on emerging contaminants such as pharmaceuticals (including antibiotics and hormones) and personal care products to provide background concentrations and evaluate the impact of these on biota and drinking water from the streams and rivers in the Illinois River Watershed.

d. Understand the hydrogeologic connection between groundwater and the Illinois River Watershed as a vector for contaminants.

Recommendation VI: Add an IMP goal to assess groundwater resources and withdrawal impacts on the Illinois River Watershed

The importance of groundwater resources for agricultural, domestic, municipal, and industrial needs should be recognized and considered with regards to surface water-groundwater interactions in the Illinois River Watershed. Groundwater was not included in the 1997 IMP, and several key groundwater studies are recommended related to the objectives and goals of IMP. More detailed discussion of these recommendations can be found in Appendix B.

a. Restore and maintain programs to monitor groundwater, especially irrigation withdrawals (which now are not monitored), and examine the impacts of withdrawals on the Illinois River Watershed. The ISWS had a short-lived program to monitor irrigation withdrawals, but funding ceased after approximately two years.

b. Undertake several integrated surface water-groundwater studies:
c. Examine how groundwater withdrawals have resulted in changes in natural groundwater discharge, either by capturing groundwater that would otherwise have discharged to a surface water or by inducing flow from a surface water into the aquifer. Although both surface and groundwater flow models exist in many watersheds throughout the state, a quantitative assessment of reductions in natural groundwater discharge should involve the coupling of these two models.

d. Determine an allowable reduction in natural groundwater discharge that will minimize the impact of withdrawals on the ecology of sensitive species.

e. Initiate and maintain the collection of seasonal groundwater data of nonpoint source contaminants in order to calibrate coupled groundwater-surface water solute transport models. Groundwater can be a delivery mechanism of nonpoint source contaminants (such as nitrate or chloride) to surface waters.

f. Evaluate the impacts of communities switching from groundwater to surface water and subsequent effluent effects in the Illinois River Watershed.

**Recommendation VII: Add an IMP goal to implement cultural resources protections and inventory**

When the IMP was adopted, protection of cultural resources in the Illinois River Watershed was not included though they can be greatly impacted by erosion, sedimentation, and flooding. Large segments of the cultural properties of the Illinois River system are a degrading, non-renewable resource beset by specific management challenges currently mediated only by irregular inventories, overviews of resource context and potential, and project-specific impact investigations typically conducted under inopportune conditions. Several actions are recommended:

a. Initiate an assessment system for erosion that includes cultural resources that are being continuously eroded by the Illinois River and its tributaries that would both protect the resources and streamline planning hurdles for restoration efforts.

b. Initiate and maintain an ongoing management program able to provide scientific rigor and establish the first comprehensive cultural resources inventory for the Illinois River Watershed shoreline. To date, cultural resource management efforts under the IMP have focused on studies developing an understanding of various landforms’ potential to contain cultural resources studies rather than compiling a resource inventory with accompanying direct mediation of resource loss as needed. Such a program would need to respond proactively to opportunities to accumulate the baseline site inventories, monitor and gather curatable (and thus to some small degree mitigative) information on archaeological sites being degraded and destroyed. Resulting data would be plugged into routine management efforts of the river system, serving double duty for impact assessments serving both development needs and unintended effects of other Illinois River environmental mediations. The ISAS is extremely well equipped to carry out such a function.