**Tenmile Creek Watershed Assessment Report**

**Prepared by:**

**William P. White1, John Beardsley1, Andrew Phillips2,** Jennifer E. Carrell**2**, **Geoffrey Pociask3, Greg Sass4**

**Institute of Natural Resource Sustainability, University of Illinois at Urbana-Champaign**

1Illinois State Water Survey, Center for Watershed Science

P.O. Box 697, Peoria, IL, 61652-0679

phone: (309) 671-3196; fax: (309) 671-3106;

email: bwhite@uiuc.edu, beardsly@sws.uiuc.edu

2Illinois State Geological Survey, Geologic Mapping and Hydrogeology Center

615 E. Peabody Drive, Champaign, IL, 61801

phone: (217) 333-2513; fax: (217) 333-2830;

email: phillips@isgs.illinois.edu

3Illinois State Geological Survey, Transportation and Environment Center

615 E. Peabody Drive, Champaign, IL, 61801

phone: (217) 265-8212; fax: (217) 265-8214;

email: pociask@isgs.illinois.edu

4 Illinois Natural History Survey, Illinois River Biological Station

704 N. Schrader Avenue, Havana, IL, 62644

phone: (309) 543-6000; fax: (309) 543-2105;

email: gsass@illinois.edu

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**Rock Island District, Clock Tower Building**

**P.O. Box 2004, Rock Island, IL, 61204**

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**GLOSARY OF ACRONYMS**

Name Acronym

Best Management Practices BMPs

Biological Habitat Index BHI

Biological Stream Characterization BSC

Channel Evolution Model CEM

Channel Stability Index CSI

Clean Water Act CWA

Conservation Reserve Enhancement Program CREP

Conservation Reserve Program CRP

Conservation Practices Program CPP

Critical Trends Assessment Program CTAP

Cubic feet per second cfs

Digital Elevation Model DEM

Digital Orthophotographic Quadrangles DOQs

Environmental Quality Incentives Program EQIP

General Land Office GLO

Global Positioning System GPS

Historical Aerial Photographs HAPs

Hydrologic Unit Code HUC

Illinois Department of Natural Resources IDNR

Illinois Department of Transportation IDOT

Illinois Environmental Protection Agency IEPA

Illinois Natural History Survey INHS

Illinois State Geological Survey ISGS

Illinois State Water Survey ISWS

Illinois River Basin ILRB

Illinois River Bluffs Assessment Area IRBAA

Name Acronym

Illinois River Soil Conservation Task Force IRSCTF

Illinois River Valley Council of Governments IRVCG

Index of Biotic Integrity IBI

Land Use and Evaluation and Impact Assessment Model LEAM

Large woody debris LWD

Macroinvertebrate Biotic Index MBI

National Wetlands Inventory NWI

Natural Resources Conservations Service USDA-NRCS

Non-Government Organizations NGOs

Non-Point Source NPS

Ohio Environmental Protection Agency OEPA

Quality Habitat Evaluation Index QHEI

Ravine Overlay District R.O.D.

Resource Rich Area RRA

Tenmile Creek Watershed Assessment TCWA

Tenmile Creek Watershed Committee TCWC

Tri-County Regional Planning Commission TCRPC

Soil and Water Conservation Districts SWCDs

Special Area Management Plans SAMPs

United States Army Corp of Engineers USACE

United States Department of Agriculture USDA

USDA/Soil Conservations Service SCS

United States Environmental Protection Agency USEPA

Watershed Land Treatment Program WLTP

Water and Sediment Control Basins WASCOBs

1. **STUDY AUTHORITY**
	1. **Authority, Section 519**

Authority for the Tenmile Creek watershed assessment comes from Section 519 of the Water Resources Development Act (WRDA) of 2000. The primary purpose of Section 519 funding currently used in Illinois is for planning, conservation, evaluation, and construction of measures for fish and wildlife habitat conservation and rehabilitation, and stabilization and enhancement of land and water resources in the Illinois River basin (ILRB).

* 1. **Proposed Sponsors**

Proposed sponsors include the U.S. Army Corps of Engineers (USACE) Rock Island District serving as federal sponsor and the State of Illinois as local sponsor. The Illinois Department of Natural Resources (IDNR) serves as primary coordinator and facilitator for the local sponsor.

1. **STUDY FRAMEWORK AND PURPOSE**

This Tenmile Creek watershed assessment (TCWA) documents past and current watershed conditions to identify potential restoration needs and locations. Both historical and new data were analyzed. Assessment data are being used specifically to understand past and current conditions and generally document previous conservation practices. The TCWA also was conducted to help locate, characterize, and prioritize potential conservation and restoration practices. Information provided in the TCWA eventually will be used to guide project considerations, including siting feasibility study projects, and design/construction of multi-objective restoration projects. Projects will be selected that reduce erosion, restore habitat, and protect overall ecosystem health to meet goals and objectives of the ILRB Comprehensive Plan (USACE, 2007). Those objectives include: 1) implementing projects that produce independent, immediate, and sustainable restoration; 2) implement multi-goal projects with systemic impacts; 3) evaluating alternatives that address common system problems; and 4) using adaptive management concepts while being responsive to long-term management and maintenance needs (USACE, 2007).

The assessment provides scientific guidance for the planning process and is essential for determining whether more detailed reconnaissance studies should begin and, if so, where. Those decisions will be based on preliminary appraisal of federal interest, estimated costs, potential benefits, and possible environmental impacts of various alternatives. This assessment also matches potential projects with appropriate federal agencies for further evaluation and/or implementation.

A framework to assess areas and select potential targets for critical restoration is required to implement a comprehensive plan for restoring ILRB ecosystem functions efficiently and effectively (White et al., 2005). Watersheds within the ILRB were prioritized for assessment of ecosystem restoration potential using criteria developed and applied by an IDNR-USACE system team, with input from regional teams and other study committees (Table 1, USACE; White et al., 2005). Assessment protocols used rapidly identified and described significant erosion problem areas within the ILRB as erosion and sedimentation were identified as two of the most important problems in the Integrated Management Plan (State of Illinois, 1997) and the Comprehensive Plan (USACE, 2007). Sediment delivery and biological conditions were major criteria, but other criteria also were used to select initial assessment areas from broad areas of interest within the entire basin (White et al., 2005). These criteria include:Basin location (primarily sub-basins, watersheds, and sub-watersheds draining directly into Peoria Pool, areas upstream, and Alton and LaGrange Pools).

# Sediment budget information for the ILRB (assess watersheds with the most potential to value sediment delivery to the Illinois River).

# Potential to reduce sediment delivery to the Illinois River.

# Increase base flows and/or decrease peak flows. Increased base flows ensure sufficient flow and depth for aquatic organisms during periods of low precipitation while decreased peak flows reduce occurrences of flash floods.

# Threats to ecological quality or system integrity (increased or changed population rate, rate of change in impervious surface rate, water quality impairment, etc.).

# Biologically significant areas and ecosystem partnership concerns (Biologically Significant Streams, Resource Rich Areas, regionally significant species and areas, etc.).

# Potential to improve, protect, and expand habitat for regionally significant species, patch size and spacing.

# Potential to be self-sustaining.

# Level of local, state, and federal support, including recommendations from agencies, non-government organizations (NGOs), the ILRB Ecosystem Restoration Project regional teams, Conservation 2000 Ecosystem Partnerships (now called Partners in Conservation), regional planning commissions, watershed planning and technical advisory groups, and other local coordination groups.

# Economic limitations and opportunities.

Tenmile Creek was one of several watersheds, all direct tributaries to Peoria Pool, given highest priority by an IDNR-USACE system team and recommended for reconnaissance-level watershed assessment because of criteria listed above and similarly outlined in Table 1. It was also necessary to develop additional criteria for targeting and prioritizing potential individual restoration sites within each watershed. These additional criteria are similar to those used to select the initial list of watersheds for assessment but with more detail on individual project concerns (White et al., 2005). Recommended criteria for selecting individual project sites include but are not limited to:

* Sediment contributions from the watershed and particularly the site in question.
* Availability of a watershed plan and progress with planning and implementation.
* Landowner willingness to participate.
* Availability of access.
* Future potential damages if a project is not implemented.
* Federal, state, and local ability to improve the area.
* Economic opportunities or limitations influencing project success.

The TCWA is part of a long-term project to provide watershed-specific information at a scale more appropriate for ecosystem restoration recommendations than previous assessments. This study also addresses some directives of the Integrated Management Plan for the Illinois River Watershed (State of Illinois, 1997), including generating site-specific data to understand causes of tributary stream instability and evaluate public lands for wetland and surface water restoration. Finally, this study partly fulfills four of the five goals of watershed assessment recommended by Holtrop and Pegg (2004):

* Identify defining physical limits of the watershed.
* Document past and current watershed conditions.
* Identify practices and processes with watershed impacts.
* Recommend restoration projects based on identified cause and effect relationships.

However, the TCWA does not include a reference watershed in its scope as recommended by Holtrop and Pegg (2004).

1. **PROJECT LOCATION**
	1. **Location**

Tenmile Creek watershed is located in the ILRB middle sub-basin and within Woodford and Tazewell Counties (Figure 1). The 11,027-acre or 17.2-square-mile watershed (NRCS, 2002) drains directly into Upper Peoria Lake in Peoria Pool, one of the largest riverine lakes on the Illinois River. The watershed lies within Hydrologic Unit Code 071300011705 (NRCS, 2002). Although the eastern boundary of the Hydrologic Unit approximately coincides the watershed boundary, the western boundary crosses the Illinois River and thus is not a watershed. To resolve this problem, we modeled the watershed in a GIS using our 2005 stream network and a mosaic of USGS 30 m digital elevation models (Figure 1). We also Tenmile Creek originates in Washington Township, Tazewell County then flows approximately 10 miles to its confluence with the Illinois River at the Narrows of Peoria Lake near Peoria Heights. Spring Creek and Wolf Creek are larger tributaries of Tenmile Creek.

* 1. **Study Area Congressional District**

The study area is located in the State of Illinois 18th Congressional District represented by Congressman Aaron Schock (Figure 2). The 18th Congressional District of Illinois contains all or parts of 20 counties in Central and Western Illinois. The district is a mixture of urban (Peoria, Springfield and rural areas. The district contains some of the most productive farmland in the world as well as maintaining a strong manufacturing base. Several historic and scenic rivers flow through the farm fields, small towns, and large cities of the district, The counties in the 18th District are: Adams, Brown, Bureau, Cass, Knox, Macon, Marshall, Mason, Menard, Morgan, Peoria, Pike, Putnam, Sangamon, Schuyler, Scott, Stark, Tazewell, and Woodford. The 18th District also contains all 11 of the counties that Abraham Lincoln represented during his one year term (1847-1849) in Congress.

Figure 1. Location of Tenmile Creek in Woodford and Tazewell Counties. The Tenmile Creek watershed drains a steep bluff region and flows into the Illinois River on the eastern shore of Peoria Lake near the Tazewell and Woodford County boundaries

Figure 2. The 18th Illinois Congressional District encompasses much of the middle Illinois River valley, including Tenmile Creek.

1. **PRIOR STUDIES, REPORTS, AND EXISTING PROJECTS**

This section briefly discusses prior studies, reports, existing documents, and other activities pertinent to this study. Planning and implementation of erosion control and water management projects have occurred in the Tenmile Creek watershed in the past.

* 1. **Regional Studies**

Tenmile Creek is in the Illinois River Bluffs Ecosystem Partnership Area in the portion designated as the Peoria Wilds Resource Rich Area (or the Peoria Wilds RRA) (Figure 3). These areas were identified under the IDNR Critical Trends Assessment Program (CTAP) and the IDNR Ecosystems Program. Regional analyses of Partnership Areas using existing statewide data were completed in the 1990s. The goal of those assessments was to provide regional baseline data to help set priorities and develop management plans. Reports for the Illinois River Bluffs Ecosystem Partnership comprise four volumes covering area geology (IDNR, 1998a); water resources (IDNR, 1998b); living resources (IDNR, 1998c); and the socio-economic profile, environmental quality, and archaeological resources (IDNR 1998d). Although the CTAP assessments were comprehensive, scale of existing data was too coarse for adequate assessment of past and current conditions of the watershed and fluvial systems for use in suggesting project implementation priorities.

Figure 3\_peoria\_wilds. Ten Mile Creek lies within the IDNR-designated Peoria Wilds Resource Rich Area of the Illinois River Bluff Assessment Area (IDNR 1996). The Peoria Wilds is a biologically diverse area of dissected bluffs surrounding the Illinois River floodplain.

* 1. **Watershed Studies**

Ecosystem restoration analysis and implementation in Tenmile Creek began when the Tri-County Regional Planning Commission (TRRPC) organized the Tenmile Creek Watershed Planning and Technical Advisory committees in 2002. State, regional, and local representatives participated. Their findings were published in 2004 (TCRPC 2004). The findings included inventories of natural resources and plans to mitigate headwater stream erosion and water quality degradation. The plans included implementation of urban stormwater ordinances to reduce flooding, stream corridor BMPs, particularly riparian buffers and water detention basins, to reduce sedimentation and improve water quality and habitat, forestry management to improve habitat, and educational initiatives to achieve these goals. Recognizing that the analysis was based on limited information, a detailed geomorphologic study was recommended to guide sedimentation and erosion projects. Implementation of these recommendations is not yet realized (see *Land Use Planning*, below).

* 1. **Best Management Practices**

Various intrinsic (land use, land cover, and geology) and extrinsic (climate change) forcings have caused disturbances in stream systems throughout the ILRB (IDNR, 1998b). For example, rapid conversion of native prairie to agriculture in the past represents an extreme change in land and water use that may have triggered erosion and deposition cycles that remain detrimental to native habitats, soils, and property.

To mitigate disturbances to the landscape and stream systems, traditional water management and erosion control projects (e.g., grassed waterways, terraces, ponds, water and sediment control basins or WASCOBs, etc.) have been implemented outside the channel in the Tenmile Creek watershed. Such projects may alter water and sediment loadings to the Tenmile Creek mainstem or have either positive or negative effects immediately after construction. For example, without compensating for flow regime changes or channel slope adjustments, sediment detention in upland areas can result in channel migration and/or channel incision, which would induce channel erosion and change channel morphology (White et al., 2007). By contrast, coordinated implementation of best management practices (BMPs) in and beyond the channel should reduce peak discharge, increase base flow, and establish a more balanced sediment regime.

Therefore, the TCWA intends to build on lessons from past BMP implementation to guide future projects. Further, a central focus of recommended treatments will be to coordinate upland and in-channel projects to enhance the ecological system by naturalizing or optimizing hydrologic, hydraulic, and sediment regimes. Treatments could focus on channel bed grade control, streambank stabilization, hydrologic and hydraulic optimization, wetland and riparian habitat restoration, or combinations thereof. Potential projects include riffle and pool structures for multiple benefits, such as channel bed control and oxygenation of water, lunker structures for bank protection and fish habitat, bioengineering techniques for bank stabilization and native plant diversity, improved stream connectivity for fish passage, improved riparian connectivity for nutrient filtering and terrestrial habitat, or channel re-meandering to reconnect channel-floodplain systems for naturalizing hydraulic and sediment conditions and enhanced habitat.

* 1. **Local Forest Management Effort**

The Tri-County Regional Planning Commission created the Mossville Bluffs Watershed Restoration Master Plan in 2002 with funding made available through the IDNR Conservation 2000 program. Although the Mossville Bluffs lie on the opposite side of the river from Tenmile Creek, the Master Plan outlines valuable procedures for implementing erosion and sediment control, rural and urban forest management, stormwater management, and habitat enhancement with community involvement. The Mossville Bluffs Watershed Restoration Master Plan identified an opportunity to create a ravine overlay district (R.O.D.) to be used as a mechanism to continue the ongoing preservation and rehabilitation of Peoria lakes and the Illinois River valley. After verbal encouragement from the Illinois River Valley Council of Governments (IRVCG), (an association of local municipal representatives), it became a priority to investigate the opportunity for developing a regional R.O.D.

The R.O.D. was created as a model for a zoning district to protect rapidly eroding bluff and wooded areas (particularly those areas under pressure from land development). Recent analyses completed using the Land Use and Evaluation and Impact Assessment Model (LEAM) predict that encroaching development will consume approximately 8,500 acres (9.5%) of Peoria area forests over the next 30 years. The LEAM is a tool for predicting regional growth patterns and analyzing subsequent results of those patterns. It was created at the University of Illinois at Urbana-Champaign and brought to Peoria as a demonstration project. Several groups made the LEAM project possible: IDNR, the Illinois Department of Transportation (IDOT), the Illinois Department of Agriculture, the Tri-County Regional Planning Commission, and the Governor’s Sub-Cabinet on Balanced Growth. The model would help R.O.D. development by identifying threatened natural areas, gathering anecdotal information from local landowners, and analyzing potential impacts of growth on natural areas. Results of the LEAM modeling system identify the possibility of preserving a substantial portion of sensitive areas via tools such as the proposed R.O.D. Design of the R.O.D. model ordinance will allow wide use and adoption by entities both inside and outside the Tri-County area.

Currently in the Tenmile Creek watershed the ISWS has introduced the benefits of a forestry plan to Caterpillar Inc. The ISWS coordinated a meeting between Caterpillar, Inc, and the IDNR regional forester, and have developed contacts with local contractors to develop a forestry plan covering XXX acres.

* 1. **Lake Front and River Development Plan**

The ISWS and Heartland Water Resources Council (HWRC) are refining a plan for the conservation and protection of Peoria Lakes. Currently the plan is divided into 3 segments; one detailing conservation areas in Upper Peoria Lake, a second segment outlining a transitional management strategy for the lower area of Upper Peoria Lake, and a third plan for Lower Peoria Lake which concentrates on a side conservation channel with islands and beneficial use of dredged materials. Research needs are being outlined and currently recommend a study of the hydrology and hydraulics to aide in design and construction of islands and a conservation channel among other conservation and development measures. Funding is being sought for the Hydrology and Hydraulics efforts to initiate this strategy.

Plans are already underway to revitalize one section of the riverfront. The City of Peoria’s Department of Economic Development is developing landscape design ideas for the southern gateway to the City of Peoria which is now primarily an obsolete industrial development. The City of Peoria is considering major reinvestment opportunities by intensively redeveloping the conservation amenities along Peoria’s riverfront. One component of a plan under consideration is to develop a public “green edge” or linear park along the river from Water Street to War Memorial Drive. Over time the existing river edge could be converted to parks with a scenic riverfront drive, quality mixed use development with some new residential homes, beautification of the area and streets, enhanced connectivity between the downtown and riverfront areas, and enhancement of the natural environment.

Additional plans include setting sediment traps within Tenmile and Blue Creek to reduce the flow of sediment into Peoria Lake and constructing an island just downstream of the Blue Creek delta. The objective is to trap sediment before it is deposited in Peoria Lake. In turn, the trapped sediment would provide a resource for island construction [reference island project]

1. **PLAN FORMULATION**
	1. **Methods of Investigation**

The Geomorphic Watershed Assessment Protocols developed by (Keefer et al., 2009) provides the methodological framework for the assessment. However, this interdisciplinary watershed assessment was accomplished through a variety of methods. Fieldwork encompassed a wide range of activities, from surveys of fish assemblages, to documentation and assessment of channel form and characteristics, to stratigraphic studies. ISWS investigations focused on contemporary channel conditions observed from aerial reconnaissance (i.e., video-recorded helicopter fly-over) and channel assessments based on field observations. ISGS investigations focused on regional and watershed-scale conditions, landscape change, and geomorphic process analysis. The INHS investigations included review of existing data on biologic communities at the watershed scale and stream sampling for fish communities at the reach scale.

* + 1. **Geomorphic Watershed Assessment Protocols**

The geomorphic condition assessment for the Tenmile Creek waters was conducted using methods outlined by Keefer et al., (2009). The geomorphic assessment has two levels of investigation: 1) watershed-scale characterization and 2) reach-scale characterization. The TCWA includes only the watershed-scale characterization in order to identify potential sites for reach-scale characterization for potential feasibility studies.

The objective of the watershed-scale characterization is to identify opportunities for habitat improvement, stream stabilization, and reducing sediment delivery to the Illinois River. The watershed-scale characterization includes both office and field components and is similar to USACE’s reconnaissance-level studies. In addition to the office and field components, the watershed-scale characterization included helicopter aerial reconnaissance during which GPS-tracked aerial video was acquired to aid rapid determination of channel instability. The office component involves compilation and geographic analysis of existing data, as well as analysis of historical aerial photography to assess the magnitude and mode of channel planform change along trunk streams over time (see Stream Dynamics Assessment below). Some of the typical data sources used in the watershed-scale characterization are geologic maps, physiography, land use, soil surveys, topographic maps, aerial photos, drainage project plans, bridge surveys, hydrologic and sediment data, and channel surveys. Many of these data are used to characterize watershed physiography by assessing various overlays of geographic data (e.g., channel slope versus soil parent material, hillslope versus soil erodibility). Also, historical and recent aerial photography are compared to qualitatively identify historical trends in land use or land cover. Through this component of the characterization it is possible to identify: 1) landscape and channel disturbances, 2) land use practices that may contribute to watershed problems, 3) the magnitude and modes of historical channel planform adjustment, and 4) geologic or physiographic controls on channel adjustment.

The field component consists of stream channel surveys throughout the watershed. During the field survey, rapid measures of basic channel geometry were collected and located using a GPS. These data were used to rank channel stability and physical habitat quality using a channel-stability index (CSI), biological/habitat ranking scheme (BHI), and the Qualitative Habitat Evaluation Index (QHEI). CSI, BHI and QHEI rankings were calculated, compiled in a GIS and examined in the context of the physiographic/historical characterization to discern whether channel adjustments or landscape changes are 1) discrete and localized adjustments, or 2) system-wide and possible causes can be identified.

* + - 1. **Aerial Reconnaissance**

Low-altitude, rapid aerial reconnaissance was conducted along 1292.04 miles (2079.18 km) of stream channels in the ILRB including the Tenmile Creek Watershed in spring 2004 as a first phase of watershed and stream assessment efforts. The aerial survey was flown with a helicopter outfitted with a high-resolution, stabilized aerial video camera and Global Positioning System (GPS). Continuous, simultaneous video footage and synchronized GPS loca­tions were obtained along the mainstem channel of Tenmile Creek. Sites that appeared from the air to be unstable, (i.e., active sediment delivery to the stream channel from mass wasting, bank erosion, or bed inci­sion, if detectable) were recorded and GPS coordinates marked. These sites were further inspected during subsequent watershed-scale field investigations and office analyses. Although sediment delivery or channel migration rates cannot be determined from the aerial survey, this rapid reconnaissance approach was used to quickly identify channel and near-channel sediment sources and disturbances that may indicate recent channel or hillslope destabilization. The rapid aerial reconnaissance was used to identify potential problem areas in or near the channel that otherwise may not be recognized for years which helped to focus subsequent field assessments.

* + - 1. **Existing Datasets**

In the office, existing datasets and reports for the region and the watershed were compiled from federal, state, and local agencies, and reviewed to provide context for the TCWA. Most of the existing data are relatively coarse in scale, 1:100,000 or greater, and were used for only generalized characterization of the watershed.

* + - 1. **Channel Stability Index**

The basic field data collection component is a modification of the channel-stability ranking scheme from Kuhnle and Simon (2000). The channel-stability ranking scheme has two elements: 1) rapid measurement of reach-averaged channel geometry, bed and bank material descriptions, and reach gradient and 2) ranking of channel characteristics into a channel-stability index. These two elements characterize the relative degree of channel stability between reaches throughout the watershed. The rapid field measurements are estimated using a laser rangefinder, hand level, gravelometer, and a Unified Soil Classification System card. The channel-stability index is the sum of nine evenly weighted physical channel characteristics (Simon and Downs, 1995). In general, sites with a channel-stability index greater than 20 have substantial potential for critical instability and an index of 10 and lower are considered relatively stable (Simon and Downs, 1995). Sites with an index between 10 and 20 have potential to become unstable (Keefer, personal communication, 2004). The principal use of the channel-stability index is to determine the relative distribution of the stability rankings between sites to detect possible system-wide channel responses within a watershed context. The advantage of the CSI is the comparison of results between sampled reaches throughout the channel network. All sites are ranked and mapped using GIS by the channel-stability index and each variable to present their spatial distribution. In combination with overlays of geographic information compiled in the office component, the mapped indices and variables are used to identify possible system-wide trends in channel character. If trends are not present, identified instabilities could be assumed to be localized (Simon and Downs, 1995)

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* + - 1. **Physical Habitat Quality Indices**

Stream channel habitat quality for the TWCA was assessed using both the biological/habitat index (BHI) ranking scheme, and the Qualitative Habitat Evaluation Index (QHEI). The metrics of the BHI ranking scheme (Barbour et al., 1999) are similar to the Quality Habitat Evaluation Index (QHEI) method (Ohio Environmental Protection Agency, 1987) but are simplified to facilitate more rapid assessment and were used in several previous ILRB watershed assessments. Although the QHEI is now the established biological habitat evaluation tool for ILRB watershed assessments, the BHI was also evaluated so that the results of the TCWA can be compared to past watershed assessments where QHEI was not evaluated.

The BHI biological/physical habitat index,, is a modification of the *Rapid Bioassessment Protocols (RBPs) for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish* developed for the U.S. Environmental Protection Agency by Barbour et al. (1999; online access at <http://www.epa.gov/owow/monitoring/rbp/>). The purpose of these protocols is to provide an option for performing rapid and cost-effective biological assessment techniques and is not intended to replace more robust and place-specific bioassessment studies (Barbour et al., 1999). Kuhnle and Simon (2000) adapted the RBP physical characterization/water quality field data sheets because it “accounts for those physical characteristics that can directly affect biologic integrity”. Below is a background summary from the RBPs publication:

“The RBPs are essentially a synthesis of existing methods that have been employed by various State Water Resource Agencies (e.g., Ohio Environmental Protection Agency [EPA], Florida Department of Environmental Protection [DEP], Delaware Department of Natural Resources and Environmental Control [DNREC], Massachusetts DEP, Kentucky DEP, and Montana Department of Environmental Quality [DEQ]). Protocols for 3 aquatic assemblages (i.e., periphyton, benthic macroinvertebrates, fish) and habitat assessment are presented. All of these protocols have been tested in streams in various parts of the country. The choice of a particular protocol should depend on the purpose of the bioassessment, the need to document conclusions with confirmational data, and available resources. The original Rapid Bioassessment Protocols were designed as inexpensive screening tools for determining if a stream is supporting or not supporting a designated aquatic life use. The basic information generated from these methods would enhance the coverage of broad geographical assessments, such as State and National 305(b) Water Quality Inventories. However, members of a 1986 benthic Rapid Bioassessment Workgroup and reviewers of this document indicated that the Rapid Bioassessment Protocols can also be applied to other program areas, for example:

* Characterizing the existence and severity of impairment to the water resource
* Helping to identify sources and causes of impairment
* Evaluating the effectiveness of control actions and restoration activities
* Supporting use attainability studies and cumulative impact assessments
* Characterizing regional biotic attributes of reference conditions

Therefore, the scope of this guidance is considered applicable to a wider range of planning and management purposes than originally envisioned, i.e., they may be appropriate for priority setting, point and nonpoint-source evaluations, use attainability analyses, and trend monitoring, as well as initial screening.”

The RBP habitat assessment field data sheets (low- and high-gradient) have 10 equally weighted parameters with a numerical scale from 0-20, where higher the score the more optimal the habitat quality (see <http://www.epa.gov/owow/monitoring/rbp/ch05main.html>). Kuhnle and Simon (2000) used the low-gradient field sheet and only modified the numerical scale from 0-20 to 0-4 to coincide with the Channel-Stability Ranking Scheme numerical scale. Except for minor editing of parameter descriptions, all other aspects are the same and scored individually then summed for an overall BHI site score. One further modification was made to the Kuhnle and Simon (2000) scheme for the TCWA. The BHI contains two options for one parameter based on channel gradient (sinuousity for low gradient streams or pool-riffle sequence for high gradient streams), which further streamlined the assessment for rapid field work. The RBP by Barbour et al., (1999) is used as the core guidance document when performing the BHI.

The QHEI is a physical habitat index that provides an evaluation of habitat characteristics that are important to fish communities (Ohio Environmental Protection Agency 2006). The QHEI consist of six principal metrics: 1) substrate, 2) in-stream cover, 3) channel morphology, 4) riparian zone and bank erosion 5) pool/glide and riffle-run quality, and 6) map gradient. Each metric is scored individually and all metrics are summed to provide the total QHEI site score. Table 2 shows the narrative quality rating for ranges of QHEI scores. The maximum possible QHEI site score is 100.

Table 2. General narrative ranges assigned to QHEI Scores by the Ohio EPA (2006). Ranges vary slightly in headwater (< 20 sq mi) vs. larger waters.

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| Narrative Rating | QHEI Range |
| Headwaters | Larger Streams |
| Excellent | ≥ 70 | ≥ 75 |
| Good | 55 to 69 | 60 to 74 |
| Fair | 43 to 54 | 45 to 59 |
| Poor | 30 to 42 | 30 to 44 |
| Very Poor | < 30 | < 30 |

While the habitat quality ratings shown in the table above provide guidelines for assessing stream habitat quality for the TCWA, this quality rating was developed in Ohio by comparing QHEI values with rigorous biological sampling over the range of conditions in that state. It is uncertain whether these ratings would reflect biological integrity and diversity in Illinois streams because they have not been calibrated to the range of physical habitat conditions in Illinois using data from biological surveys.

The six-stage Channel Evolution Model (CEM), developed by Simon and Hupp (1986) and Simon (1989), was used both within the Channel-Stability Ranking and for consideration in spatial assessment of watershed condition (Figure [CEM] Table [CEM]). The six-stage CEM can be useful for watershed assessment in the loess area of the Midwest because it can provide a process-based context for channel adjustment after a major channel disturbance (i.e., dredging/channelization) in sand-bedded streams with cohe­sive alluvial banks (Simon 1989; Simon and Hupp, 1986; USACE, 1990; Federal Interagency Work­ing Group, 1998). If the spatial distribution of CEM stage throughout the watershed and the history of major channel disturbanc­e are known, then the CEM can be used to assess potential future stream response, including potential for slope and streambank instability. In this case, the CEM provides a consistent rationale that can be used for prioritization of restoration activities. However, factors such as variable geologic controls, ongoing disturbances throughout a watershed (e.g., agricultural tiling, urban development, climate change) can complicate interpretation of CEM stage. Although the CEM is generally applicable to watersheds within the ILRB that have similar conditions under which the model was developed, it has limited applicability in low-gradient streams and is not applicable where the bed or banks are not alluvial (e.g., bedrock or resistant glacial deposits).

The six-stage CEM is depicted in Figure [CEM] and each channel stage and associated characteristic processes and forms are given in Table [CEM]. In the idealized six-stage CEM, the elevation of the post-disturbance bankfull level is lower than the pre-disturbance channel and the pre-disturbance floodplain forms a terrace above the new active floodplain. Relatively stable reaches occur downstream (Stages V and VI), and less stable reaches (Stages II and III) are upstream of those classified as Stage IV (i.e., threshold stage; Federal Interagency Working Group, 1998). This progression happens because initiation of channel incision by a major disturbance or modification produces an increased gradient (e.g., headcut or knickpoint) locally that ad­vances upstream until it meets more resistant bed and bank material or until stream energy becomes too low to support erosion of the bed due to decreased slope or discharge in upper reaches of the watershed. Thuse Stage I and Stage VI channels of the CEM generally indicate relative stability.

Table 7. Six Stages of Simon (1989) and Simon and Hupp (1986) Channel Evolution Model

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| **Stage** | **Dominant Processes** | **Characteristic Forms** | **Geobotanical Evidence** |
| No. | Name | Fluvial | Hillslope |  |  |
| I | Pre-modified | Sediment transport – mild aggradation; basal erosion on outside bends; deposition on inside bends. | - | Stable, alternate channel bars; convex top-bank shape; flow line high relative to top bank; channel straight or meandering. | Vegetated bank to flow line. |
| II | Constructed | - | - | Trapezoidal cross section; linear bank surfaces; flow line lower relative to top bank. | Removal of vegetation (?). |
| III | Degradation | Degradation; basal erosion on banks. | Pop-out failures | Heightening and steepening of banks; alternate bars eroded; flow line lower relative to top bank. | Riparian vegetation high relative to flow line and may lean towards channel. |
| IV | Threshold | Degradation; basal erosion on banks. | Slab, rotational and pop-out failures. | Large scallops and bank retreat; vertical-face and upper-bank surfaces; failure blocks on upper bank; some reduction in bank angles low line very low relative to top bank. | Tilted and fallen riparian vegetation. |
| V | Aggradation | Aggradation; development of meandering thalweg; initial deposition of alternate bars; reworking of failed material on lower banks. | Slab, rotational and pop-out failures; low-angle slides of previously failed material. | Large scallops and bank retreat; vertical face, upper bank, and slough line; flattening of bank angles; flow line low relative to top bank; development of new flood plain (?) | Tilted and fallen riparian vegetation; reestablishing vegetation on slough line; deposition of material above root collars of slough-line vegetation. |
| VI | Restabilization | Aggradation; further development of meandering thalweg; further deposition of alternate bars; reworking of failed material; some basal erosion on outside bends deposition of flood plain and bank surfaces. | Low-angle slides; pop-out failures near flow line. | Stable, alternate channel bars; convex-short vertical face on top bank; flattening of bank angles, development of new flood plain possible; flow line high relative to top bank. | Reestablishing vegetation extends up slough line and upper bank; deposition of material above root collars of slough-line and upper-bank vegetation; some vegetation establishing on bars. |

Figure 32. Figure 3100. Illustration of the six stages of channel evolution following disturbance from Simon (1989) Figure 5: see also USACE, 1990). “Construction Stage” can be generalized to “Disturbance Stage”

* + 1. **Geologic and Geochronological Methods**

Geologic analysis used archived and new data. Field notes from geologists investigating the area from the 1930’s to the 1960’s were compiled and cast into our GIS. The notes mainly documented stratigraphic relationships, but also included loess thickness observations, occurrences of buried soils (paleosols), and lithologic variability of near-surface (<= 5 ft depth) geologic units. Recent regional mapping by Johnstone (2003) and high resolution mapping of the adjacent Spring Bay quadrangle by Stumpf and Weibel (2005) provided a conceptual framework. Soil parent materials were interpreted from C-horizon designations in Soil Series descriptions (Soil Survey Staff 2006, 2007) and cross-referenced to Stumpf and Weibel (2004) and Windhorn (2005).

Understanding of the geology below the upper 5 ft was derived mainly from well records stored in the ISGS Geologic Records Unit. The records are dominantly field logs submitted by water well drillers, but also include geotechnical borings from Department of Transportation investigations and a few stratigraphic test borings from the ISGS (Fig. tm\_pm). The water well locations were not verified because of the time and cost constraints of this project. Errors can be caused by imprecise or incorrect reporting of locations, data entry errors, or imprecise spatial projections. Although many of the water wells may be within 100 ft of their true location, it is our experience that 300-1000 ft or greater errors in horizontal location are common. These in turn can cause errors in elevation of 10 to 100’s of feet in this region when elevation was not provided. Further, water well log descriptions tend to be crude. However, distinctions of fine sediment from sand and gravel, and unlithified sediment from unweathered bedrock are considered reliable. The value of water wells stems from their numbers and the fact that many penetrate to or through bedrock. Wells shown on the map as occurring within Peoria Lake are predominantly test wells drilled in 1902 for the City of Peoria. It is not known whether those locations are correct or not, but their logs are informative and are associated with sample sets in the ISGS Samples Library.

Figure 4. Fig. tm\_pm. Parent materials map derived from C horizon descriptions in SSURGO soils data (Soil Survey Staff 2006, 2007). Hydric soils shown only within the Ten Mile Creek watershed.

By contrast to the water well records, the locations of geotechnical borings were approximately verified. They were originally obtained mainly for bridge construction analysis. Lithologic descriptions tend to be precise, or at least consistent, and are considered reasonably accurate. However, geotechnical borings are both relatively few and shallow, ranging from 10 to 100 ft deep, and dominantly penetrate valley fill sequences. Furthermore, most lie outside the watershed boundary. The two stratigraphic borings shown on figure tm\_pm are shallow, only 23 and 42 ft deep, but were described in detail.

Field investigations were undertaken to characterize current geomorphic conditions, examine outcrops along valley walls, stream banks, and channel beds, and correlate them to existing maps (i.e. Johnstone 2003; Stumpf and Weibel 2005). Sediment textures were determined by tactile methods.

Cores of trees, dominantly oak, locust, and maple, for dendrochronologic analysis were obtained with a 0.200 in Haglöf increment borer. Landscape position, straightness of trunk, and trunk diameter at the sample height (typically 3 ft), were noted. The cores were mounted on wooden blocks and, once dried, sanded at graduated grits to 220 grit. Tree rings were counted at 10x magnification. The age of the largest vertical tree on a surface was used as an estimate of the minimum age of that surfaces. Because of the unsuitability of most of the available species, cross dating between trees was not possible.

Magnetic fly ash is a component of soot from high-temperature coal combustion (Olson and Jones 2001). It is broadly silt-sized, but because it has a density considerably greater than quartz, it is transported and deposited with the coarse silt to fine sand-sized sediment fraction. The occurrence of fly ash in a soil profile identifies the sediment as having been deposited since the beginning of the Industrial period. In the Peoria area, this may be possibly extend as far back as the introduction of steamships in the area in the early-mid 1800’s, but certainly after the introduction of rail and industrial coal combustion in the mid-late 1800’s (Barrows 1910; Olson and Jones 2001). Installation of particulate scrubbing technologies on emissions stacks in the late 1900’s reduced the rain of fly ash, but may not have eliminated it. To quantify magnetic fly ash content, suites of samples down a sediment profile were obtained. The sand fraction was removed by wet sieving at 63 um. Twelve (12) g aliquots were subsampled, ground, and dispersed in a sodium hexametaphosphate solution. All magnetic particles were extracted and purified with a magnet. Fly ash particles are easily recognized by their spherical shape and black color. For each sample, fifty (50) of the magnetic particles were examined under a 20 x optical microscope and classed as fly ash or non-fly ash.

Magnetic Susceptibility (MS) is a measure of the total magnetic strength of a sediment. It increases with the mass and magnetic character (mineralogy, size, shape, orientation; Maher 1986) of the constituent magnetic particles. Magnetic particles can be primary, i.e., derived from parent rocks or fly ash, or can be secondarily added or removed by soil-forming processes. Sediment samples were passed through a 2 mm sieve and lightly ground to uniform particle size. The ground sediment was transferred to 1 cm3 plastic cubes and massed. MS was determined with a Bartington MS2 meter with an MS2B dual frequency sensor and scaled to the mass of the sediment.

* + 1. **Stream Power Estimates**

The overall geomorphic potential of the Tenmile Creek watershed was assessed by examining the distribution of channel slope and stream power within the watershed. Energy gradient (approximated by channel slope) is a primarily control on geomorphic adjustment in stream channels. The energy gradient and discharge are the principal factors that determine *stream power*—a measure of the energy available to erode or transport sediment (Rhoads, 1995).

In the absence of abrupt natural or anthropogenic disturbance, channel gradient changes gradually and progressively. Abrupt changes in gra­dient by manipulation or natural disturbance (*e.g.*, mass wasting) can lead to accelerated erosion or bank failure in the watershed. Likewise, an increase in frequency and/or magnitude of discharge regime will increase the stream’s capacity for erosion and sediment transport.

Brookes (1988) related the response of straightened stream channels to stream power and found that channels with stream power values higher than 100 W/m2 at bankfull discharge regained their sinuosity, channels with stream power between 35 and 100 W/m2 adjusted by mainly erosive processes and those below 35 W/m2 adjusted mainly by depositional processes. Based on these guideline levels, determination of stream power can provide a context for the potential for geomorphic response within a watershed, particularly if channel instability and dynamics are also examined (c.f. Herricks et al. 2004).

Potential responses to gradient change include incision due to increased gradient and deposition due to decreased gradient. Simon (1989) showed that channel disturbance caused by dredging and straightening of alluvial channels can initiate a sequence of morphologic changes characterized by channel incision upstream of the channel disturbance followed by a secondary depositional stage and deposition downstream of the disturbance. Conversely, manipulation by impoundment or grade control can initiate increased deposition due to a local reduction in gradient upstream and increased erosion due to a local increase in downstream gradient (Montgomery and Buffington 1998; Simon and Darby 2002).

For selected locations along Tenmile, Spring and Wolf Creeks, estimates of stream power per unit wetted area of the channel (ω) in W/m2 were calculated by:

 *ω = γQ Se /W*

where:

 *γ* is the specific weight of water (9810 N/m)

 *Q* is discharge (m3/s)

 *Se* is the energy gradient (approximated by channel slope)

 *W* is channel top-bank width (m)

Discharge values extracted from the Illinois Stream Stats website (USGS 2009). The 2-year peak flow (PK2) was assumed to approximate bankfull discharge. Details regarding development of the regional regression used to estimate discharge are available in Soong et al. (2004). Energy gradient input values were approximated using the channel slope estimates described above, and channel width was taken as the average channel top-bank width measured by the ISWS field crew. The stream power assessment values were then mapped for use in GIS overlays for comparison and evaluation with other channel condition parameters.

* + 1. **Stream Planform Dynamics Assessment**

Stream planform dynamics were analyzed by comparing the 1939 channel position and planform of Tenmile, Spring and Wolf creeks to the 1998 position and planform using methods adapted from Phillips et al. (2002, see also Urban and Rhoads 2003). Historical aerial photographs (HAPs) taken in 1939 were obtained from the ISGS Digital Archive of Illinois Historical Aerial Photography (<http://www.isgs.uiuc.edu/nsdihome/webdocs/ilhap/>) and orthorectified. Stream channel centerlines were digitized on-screen from the 1939 imagery and 1998 digital orthophotographic quadrangles (DOQs) in a GIS environment. “Buffers” were generated in the GIS for each stream trace using the respective image root-mean-square error. Areal “change polygons” were generated by merging pairs of buffers and extracting the interstitial “donut-holes”. The change polygons are the metric representing the net areal change in stream planform between 1939 and 1998. Therefore the polygons cannot be used to interpret stream dynamical behaviors that occur at timescales less than the duration between the photo years. In fact, because time and funding constraints within this project limited the analysis to only the earliest and latest available images, cause-and-effect relationships are tentative. Rather, interpretations are limited to broad styles, locations, and relative rates of planform change.

* + 1. **Biological Sampling**
	1. **Watershed Condition Assessment**
		1. **General Geomorphic Setting and Recent Geologic History**

The middle Illinois River valley has been sculpted by repeated glaciations and intervening non-glacial rivers over the Quaternary Period (Taylor et al., in review). There were at least three major glacial episodes. Prior to and between glaciations, the Ancient Mississippi River eroded a deep and wide valley into the dominantly soft shale bedrock (McKay et al., 2009). During the earliest glaciations, the pre-Illinois and Illinois Episodes, ice sheets covered most of Illinois. During the last (Wisconsin) glacial episode, glaciers reached their maximum extent in the Peoria region and left several moraines draped over the landscape. The Mississippi was permanently diverted to its present course at that time. Floods during deglaciation left terraces of glaciofluvial sediment as high as 100 ft above the present elevation of the Illinois River.

The Ten Mile Creek watershed is one of many short, steep-walled basins draining the glacial landscape on the east side of the Illinois River. The uplands surrounding the watershed comprise amalgamated end moraines of the Wisconsin glacial episode (Fig\_x\_landforms). Ice flowing from the northeast completely covered the watershed during the maximum ice extent (1, Fig.\_moraines). During the subsequent ice positions, initial incision of the watershed by outwash likely occurred (2 & 3, Fig.\_moraine). The overall retreat from these positions may have occurred over much less than 1000 yr (Curry et al. 2009). Deposits of older glacial episodes are mainly buried but crop out along valley walls and in stream beds. Bedrock is not exposed at the surface.

Figure 5. Figure moraines. Regional view of glacial moraine positions. The watershed boundaries were created in order by the Bloomington (1), Washington (2), and Metamora (3) moraines. Arrows indicated general local ice flow directions. Initial incision of the Ten Mile creek watershed likely occurred by outwash after retreat of the Bloomington Moraine.

Ten Mile Creek has two major tributaries, Spring and Wolf Creeks (Fig. 1). Zero-order streams (swales with no definite channel that feed into larger streams) begin at the boundaries of the watershed at elevations of approximately 830 ft. Dendritic drainage systems collect over the steep drop to the Illinois Valley bluffs at about 490 ft elevation. From there, the channelized downstream reach of Ten Mile Creek traverses a relict alluvial fan to a confluence with the Upper Peoria Lake portion of the Illinois River at Illinois River Mile 166. The normal lake elevation of 440 ft, the watershed base level, is controlled by the Peoria Lock and Dam.

The upper portions of the watershed are steeply sloping where they are incised into the flanks of glacial moraines. The slope of the alluvial fan is much shallower.

The slope of the uplands, main streams, and alluvial fan is low, but stream incision has generated slopes generally >30% along most valley walls (Fig. x\_slope). The stream valley slopes are generally low, 0.002-0.02, with short, steeper reaches. Several higher-order tributaries feature significantly higher slopes. Each of Ten Mile, Wolf, and Spring Creeks feature convex profiles in their middle reaches (fig\_x\_profiles).

Figure 6. fig\_x\_slope. Slope of the land surface and stream channels in Ten Mile Creek watershed. Land surface slope categories adopted from NRCS (1996); channel slope categories based upon distribution within watershed.

Figure 7. Fig\_x\_profiles. Longitudinal profiles of stream slope, plotted for the ten longest streams in the watershed. Elevations and distances determined from USGS topographic maps.

During the Wisconsin Episode glacial maximum when the ice front was in the region, the watershed carried meltwater and outwash from the moraines. The outwash comprised high-caliber bedload (gravel) as well as sand and suspended sediment. The sediment was delivered to the Illinois River Valley where the bedload was deposited because of a rapid decrease in valley slope to construct an alluvial fan. Subsequent lowering by incision of the Illinois River floodplain has left some of this sediment in raised terraces (Fig\_x\_landforms). Strong winds in the waning phases of glaciation shaped exposed sands on the Illinois floodplain and terraces into dunes and carried silt into the uplands where it was deposited as a blanket of loess.

Post-glacial runoff has been much lower than in the glacial period. Thus boulders and cobbles left on the land surface or eroded from valley walls and alluvial banks are largely left as lag deposits. Transport is likely highly episodic. However, active sand and gravel bars throughout the watershed indicate sufficient energy to transport bedload is commonly available.

A small fan delta at the modern mouth grows today. Channel manipulation over the last century has artificially changed the locus of deposition. Prior to 1824 when mapped by the General Land Office (INHS 2003a; Fondulac in http://landplats.ilsos.net/FTP\_Illinois.html), the stream wandered across the alluvial fan, terminating at a position southwards of the current stream mouth (Fig. tm\_mouth). The stream had already been diverted to a more northerly position when Woermann mapped it in 1902. By 1939, the channel across the alluvial fan had been completely straightened. However, although the land was cultivated, there continued to be evidence of its original distributary nature, common to other bluff streams, with splays across the fan emanating from the channel. The mouth was relocated yet again during the mid-century an additional 0.5 mi south. The channel appears to have avulsed naturally to its present position between 1988 and 1998. Comparison of the terminus of the 1824 stream with the 1902 shoreline suggests about 750 ft of net progradation over that period. Progradation has ceased since then either by reduced sediment delivery or indirectly from navigational channel maintenance. The shoreline has actually retreated 150-200 ft since 1939 with transgression of Peoria Lake.

Figure 8. Fig. tm\_mouth. Changing configuration of mouth of Ten Mile Creek through time. Prior to 1824 the creek wandered across the alluvial fan as a distributary channel. The channel was manipulated by 1902 and the mouth was relocated southwards by channelization twice after 1902. The mouth avulsed naturally out of the channel sometime between 1988 and 1998 (base photograph). Positions determined from GLO map (INHS 2003a), Woermann (1902), and subsequent aerial photography. Gray line is the watershed boundary.

Headwater streams in the watershed are generally downcutting, but locally incision is inhibited by clay-rich glacial sediments. Mass wasting of valley walls is occurring along several reaches. Ponding by beaver dams occurs along some reaches of upper Ten Mile Creek. A set of three terraces, too small to show on Fig. tm\_landforms but readily apparent in the field, occur within the valleys. Sand deposits from 4-12 ft thick were deposited within Wolf Creek within the last 50 yrs. A sediment detention basin at the hydrologic base of the Proving Grounds likely traps most bedload, dominantly sand, upstream of that point. The sediment in the basin is episodically dredged and redistributed over the working area.

Low sloping areas across the watershed have been cultivated for over 100 years. Except for the Proving Grounds area, secondary forest growth has recovered much of the upland surface and especially the steeper slopes while the area of cultivated ground has diminished considerably. Urban and residential development have substantially increased, including the city of Washington’s sewage treatment plant on Wolf Creek.

* + 1. **Cultural Setting**
			1. **Population**

When Joliet and Marquette first traveled the Illinois River in 1673, they found small Algonquin settlements on the shores of Pimitoui (“Fat Lake”), now known as Upper Peoria Lake. Settlers of the By 1830 the indigenous population was greatly diminished, whereas European settlement began in earnest. An 1844 census of Europeans counted 1600 people within Peoria County, which then encompassed a large portion of Western Illinois from East Peoria to the Mississippi River (Drown 1844). Tazewell County was incorporated out of Sangamon County in 1827, and Woodford County, in turn, incorporated out of Tazewell County in 1841.

Figure 9. [Regional population 1800-2000]???

Most of Tenmile Creek Watershed is rural, located in unincorporated areas of Woodford and Tazewell Counties. Urban development is limited to 136 acres in the northern part within the Village of Germantown Hills, and 415 acres in the southwest within the City of Washington (Figure 1, TCRPC 2004a). Germantown Hills and Washington are suburban communities of the larger Peoria metropolitan area, (MSA population 375,672 (Tele Atlas, Inc. and ESRI 2008)). The populations of Woodford and Tazewell Counties have increased significantly since World War II, but lag the state as a whole since the 1870’s (IDNR 1998d). Census block data show that approximately 3,195 people lived in the watershed in 2007.

* + - 1. **Political Boundaries**

Tenmile Creek watershed occurs in both Woodford and Tazewell Counties and is subject to local county ordinances and local municipal laws. County engineers and township road commissioners also would be interested in stream channel work because the watershed has both bridge crossings and fords.

* + - 1. **Non-Governmental Organizations**

Some nongovernment organizations (NGOs) operate or have interest in Tenmile Creek watershed. These include the Illinois River Bluffs Ecosystem Partnership, Heartland Water Resources Council, The Nature Conservancy, Audubon Society, Sierra Club, and the Illinois River Soil Conservation Task Force.

Table 2. NGO stakeholders in the Tenmile Creek watershed

|  |  |
| --- | --- |
| **Non-governmental Organizations** | **Type\*** |
| American Eagle Foundation | I |
| Friends of the Illinois River | I |
| Heartland Water Resources Council of Central Illinois | I |
| Illinois River Bluffs Ecosystem Partnership | I |
| Illinois Stewardship Alliance | I |
| Living Upstream—Peoria Chapter (The Sun Foundation) | I |
| Peoria Audubon Society | I |
| Peoria Wilds not-for-profit Volunteers | I |
| Prairie Rivers Network | I |
| Sierra Club—Heart of Illinois Group | I |
| The Nature Conservancy—Peoria Office | I |
| Trees Forever—Illinois Buffer Partnership | I |
| Ducks Unlimited—Central Region | II |
| Peoria BassMasters | II |
| Pheasants Forever—Illinois River Valley Chapter | II |
| Tri-County Riverfront Action Forum Inc | III |
| Village of Germantown Hills Chamber of Commerce | III |
| Tazewell Farm Bureau | III |
| Woodford Farm Bureau | III |
| Caterpillar Trail Water District | IV |
| Ameren/CILCO & Central Illinois Light Co | IV |
| National Great Rivers Research and Education Center | V |
| Bradley University, Dept. of Biology | V |
| Tenmile Creek Watershed |  |

* + - 1. **Other Stakeholders**

Other stakeholders include a local historical society and the IRVCG. The inactive Tenmile Creek Drainage District covered 317.33 acres. It is not known whether this drainage district will remain inactive. No other drainage district is known to exist in or near Tenmile Creek watershed.

Table 3. Government agency stakeholders in the Tenmile Creek watershed

|  |  |
| --- | --- |
| **Government Agencies** | **Type\*** |
| Village of Germantown Hills—Economic Development | L |
| Village of Harvard Hills—Economic Development | L |
| Peoria Park District | L |
| Tri-County Regional Planning Commission | C |
| Tazewell County Soil and Water Conservation District | C |
| Woodford County Soil and Water Conservation District | C |
| Illinois Nature Preserve Commission Area 4 | S |
| Illinois Nature Preserve Commission Area 5 | S |
| IDNR Region 1 Forester | S |
| Illinois River Coordinating Council | S |
| Illinois Department of Transportation | S |
| Upper Mississippi River Basin Association | S |
| Illinois Attorney Generals’ Office | S |
| Illinois Environmental Protection Agency | S |
| US Fish and Wildlife Service—National Fish Habitat Initiative | F |

\* Government Level: L=Local, C=County, S=State, F=Federal

Table 4. Government officials who are stakeholders in the Tenmile Creek watershed

|  |  |
| --- | --- |
| **Government Officials** | **Type\*** |
|  |  |
| Mayor Office Village of Germantown Hills, Illinois | L |
| Mayor Office Harvard Hills, Illinois | L |
| Tazewell County Board | C |
| Woodford County Board | C |
| State Representative Michael Smith | S |
| State Representative Keith Sommer | S |
| Congressman Aaron Schock | F |
| Senator Richard Durbin | F |
| Senator Roland Burris | F |

\*Government Level: L=Local, C=County, S=State, F=Federal

* + 1. **Landscape, Land Cover, and Land Use**
			1. **Historical Landscape**

Information about the landscape in Tenmile Creek watershed before it was settled by Europeans was obtained from the United States General Land Office (GLO) records (Figure GLO). From 1804 to 1843, the GLO surveyed the land of Illinois and recorded information on its vegetation and features. Maps of the original surveys have been digitized by the Illinois Natural History Survey (INHS 2003a). Pre-settlement land cover also can be inferred from surface soil color data as reported on NRCS soil maps (Figure Soils\_LC, Illinois NRCS 2005). In Illinois, dark soils formed under prairies (mollisols) and light soils under forests (alfisols). The soils in riparian corridors are also dark in color, though they may not have formed under prairies. In general, the soils-derived land cover map is similar to GLO-derived map confirming that forests dominated the area in pre-settlement times, with some prairie in the eastern part of the watershed. The area shown as wetland is relatively small and is not the same for both data sources**.**

Figure 10. Figure GLO. The landscape was dominated by oak forest when first surveyed in the early 1800s by the U.S. Government Land Office (INHS 2003a).

Figure 11. Figure Soils\_LC. The color of the soil A horizons is distinctive of the long term landcover under which they developed. This map supports the landcover analysis from Government Land Office data (INHS 2003a), and may give a better appreciation of the distribution of the small but significant prairie openings.

* + - 1. **Ecoregions**

Tenmile Creek lies within 3 distinct EPA Level IV Ecoregions, the descriptions of which are excerpted and summarized here from Woods et al. (2006; Fig\_x\_ ecorgions). Ecoregions are a national dataset that denotes areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Omernik 1995). They are useful for structuring and implementing ecosystem management strategies across political boundaries and across agencies. Ecoregions stratify the environment according to its probable response to disturbance and recognize the spatial differences in the capacities and potentials of ecosystems. The Illinois ecoregion delineations are based on several criteria: (1) physiography, (2) natural vegetation, (3) soil, (4) surficial and bedrock geology, (5) climate, (6) land use and land cover, and (7) regional biogeography. A critical component is the recognition of the pervasive effects of people in the landscape, unlike the Natural Divisions of Illinois (Schwegman 1976), which are focussed on pre-settlement conditions (Omernik 1995). Level IV Ecoregions are published at 1:1,000,000 scale, derived largely from 1:250,000 scale data sets.

Figure 19. Figure ecorgions. Level IV Ecoregions in the Tenmile Creek area, from Woods et al. (2006).

***Upper Mississippi Alluvial Plain***

This ecoregion occurs in the western part of the Tenmile Creek watershed, near it’s confluence with the Illinois River (Fig\_x\_ ecorgions). It includes the lower portion of the alluvial fan (Fig. tm\_landforms). The ecoregion encompasses the broad floodplains and low river terraces of the Mississippi River and its major tributaries above the Mississippi’s confluence with the Missouri River, including much of the Illinois River. Levees, oxbow lakes, islands, and scattered sand sheets and dunes occur. Soils were mostly derived from thick silty and clayey alluvium, and are usually poorly drained. Others soils developed from sandy outwash. Both the alluvial plain and the river channel have been heavily modified in the last 100 years. Prior to the 19th century, bottomland forests, prairies, and marshes were common. Bottomland forests were adapted to prolonged flooding, and dominated by silver maple, American elm, and green ash; fewer tree species occurred than in the bottomlands downstream from the Mississippi’s confluence with the Missouri River. Mesic and wet prairies occurred on wide bottomlands, and dry prairie grew on the sand sheets. Today, the natural vegetation has largely been replaced by agriculture, with corn and soybeans as the major crops.

***River Hills***

Most of Tenmile Creek lies within the River Hills ecoregion (Fig\_x\_ ecorgions). The dissected and forested hills, bluffs, cliffs, and ravines of this ecoregion flank the floodplains of the Mississippi, Illinois, and lower Sangamon rivers in west central Illinois. This ecoregion is characteristically underlain by limestone and sandstone, and is covered by deep loess. Most of the area was glaciated by pre-Wisconsin Episode ice. Areas of karst occur where limestone is near the surface. Sugar maple, basswood, and red oak are common on mesic sites, whereas black and white oaks occur on drier sites, and post oak is found near ridge tops. Floodplain forests grow on bottomlands, and are dominated by silver maple, cottonwood, hickories, and sycamore. The River Hills ecoregion is part of an extensively forested habitat corridor along the Mississippi River. Wooded valleys in this ecoregion are important nighttime roosting areas for wintering bald eagles. Modern land use in the ecoregion is a mixture of cropland, pastureland, and forest. Forests are now most commonly found on steeper slopes. Patterns of land use are more varied than in adjacent ecoregions

***Illinois and Indiana Prairies***

This ecoregion constitutes a relatively small area in the eastern part of Tenmile Creek watershed. This ecoregion is characterized by vast, glaciated, flat to rolling plains and by dark, very fertile soils that developed under tall-grass prairie. Marshes and wet prairies naturally occurred in poorly drained areas, and forests grew on concentric moraines and floodplains. Overall, at the time of settlement, trees were less common than in neighboring ecoregions, and native vegetation was distinct from the hardwood forests that covered the drift plains of Indiana. The soils of the Illinois/Indiana Prairies are typically rich in organic material and developed from loess, glacial drift, or lacustrine sediments.

In the 19th century, to make the land more suitable for cropland and settlement, extensive parts of the till plains were tiled, ditched, and tied into existing drainage systems. In so doing, once abundant aquatic habitats have been modified, reduced in size, or eliminated, and nearly all of the original prairies have been replaced by agriculture. Main crops are corn and soybeans. Agriculture has affected stream chemistry, turbidity, and habitat. Streams in the loess-mantled western part of this ecoregion, including Tenmile Creek, are more turbid and have lower fish species diversity than eastern areas.

* + - 1. **Land Cover**

Land Cover is the physical occurrence of earth materials, vegetation, or built environments at the earth surface. It can be determined via remote sensing methods or by field survey. Land cover is distinct from land use, although the two analyses are often described together. We compiled several land cover data sets covering a range of time periods and at varying scales. They cannot be directly compared because of the different resolutions, source data, analysis methods, and class definitions. It is illustrative to examine them together, however, to understand broad historical trends.

The Cropland Data Layer (CDL) Program of the USDA National Agricultural Statistics Service (USDA, NASS, 2009) provides the most recent land cover data from 2008 as a geo-referenced, classified, land cover raster at 60-m resolution (Figure NASS\_LC). This resolution is fairly coarse for analysis and is best suited to regional analysis. However, this data layer is included in this watershed analysis because expected annual updates could provide data for future assessment level watershed land-cover monitoring. The quality control is very high for the agricultural components. Non-agricultural components such as wetlands and developed areas are less assured. These data show that land cover in Tenmile Creek watershed is 34% agricultural, 1% barren, 46% forested, 15% urban, 0.6%, surface water, and 3% wetland. A more detailed breakdown of land cover classes is shown in Table X.

Figure 12. Figure 1634 [NASS\_LC] Land cover classes by acreage and percentage USDA, NASS (2009).

Table X. 2008 NASS (USDA, NASS, 2009) land cover classes by acreage and percentage. NLCD refers to classes identified using a different set of training data from the National Land Cover Dataset, primarily for non-agricultural areas.

|  |  |  |
| --- | --- | --- |
| CLASS\_NAME | Acres | Percent |
| Corn | 1111.24 | 9.46 |
| Soybeans | 662.56 | 5.64 |
| Winter Wheat | 25.57 | 0.22 |
| W. Wht./Soy. Dbl. Crop | 5.42 | 0.05 |
| Alfalfa | 6.97 | 0.06 |
| Misc. Vegs. & Fruits | 0.77 | 0.01 |
| Seed/Sod Grass | 0.77 | 0.01 |
| Fallow/Idle Cropland | 1.55 | 0.01 |
| Pasture/Grass | 155.76 | 1.33 |
| Woodland | 2.32 | 0.02 |
| NLCD - Open Water | 68.97 | 0.59 |
| NLCD - Developed/Open Space | 945.41 | 8.05 |
| NLCD - Developed/Low Intensity | 671.86 | 5.72 |
| NLCD - Developed/Medium Intensity | 157.31 | 1.34 |
| NLCD - Developed/High Intensity | 13.95 | 0.12 |
| NLCD - Barren | 99.19 | 0.84 |
| NLCD - Deciduous Forest | 5449.27 | 46.40 |
| NLCD - Grassland Herbaceous | 102.29 | 0.87 |
| NLCD - Pasture/Hay | 1937.31 | 16.50 |
| NLCD - Woody Wetlands | 323.14 | 2.75 |
| NLCD - Herbaceous Wetlands | 3.10 | 0.03 |

In 2000 the Illinois Natural History Survey’s Gap Analysis Program (GAP) created a land cover dataset at a resolution of 30 m, (INHS 2003b, Fig\_x\_gap\_lc\_detailed). Although the resolution is higher than the NASS (USDA, NASS, 2009) data, it is still regional in scale. The data classified Tenmile Creek in 2000 as 46% agricultural, 2% barren and exposed, 36% forested, <1% surface water, 9% urban and built-up land, and 6% wetland. Table X shows a more detailed breakdown of this land cover analysis.

Figure 13. fig\_x\_gap\_lc\_detailed. Detailed land cover of the Ten Mile Creek watershed, from Illinois Gap Analysis Program (INHS 2003b), 1:100,000 scale.

Table X. GAP (INHS 2003b) land cover classes

|  |  |  |
| --- | --- | --- |
| CLASS\_NAME | Acres | Percent |
| Corn | 1290.5 | 10.98 |
| Soybeans | 1626.3 | 13.84 |
| Winter Wheat | 17.8 | 0.15 |
| Winter Wheat/Soybeans | 8.5 | 0.07 |
| Rural Grassland | 2559.7 | 21.79 |
| Dry-Mesic Upland Forest | 3538.7 | 30.12 |
| Mesic Upland Forest | 334.9 | 2.85 |
| Partial Canopy/Savanna Upland Forest | 355.2 | 3.02 |
| Coniferous Forest | 3.8 | 0.03 |
| High Density Urban | 675.4 | 5.75 |
| Low/Medium Density Urban  | 298.2 | 2.54 |
| Urban Open Space | 100.5 | 0.86 |
| Shallow Marsh/Wet Meadow | 2.2 | 0.02 |
| Deep Marsh | 1.6 | 0.01 |
| Seasonally/ Temporarily Flooded Wetland | 31.6 | 0.27 |
| Wet-Mesic Floodplain Forest | 207.0 | 1.76 |
| Wet Floodplain Forest | 447.0 | 3.80 |
| Shallow Water Wetland | 1.6 | 0.01 |
| Surface Water | 20.0 | 0.17 |
| Barren and Exposed Land | 228.4 | 1.94 |

The GAP land cover data from 2000 and the NASS data from 2008 are of different resolutions and were derived from different satellite sources and different image classification methods. Therefore, a detailed change detection analysis would not be accurate. Together, the data do show, however, an increase in urban land and a decrease in agricultural land, a expected trend.

Riparian land cover at other points in time was also compiled from The Illinois Stream Information System (ISIS 1989) and field observations collected for this study by the ISWS. Both of these data sets characterize conditions along the stream channels. The ISIS Bankside Land cover data were developed from inspection of oblique aerial photography (ISIS 1989). The ISWS data set was extracted from Qualitative Habitat and Evaluation Index parameters (QHEI 2008) described below.

To examine recent land cover change with time, Figure LC\_change [FIG 5100] shows bankside land cover within a 100-meter wide buffer along Tenmile Creek, with data extracted from (ISIS 1989), GAP (INHS 2003b, data from 2000), and the ISWS field data (this study). The different land cover classes used by the 3 datasets were standardized. We chose to keep the classification scheme of the QHEI data because it employed the fewest classes. Data from the other 2 sources were reclassified and generalized into the QHEI classes. For each possible time interval (1989–2000, 2000–2008, and 1989–2008), the score of the beginning date was subtracted from the score of the ending date. The results show the change in the QHEI score for each stream segment. Because the datasets for each year are based on different source types (ISIS on aerial photo interpretation, GAP on satellite image classification, and QHEI on field observations) the resulting areas of change should be considered an approximation. Segments with a change of -1 to 1, shown in yellow, can be considered minor or within the margin of error, given the data translation issues. Segments with a change between -1 and -3, shown in red, imply habitat degradation. These areas may be candidates for restoration.

Figure 14. Figure 5100. Tenmile Creek Land Cover through Time.

* + - 1. **Land Use**

**Agriculture**

In 2008 approximately 34% of Tenmile Creek watershed was used for agriculture (USDA, 2009). Specifically, 17.8% was used for pasture, grass, or hay; 9.5% was used for corn; 5.6% was used for soybeans; and 1.2% was used for other crops, including winter wheat and alfalfa (Fig. NASS\_LC). About 194 acres of land, less than 2% of the total watershed, in Spring Creek valley mostly classified as Dry-Mesic Upland Forest is shown on plat maps as managed by a timber company (Fig. 1295\_misc\_LU) although there is no field evidence that it is currently worked. The specific agricultural practices used to manage these crops can have significant impacts for water and sediment runoff. However, the types of agricultural practices are not known. In his sediment delivery analysis, Windhorn (2003) noted some variability in tillage across the watershed, but the observations were instantaneous and are not available for analysis.

Figure 15. Fig. 1295\_misc\_LU. Land use features that potentially impact stream ecosystems.

Prime farmland and farmland of state importance occurs level portions of the uplands, in the middle valley, and on the alluvial plain (Figure tm\_primefarmland; Soil Survey Staff 2006, 2007). Much of the upland is classed as not prime farmland. Where the land has not been disturbed, this is probably due to steep (E-G class) slopes (c.f. . tm\_slope).

Figure 17. Figure primefarmland. Farmland classifications from Soil Survey Staff (2006, 2007)

**Industry**

*Industrial Land*

Roughly 22% (2,543 acres) of the land in the watershed is owned by the heavy equipment manufacturer, Caterpillar. Until the late 1960s, most of this land was used as proving grounds, where earth-moving equipment was tested. As a result of a conservation program, the amount of land used for testing was reduced to approximately 300 acres (Kramer 1980). The program has allowed the rest of the proving grounds to be revegetated and serve as a buffer zone.

*Mining*

One mine for gravel from the middle Tenmile channel and possibly the adjacent terrace is indicated on topographic maps (Fig. misc\_LU). It is now abandoned. Several polygonal depressions on the terrace treads between the gravel pit and the Spring Creek confluence may also have been borrow areas. There are no current mining operations.

*Sewage Treatment, and Stormwater Runoff*

The Village of Germantown Hills has a municipal sewage treatment plant on Wolf Creek built in 1997 (<http://www.germantownhills.com/village/waste.htm>, Fig. misc\_LU). There are currently no stormwater runoff facilities operating in the watershed, although stormwater ordinances are under development (TCRPC 2004a; see Land Use Planning, below). Runoff is transferred to the channels by ditch or culvert.

*Former Landfills*

The TCRPC (2004a) reported two private landfills within the watershed, 15 and 30 acres in size respectively. Their location is uncertain. Both have been closed for over 30 years, but neither is monitored.

*EPA-Permitted Activities*

Figure Misc\_LU shows where the U.S. Environmental Protection Agency (EPA) has granted permits for polluting activities (<http://www.epa.gov/enviro/emef/>, accessed 5/18/2009). Five water dischargers are listed, though 3 of the permits on record have expired (Table NPDES). There is also one hazardous waste permit listed for an Illinois EPA remediation site and an air emissions permit for the Caterpillar proving grounds.

Table NPDES

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Permit for | Type | Expiration |
| GERMANTOWN HILLS WWTP #2 | BOD 5-day, pH, TSS, flow, Cl, BOD carbon. 20C | water dischargers | 12-31-07 |
| CATERPILLAR TRAIL PWD | pH, TSS, Fe, flow, Cl, total resid. | water dischargers | 03-30-10 |
| PEORIA CATERPILLAR-PROV GROUND |  | water dischargers | 05-31-08 |
| CATERPILLAR-PROVING GROUND | BOD 5day, pH, TSS, oil/grease freon, flow, Cl | water dischargers | 03-31-11 |
| CATERPILLAR INC- PEORIA PROVING GROUND | CO, VOC, SO2, NO2, TSP | POTENTIAL UNCONTROLLED EMISSIONS < 100 TONS/YR |  |
| IL EPA RPMS HARMON AUTO SAL |  | hazardous waste |  |
| MALLARD CROSSING LTS 1,2,3,6 |  | water dischargers | 05-31-08 |

**Transportation**

Three major roads cross the Tenmile Creek watershed (Figure 1). U.S. Route 24 runs through the City of Washington in the southern part of the watershed. State Route 116 runs NE-SW along the northern watershed boundary and crosses Tenmile and Spring Creeks in the eastern part of the watershed. State Route 26 crosses Tenmile Creek near its confluence with Spring Creek. The expansion of SR 116 from two to four lanes in the late 1970s was a major factor contributing to the growth of Germantown Hills in subsequent decades (TCRPC 2004b).

The Illinois Department of Transportation (IDOT) is in the process of conducting The Eastern Bypass Study, which will determine the best location for a proposed, fully controlled or partially controlled highway that would connect Interstate 74 with Illinois Route 6, east and north of Peoria (Figure Eastern Bypass, IDOT 2008). The proposed highway would likely traverse Tenmile Creek watershed and would have profound effects on “(1) the amount of stormwater flushed into the creek system from the additional impervious areas; (2) the non-point source pollutants (oils, antifreeze, litter) entering the stream; and (3) the urbanization of the watershed,” (TCRPC 2004a). The TCRPC recommended that stormwater detention and filtration infrastructure be a priority as the planning for the Eastern Bypass continues. Impacts on stream channel stability downstream of the corridor should also be investigated, and appropriate grade stabilization structures should be put into place beforeroad construction. Additionally, the City of Washington and the Village of Germantown Hills should implement appropriate conservation zoning to protect valued forested bluffs and prime farmland in the watershed (TCRPC 2004a).

Figure 16. Figure 9253. Study area of the Eastern Bypass around Peoria (adapted from http://www.easternbypass.com/files/ResourceMaps/BaseMap-April2009Draft.pdf).

The TCRPC (2004a) identified 26 culverts within the watershed (Fig. 1295\_misc\_LU). Their ages and condition are not generally known, although several were inspected during ISWS field investigations. Depending on their relative size, construction, and geologic setting, culverts can serve as both grade control and foci of channel instability, flow inhibitors and flood conveyance races, and channel bed datums.

**Urban Areas and Impervious Surfaces**

Residential subdivisions constitute a relatively small part of the watershed, because they are only part of the roughly 10–15% of the watershed that is urbanized, but their proportion is likely to grow as the communities of Washington and Germantown Hills expand. There also are several rural residences and low-density subdivisions in the unincorporated areas of the watershed. Most of the forested areas outside the Caterpillar property are currently zoned as residential in Woodford County or planned as rural residential in Tazewell County (TCRPC 1996, Figure 997 Future Land Use).

**Zoning**

**Public Lands with Ecological Designations**

Figure Conservation shows 3 conservation areas in Tenmile Creek watershed: the 10-acre Caterpillar Hill Prairies, a 127-acre Illinois River Fish and Wildlife Area, managed by the Illinois Department of Natural Resources (IDNR), and the Fondulac Park District’s 270-acre Spring Creek Preserve. The *Spring Creek Preserve Forested Restoration Plan* (2003–2005, Appendix?) calls for controlled burning, invasive species removal, and the placement of log check dams in an eroding ravine on the Spring Creek property.

Figure 18. Figure 1254 Conservation areas and related features within the Tenmile Creek watershed.

The entire Tenmile Creek watershed lies within 2 larger areas targeted for conservation: the Illinois River Bluffs Assessment Area and the Peoria Wilds Resource-Rich Area (Figure 3). The Illinois River Bluffs Assessment Area was designated by IDNR for the purposes of the Ecosystems Program. The program is funded through Conservation 2000, an ongoing state initiative to enhance and preserve Illinois’ natural areas through partnerships of public and private stakeholders (IDNR, 1998a,b,c,d). Within IRBAA lies the Peoria Wilds, one of several Resource-Rich Areas designated by IDNR for the purpose of guiding ecosystem-specific conservation strategies. In 2003, Tenmile Creek Watershed was selected as one of seven priority watersheds in the Illinois River Bluffs Ecosystem Partnership due to its high degree of habitat quality, the threat of degradation from development, and the planning efforts underway (TCRPC 2004a). Priority watersheds are given preference for funding through the Conservation 2000 program.

**Land Use Planning**

Germantown Hills has experienced significant growth since the early 1990s, resulting in an expansion of the sewer and water treatment facilities in 1997 (TCRPC 2004a, Fig. misc\_LU). Growth is also anticipated along the U.S. Route 24 bypass north of the City of Washington in Tazewell County (TCRPC 2004a). Comprehensive plans of the two municipalities and two counties in the watershed show that they are planning for more residential, commercial, and light industrial land within Tenmile Creek watershed (Figure Land Use Planned). The implications of this are that some land currently used for agriculture will become urbanized. Tazewell and Woodford Counties are scheduled to release new comprehensive plans in fall of 2009.

To promote the reduction of sedimentation, erosion, and contamination in the Illinois River and its tributaries, the TCRPC provides model stormwater and riparian ordinances as guides to local planners. However, the ordinances have not been implemented by local jurisdictions within Tenmile Creek watershed (Melissa Eaton, TCRPC, personal communication, 4-20-09). The TCRPC is currently in the process of creating a Regional stormwater management plan: http://www.tricountyrpc.org/environment-page/regional-stormwater-plan.

* + 1. **Physical and Chemical Conditions**
			1. **Geologic Setting**
				1. **Bedrock Geology**

Bedrock is the lithified sediment that occurs below all Quaternary deposits. The bedrock, dominantly shale with lesser sandstone, around Ten Mile Creek is relatively deeply buried. Well records indicate a spur with upper elevations of ~460 ft amsl subparallel to the bluff line. The bedrock surface descends to the thalweg of the Ancient Mississippi Bedrock Valley, elevations <300 ft amsl, under the eastern border of the watershed (c.f. Berg et al., 2009).

* + - * 1. **Surficial Geology**

***Soil Parent Materials***

The parent material of a soil is the mineral material, weathered or unweathered, as well as its mode of genesis (by water, wind, ice, hillslope movement, etc.), which in turn influences its uniformity and other physical characteristics. A soil parent material map for Ten Mile Creek (Fig. 5900 fig\_tm\_pm) was developed from soil survey data (Soil Survey Staff 2006, 2007), correlated from Stumpf and Weibel (2004). The map classifies the upper 5 ft of sediment and is used as a relatively quick approximation of the surficial geology.

Figure 20. Fig\_5900\_tm\_pm. Parent materials classes interpreted from soil survey data (Soil Survey Staff 2006, 2007). Parent materials approximate the distribution of geologic units within the upper 5 ft of the land surface.

*Orthents*. The Ten Mile watershed includes sediment recently deposited by people through land grading or fill. Original soils have been removed, though a thin, new soil may be developing. Orthents in this areas are typically loamy reflecting the loamy parent of till, outwash, or dune sand. Actual sediments are highly variable and must be determined by site investigations. The major area of orthents is the Proving Grounds. Other sizable areas are the City of Washington’s Oak Ridge Park (Fig. tm\_pm) and a housing development North of IL 24.

*Disturbed Ground*. Disturbed ground consists of areas where original land has been removed by mining, mine spoils have been deposited, or significant areas of pavement have been created (c.f. Urban land, Soil Survey Staff 2006). The geologic characteristics are highly variable must be determined by site investigations. Runoff may be increased in these areas because of increased imperviousness.

Several gravel mines or borrow pits, now abandoned, occur within the middle valley (Fig. Misc\_LU). A automobile junkyard and an adjacent trailer park occur on the south margin of the alluvial fan. Smaller areas occur in a commercial establishments on the outskirts of Germantown Hills and a religious facility west of Washington.

*Colluvium*. Colluvium is sediment that has been moved down hillslopes by water, wind, or gravity processes and accumulated in depressions on the uplands and on foot slopes. It was eroded from prexisting deposits, typically till, outwash, or loess, and transported relatively short distances. Colluvium in the Ten Mile watershed is generally silty or clayey, and can be either stratified or massive.

*Organic Soil Material*. Peat, muck, or organic-rich silt, dark gray to black in color, and usually water saturated, accumulates in low-lying areas including abandoned channels, shallow lakes, and other depressions on the modern floodplain.

The largest area of organic soil material on the modern floodplain is classed as the hydric Houghton and Palm soils. Hydric soils on the upland also occur that may have had similar original properties, but their current properties have been altered by decades of drainage.

*Alluvium.* Sediment deposited by streams in the post-glacial episode occurs within stream valleys and as a veneer on floodplains. Much of this modern alluvium is fine-grained, redeposited loess, but also includes sand, gravel remobilized from till and glacial stream deposits. The alluvium may contain humus, wood fragments, and shells. It is soft and thus tends to be erodible. Thicknesses range from up to 5 ft thick in tributary valleys including Spring, Wolf, and upper Ten Mile creeks, to more than 10 ft thick in Ten Mile Creek below the dam and 10’s of ft thick in the alluvial fan.

*Eolian Sand.* Postglacial dunes and undulating sandy deposits composed of windblown sand on occur on terraces in the Illinois Valley. They comprise very fine- to medium-grained sand, loose, and are non-calcareous in upper part. Deposits are less than 10 ft thick and are capped by a veneer of recent floodplain deposits. The map units may also include minor outwash components.

*Loess*. Loess is the uppermost sediment on much of the upland landscape. Loess is mainly yellow gray to yellow brown silt loam to gritty silt loam. Buried units also occur. It can be highly erodible, especially where leached of calcium. Loess is susceptible to piping, which increases its erodibility.

Loess accumulated mainly during the late glacial phases. It was blown by west-east winds off of the sandy outwash plain in the Illinois Valley and was deposited as a wedge that thins rapidly eastward. On uneroded hilltops along the bluff line, statewide maps depict loess as generally 10-15 ft thick. However, 12-20 ft of “yellow clay” that is likely loess was typically described in water well logs from both on moraines and on the Till Plain (Fig. tm\_landforms). By contrast, the loess appears to have been eroded off of portions of incised areas of the Ten Mile watershed. Loess is thin to absent on landforms constructed after the main period of loess deposition (ending approximately 12,500 radiocarbon years ago), particularly modern floodplains.

In lower Spring Creek, the stream has eroded through the upper sequences and now flows on the Robein Silt, a weak, organic rich soil developed in loess from a mid-Wisconsin Episode interglacial period (Hansel and Johnson 1996). The Robein Silt is relatively resistant to erosion because of its high clay content.

*Glacial Till*. Glaciers deposited unsorted mixtures of gravel, sand, silt, and clay (“diamicton”) at their base or at the ice fronts. Diamicton here ranges from loamy to silty clay loam textured. It is dense (hard to firm) and pinkish to gray brown in color. It has low erodibility where it is uniform and especially where it is enriched in clay, particularly paleosol horizons.

The base of the till has up to 100 ft of relief, and typically overlies outwash in this region (Fig. SB\_xs). The till forms the uplands, including moraines and Tiskilwa till plain. The Tiskilwa is the most uppermost till unit, but buried, older units occur and can be exposed in outcrop.

Figure 21. Figure SB\_xs. Geologic cross-section from the Illinois River valley to the uplands, after Stumpf and Weibel (2005). See Figure tm\_pm for location.

*Glacial Outwash*. Glacial outwash comprises stratified sand to gravel or boulders, with typically little silt. It is yellow brown to gray brown in color. It is commonly cemented with calcite. Where cemented, it can uphold steep slopes (A. Stumpf, 2009, personal communication).

Outwash includes glacial stream sediment sourced both at the moraines bordering the watershed as well as from within the Illinois Valley. It is found as bars, channel deposits, and terraces. Much of the sediment was deposited during deglacial flooding. The flooding filled lower valley of Ten Mile Creek up to elevations of 530-550 ft; remnant were left as terraces (Terrace P1, P2, Fig. tm\_landforms). The terrace sediment probably fines up-valley and onlaps with glacifluvial sediment sourced at moraines.

Buried deposits of sand and gravel also occur (below). A pervasive sand and gravel deposit occurs below 500 ft elevation as determined from well logs (Fig. SB\_xs). It does not crop out presently. A simple model of incision by incrementally lowering the entire surface of the watershed, indicates 20-30 ft of incision would be required to expose the deposit in the Middle Valley (Fig. SGcrop).

Figure SGcrop. Map showing areas of potential outcrop of sand and gravel. Upper lenses may be exposed along incised valley walls. Lower beds would require >25 ft of incision to be exposed.

***Landform – Sediment Assemblages***

Landform-sediment assemblages are informal map units of distinct land forms and the geologic materials that underlie them. The landforms are identifiable by topographic map, airphoto, or field survey (fig\_tm\_landforms). The geologic materials are lithologically distinct and may be either exposed or concealed and thus visible only by drilling.

*Moraines*. End moraines are elevated landforms constructed by amalgamation of sediment at ice fronts through debris flow, outwash, and stacking of basal till. Regional studies indicate these moraines are built of stacks of outwash, basal till, supraglacial deposits, and loess (Stumpf and Weibel 2004; Willman 1973).

Well records in the Bloomington Moraine (fig\_tm\_landforms) describe common lenses of sand and gravel within diamicton between depths of X and Y. The lenses are M to N ft thick and appear to be discontinuous. This patchy but consistent lithology was modeled as a uniform unit of mixed sand, gravel, and diamicton in Fig\_x\_SGcrop. This model shows that the unit should be cropping out in the upper tributaries of Spring Creek. Field investigations show unstable channel cross sections and several knickpoints in upper Spring Creek (see Channel Condition assessment, below). These may be related to the heterogeneous lithology of the valley walls.

Mostly concealed but locally exposed in outcrop are the Sangamon Geosol, a major pre-Wisconsin Episode interglacial soil, and Illinois Episode till and outwash. The Sangamon Geosol is pervasively developed in the upper part of the Illinois Episode sediments. Typically the upper soil horizons have been eroded, and only the clay-rich B horizon is left. This soil can be a erosion-resistant and relatively impermeable layer that can uphold steep slopes or perched water tables. It may thus constitute the step of a knickpoint or the base of a slide. Outcrops were observed in upper Ten Mile Creek.

The Tiskilwa Till Plain is an area of ground moraine. It was constructed of till deposited at the base of the glaciers. In addition to relatively low relief, it is tends to be more compacted and uniform in its properites than the end moraines.

*Terraces*. Terraces in the Illinois Valley are eroded benches comprised of a 0-5 ft veneer of fine sediment, probably post-glacial alluvium or colluvium, over interbedded fine sand to gravel, with beds 5-50 ft thick. The deposits typically fine upwards, although gravel can occur at the surface (Fig. SB\_xs). Only the larger terraces are depicted in Fig. tm\_landforms. There are also other terraces within Spring, Wolf, and upper Ten Mile creeks that are readily observed in the field but are too small to delineate at that scale.

Water well records indicate that terraces within Ten Mile Valley contain deposits of 4-20 ft of clay to silty clay loam over interbedded sand, gravel, and clay. Sand and gravel beds range from 5-50 ft thick, clay beds from 5-10 ft thick. The surficial fine sediment layers are likely a mixture of loess and alluvial or colluvial sediment derived from loess. The coarse material is glacifluvial sediment, either sourced from the trunk valley or on the moraines. The buried clay is likely backwater lake sediment deposited when the valley mouth was dammed by sediment, water, or both.

Three terrace levels can be distinguished in the tributary valleys. The lowest terrace, T1, lies 1-3.5 ft above the modern thalweg and comprises lightly vegetated surfaces with weak to no soil development. Saplings, including willow and hackberry, on its surface are less than 5 years old, but the position suggests it should be included in the active floodplain. The middle terrace, T2, lies 4-7 ft above the modern thalweg. It is comprised of uniform to bedded sand and silt loam. It is low enough that it may be periodically flooded. However, trees 27-46 years old (n=6) indicate a moderate period of stability. The highest terrace, T3, lies 11-15 ft above the modern thalweg. It slopes smoothly up to the valley walls. It is possibly correlative to the terraces shown in middle Ten Mile Creek (Fig. tm\_landforms). Trees on that surface ranged in age from 70-99 years (n=4). On the valley slope, sampled oaks and maples aged 100-160 years (n=3). The sediment in T3 is a sequence of bedded sand and coarse gravel fining up to 3-4 ft of silt loam with few gravel clasts.

*Alluvial Fan*. Sediment in the alluvial fan is much more variable than in the dune fields or on the terraces. Upper fine sediment layer (clay to loam) is 2-30 ft thick with common lenses of sand or gravel. At depth, fine sediment is interbedded with predominantly sand but also gravel. Beds are 2-50 ft thick. The upper sediment is a mixture of overbank sedimentation from Ten Mile creek and post-glacial floodwaters of the Illinois River. Glacial lake sediment buried below sand is depicted in Fig. SB\_xs.

*Concealed Deposits*. Below all other sediments but above bedrock is a 50-200 ft thick layer of sand and gravel outwash recognized regionally as a major aquifer (Fig. SB\_xs; McKay et al., 2009).

There are no known outcroppings of this concealed sand layer within the watershed. Modeling indicates that 20-25 ft of incision in lower Ten Mile Creek would be necessary to expose the deposit (Fig. SGcrop).

* + - * 1. **Groundwater Occurrence and Usage**

There appear to be abundant groundwater supplies within the watershed. The ISGS maintains a database of the water well permits and construction records that all drillers are required to report. Although some of the records from the watershed date as far back at 1902, records older than a few decades tend to be incomplete. There are 254 known water wells in the watershed/alluvial fan area. Nearly all residences and businesses within this area of interest obtain water from either private or small community wells (20 community wells for subdivisions and trailer parks are monitored by IEPA; Wade Boring, personal communication, 2007). There are no known municipal (large community) wells. Of the 254 wells, 189 records contain information about the producing formation or screen depth. These fall into two groups. In the first group, 50 wells draw water from relatively shallow sources (the top of acquifer is 3-100 ft deep). These wells are located either on the alluvial fan or on the Metamora Moraine and adjacent landforms on the north flank of the watershed. In the second group, 130 wells draw water from 200-360 ft deep, i.e., the deep sand layer shown in Fig SB\_xs, locally known as the Sankoty Sand (Willman and Frye 1970).

Aquifers less than 100 ft deep below most of the uplands within the watershed in Tazewell County were classified as moderately highly to highly sensitive to contamination based on aquifer extent and thickness of the fine-grained sediment cover by Johnstone (2003) after Berg (2001). The alluvial fan area was classified as moderately highly to very highly sensitive. These results are consistent with a coarser, statewide analysis (Keefer 1995), and so similar landforms in Woodford County likely have similar characteristics. The deep aquifer was not considered in the analysis.

* + - 1. **Hydrogeomorphic Setting**
				1. **Channel Gradient and Stream Power**

Channel slopes in the Tenmile Creek Watershed were estimated using stream channels digitized by ISGS and 3 m contours derived from a seamless USGS digital elevation model. The slopes estimated from these sources were cross-checked with slopes estimated by interpolating stream distance between contours on USGS topographic maps. The distribution of channel slope in the watershed is shown in Figure [xSlope]. Of the nearly 55 miles of streams for which gradient was estimated, about 42% were lower than 0.01 and about 75% were lower than 0.02. Most stream segments with gradients greater than 0.02 occur in first order tributaries.

Ten Mile, Wolf, and Spring Creeks each feature convex profiles in their middle reaches (fig\_x\_profiles). By contrast, alluvial channels with stream power adjusted to the imposed sediment load are expected to feature continuously concave profiles. These deviations could be caused by relatively resistant strata in the stream bed, deposition induced by reduction of flow velocity, a new source of sediment that overloads the stream capacity, or other phenomena.

Figure 22a, 22b. Figures [powermap] and [fig\_x\_power] show the locations and the profiles of stream power estimates along Tenmile, Spring and Wolf creeks. There is a general increase in stream power downstream with increasing catchment area and thus increasing discharge. There is little correlation between stream power and either channel slope or discharge, suggesting that local conditions prevail.

Figure 23. Figure powermap. Locations of estimates of stream power based on Illinois Stream Stats (USGS 2009).

Figure 24. Figure 100000 fig\_x\_power. Profiles of estimated stream power along Ten Mile, Spring, and Wolf Creeks. Horizontal line of 35 W·m-2 is an approximate threshold of erosion-dominated stream adjustment.

The middle portion of Tenmile Creek encompassing the Proving Grounds shows the highest stream power values. Notable spikes in stream power occur along Tenmile Creek near Station TM8 and in the upper portion of Wolf Creek where channel slope steepens abruptly. The spike at TM8 may be due mainly to a narrowing of the channel there; width is about ½ that at the neighboring locations. The stream at TM8 is impinging on the valley wall and armoring of the right bank by piles occurs, thus energy may be focussed into incision. By contrast, it was observed that the TM8 reach was dominantly depositional compared to mixed depositional/erosional both up- and downstream. This may be attributed to the surveys having been taken during low flow conditions. A second local maximum at TM19 (RM 4.2) occurs just downstream of the CAT detention pond where the channel is both deeper and wider than at downstream locations. Stream power values are near or below the erosional/depositional threshold (35 W/m2) along the portion of Tenmile Creek that passes across the alluvial fan and in the uppermost portions of each creek.

* + - * 1. **Hydrology, Sediment Transport, Erosion and Sedimentation**

There are no hydrologic flow or precipitation data for Tenmile Creek. Nearby gauged sites include Fondulac, Farm, and Ackerman Creeks in Tazewell County. Precipitation data are available from East Peoria (online access at <http://www.isws.illinois.edu/warm/>). The preceeding stream power analysis was based on regional hydrologic curves.

A waterbody inventory was conducted to determine the location, distribution, and density of surface water features other than streams in the watershed. The influence of waterbodies on the catchment hydrology depends on their number, storage capacity, base level, and outflow. This inventory gives only the number and locations of waterbodies. Analysis beyond what is presented here would be required to evaluate the effect that waterbodies may have on the reduction of peak discharges, increase in base flow, and channel incision or aggradation. However, this inventory can be used to guide selection of areas for further analysis.

The inventory was conducted by inspection of the 1998 DOQ, 2004 NAIP infrared, and 2007 NAIP true color aerial imagery (Figure 1) supported by digital image analysis of the infrared imagery. Based on this inventory, there are a total of 57 waterbodies covering over 60 ac within the Tenmile Creek watershed (Table [Waterbodies]). Eighteen (18) of these are located within the Proving Grounds; they account for nearly one half (~35 ac) of the total waterbody area in the watershed, and the sediment detention basin below the confluence of Tenmile and Wolf Creeks itself accounts for one fourth (15 ac) of the total waterbody area. Many of the remainder of the waterbodies are impoundments along tributaries throughout the watershed. Many of these are located at the heads of streams. Some of the waterbodies appear to be intermittent or ephemeral, but their status cannot be confirmed without additional field work, imagery data, or both. During a field visit in December, 2007, two ponds totalling about 75 ac and managed for waterfowl were observed adjacent the channelized reach of Tenmile. They were not digitized for this data set because they do not appear in our most recent (2007) imagery.

Table [Waterbodies]. Occurrence of waterbodies in subbasins of Tenmile Creek

|  |  |  |
| --- | --- | --- |
| Subbasin Name | Number of Waterbodies | Acres |
| Spring Creek | 3 | 2.2 |
| Wolf Creek | 13 | 9.2 |
| Tenmile Creek | 40 | 47.0 |
| Other | 1 | 2.5 |

***Erosion and Sedimentation***

Field investigations have revealed considerable erosion and sedimentation over the past half century in Wolf and Spring Creeks.

*Fluvial Processes*. Fluvial terraces indicate episodes of downcutting, possibly related to climate and land use changes over time. In Wolf Creek, one 7 ft high cutbank featured bedded sandy loam with a glass bottle buried at 5 ft depth. The bottle was estimated to date from the 1954 to 1964 based on its serial number, and indicates a minimum average sedimentation rate of 1.1 in/yr (28 mm/yr). A polystyrene cup at 3 ft depth confirms the upper part of the deposit dates no earlier than the late 1950’s to early 1960’s. Sedimentation rates were possibly greater, with the entire alluvial sequence deposited in brief episode (years?). About 1500 ft upstream (field id isgs\_W11), a small car (Fig.x\_crossley) was found buried under 2 ft of loamy alluvium. The deposit is probably correlative to W3. Rounded cobbles and boulders piled against the upstream side of the car indicate sufficient energy to transport high-calibre bedload at the time of burial.

Figure 25. Fig.x\_crossley. A buried car helps to date the time of deposition of some floodplain sediment.

Sedimentation rates over the past ~150 yr can also be estimated by the occurrence of fly ash (see Methods). Fly ash contents were determined for 3 alluvial sections within the watershed (fig\_x\_flyash ). They indicate high and rapid historical sedimentation (fig\_x\_flyash). Fly ash content generally decreases exponentially with depth, possibly a consequence of increasing coal combustion with time. At S15, 6 ft of fine to medium sand occurs over open-work gravel in a floodplain cutbank. Fly ash content decreased from 74 % at 0.5 ft depth to 0 % at 5 ft depth, with a sudden increase at 6 ft. The increase anamolous at the bottom is possibly attributed to secondary intruduction of the fly ash into the open gravel matrix. By contrast, other studied profiles consistently decrease with depth. If the first (deepest) occurrence of fly ash is assumed to represent ~1850, then the average sedimentation rate is ~0.3 in/yr (8 mm/yr). Further, the sequence indicates an early period of valley infilling followed by downcutting.

Figure 26. Fig\_x\_flyash. The occurrence of fly ash helps date a deposit to the Historical period. Assuming a constant rainout, abundance is an indicator of sedimentation rate.

Windhorn (2003) estimated that the watershed yields 23,500 tons/year of sediment. Potential sediment availability from upland, gully, and stream sources was visually estimated, after Windhorn and D’Avello (2002). These estimates were scaled with a yield factor that accounts for efficiency of sediment transfer. Windhorn recognized that the streambank contributions could be significantly underestimated, as has been pointed out by Bhomik et al. 1993. Bedload contributions were poorly known. He also did not consider sediment trapping by ponds, although the Caterpillar detention base has a large effect on sediment transfer.

*Mass Wasting.* Mass wasting of high valley walls is common to many watersheds drain­ing directly into Peoria Lake (Figx\_masswasting\_S7). . Slumps and slides episodically contribute large amounts of glacial sedi­ment directly into streams. Twenty-five sites of mass wasting were identified throughout the Tenmile Creek watershed and others are likely to exist Observed deposits and scarps are typically 80-120 ft in length at the toe, with the head of the scarp 15-75 ft above the stream bed. The largest slide observed in a small tributary to Ten Mile Creek is estimated to be 500 ft long with a scarp 100 ft high. The loose, wet sediment fills the valley bottom.

Figure 27. Figure masswasting\_S7. Large landslide and exposed scarp in Spring Creek, ISGS location S7, looking downstream. Scarp is about 50 ft above the bed. Floodplain is on the left.

Mass wasting tends to occur where a stream undercuts up­land valley walls by lateral migration. The persistent erosion at the toe of the slope maintains a steep escarpment (Figure ?). It is also possible that overall incision leaves oversteepened walls at the base of slope. Although mass wasting ap­pears to continue despite the colonization by woody vegetation at toe of slope in some instances, the deposit may self-stabilize if the young woody vegetation becomes better established. Slope failures of this type occur in a similar geologic setting in southwestern Illinois. Straub et al. (2006) found there that slope failures occurred during waning of flood flows as hy­drostatic support of the base of the slope decreased.

* + - * 1. **Channel Bed Materials**

The character of channel bed materials largely dictates the mobility of bedload and the susceptibility of the channel to incision. The channel bed material in the Tenmile Creek watershed consists mainly of poorly-graded gravels and sands with little or no fine material. No consistent synoptic textural trends occur. This bed material is derived primarily from reworked alluvium (floodplain and channel deposits) except where the channel has incised into glacial deposits or where hillslope failures supply the channel with material directly from glacial and loess deposits from the valley walls. Along reaches where bedforms are patchy or do not occur, the streams flow on cohesive till or loess deposits.

The hydrologic conditions in nearby watersheds (e.g. Senachwine Creek, Partridge Creek) suggest that flows in Tenmile Creek are only rarely able to transport bedload coarser than fine gravel, although most flows are capable of transporting fine material (silt and clay particles) through the watershed and into Peoria Lake. This is evident from ISWS field observations, which indicate that the primary channel bed material throughout the watershed consists of gravel sand mixtures with little or no fine material and coarser materials were found in only a few cases. The coarser materials (cobble or larger) were noted immediately downstream of the spillway downstream of the proving grounds, within the proving grounds and in a few upper reaches of Tenmile and Spring Creeks (Figure [Bed\_Material\_Knickpoint \_Map]). These lag deposits likely indicate localized zones of higher stream energy (i.e. knickpoints) within the channel or local sources of large calibre sediment where incision may now be inhibited by the coarser material (cobbles and boulders) armoring the bed.

Figure 28. Figure HI\_pmbedm. Map of soil parent materials (Fig. tm\_pm) with observations of channel bed materials, knickpoints, and mass wasting.

* + - * 1. **Stream Planform Change**

Streams evolve dynamically with time in response to natural (e.g., climate, geology) and anthropogenic (e.g. land use, channel manipulation) forcings. Stream channels change their planform, cross section form, or both, by eroding their banks laterally, scouring the bed, or depositing sediment on floodplains and within channels. The rates and modes of these behaviors are functions of the geomorphic, hydrologic, and geologic settings. The net planform change between 1939 and 1998 was quantified as polygonal areas determined with digital methods (see Methods, above).

Change polygons were divided into five dynamic behavior classes: lateral or downstream migration, avulsion, channelization, post-channelization response by various mechanisms, and chute development. *Lateral or downstream migration* is a natural process by which streams erode sediment from their outside banks and deposit sediment along their inside banks. *Avulsion* is an abrupt change in channel position. It can be caused by rapid influx of sediment from mass wasting, or result from transformation of a *chute*, an ephemeral channel that occurs on floodplain during high flow, into the main channel through incision and stream capture. *Chutes* may also be short-lived features that do not develop fully to an avulsed channel. *Channelization* is anthropogenic avulsion, in which channel bends are straightened or channels are moved from their original positions. Channelization is usually recognized on imagery as an abrupt change in channel planform that results in a straightened channel where construction activities and an apparent advantage to expedited drainage are evident. Where avulsion, chute formation, or migration occur after a reach shows evidence of channelization, *post- channelization* is assigned as the dynamic class.

The preliminary results from assessment of channel dynamics between 1939 and 1998 are given in Tables I and II below and areal planform change is depicted in Figure [PLANFORM CHANGE]. The ratio of total areal change per unit stream length is a metric of total planform change, with planform stability inversely related to magnitude. Total areal change per unit stream length was greatest (12.9 m2/m) in the middle valley and least in the headwaters (1.0 m2/m) of the watershed. Most occurrences of planform change not associated with the Caterpillar Proving Grounds occurred via lateral and downstream migration in Spring Creek, Wolf Creek, and the upper tributaries of Tenmile Creek. The largest planform changes outside of the Proving Grounds occurred in the middle valley approximately 1 km downstream of the detention pond and in the lower portions of Spring and Wolf Creeks. These changes were substantially smaller than those within and just upstream of the proving grounds. Relative planform stability between 1939 and 1998 outside of the Proving Grounds could be due to could be due to several factors including increased forested area in the headwaters, regulation of flow and sediment load by the dam and reservoir just downstream of the Proving Grounds in the middle valley, and raised base-level due to the regulation of water levels in Peoria pool after construction of the Peoria Lock & Dam in 1938. Channelization was a relatively small portion of the total change further downstream. Field observations of active slumping and the use of rip-rap and fill to stabilize banks along Tenmile Creek near the intersection of Tenmile Creek Road and North Randy Drive CR1050N suggest that channel widening or deepening or both are occurring. The width of the middle valley of Tenmile Creek appears to have narrowed between 1939 and 1998.

Figure 29. Figure planform\_change. Net movement of channel based upon interpretations of 1939 and 1998 air photos.

This stream dynamics analysis component of the overall project characterizes the dominant modes and relative activity of stream planform change through the watershed. In common with many other streams in the region, human modification by relocating or damming the streams is a dominant process in planform change. However, it is clear that the system has enough energy to modify its planform naturally. Evidence of lateral migration is common in Wolf, upper Tenmile, and Spring creeks. Further, a meandering inset channel appears to be developing within the channelized alluvial fan reach. Most instances of avulsion occurred in Spring Creek valley, and may have been caused by sediment piles from the mass wasting that was noted commonly along the steep valley walls although causal links cannot be determined from the extent of this study. However, at least one instance of avulsion by alluvial processes was also observed (ISGS field point SC13). The direct contribution of large mass-wasting events to sediment loads appears to be lower than remobilization of alluvium by meander migration.

At this level of study – examining only two points in time -- we cannot determine when the observed changes occurred, or whether they are in stasis or are progressive. As well, the correlations between areas of planform change and habitat, landscape erosion, channel form, and sediment delivery are yet to be determined. By comparison with limited field investigations it is clear, however, that there is sufficient stream power for Tenmile, Wolf, and Spring Creeks to erode their banks and transport much of the sediment loads delivered to them by overland and mass wasting processes. However, the relative effects of slope, discharge, land cover, and geology (erodibility of channel banks and substrate, availability of bedload) must be distinguished in order for project selection and design to proceed. When combined with the channel geomorphology field studies, we may be able to better assess the evolution of channel form and incision.

It is important to reiterate that correlations between landscape or channel change and stream response are tentative. More comprehensive analyses of stream dynamics are needed for individual project design and implementation. In particular, we cannot determine the response of streams after direct modification of stream channels (‘channelization’) or other identifiable land use changes. As well, only net rates of planform evolution can be estimated; actual rates may be significantly higher. Understanding these responses is important for predicting the long term survival of stream restoration projects. Greater understanding could come from examining imagery of intervening years and estimating long term and synoptic trends in stream power.

Table I: Channel planform change, Tenmile Creek Watershed, 1939-1998

|  |  |  |  |
| --- | --- | --- | --- |
| Dynamic Class | Number of Occurrences | Total Area (m2) | Total Areal Change (%) |
| Avulsion | 22 | 16835 | 6 |
| Channelization | 17 | 110545 | 39 |
| Lateral or downstream migration  | 310 | 110154 | 39 |
| Reservoir/Dam | 3 | 46338 | 16 |
| Total | 352 | 283871 | 100 |

Table II: Channel planform change breakdown by slope class

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Valley Segment | Valley-slope range  | Channel length assessed  | Areal change (m2) | Areal change/unit stream length (m2/m) |
| Proving grounds  | Total |
| Alluvial Fan | <0.004 | 2705 | n/a | 10035.9 | 3.7 |
| Middle Valley | 0.004-0.010 | 9449 | 81653.5 | 122079.6 | 12.9 |
| Headwaters | >0.010 | 151196 | 71887.6 | 151755.6 | 1.0 |
| All |  | 163350 | 153541.1 | 283871.1 | 1.7 |

* + - 1. **Geomorphic Condition and Physical Habitat Quality Assessment Results**

***Aerial Reconnaissance***

A list of sites identified for analysis within the Tenmile Creek Watershed based on the aerial reconnaissance is given in Table [Aerial Problem Areas]. A total of # potential problem sites were initially identified. Based on review of recent historical aerial panchromatic photographs covering areas out­side of GPS-tracked aerial reconnaissance, another # potential problem sites were identified. These # potential project sites (Figure [Aerial Problem Areas]; Table [Aerial Problem Areas]) were investigated in the field for geomorphic and physical habitat characteristics in summer 2008. The locations of potential problem areas/project reaches identified from the rapid aerial reconnaissance and still aerial photos were mapped and compared with maps of geomorphic and biologic field data and sites were either added to or eliminated from the list of potential project sites based on field verification. Sites that continue to remain on the list for potential restoration will be monitored and analyzed further for project feasibility determinations.

Table [Aerial Problem Areas]. Potential Project Sites Identified During Aerial Reconnaissance.

|  |
| --- |
| Tenmile Creek |
| Points | Longitude | Latitude | Description |
|  |  |  |  |
| 1 | 89 32' 43.40'' W | 40 44' 14.75'' N | Mouth |
| 2 | 89 32' 29.40'' W | 40 44' 07.43'' N | Beaver Dam, Bank Erosion |
| 3 | 89 30' 01.74'' W | 40 44' 53.23'' N | Riffle, Bank Erosion |
| 4 | 89 29' 31.86'' W | 40 44' 58.69'' N | Bank Erosion, Riffle, Grade Control |
| 5 | 89 29' 04.64'' W | 40 45' 04.89'' N | Riffle Dam (Caterpillar Proving Ground) |
| 6 | 89 28' 32.68'' W | 40 44' 58.36'' N | Bank Erosion, Grade Control (CAT P.G.) |
| 7 | 89 28' 05.10'' W | 40 44' 25.61'' N | Mass Wasting, Log Jam, Grade control |
| 8 | 89 27' 36.19'' W | 40 44' 15.39'' N | Mass Wasting, Beaver Dams, Riffle |
|  |
| Spring Creek |
| Points | Longitude | Latitude | Description |
| 1 | 89 31' 16.91'' W | 40 44' 9.24'' N | Mouth |
| 2 | 89 30' 43.81'' W | 40 43' 41.00'' N | Mass Wasting, Bank Erosion, Log Debris |
| 3 | 89 30' 32.09'' W | 40 43' 32.05'' N | Bank Erosion, Log Debris |
| 4 | 89 30' 8.15'' W | 40 43' 19.85'' N | Mass Wasting, Bluff Erosion, Log Debris |
| 5 | 89 29' 24.09'' W | 40 43' 12.39'' N | Log Debris |

LB = Left Bank, RB = Right Bank

Figure 30. Figure 2900. Map showing the location of the aerial reconnaissance sites.

Figure 31. Figure 3000. Map showing the location of the ISWS field sites.

***Channel Evolution Model***

The spatial distribution of CEM stages based on the 2007-2008 field data collection campaign in the Tenmile Creek Watershed are shown (Figure [CEM\_MAP]). Overall, the watershed has 59 miles of 1st, 2nd, and 3rd order streams (Strahler 1952) as digitized by ISGS. (See Appendix D for a list of longest stream sections in the Tenmile Creek watershed). Stream segments along Tenmile Creek, as well as Wolf and Spring Creeks were assessed. 17.1 miles had 78 assessed segments: 40 segments (51%) in Stage IV, 21 segments (27%) in Stage V, 7 segments (9%) in Stage III, 6 segments (8%) in Stage II, and 4 segments in Stage VI. Most of the channel segments in the Tenmile Creek watershed were classed as Stage IV.

The Tenmile Creek mainstem, from its mouth at the Illinois River to a point about 8.0 miles upstream, had 31 assessed segments: 11 segments (35%) in Stage V, 8 segments (X%) in Stage IV 6 segments (6%) in Stage VI, 12 segments (12%) in Stage IV, and 17 segments (17%) in Stage II. The Tenmile Creek mainstem had more Stage V channel segments than any of its trib­utaries. An 3.9 mile reach of Spring Creek had 34 assessed segments: 24 segments (70%) in Stage IV, 6 segments (18%) in Stage V, and 4 segments (12%) in Stage III. Wolf Creek had 13 assessed segments within a 3.6 mile reach: 8 segments (61%) in Stage IV, 4 segments (31%) in Stage V, and 1 segment (8%) in Stage III. There were no Stage I, II or VI segments.

Figure 33. Figure 6300. Channel Condition Analysis Channel Evolution, Quad II

Figure 34. Figure 38 Preliminary field data from the Tenmile Creek mainstem

Figure 35. Figure 39 Preliminary field data from Spring Creek

Figure 36. Figure 40 Preliminary field data from Spring Creek tributary (S4)

Figure 37. Figure 41Preliminary field data from Wolf Creek

***Channel Stability and Physical Habitat***

The CEM classifications determined in the field in Tenmile Creek watershed generally correlate well with channel stability indices (CSIs). Significant autocorrelation between CEM stage and channel stability indices is expected because CEM stage is a parameter in the stability ranking scheme, and the two indices share some common parameters such as bed material and chan­nel configuration. When poor correlations between stage and stability indices occur, they can almost always be explained by influences from singular factors such as bedrock exposure, mass wasting, large woody de­bris accumulations.

Channel stability metrics in certain stream segments and CEM can be poorly correlated in some cases (Figure ##). The var­ied sediment textural classes that comprise the bed material in Stage IV, V, and VI channels in this watershed impact channel processes, influc channel evolution. For example, Stage IV channels already have de­graded and widened to a new state of dynamic stability (Channel Stabil­ity Index <10) and often occur where there are large sediment loadings from mass wasting of valley walls. Such a circumtance is also found where sediment loadings are low because bedrock inhibits channel inci­sion and channel banks are relatively low (insets in Figure 33). As such, instances of mass wasting, exposure of bedrock or large woody debris in the channel bed modify local channel conditions and lead to poor cor­relations between stage and channel stability indices.

Physical habitat quality scores (QHEI) plotted versus CEM and CSI show… (Figure CSI\_QHEI). Sites having CSI and BHI scores that fall into the upper right quadrant of Figure 32 indicate better habitat quality systems, while stream segments having CSI and QHEI scores that fall into the lower left quadrant are in criti­cal condition, both in terms of stability and habitat conditions. Sites hav­ing CSI and BHI scores that fall into the upper left quadrant are unstable sites that seem to support better habitat, while stream segments having CSI and BHI scores that fall into the lower right quadrant are deemed to have potential instability or are transitional with poor habitat.

Table 8. Results of CEM stage and Habitat analysis

|  |  |  |  |
| --- | --- | --- | --- |
| **CEM** **STAGE** | **GENERAL** **STABILITY** **CONDITION** | **DYNAMIC STYLE** | **BIOLOGICAL/HABITAT QUALITATIVE CONDITION** |
| I | Stable | In Equilibrium | Highest |
| II | Transitional | Stable to Degrading | Variable |
| III | Unstable | Degrading | Low |
| IV | Unstable | Degrading | Low |
| V | Transitional | Stable to Aggrading | Variable |
| VI | Stable | In Equilibrium | Highest |

* + - * 1. **Water Quality**

Existing water quality datasets are generalized and not specific to Tenmile Creek and its tributaries. The IEPA (2004) assessed Creek as having fully attained its designated use in the aquatic life category based on waterbody-specific monitoring data. Tributaries of Creek, including Creek, Creek, Creek, Creek, Creek, were listed in that report but were not assessed.

Many NPS control projects have been implemented in watershed with funding made available through Section 319 of the CWA. Any BMPs implemented under Phase II of the Creek watershed Project were estimated to have reduced sediment load in Creek by 8507 tons/year, phosphorus by 1767 pounds/year, and nitrogen by 14,073 pounds/year (IEPA, 2006b).

Figure 38. Figure 3500. Regional estimated phosphorous Yield (Illinois EPA, 1999).

Figure 39. Figure 3600. Regional estimated nitrate yield (Illinois EPA, 1999).

The IEPA (2000) classed Tenmile Creek among the watersheds with the highest nutrient yields in Illinois, with total nitrate levels in watershed of 6.0-9.9 milligrams per liter (mg/L) and phosphorous levels >4.5 mg/L (Figures 42 and 43). These values are based on regional studies of similar watersheds. Measurements of nitrate concentrations at the mouths of agricultural watersheds during spring and fall field applications were low (x mg/L). During the low-flow period of late summer, nitrate concentrations were below detection limits. Nitrate and phosphate loadings from Tenmile Creek to the Illinois River are negligible compared to those of the metropolitan Chicago area (K. Hackley, USEPA, Personal Communication, 2006).

* + 1. **Biological Conditions**
			1. **Terrestrial Ecosystem**
				1. **Reptiles**

Potential species richness of reptiles in the Tenmile Creek watershed according to GAP data (INHS 2005) was high in almost all areas adjacent to the creek and its tributaries. Reptile species richness was greater, more contiguous, and more evenly distributed spatially in the Tenmile Creek watershed compared to the Senachwine Creek watershed suggesting more suitable habitat conditions within the Tenmile Creek watershed. The overall probability of species richness was higher for the Tenmile Creek watershed (maximum = 30 species) than the Senachwine Creek watershed (maximum = 26 species).

Figure 40. Figure 100 Map showing the Potential Richness of Reptiles based on GAP Data (NHS 2005).

* + - * 1. **Summer Birds**

Potential species richness of summer birds in the Tenmile Creek watershed according to GAP data (INHS 2005) was high in almost all areas adjacent to the creek and its tributaries. Summer bird species richness was greater, yet variable, and more evenly distributed spatially in the Tenmile Creek watershed compared to the Senachwine Creek watershed suggesting more suitable habitat conditions within the Tenmile Creek watershed. The overall probability of species richness was lower for the Tenmile Creek watershed (maximum = 62 species) than the Senachwine Creek watershed (maximum = 64 species).

Figure 41. Figure 200 Map showing the Potential Richness of Summer Birds based on GAP Data (INHS 2005).

* + - * 1. **Mammals**

Potential species richness of mammals in the Tenmile Creek watershed according to GAP data (INHS 2005) was high in almost all areas adjacent to the creek and its tributaries. Mammal species richness was greater and more evenly distributed spatially in the Tenmile Creek watershed compared to the Senachwine Creek watershed suggesting more suitable habitat conditions within the Tenmile Creek watershed. The overall probability of species richness was higher for the Tenmile Creek watershed (maximum = 28 species) than the Senachwine Creek watershed (maximum = 27 species).

Figure 42. Figure 300 Map showing the Potential Richness of Mammals based on GAP Data (INHS 2005).

* + - 1. **Aquatic Ecosystem**
				1. **Wetlands**

Hydric soils have properties that show they are, or were once, wetlands. Figure 2315 shows soil map units within the watershed that are considered to have hydric properties throughout (Soil Survey Staff, 2006, 2007), as well as existing wetlands identified in GAP landcover data (INHS 2003b). These areas have potential for wetland recreation or restoration to achieve ecosystem restoration goals, including sediment runoff reduction, improved wetland quality, and flood control. Hydric soils cover about of the watershed and range in size from 0.04 to 640 acres, although the median size is 5.8 acres. Some soil map units have small inclusions of hydric soils. They are smaller than 0.3 acres each, and thus are assumed to be unlikely sites for wetland projects.

The existing wetlands were shown in Figure 2315 are independent of the National Wetlands Inventory or NWI. Although the precision of the GAP data (INHS 2003b) are low because of the relatively coarse scale, the GAP data are preferred over NWI data because aerial imagery source data were 25 years newer, fluctuating water regimes were characterized, and results do not suffer from the digitization error inherent in the NWI creation (D. Luman, ISGS, Personal Communication, 2006). Various wetland land cover classes occur over about 6% of the watershed.

Figure 43. Figure 2315. Priority wetland areas in the Tenmile Creek watershed.

To prioritize areas for potential wetland restoration projects, proximity to main stream courses and existing wetlands were considered (Figure 49). Areas within 1000 feet of a stream were ranked higher than those further away because of the project focus on stream corridors. Areas where wetlands do not presently occur were given priority over existing wetlands, with the goal of distributing wetland function more widely across the watershed. Existing wetlands were ranked lower in this analysis. However, they could also be considered highly valuable as the core a more extensive restored wetland because wetland function already exists. It may be easier for projects to enhance an existing wetland than it is to restore an area with deceased wetland function. Thus in Figure 49, Priority 1 are those areas not presently wetland and within 1000 feet of a major stream channel; Priority 2 are those that have one or more wetlands (INHS 2003b) and are within 1000 feet of a major stream channel; and Priority 3 wetlands are those wetlands more than 1000 feet from a stream channel (Table 10). Priority 4 are reas with hydric soils but no existing wetlands and more than 1000 feet from a stream.

Fig\_x\_priority\_wetlands. Areas prioritized for wetland enhancement or restoration. Wetlands shown include areas of 100% hydric soils (Soil Survey Staff 2006, 2007) and existing wetlands identified in GAP landcover data (INHS 2003b).

* + - * 1. **Biological Stream Characterization**

A Biological Stream Characterization (BSC) Work Group was convened to develop a statewide biological classification of Illinois streams in 1984. The first BSC report, published as Special Report No. 13 of the State Water Plan Task Force (Hite and Bertrand, 1989), provided a map of streams rated and described the process and criteria for developing BSC ratings. The BSC report was developed as an aquatic resource management tool. Criteria used to identify streams or stream segments were based primarily on the fish community as enumerated by the Index of Biotic Integrity (IBI). The 12-metric IBI encompasses trophic composition, abundance, and condition of the fish community (Karr et al., 1986). The IBI scoring system was adjusted to reflect regional differences and stream size (Hite and Bertrand, 1989). Resulting scores ranged from 12 to 60, with higher scores reflecting a fish community characteristic of a system with little human influence and lower scores for a fish community that departs significantly from the reference condition.

When qualitative stream fish data were unavailable, BSC scores were derived from subjective evaluation of fishery information or macroinvertebrate community data. The Macroinvertebrate Biotic Index (MBI) used for this BSC is a modification of a biotic index developed in Wisconsin (Hilsenhoff, 1982). Tolerance values assigned to each taxon and relative abundance of those taxa in the sample are summed to achieve a 0-11 scale, where low values indicate good water quality and high values, degraded water quality (Hite and Bertrand, 1989). The MBI primarily was used to rate poor (Class D) and very poor (Class E) streams (Bertrand et al., 1993; Table 11).

The BSC objectives were to inventory the nature, extent, and distribution of Illinois stream resources and to identify stream segments of exceptional quality that warrant special consideration for protection. A five-tiered classification system was developed, and streams were ranked into categories (Table 11).

The Creek mainstem was classified as a Class B stream (Bertrand et al., 1993; Figure 17). Those highly valued aquatic resources are characterized as good fishery for important gamefish species even though species richness may be moderately below expectations for the size of the stream or geographic region. Smaller tributary streams to Creek were not rated because of lack of data.

* + - * 1. **Aquatic Macroinvertebrates**

A 2003 aquatic macroinvertebrate survey of Tenmile Creek suggested high species richness and diversity compared to other tributaries to the Illinois River. In the 2003 survey, 30 species were collected with a Shannon-Wiener diversity index score of 2.14. The Nature Conservancy noted higher diversity of mayflies and caddisflies compared to Partridge or Ackerman creeks. Species richness was intermediate at Tenmile Creek (30) compared to Partridge Creek (34) and Ackerman Creek (22). Aquatic macroinvertebrate species diversity was also intermediate at Tenmile Creek (2.14). Species diversity was 2.59 for Partridge Creek and 1.62 for Ackerman Creek. The Nature Conservancy suggested that aquatic macroinvertebrates may be negatively influenced in the upper and middle portions of the creek by urbanization, high pesticide runoff, hydrologic variability, and in-stream mining. Mayfly taxa collected were considered ecologically tolerant to organic pollution and low dissolved oxygen (i.e. Hydropsychidae, Baetidae, Caenidae). The results of the aquatic macroinvertebrate collection in 2003, in accordance with fish collections, suggest that Tenmile Creek is intermediate in habitat quality for aquatic organisms compared to other local tributaries to the Illinois River.

***Mussels***

Freshwater mussels comprise one of the most endangered taxa on earth. Thirty-two mussel species have been collected in Tazewell County, Illinois. The status of the mussel community in Tenmile Creek is unknown.

Table 100.Common and scientific name of mussels collected in Tazewell County, Illinois by the Illinois Natural History Survey, 1947-1998.

|  |  |
| --- | --- |
| Common name | Scientific name |
| Elktoe | *Alasmidonta marginata* |
| cylindrical papershell | *Anodontoides ferussacianus* |
| rock-pocketbook | *Arcidens confragosus* |
| white heelsplitter | *Lasmigona complanata* |
| creek heelsplitter | *Lasmigona compressa* |
| fluted-shell | *Lasmigona costata* |
| giant floater | *Pyganodon grandis* |
| squawfoot | *Strophitus undulates* |
| paper pondshell | *Utterbackia imbecilis* |
| threeridge | *Amblema plicata* |
| Spike | *Elliptio dilatata* |
| Wabash pigtoe | *Fusconaia flava* |
| washboard | *Megalonaias nervosa* |
| round pigtoe | *Pleurobema sintoxia* |
| pimpleback | *Quadrula pustulosa* |
| mapleleaf | *Quadrula quadrula* |
| pistolgrip | *Tritogonia verrucosa* |
| mucket | *Actinonaias ligamentina* |
| plain pocketbook | *Lampsilis cardium* |
| fatmucket | *Lampsilis siliquoidea* |
| yellow sandshell | *Lampsilis teres* |
| fragile papershell | *Leptodea fragilis* |
| black sandshell | *Ligumia recta* |
| pink heelsplitter | *Potamilus alatus* |
| pink papershell | *Potamilus ohiensis* |
| Lilliput | *Toxolasma parvus* |
| fawnsfoot | *Truncilla donaciformis* |
| deertoe | *Truncilla truncata* |
| Ellipse | *Venustaconcha ellipsiformis* |
| rainbow | *Villosa iris* |
| zebra mussel | *Dreissena polymorpha* |
| Asian clam | *Corbicula fluminea* |

* + - * 1. **Fish communities**

***Fish community of Tenmile Creek, 2007-2008***

The Illinois River Biological Station sampled the fish community of Tenmile Creek at three locations; one within the upper reach (40°44’52.13”N, 89°28’31.84”W) (2008), one within the middle reach (40°44’50.29”N, 89°29’50.83”W) (2007), and one in the lower reach (40°44’13.07”N, 89°31’06.31”W) (2007). Fishes at each location were sampled using backpack electroshocking in habitats with structurally diverse streambeds (i.e. pools, riffles) and with an electric seine in habitats with homogenous streambeds (i.e. runs). Each site was 150 m long and electroshocking proceeded from a downstream to upstream direction at each site. Block nets were placed at each endpoint of the site to prevent fish movements out of the sample area. Stunned fishes were collected by at least two dip netters located just downstream of the electroshocker or seine. All captured fishes were identified to species, measured, and generally returned to the creek alive. Voucher and unidentifiable fishes were preserved for later identification in the laboratory. In total, 15 fish species representing five families were collected from Tenmile Creek. Shannon-Wiener fish species diversity from 2007-2008 sampling was 1.61.

*Catostomidae*

The family Catostomidae (suckers) are comprised of 10 genera, with 8 representative genera native to Illinois. The catostomids are distinguished by a subterminal mouth used for benthic feeding. The suckers are considered indicators of high water quality, as they have low tolerance for degraded habitat conditions. White sucker *Catostomus commersoni* were collected from Tenmile Creek in 2007-2008.

White sucker *– Catostomus commersoni*

White sucker are a statewide inhabitant of Illinois. No evidence exists for the loss of this species within the state; however, distributions are limited by deteriorations of preferred habitat and pollution. This species is not widely represented in the state’s large rivers. White sucker are typically found in high water quality, sand and gravel creeks and small rivers. Spawning occurs in riffles and pools over gravel in March to May. White sucker primarily consume benthic invertebrates. The presence of white sucker in Tenmile Creek suggests that this system may contain higher water quality than many other Illinois River tributaries. The presence of riffles and pools within Tenmile Creek may suggest that reproduction can occur; however, we collected relatively few white sucker during sampling efforts.

*Centrarchidae*

The family Centrarchidae (basses and sunfishes) are native to the United States, widely distributed, and represent about 30 species. Centrarchids are habitat generalists and are typically found in low gradient streams, ponds, lakes, rivers, and reservoirs. Centrarchids are nest guarding spawners that may require more than a month to complete spawning under stable water conditions. The centrarchids are among the most popular freshwater sportfishes in the world. Bluegill *Lepomis macrochirus*, green sunfish *Lepomis cyanellus*, and largemouth bass *Micropterus salmoides* were collected from Tenmile Creek in 2007-2008.

Bluegill – *Lepomis macrochirus*

Bluegill are native to the eastern United States (i.e. east of the Rocky Mountains) and now inhabit all states within the continental United States due to stocking. Currently, bluegill populations are not threatened in any state. Bluegill are common in clear creeks, rivers, ponds, and lakes and may be considered a cosmopolitan species. Bluegill are generally considered a warmwater fish, which depends on warm temperatures for spawning. Bluegill spawn in colonies, which may consist of 10-50 crater-like nests located within close proximity to one another. Males create the nest, attract females, and guard the nest and young during the spawning period in spring, which may last for up to a month. Bluegill diets generally consist of zooplankton, microcrustaceans, snails, insects, and fish. The bluegill collected in Tenmile Creek are likely transients that have migrated upstream from the Illinois River. Due to the intermittency of the creek, it is highly likely that bluegill are not residents within Tenmile Creek and do not maintain a self-sustaining population.

Green sunfish – *Lepomis cyanellus*

Green sunfish are a pioneering species common to small ponds and low current velocity streams. The species is less common in large lakes and rivers. Feeding habits are similar to that of bluegill; however, the large gape of the green sunfish likely makes feeding habits intermediate between bluegill and largemouth bass. Spawning behavior is similar to other centrarchids including nest building and parental care by males. Spawning begins in May and is protracted throughout the summer. The green sunfish occurs statewide in Illinois and is a highly ecologically tolerant species. The characteristics of Tenmile Creek suggest that a self-reproducing population of green sunfish is not likely in the creek and that green sunfish are transients from the Illinois River.

Largemouth bass – *Micropterus salmoides*

Largemouth bass are native to most of the eastern United States (i.e. east of the Rocky Mountains) and are now stocked in all of the continental United States. Largemouth bass are popular sportfishes that are not protected. Largemouth bass are well-suited to turbid waters and are abundant in creeks, rivers, ponds, lake, and reservoirs. Due to their popularity as sportfishes and ecological tolerances, largemouth bass may be considered a cosmopolitan species. Largemouth bass are a warmwater, nest-guarding species. Male largemouth bass create a nest, attract a female, spawn, and guard nests and young for up to a month in spring. Largemouth bass do not spawn in colonies. Largemouth bass diets consist of fish, crayfish, macroinvertebrates, and terrestrial invertebrates and vertebrates. The largemouth bass collected in Tenmile Creek are likely transients that have migrated upstream from the Illinois River. Due to the intermittency of the creek, it is highly likely that largemouth bass are not resident species within Tenmile Creek and do not maintain a self-sustaining population.

Cyprinidae

The family Cyprinidae (minnows) represents the largest family of fishes in the world with over 1,500 species. About 250 species are native to North America. Minnow species are ubiquitous and the family represents high plasticity in habitat preferences, diet, and behavior. Minnows are highly fecund, thus representing the classic r-selected family and serve as the forage base in many aquatic systems. Individual cyprinid species vary greatly in habitat needs, their ability to cope with environmental changes, and presence or absence of species may be indicative of habitat conditions. Blacknose dace *Rhinichthys obtusus*, bluntnose minnow *Pimephales notatus*, central stoneroller *Campostoma anomalum*, creek chub *Semotilus atromaculatus*, fathead minnow *Pimephales promelas*, red shiner *Cyprinella lutrensis*, river shiner *Notropis blennius*, sand shiner *Notropis stramineus*, and suckermouth minnow *Phenacobius mirabilis* were collected in Tenmile Creek in 2007-2008.

Blacknose dace – *Rhinichthys obtusus*

Blacknose dace are native to the northeastern United States and Canada and their range extends west to the eastern Dakotas and extreme northeastern Kansas. Blacknose dace are not protected in the central United States. Blacknose dace typically inhabit clear permanent streams and are occasionally found in lakes and moderately turbid streams. The blacknose dace is commonly found in gravel runs and pools. Blacknose dace spawn in sand and small gravel riffles and do not provide parental care. Young-of-year blacknose dace typically migrate into headwaters where there may be too little water for other fishes to survive. Blacknose dace diets consists of insects, aquatic invertebrates, and small amounts of algae. In Illinois, the blacknose dace is typically restricted to spring-fed streams that remain cool in the summer months. The species is not tolerant to silt and high temperatures. The blacknose dace collected in Tenmile Creek likely represent resident species with adequate habitat present to allow a self-sustaining population. The intermittency of Tenmile Creek does not appear to be an impediment to this fish species, which may suggest a high quality creek for this species.

Bluntnose minnow – *Pimephales notatus*

Smith et al. (1979) states that bluntnose minnow are the most abundant and widespread species in the state. It is common to hard-bottomed pools in creeks and small rivers, but also inhabits other aquatic systems except swamps and highly polluted waters. Bluntnose minnow are primarily invertivores. Spawning occurs in May and June. The male creates a depression under structure (e.g. rocks), under which, the female deposits eggs and the male guards until hatching. Due the habitat present within Tenmile Creek and the ubiquitous nature of bluntnose minnow, the population is likely self-sustaining.

Central stoneroller – *Campostoma anomalum*

Central stoneroller are widespread in the eastern United States and are common to the streams of the southern high plains. The central stoneroller is absent from North Dakota and the Atlantic and Gulf coasts. The central stoneroller is not threatened in any state. In Illinois, the central stoneroller is an ecologically tolerant species that is abundant in creeks, except for in the south-central part of the state. The central stoneroller is one of the more widespread and abundant minnows in the Midwest. Central stoneroller habitat consists of permanent, small streams with rocky, sandy, and bedrock riffles. In summer, central stoneroller may occur in pools when water levels become low. The species is intolerant of silt. Male central stonerollers create spawning pits in gravel riffles and abandon eggs before hatching. Central stoneroller diets consist primarily of algae and encrusted organisms. The central stoneroller collected in Tenmile Creek likely represent resident species with adequate habitat present to allow a self-sustaining population. The intermittency of Tenmile Creek does not appear to be an impediment to this fish species, which may suggest a high quality creek for this species.

Creek chub – *Semotilus atromaculatus*

Creek chub inhabit the United States from the northern Great Plains to the Atlantic Coast. Creek chub are not present in the Gulf Coastal plain. The creek chub is not threatened in any state. The creek chub is the most widespread member of the genus *Semotilus*. Creek chub typically inhabit small, clear streams and sometimes clear lakes. Creek chub are generally abundant in low gradient streams with mud or clay substrates. They are ecologically tolerant of turbid and warm water conditions. Creek chub spawn over gravel bottoms in flowing water by creating a pit for the female to lay her eggs into. Following egg deposition, the male creek chub moves gravel on top of the eggs to create a low ridge of gravel. The diet of the creek chub consists of invertebrates, plant material, and occasionally small fish. The creek chub collected in Tenmile Creek likely represent resident species with adequate habitat present to allow a self-sustaining population. The presence of creek chub may indicate that the benthic habitat of the creek is adequate and that turbidity is not abnormally high. However, the collection of creek chub in a stream often denotes a modified habitat by pollution or siltation.

Fathead minnow – *Pimephales promelas*

Fathead minnow are found in northern and western portions of Illinois. The species typically occurs in slow moving creeks, ditches, and ponds dominated by mud bottoms. In general, fathead minnow are not present when bluntnose minnow are present. Fathead minnow are detritivores and insectivores. Reproductive ecology is similar to that of the bluntnose minnow. Although bluntnose and fathead minnow were both collected in Tenmile Creek at low abundances, available habitat and each species life history characteristics suggest a self-sustaining population.

Red shiner – *Cyprinella lutrensis*

Red shiner are an ecologically tolerant species typically occurring in western Illinois; however, range expansions continue eastward. The red shiner prefers moderately-flowing creeks with sand and sand-silt-gravel substrates. The species is very tolerant to changes in turbidity, siltation, and fluctuating water levels. Red shiner typically consume terrestrial and aquatic invertebrates. Spawning takes place in May through August below riffles. Eggs are fertilized and broadcast to adhere to bottom substrates. Due to the ecological tolerance and available spawning habitat in Tenmile Creek, it is likely that the red shiner population is self-sustaining.

River shiner – *Notropis blennius*

River shiner are present in the large and medium-sized rivers of Illinois, but do not ascend the Illinois River a great distance. River shiner are less abundant in the Illinois River compared to the Mississippi River. River shiner typically inhabit clear flowing streams over sand and gravel substrates. River shiner are not tolerant of high turbidity. The river shiner is a schooling, mid-water species. Little is known about the feeding and reproductive behavior of river shiner. The presence of river shiner may suggest that Tenmile Creek is not abnormally turbid and provides adequate feeding and spawning habitat.

Sand shiner – *Notropis stramineus*

Sand shiner are abundant throughout the northern four-fifths of Illinois and absent in extreme southern Illinois. Sand shiner were likely more abundant historically prior to increased stream degradation through pollution and siltation. Sand shiner are common to permanent streams and lakes where sand and gravel substrates are available. Greatest abundances of sand shiners are found in fast-flowing creeks with bottoms of mixed sand and gravel. Sand shiner are generally absent in turbid streams with substrates of clay or silt. Little information is available on its spawning habits. Sand shiner diets typically consist of plant material and aquatic insects. The sand shiner collected in Tenmile Creek likely represent a resident species with adequate habitat present to allow a self-sustaining population. Due to their ecological tolerances, the presence of sand shiner may indicate that intermittency, high turbidity, and clay and silt bottoms are not characteristics of Tenmile Creek.

Suckermouth minnow – *Phenacobius mirabilis*

Suckermouth minnow are distributed widely in the United States and their distribution spans from Ohio and West Virginia through the Dakotas and eastern Wyoming, south to New Mexico and Alabama. Suckermouth minnow are endangered in New Mexico and are a species of special concern in South Dakota and Wyoming. Suckermouth minnow are considered to be pioneering species. Suckermouth minnow prefer riffles of permanent streams with gravel and sand bottoms. Suckermouth minnow avoid high-gradient streams with cool water. The species is ecologically tolerant of intermittency and high turbidity as long as flows keep riffles free of silt. Suckermouth minnow are thought to spawn in late spring in riffles and their spawning habitat is the same habitat used for the species throughout the year. Little additional information exists on the spawning behavior of suckermouth minnow. The diet of suckermouth minnow consists of invertebrates. The suckermouth minnow collected in Tenmile Creek likely represent a resident species with adequate habitat present to allow a self-sustaining population. The presence of suckermouth minnow may suggest that siltation is not abnormally high in Tenmile Creek.

Ictaluridae

The Ictaluridae (catfishes) are characterized as scaleless with barbels and an adipose fin. The family consists of 37 species ranging in size from several inches (madtoms) to two species capable of exceeding 100 pounds in size (flathead catfish *Pylodictis olivaris*, blue catfish *Ictalurus furcatus*). Prior to stocking and aquaculture, the catfishes were restricted to North America and were not native west of the Rocky Mountains. Barbels of catfishes are covered with taste receptors and are thus bottom feeders, which are typically present in highly turbid waters. Catfishes spawn in cavities, depressions, brush, and rock. Males guard the eggs and young until juvenile fish are several weeks old. Catfishes are very ecologically tolerant of siltation, pollution, and low dissolved oxygen levels. Yellow bullhead *Ameiurus natalis* were collected in Tenmile Creek in 2007-2008.

Yellow bullhead – *Ameiurus natalis*

Yellow bullhead are native to North America and common in the eastern half of the United States. Yellow bullhead are uncommon in the High Plains from western North Dakota to west Texas. Yellow bullhead are a species of special concern in North Dakota. Yellow bullhead prefer clear waters with a firm substrate of sand, gravel, and/or rock. Yellow bullhead are typically considered a stream species. The yellow bullhead collected in Tenmile Creek likely represent a resident species with adequate habitat present to allow a self-sustaining population. Conditions in Tenmile Creek appear adequate to sustain the cosmopolitan yellow bullhead.

Percidae

The Percidae (perches and darters) are a widely distributed family that spans much of Asia, Europe, and North America. Over 100 percid species are native to North America. Darters are endemic to North America. The Percidae are characterized by fusiform bodies, one or two spines associated with the anal fin, and spiny and soft dorsal fins. Sizes of percids range from large walleye (*Sander vitreus*) (> 20 pounds) to small darters (< 3 inches). Reproductive biology of percids is varied from non-nest guarding North American species to nest-guarding European species. Darters are well known for the brilliantly colored male darters during spawning season. Percids occupy a wide range of aquatic habitats and conditions (lakes, streams, rivers, ponds), however the presence of darters generally signifies higher water quality conditions. Orangethroat darter (*Etheostoma spectabile*) were collected in Tenmile Creek in 2007-2008.

Orangethroat darter – *Etheostoma spectabile*

The range of the orangethroat darter is primarily limited to the drainages of the Illinois, Mississippi, and Wabash rivers in Illinois. The orangethroat darter is completely absent from many watersheds in the state of Illinois. The orangethroat darter is more ecologically tolerant than the closely related rainbow darter (*Etheostoma caeruleum*). Typical habitats of orangethroat darter include riffles and pools of small creeks with sand and gravel substrates. Orangethroat darter are considered pioneer species. Spawning occurs in April in Illinois. Males are territorial and spawning occurs on riffles with fine gravel. The diet of the orangethroat darter consists of black fly larvae, bloodworms, caddisfly larvae, and other larval insects and fish eggs. The collection of orangethroat darter in Tenmile Creek suggests a resident species with suitable habitat to complete its life history. The ecologically tolerant nature of orangethroat darter suggest reasonable water quality and habitat conditions of Tenmile Creek.

The fish community composition of Tenmile Creek suggests intermediate in-stream habitat conditions along a gradient from highly degraded to pristine creek conditions. The fish community represents a mixture of transient (Centrarchidae, Ictaluridae) species whose likely source is the Illinois River and resident species, which may be found year-round in Tenmile Creek and have established breeding populations (Catostomidae, Cyprinidae, Percidae). The relatively high fish species richness observed in Tenmile Creek is suggestive of a diversity of in-stream habitats with adequate pools, riffles, and runs and associated gravel, sand, and silt substrates. Siltation does not appear to be a major issue for the fish populations of Tenmile Creek; however, several species collected are only found in such habitats. Barring major issues of siltation, Tenmile Creek appears to offer several niches for unique and cosmopolitan native fish species. Invasive species were not collected from Tenmile Creek in 2007-2008.

Table 200. Common name, scientific name, family, and number of each fish species collected in 2007-2008 collections conducted by the Illinois River Biological Station on Tenmile Creek.

|  |  |  |  |
| --- | --- | --- | --- |
| Common name | Scientific name | Family | Number |
| white sucker | *Catostomus commersoni* | Catostomidae | 3 |
| bluegill | *Lepomis macrochirus* | Centrarchidae | 9 |
| green sunfish | *Lepomis cyanellus* | Centrarchidae | 5 |
| largemouth bass | *Micropterus salmoides* | Centrarchidae | 24 |
| blacknose dace | *Rhinichthys obtusus* | Cyprinidae | 767 |
| bluntnose minnow | *Pimephales notatus* | Cyprinidae | 6 |
| central stoneroller | *Campostoma anomalum* | Cyprinidae | 1778 |
| creek chub | *Semotilus atromaculatus* | Cyprinidae | 241 |
| fathead minnow | *Pimephales promelas* | Cyprinidae | 2 |
| red shiner | *Cyprinella lutrensis* | Cyprinidae | 50 |
| river shiner | *Notropis blennius* | Cyprinidae | 931 |
| sand shiner | *Notropis stramineus* | Cyprinidae | 154 |
| suckermouth minnow | *Phenacobius mirabilis* | Cyprinidae | 47 |
| yellow bullhead | *Ameiurus natalis* | Ictaluridae | 1 |
| orangethroat darter | *Etheostoma spectabile* | Percidae | 191 |

Table 300.Common name, scientific name, family, and number of each fish species collected in 2007-2008 collections conducted by the Illinois River Biological Station categorized by reach on Tenmile Creek.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Common name | Scientific name | Family | Number |
| Upper | bluegill | *Lepomis macrochirus* | Centrarchidae | 1 |
|  | blacknose dace | *Rhinichthys obtusus* | Cyprinidae | 72 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 81 |
|  | central stoneroller | *Campostoma anomalum* | Cyprinidae | 186 |
|  | green sunfish | *Lepomis cyanellus* | Centrarchidae | 4 |
|  | red shiner | *Cyprinella lutrensis* | Cyprinidae | 46 |
|  | river shiner | *Notropis blennius* | Cyprinidae | 129 |
| Middle | bluegill | *Lepomis macrochirus* | Centrarchidae | 3 |
|  | blacknose dace | *Rhinichthys obtusus* | Cyprinidae | 19 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 11 |
|  | central stoneroller | *Campostoma anamolum* | Cyprindae | 284 |
|  | fathead minnow | *Pimephales promelas* | Cyprinidae | 2 |
|  | green sunfish | *Lepomis cyanellus* | Centrarchidae | 1 |
|  | largemouth bass | *Micropterus salmoides* | Centrarchidae | 2 |
|  | orangethroat darter | *Etheostoma spectabile* | Percidae | 3 |
|  | red shiner | *Cyprinella lutrensis* | Cyprinidae | 4 |
|  | river shiner | *Notropis blennius* | Cyprinidae | 17 |
|  | suckermouth minnow | *Phenacobius mirabilis* | Cyprinidae | 3 |
|  | sand shiner | *Notropis stramineus* | Cyprinidae | 7 |
|  | white sucker | *Catostomus commersoni* | Catostomidae | 2 |
| Lower | bluegill | *Lepomis macrochirus* | Centrarchidae | 5 |
|  | blacknose dace | *Rhinichthys obtusus* | Cyprinidae | 676 |
|  | bluntnose minnow | *Pimephales notatus* | Cyprinidae | 6 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 149 |
|  | central stoneroller | *Campostoma anamolum* | Cyprinidae | 1308 |
|  | largemouth bass | *Micropterus salmoides* | Centrarchidae | 22 |
|  | orangethroat darter | *Etheostoma spectabile* | Percidae | 188 |
|  | river shiner | *Notropis blennius* | Cyprinidae | 785 |
|  | suckermouth minnow | *Phenacobius mirabilis* | Cyprinidae | 44 |
|  | sand shiner | *Notropis stramineus* | Cyprinidae | 147 |
|  | white sucker | *Catostomus commersoni* | Catostomidae | 1 |
|  | yellow bullhead | *Ameiurus natalis* | Ictaluridae | 1 |

**Fish community of Tenmile Creek, 2003**

The Illinois Department of Natural Resources conducted a fish survey of Tenmile Creek in 2003 in one upper, middle, and lower reach of the creek. The IDNR collected 17 fish species comprising a Shannon-Wiener diversity of 1.74. According to this survey, fish species richness and diversity was greater in Tenmile Creek compared to other similar local watersheds. Nevertheless, an H value equal to 1.74 was considered fair-poor compared to other streams in the Peoria Lakes Basin. Tenmile Creek’s fish community exhibited a high number of pollution intolerant species (25% of the community) compared to other streams.

The fish survey conducted by the Illinois River Biological Station in 2007-2008 showed a similar fish community to that recorded in 2003. However, slight differences in fish species richness, the fish community, and fish species diversity were recorded. The IDNR collected 17 fish species, while the IRBS only collected 15. Fish species common to both surveys included central stoneroller, creek chub, bluegill, bluntnose minnow, red shiner, sand shiner, blacknose dace, largemouth bass, orangethroat darter, and green sunfish. Fish species unique to the 2003 survey were bigmouth shiner, southern redbelly dace, emerald shiner, hornyhead chub, black bullhead, fantail darter, and golden shiner. Fish species unique to the 2007-2008 survey include white sucker, fathead minnow, river shiner, suckermouth minnow, and yellow bullhead. About 53% of the total catch in 2003 was represented by species not collected in the 2007-2008 surveys. Bigmouth shiner and southern redbelly dace were the most notable species not collected in 2007-2008 surveys. About 23% of the total catch in 2007-2008 was represented by species not collected in the 2003 survey; most notably river shiner and suckermouth minnow. The loss of southern redbelly dace in the 2007-2008 surveys is troubling due to the pollution intolerant nature of this species, which may suggest degrading conditions within the Tenmile Creek watershed. The remaining unique species to each survey were captured at low abundances suggesting small or transient populations of these species in Tenmile Creek.

Fish species diversity was similar in the Tenmile Creek watershed among the 2003 and 2007-2008 surveys. Shannon’s H was slightly lower in the 2007-2008 surveys (1.61) compared to the 2003 survey (1.74). Despite being slightly lower, Tenmile Creek would still fall in the category of fair-poor fish species diversity compared to other Peoria Lakes Basin tributaries.

Fish species richness, total catch, and species diversity was variable among reaches of Tenmile Creek and across sampling periods. The 2003 survey suggested the poorest conditions in the watershed for the upper reach only collecting 4 species comprised of 48 individuals and a H value of 0.87. Nine and 16 fish species were collected in the middle and lower reaches, respectively. Species diversity for the 2003 sampling was greatest in the middle reach at 1.62. Surveys in 2007-2008 showed different patterns, particularly for the upper reach. The upper reach showed collections of 7 species comprised of 519 individuals with a 1.54 fish species diversity score. Our analysis suggests that habitat conditions of the upper reaches may be improving over time. In contrast, the middle reach appears to have degraded the most between surveys. Although fish species richness was highest in the middle reach during 2007-2008 surveys (13 species), total catch (358) and species diversity (0.94) was lowest. Our observation may suggest that the middle reach of Tenmile Creek is degrading over time. Similarly, the lower reaches in both surveys showed high fish species richness, high total catches, and good species diversity suggesting maintained habitat conditions for fishes.

Table 400.Common name, scientific name, family, and number of each fish species collected in 2003 collections conducted by the Illinois Department of Natural Resources categorized by reach on Tenmile Creek.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Common name | Scientific name | Family | Number |
| Upper | bigmouth shiner | *Hybobsis dorsalis* | Cyprinidae | 34 |
|  | central stoneroller | *Campostoma anomalum* | Cyprinidae | 1 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 7 |
|  | southern redbelly dace | *Phoxinus erythrogaster* | Cyprinidae | 6 |
| Middle | bluegill | *Lepomis macrochirus* | Centrarchidae | 42 |
|  | bluntnose minnow | *Pimephales notatus* | Cyprinidae | 12 |
|  | bigmouth shiner | *Hybobsis dorsalis* | Cyprinidae | 28 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 28 |
|  | emerald shiner | *Notropis atherinoides* | Cyprinidae | 1 |
|  | hornyhead chub | *Nocomis bigguttatus* | Cyprinidae | 4 |
|  | red shiner | *Cyprinella lutrensis* | Cyprinidae | 124 |
|  | sand shiner | *Notropis stramineus* | Cyprinidae | 6 |
|  | southern redbelly dace | *Phoxinus erythrogaster* | Cyprinidae | 17 |
| Lower | black bullhead | *Ameiurus melas* | Ictaluridae | 1 |
|  | blacknose dace | *Rhinichthys obtusus* | Cyprinidae | 1 |
|  | bluegill | *Lepomis macrochirus* | Centrarchidae | 8 |
|  | bluntnose minnow | *Pimephales notatus* | Cyprinidae | 6 |
|  | bigmouth shiner | *Hybobsis dorsalis* | Cyprinidae | 187 |
|  | central stoneroller | *Campostoma anamolum* | Cyprinidae | 5 |
|  | creek chub | *Semotilus atromaculatus* | Cyprinidae | 10 |
|  | fantail darter | *Etheostoma flabellare* | Percidae | 4 |
|  | golden shiner | *Notemigonus crysoleucas* | Cyprinidae | 2 |
|  | green sunfish | *Lepomis cyprinellus* | Centrarchidae | 1 |
|  | hornyhead chub | *Nocomis bigguttatus* | Cyprinidae | 1 |
|  | largemouth bass  | *Micropterus salmoides* | Centrarchidae | 1 |
|  | orangethroat darter | *Etheostoma spectabile* | Percidae | 6 |
|  | red shiner | *Cyprinella lutrensis* | Cyprinidae | 4 |
|  | sand shiner | *Notropis stramineus* | Cyprinidae | 7 |
|  | southern redbelly dace | *Phoxinus erythrogaster* | Cyprinidae | 18 |

**Fish community of Tenmile Creek, 1997**

Twenty-four fish species were collected in Tenmile Creek during 1997 sampling. Fifteen species captured in 1997 were not collected in 2003, while 14 species collected in 1997 were not collected in 2007-2008. Most notable losses were pollution intolerant indicator species of aquatic ecosystem health, such as the golden redhorse, shorthead redhorse, northern hog sucker, and silver redhorse. Invasive common carp were not collected in surveys conducted after 1997. Surveys in 2003 collected 8 new fish species, while surveys in 2007-2008 included two new species. The loss of several redhorse and sucker species suggests degrading water quality and habitat conditions over time. Further, high extirpation and recolonization rates over time, as evidenced by changes in the fish community, suggests a moderately disturbed watershed.

Table 500. Common name, scientific name and presence or absence of collections for each fish species in the 1997, 2003, and 2007-2008 surveys. An X denotes collection.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Common name | Scientific Name | 1997 | 2003 | 2007-2008 |
| golden redhorse | *Moxostoma erythrurum* | X |  |  |
| shorthead redhorse | *Moxostoma macrolepidotum* | X |  |  |
| yellow bullhead | *Ameiurus natalis* | X |  | X |
| stonecat | *Noturus flavus* | X |  |  |
| rock bass | *Ambloplites rupestris* | X |  |  |
| green sunfish | *Lepomis cyanellus* | X | X | X |
| bluegill | *Lepomis macrochirus* | X | X | X |
| smallmouth bass | *Micropterus dolomieu* | X |  |  |
| fantail darter | *Etheostoma flabellare* | X | X |  |
| johnny darter | *Ethestoma nigrum* | X |  |  |
| striped shiner | *Luxilus chrysocephalus* | X |  |  |
| redfin shiner | *Lythrurus umbratilis* | X |  |  |
| hornyhead chub | *Nocomis bugguttatus* | X | X |  |
| sand shiner | *Notropis stramineus* | X | X | X |
| suckermouth minnow | *Phenacobius mirabilis* | X |  | X |
| bluntnose minnow | *Pimephales notatus* | X | X | X |
| creek chub | *Semotilus atromaculatus* | X | X | X |
| white sucker | *Catostomus commersoni* | X |  | X |
| northern hog sucker | *Hypentelium nigricans* | X |  |  |
| silver redhorse | *Moxostoma anisurum* | X |  |  |
| central stoneroller | *Campostoma anomalum* | X | X | X |
| red shiner | *Cyprinella lutrensis* | X | X | X |
| steelcolor shiner | *Cyprinella whipplei* | X |  |  |
| common carp | *Cyprinus carpio* | X |  |  |
| bigmouth shiner | *Hybobsis dorsalis* |  | X |  |
| southern redbelly dace | *Phoxinus erythrogaster* |  | X |  |
| emerald shiner | *Notropis atherinoides* |  | X |  |
| black bullhead | *Ameiurus melas* |  | X |  |
| blacknose dace | *Rhinichthys obtusus* |  | X | X |
| largemouth bass | *Micropterus salmoides* |  | X | X |
| orangethroat darter | *Etheostoma spectabile* |  | X | X |
| golden shiner | *Notemigonus crysoleucas* |  | X |  |
| fathead minnow | *Pimephales promelas* |  |  | X |
| river shiner | *Notropis blennius* |  |  | X |

* + - 1. **Threatened and Endangered Species**

Nineteen species are listed as threatened or endangered in Tazewell County, Illinois. Lake sturgeon, starhead topminnow, redspotted sunfish, and ironcolor shiner were not collected in fish surveys conducted in 1997, 2003, and 2007-2008. The status of other threatened and endangered species within the Tenmile Creek watershed is unknown.

Table 700.Common name, scientific name, state status, and last observed year for threatened and endangered species in Tazewell County, Illinois. LT = listed as threatened and LE = listed as endangered.

|  |  |  |  |
| --- | --- | --- | --- |
| Common name | Scientific name | State status | Last Observed |
| lake sturgeon | *Acipenser fulvescens* | LE | 2007 |
| forked aster | *Aster furcatus* | LT | 1987 |
| Tennessee milk vetch | *Astragalus tennesseensis* | LE | 2002 |
| kittentails | *Besseya bullii* | LT | 2003 |
| decurrent false aster | *Boltonia decurrens* | LT | 2006 |
| starhead topminnow | *Fundulus dispar* | LT | 1967 |
| bald eagle | *Haliaeetus leucocephalus* | LT | 2007 |
| Illinois mud turtle | *Kinosternon flavescens* | LE | 2006 |
| loggerhead shrike | *Lanius ludovicianus* | LT | 1990 |
| redspotted sunfish | *Lepomis miniatus* | LT | 1967 |
| ironcolor shiner | *Notropis chalybaeus* | LT | 1963 |
| black-crowned night heron | *Nycticorax nycticorax* | LE | 2003 |
| broomrape | *Orobanche ludoviciana* | LT | 1968 |
| heart-leaved plantain | *Plantago cordata* | LE | 2000 |
| Wolf’s bluegrass | *Poa wolfii* | LE | 1998 |
| James’ clammyweed | *Polanisia jamesii* | LE | 1997 |
| Illinois chorus frog | *Pseudacris streckeri* | LT | 1999 |
| regal fritillary | *Speyeria idalia* | LT | 2005 |
| lakeside daisy | *Tetraneuris herbacea* | LE | 2003 |

* + 1. **Watershed Condition Summary and Conclusions**

**Past disturbance was…**

**Stream planform dyanamic shows…**

**Results of Channel evolution/CSI and Physical Habitat Assessment suggest…**

**Stream power indicates…**

**Recent land use trends shows…**

**Dominant land use practices are…**

**Biological communities have been improving/declining…**

**Forest cover has been increasing/decreasing quality has been improving/declining…**

***[General Description of Conditions and Trends]*** Data suggest that stream channels in the Tenmile Creek watershed are evolving from highly unstable conditions to more equilibrated channel forms that produce less sediment. It is anticipated that increased fragmentation of habitats, increased impermeable acreage from urban development, and intense agricultural production will continue and sustain erosion and sediment transport at rates too high to maximize ecosystem integrity or improve water quality. Although there may be actions intended to improve water quality independent of projects derived from this study, projects not implemented under a comprehensive plan will have limited effects.

* 1. **Expected Future Conditions of the Watershed without Project Implementation**
		1. **Prioritization Screening Criteria**

Because not all areas could be selected for assessment in the first few years of the ILRB assessment effort, a general set of criteria (Table 1) has been used as a “working model” to select initial sub-basins, watersheds, and sub-watersheds for initial assessment (USACE, 2007). Assessment protocols were selected and used to rapidly identify and describe significant erosion problem areas within the ILRB as erosion and sedimentation were deemed to be two of the most important problems with impacts on ecosystem integrity. Sediment delivery, hydrology, and biology were used as major criteria (Table 1, USACE, 2007); however, other criteria also were used to select initial assessment areas from broad areas of interest within the entire basin (Section II, above; White and Keefer, 2005).

It also was necessary to develop additional criteria for targeting and prioritizing potential individual restoration sites within each sub-basin, watershed, and sub-watershed (White and Keefer, 2005). These additional criteria are similar to those used to select the initial list of sub-basins, watersheds, and sub-watersheds for initial assessment but are more specific to individual project concerns (Section II, above).

 ***[Suggest addressing each criterion as below. Most of the contents could come from the original second paragraph]***

Without this project, watershed planning and implementation efforts may not proceed as vigorously as with the comprehensive project in place, and there will continue to be relatively high rates of sediment contribution to the Illinois River mainstem, including sediment delivery to specific high-value habitat from sources within the Creek watershed. A reduction of habitat acres will occur in currently connected vegetated areas of floodplain, in larger patches of forest, in grassland areas, and in riparian areas. Without the project, there likely will be no reduction in unnatural peak discharge along the Creek mainstem and its tributaries, nor a reduction in incidences of low-water stress to aquatic organisms. Exposed pipelines endanger ecosystem health ***[how?]*** and possibly public health and safety. It is considered questionable just how full-use support or even partial-use support for aquatic life can be achieved in certain areas and maintained in others. It is also possible that there will be a less vigorous and concerted effort to find contamination sites and clean up or mitigate for those hazardous wastes.

**Wildlife Restoration Priorities in the Tenmile Creek Watershed**

As was found at Senachwine Creek (ISWS, unpublished contract report), combinations of GAP data (INHS 2005) for wildlife and hydrologic and geological data allowed for the development of composite scores to rank wildlife restoration priorities. We created an index of wildlife restoration priorities for 78 sites within the Tenmile Creek watershed. Briefly, each location was given a score based upon amphibian, reptile, summer bird, and mammal species richness. Taxa-specific scores ranged from 1 (lowest categorical species richness) to 7 (highest categorical species richness for summer birds). Index scores could range from a minimum of 4 (lowest overall species richness) to 22 (maximum overall species richness). We used the 25th, 50th, and 75th percentiles of the composite score data to define restoration priorities. Composite scores ranged from 11.5 – 21 across the 78 sites. The 25th, 50th, and 75th percentiles were composite scores of 16, 18, and 20. Composites scores ≤ 16 were defined as high restoration priority, composite scores of 16 ≥ 18 were defined as intermediate-high restoration priority, scores of 18 ≥ 20 were considered intermediate-low restoration priority, and scores > 20 were considered low priority restoration sites. Thirty-one percent of the sites were considered high priority, 22% were considered intermediate-high priority, 27% were considered intermediate low priority, and the remaining 20% of the sites were considered low priority for restoration based upon wildlife species richness.

Table 600**.** Hydrologic, geologic, and wildlife species richness characteristics for 78 sites sampled in the Tenmile Creek watershed. Number range under the wildlife categories signifies species richness. The composite score was based on an index that summarized species richness for each site across all four wildlife taxa. CSI = channel stability index (E = Excellent, G = Good, F = Fair, P = poor), BHI = biotic habitat index, CEM = channel evolution model, Amph. = amphibian, Rept. = reptile, Mamm. = mammal, and Comp. = index composite score. Priority was defined as high = H, intermediate-high = I-H, intermediate-low = I-L, and low = L.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | CSI | BHI | CEM | Amph.  | Rept. | Bird | Mamm. | Comp. | Priority |
| 1 | E | 1(0,0) | 2 | 9-14 | 21-25 | 51-62 | 20-28 | 20 | I-L |
| 2 | E | 4(1,0) | 2 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 3 | E | 4(1,0) | 2 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 4 | F | 4(1,1) | 5 | 9-14 | 16-20 | 41-50 | 16-20 | 16 | I-H |
| 5 | E | 3(1,1) | 2 | 5-8 | 21-25 | 41-50 | 11-20 | 15.5 | H |
| 6 | E | 3(1,1) | 2 | 5-8 | 21-30 | 41-50 | 11-20 | 16 | I-H |
| 7 | E | 3(0,1) | 3 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 8 | G | 4(0,0) | 5 | 9-14 | 26-30 | 41-50 | 16-20 | 18 | I-L |
| 9 | G | 4(1,1) | 2 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 10 | E | 4(0,0) | 5 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 11 | E | 4(0,1) | 3 | 9-14 | 26-30 | 41-50 | 16-20 | 18 | I-L |
| 12 | F | 4(2,0) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 13 | G | 4(1,1) | 6 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 14 | G | 4(1,1) | 6 | 9-14 | 21-30 | 51-60 | 20-25 | 19.5 | I-L |
| 15 | P | 3(1,1) | 4 | 5-14 | 21-25 | 3-20 | 6-15 | 11.5 | H |
| 16 | E | 4(1,0) | 5 | 9-14 | 26-30 | 51-60 | 20-28 | 20.5 | L |
| 17 | E | 4(1,1) | 6 | 9-14 | 21-25 | 41-50 | 16-20 | 17 | I-H |
| 18 | F | 4(1,1) | 4 | 5-8 | 21-25 | 41-60 | 11-20 | 16 | I-H |
| 19 | P | 4(1,1) | 4 | 9-14 | 21-25 | 51-60 | 16-25 | 18.5 | I-L |
| 20 | F | 4(1,1) | 5 | 9-14 | 21-30 | 51-60 | 6-10 | 16.5 | I-H |
| 21 | P | 3(2,1) | 4 | 9-14 | 21-25 | 3-20 | 11-15 | 12.5 | H |
| 22 | G | 4(1,1) | 5 | 5-14 | 16-20 | 51-60 | 16-20 | 16.5 | I-H |
| 23 | G | 4(1,1) | 4 | 9-14 | 16-25 | 51-60 | 20-28 | 19 | I-L |
| 24 | F | 4(1,1) | 3 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 25 | G | 1(1,1) | 5 | 9-14 | 26-30 | 51-60 | 20-28 | 20.5 | L |
| 26 | P | 4(1,1) | 4 | 5-8 | 26-30 | 41-60 | 16-25 | 18 | I-L |
| 27 | P | 4(1,1) | 4 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 28 | F | 4(1,1) | 4 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 29 | F | 4(1,1) | 5 | 9-14 | 21-30 | 51-60 | 20-25 | 19.5 | I-L |
| 30 | F | 4(1,1) | 4 | 9-14 | 21-30 | 61-62 | 20-28 | 21 | L |
| 31 | F | 4(1,1) | 4 | 9-14 | 21-25 | 51-60 | 16-20 | 18 | I-L |
| 32 | F | 4(1,1) | 5 | 9-14 | 16-20 | 51-60 | 11-20 | 16.5 | I-H |
| 33 | G | 4(1,1) | 4 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 34 | P | 4(1,1) | 4 | 5-14 | 11-20 | 21-40 | 11-20 | 13 | H |
| 35 | G | 4(1,1) | 5 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 36 | G | 4(1,1) | 5 | 5-8 | 16-25 | 11-30 | 11-20 | 12.5 | H |
| 37 | F | 3(1,1) | 5 | 5-8 | 16-25 | 21-40 | 11-20 | 13.5 | H |
| 38 | F | 4(1,1) | 5 | 5-14 | 21-30 | 51-62 | 20-28 | 20 | I-L |
| 39 | G | 3(1,1) | 5 | 9-14 | 21-30 | 51-60 | 20-28 | 20 | I-L |
| 40 | F | 4(1,1) | 5 | 9-14 | 21-25 | 51-60 | 20-28 | 19.5 | I-L |
| 41 | G | 3(1,1) | 5 | 9-14 | 21-25 | 41-50 | 11-20 | 16.5 | I-H |
| 42 | F | 4(1,2) | 4 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 43 | E | 3(1,1) | 6 | 9-14 | 26-30 | 51-60 | 20-28 | 20.5 | L |
| 44 | P | 4(1,2) | 5 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 45 | F | 4(1,1) | 4 | 9-14 | 21-25 | 51-60 | 20-25 | 19 | I-L |
| 46 | P | 4(1,1) | 4 | 9-14 | 21-25 | 41-50 | 11-20 | 16.5 | I-H |
| 47 | P | 4(1,1) | 4 | 9-14 | 11-20 | 41-50 | 20-25 | 16.5 | I-H |
| 48 | G | 4(1,1) | 4 | 9-14 | 21-25 | 41-50 | 16.20 | 17 | I-H |
| 49 | E | 4(1,1) | 3 | 9-14 | 21-25 | 51-60 | 16-20 | 18 | I-L |
| 50 | G | 4(1,1) | 4 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 51 | G | 4(1,2) | 4 | 5-14 | 21-30 | 51-62 | 20-28 | 20 | I-L |
| 52 | E | 4(1,1) | 3 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 53 | G | 3(1,1) | 4 | 9-14 | 21-25 | 51-62 | 20-25 | 19.5 | I-L |
| 54 | G | 3(1,1) | 3 | 9-14 | 21-25 | 51-62 | 20-25 | 19.5 | I-L |
| 55 | G | 4(2,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 56 | G | 4(1,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 57 | F | 4(1,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 58 | F | 4(1,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 59 | G | 4(2,1) | 3 | 9-14 | 16-25 | 21-30 | 11-20 | 14 | H |
| 60 | P | 3(2,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 61 | F | 2(1,2) | 5 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 62 | F | 2(1,2) | 5 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 63 | G | 3(1,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 64 | E | 1(1,1) | 5 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 65 | G | 2(1,1) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 66 | F | 4(1,2) | 4 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |
| 67 | G | 4(1,2) | 4 | 9-14 | 26-30 | 51-62 | 20-28 | 21 | L |
| 68 | G | 4(1,2) | 5 | 9-14 | 21-30 | 51-62 | 20-28 | 20.5 | L |
| 69 | F | 4(1,1) | 4 | 9-14 | 21-30 | 51-60 | 20-25 | 19.5 | I-L |
| 70 | G | 3(1,2) | 5 | 9-14 | 21-25 | 41-50 | 16-20 | 17 | I-H |
| 71 | F | 4(1,1) | 4 | 9-14 | 21-25 | 41-50 | 16-20 | 17 | I-H |
| 72 | P | 3(1,1) | 4 | 9-14 | 21-25 | 41-50 | 11-20 | 16.5 | I-H |
| 73 | P | 2(2,1) | 4 | 9-14 | 21-25 | 41-50 | 16-20 | 17 | I-H |
| 74 | F | 3(1,1) | 4 | 9-14 | 21-30 | 51-62 | 20-25 | 20 | I-L |
| 75 | P | 4(1,1) | 4 | 9-14 | 21-30 | 51-60 | 20-25 | 19.5 | I-L |
| 76 | P | 3(1,1) | 4 | 9-14 | 21-30 | 51-60 | 20-25 | 19.5 | I-L |
| 77 | P | 3(1,1) | 4 | 9-14 | 21-30 | 61-62 | 20-28 | 21 | L |
| 78 | G | 4(1,1) | 5 | 9-14 | 16-25 | 41-50 | 11-20 | 16 | I-H |

[Figures 44, 45, 46, 47 and 48]

Address T&E criteria from Table 1

Discuss threats to Ecological integrity (per Table 1)

* + 1. **Future Geomorphic and Hydrologic Ramifications**

***The stream dynamics analysis showed that the middle valley downstream of the proving grounds, the lower reaches of Spring Creek, and the floodplain/delta area have been most active historically. Projects directed at reducing sediment transport should be targeted there.***

Bank erosion and episodes of mass wasting along Tenmile Creek contribute sediment directly to the channel. Data used in the CEM analysis suggest, however, that portions of the watershed continue to adjust to past disturbance due to earlier channel modifications and land-use changes. In addition, stream reaches experiencing long-term net incision were observed, and there is some evidence of continued erosion of the landscape (Figure 20). Whether these point sources contribute “excessive” amounts of sediment to Creek and the Illinois River cannot be determined within the scope of this watershed assessment. Condition of excessive sedimentation must be assessed by comparing the range of intrinsic behaviors, possible changes in land use and climate that may cause them, and their effects on ecosystem goals (e.g., habitat quantity and quality, sediment delivery, decreased peak flows, increased base flows, water quality, etc.).

Without treatments that address not only actively eroding areas, but also mechanisms that trigger increased erosion rates, within the next few decades, as the stream network continues to adjust to past disturbance, sediment yield from the watershed are expected to approximate current amounts. Some additional modifications to the channel or changes in land use in the future could trigger a new cycle of channel adjustment and potentially increase sediment yield and undermine past and current efforts to curb sediment delivery to the Illinois River.

Table 8 and Figure 31 illustrate that sediment yield is tied directly to the hydrologic regime of the watershed. Thus, future rates of erosion and sediment yield depend on both climate change and management of the hydrologic regime. The influence of climate change on watershed hydrology cannot be predicted within the scope of this study. If regional warming continues, however, total precipitation will decrease but storms will be more intense, and runoff will increase but base flows will decrease (Easterling and Karl, 2001; O’Neal et al., 2005). Water and sediment discharge estimates approximate the expected range of variability and show that higher annual discharges generally yield more sediment (Table 8 and Figure 31). Further, existing data (Bhowmik et al., 1993) show that Peoria Pool tributaries exhibit wide hydrologic variability on an event-to-event basis (i.e., “flashiness”) leading to wide swings in erosive power and available energy to transport sediment. Although flashy hydrology is, in part, due to the geologic setting, changes in land use and land cover also are likely contributors to hydrologic variability. Without projects directed at watershed hydrology, the flashy hydrologic regime will remain, and change toward a wetter climate cycle likely will increase sediment yield.

Water and sediment conveyed by the stream system intrinsically lead to dynamic channel change. Banks are eroded, but deposition also occurs during the process, with net export of sediment out of the stream system. Preliminary assessment of channel dynamics shows the principle mode of channel change as downstream and lateral migration, particularly evident in mid- and lower segments of Creek (Figure 32). Although the scale of channel change generally increases further downstream, comparison of the stream channel in 1939 and 1998 indicated notably less change within HUC 402 (Table 2). Less change along this portion of the channel most likely is related to local control of the channel by bedrock and relatively coarse bedload. Due to the intrinsic nature of natural planform dynamics (i.e., modes of change not directly due to channel modification), lateral and downstream migration are expected to continue throughout the watershed, with largest changes in the lower portion of the watershed. Channel planform probably will remain relatively stable in the middle portion of the watershed due to geologic constraints. Substantial ditching and channelization occurred in the upper part of the watershed between 1939 and 1998; channel planform adjustments likely will occur but at smaller-scales than downstream, given the tendency for channelized reaches to re-meander.

Residential development is expected to continue, especially in middle and lower portions of the watershed near access routes to and Peoria. Most of that development will be in the floodplain near. Without specific planning, however, further habitat fragmentation will occur. Long-term consequences of such development, unless actively mitigated during design planning and construction, include increased runoff from increased impervious roofs, sidewalks, and roads, and impacts on water quality from septic systems, lawn chemicals, and road salt (Zielinski, 2002). Increased impervious cover reduces infiltration rates and thus potentially contributes to upland erosion, stream flashiness, and increased peak storm flow discharges.

Residential development also places demands on groundwater and surface water. There may be reduced base flow to streams if shallow groundwater aquifers are drawn down from overuse. Some new development will have to rely on surface impoundments, which, if not designed properly, could impede efforts to naturalize volume and velocities of stream flow.

* + 1. **Future Biological Ramifications**

***With further unimpeded development, IBI and ecological sustainability will suffer. More pressure on ecosystem function would decrease ecological diversity while increasing pressures on sustaining biodiversity. Impacts on flora and fauna include less biodiversity because of fragmentation in forest management to understory environment.***

* 1. **Problems and Opportunities**

Various problems in the watershed involving mainly erosion, and sedimentation have been attributed to uncontrolled stormwater runoff stemming from increasing urban development as well as from agricultural land and degraded forested areas (TCRPC, 2004). Based on interpretation of data from this study and historical information (e.g., INHS 2003a), many of these problems may also be the result of progressive channel and hillslope adjustments triggered by major channel modifications and ditch construction during the first half of the 20th Century. Recent NPS control projects (Miller et al., 1997; Joseph et al., 2003) have applied BMPs to address those problems, and anecdotal evidence suggests improved agricultural productivity, reduced upland erosion, and reduced flooding. Impacts of these BMPs have not been evaluated in the context of geomorphologic processes, however. That is, it is not known how previous efforts have furthered other ecosystem goals, such as reduced sediment delivery, improved water quality, and enhanced habitat. Because locations of previously implemented BMPs are relatively well-documented (Figure 3) and various methods have been applied, it is possible to evaluate long-term impacts of these BMPs. Relating successes and failures of previously implemented projects in a process-based watershed context would allow increasingly informed watershed management decisions and increase probable success of future projects.

Several unfulfilled data needs potentially limit appropriate planning and design of restoration projects. By mandate, much of the information used in this study relied primarily on previously existing data. Those data were collected mainly to estimate long-term, statewide, and regional trends (e.g., CTAP and USEPA 305(b)/303(d) programs). Thus, the datasets provide only broad estimates of watershed characteristics, and data collection was not tailored to assess conditions and processes specific to the watershed. Further, the few watershed-specific datasets available were collected at intervals generally too coarse (e.g., water quality) or entirely lacking (e.g., monitoring for sediment delivery and hydrology) to adequately determining practices and processes with impacts on sediment production and yield, hydrology, and habitat in the watershed. Existing elevation data are at regional scales (100-foot horizontal accuracy) rather than local scales (3- to 30-foot horizontal accuracy), are up to 30 years old, and are provisional. Higher-resolution elevation data are critical for many aspects of watershed assessment and project implementation, particularly regarding vertical stability of the channel and slope stability. Although limitations of the existing datasets do not necessarily preclude watershed restoration planning, making project implementation decisions without more watershed-specific data may limit success of watershed restoration and/or undermine previous restoration and management efforts.

Current conditions in many tributaries to the Tenmile Creek mainstem were documented (Figure 18). Additional work is necessary, however, to assess past and ongoing processes in these and other tributaries, with a primary focus on tributaries along or just upstream of the bluff line in valleys with steep, high walls. Susceptibility of these areas to slope failure is relatively high. New cycles of channel degradation and recovery could be initiated either by natural (e.g., climate change) or artificial (e.g., channel modification) triggers. The disturbance potentially could trigger a new cycle of stream adjustment leading to bank instability, landslides, and mass wasting, and contribute a large amount of sediment to the system. Additional work should include additional rapid field assessments, and relate vertical (e.g., repeat channel surveys) and planform (e.g. ***Stream Planform Change; Section V.B.4.b.ivi***) channel changes to land and water-use changes and climate changes (cf. Phillips et al., 2002).

Potential to improve, protect and expand habitat for regionally significant species, vegetated patch size and spacing for habitat also will be important and, as with stream and riparian management, will be outlined and pursued as opportunities arise. Forest management is also expected to be an important component of restoration activities.

* 1. **Significance**
		1. **Technical Significance**

This study provides a compilation and analysis of existing data and also presents new information acquired through field investigations and from aerial imagery. Emerging technologies used include those established elsewhere but not well-known in Illinois, as well as experimental methods. Because a goal of the study is to provide a scientifically based context for project planning, much of this report relies on adaptation of established classification schemes to assess biological integrity, channel stability, and channel evolution. Innovative methods also were developed and applied to identify problems and processes both in uplands and in the channel corridor. They include:

* Interpretive maps compiled using existing geographic datasets for a summary perspective on geologic, physiographic, hydrographic, and socioeconomic character of the watershed.
* Video imagery of the channel corridor taken by helicopter flyover for rapid synoptic reconnaissance and documentation of current watershed conditions.
* Systematic examination of historical aerial photography to assess channel planform change, with critical baseline information on historical channel processes within historical context of perceived problems in the Tenmile Creek watershed.

Even so, this study was intended to be rapid, not exhaustive. Resolution of most available data does not permit definitive characterization. Further analysis is desirable, particularly for flow, sediment delivery, water quality, and terrestrial and aquatic biology. Thus, this study is a starting point for process-based analysis of the Tenmile Creek watershed to achieve ecosystem restoration goals.

Although various agricultural BMPs previously were implemented in the watershed (Figure 3), those practices mainly focus on NPS sediment on agricultural lands in the watershed. Agricultural BMPs are intended to maintain or improve productivity. By contrast, their effects on terrestrial habitat, aquatic habitat, fluvial hydrology, and sediment delivery may be profound but have not been well characterized. The BMPs may initiate new CEM conditions not yet manifested because of intrinsic process lag times, or they may be responsible for current conditions.

The TCWA adds information regarding point sources of sediment in the floodplain-channel corridor and historical context to changes in the watershed system, information essential to achieve ecosystem restoration goals. Opportunities exist for integrated management of water-sediment systems in the watershed, both on the landscape and within channel corridors. That is, individual practices may temporarily address a specific effect (e.g., streambank erosion) of a systemwide problem (e.g., abrupt changes in sediment and water discharge). Addressing symptoms rather than problems potentially could have negative long-term impacts on erosion, sedimentation, and habitat. Secondary treatments may counteract those negative effects, but identification and characterization of variability and rates of geomorphic and habitat processes are crucial next steps for informed project implementation decision making. Potential projects based on this SCWA report should incorporate long-term monitoring to document performance evaluation, long-term viability, and adaptive management needs. The TCWA baseline data greatly will supplement future monitoring data.

* + 1. **Institutional Significance**

Many federal, state, and local agencies, as well as NGOs, have interests in ecosystem restoration of Creek watershed (Table 14? Agency Roles). Comprehensive and complex planning and implementation efforts require participation of a multitude of these agencies. Potential partners include the USDA-NRCS (CREP, Environmental Quality Incentives Program, Conservation Reserve Program, Conservation Practices Program, etc.); USDA Farm Service Administration; the local SWCD’s; the Illinois Department of Agriculture Streambank Stabilization Program; IDNR (e.g. State portion of CREP, Acres for Wildlife, Forestry Incentives Program, etc.), USEPA, and IEPA (Section 319 of the Clean Water Act, etc.). County Engineers and Township road commissioners would also be interested in stream channel work because of the many bridges crossing Creek. In the context of creating the water, sediment and habitat resource management systems briefly referred to in the SCWA, there will be an important opportunity for integration of many of these Agency efforts in project planning and implementation.

Coordination between the State Scientific Surveys was a key element in preparing this comprehensive SCWA report. Along the way, many lessons were learned about data availability, application of analytical methods, and agency strengths. Opportunities to integrate agency technical and funding capabilities also were better understood. Using this report as a template should expedite future assessments of other watersheds.

* + 1. **Public Significance**

The public stands to benefit in several ways from implementing ecosystem restoration activities based on TCWA recommendations. The intent is better, more targeted preservation of sensitive resources such as high quality habitat and conservation of land and water for varied uses through improved land planning and direct treatment. These efforts will address several goals of the Comprehensive Plan (USACE, 2007), including reducing sediment loads to the Illinois River mainstem and improving water quality. Land improvement could enhance agricultural production and provide higher quality recreational fishing, hunting, bird watching, etc.. Roads and bridges, as well as other transportation and economic infrastructure, could be better protected for longer periods. The Illinois River Valley Council of Governments (IRVCG) is an organization of local municipal representatives (mayors in most cases). The IRVCG encouraged the advancement of the R.O.D. and strongly supported its development. That organization brings immediate buy-in and regional project support.

* 1. **Goals and Objectives**

Goals and objectives of future activities based on this study follow those outlined in the Comprehensive Plan (Table 15; USACE, 2006). Within the Comprehensive Plan, the desired outcome for tributaries such as Tenmile Creek is the restoration of sustainable levels of floodplain and aquatic habitat functions. A portion of this would be accomplished by restoring 150,000 acres (collectively) of isolated and connected floodplain areas within the entire ILRB (USACE, 2006). This represents approximately 18 percent of the ILRB tributary floodplain and riparian habitat areas (USACE, 2006). This level of restoration would provide the necessary building blocks for a sustainable floodplain ecosystem within the tributaries in conjunction with other restoration efforts undertaken for this effort, particularly reduction of sediment delivery. General conditions for floodplains and riparian areas include establishment, protection, and management of terrestrial patches of land (forests, prairies, savannas, etc.). Bottomland hardwood forest generally require from 500- 1,000 acres for avian species and 3,000 acres for some interior avian species. Grassland restorations requires 100-500 acres. Nonforested wetlands require a minimum of 100 acres, spaced 30-40 miles apart, and riparian zones for streams require a minimum of 100 feet on each side. Approximately 1,000 miles of impaired streams would need to be restored, approximately one-third of the streams impaired by channelization within the ILRB.

|  |  |  |
| --- | --- | --- |
| **GOAL** | **OBJECTIVES** | **POTENTIAL FEATURES** |
| Ecological Integrity | Restore and conserve natural habitat structure and function | Habitat spacing, habitat restoration (size recommendations) and connectivity |
| Goal 1: sediment reduction | Reduce sediment delivery to the Illinois River by 40% | Bank stabilization, grade control (riffles), buffers |
| Goal 2: backwaters, side channels, islands restoration | Not Applicable | Not Applicable |
| Goal 3: floodplain, riparian, aquatic restoration | Restore tributary floodplain/riparian corridor, restore X stream miles | Wetland restoration, riparian corridor restoration, stream remeandering, invasive species control |
| Goal 4: fish passage | Not Applicable | Not Applicable |
| Goal 5: naturalize hydrology (peak flow, base flow, drawdown) | Decrease peak flows, increase baseflows | Stormwater storage, infiltration areas |
| Goal 6: water quality | Maintain good or improve impaired waters | Not Applicable |

Projects implemented in the Tenmile Creek watershed could provide incremental progress toward several basinwide goals. The watershed contains channel, wetland, major river and tributary floodplain, and terrestrial areas potentially suitable for restoration. The overarching goal is to restore and maintain ecological integrity, including habitats, communities, and populations of native species, as well as processes that sustain them. Additional criteria were developed as part of the Comprehensive Plan (USACE, 2007), including giving priority to projects that improve quality and connectivity of habitats, provide habitat for regionally significant species, reduce sediment delivery, naturalize hydrology, maximize sustainability, consider and address ecological threats, improve water quality, consider other agency activities, have public support, etc.

With specific criteria in mind, all agencies and stakeholders must work together to achieve several goals:

1. Reduce total sediment delivery to the Illinois River mainstem from sources within the Tenmile Creek watershed to reduce excessive sediment load. The basinwide target is to reduce sediment delivery at least 10 percent by 2025.
2. Reduce excessive sediment delivery to specific high-value habitat both along the Tenmile Creek mainstem and tributary streams.
3. Restore, rehabilitate, and maintain as many additional acres of habitat in currently connected floodplain areas as landowner support and incentives allow.
4. Find opportunities to restore large areas of forests and patches of grasslands in the Tenmile Creek watershed and to provide incentives for this effort.
5. Restore acreage of isolated and connected floodplain along the Tenmile Creek mainstem and tributaries to enhance floodplain habitats and promote floodplain functions. The basinwide goal is to restore an additional 10% of acreage of isolated and connected floodplain.
6. Restore and/or protect additional stream miles of in-stream and riparian habitat in the Tenmile Creek watershed.
7. Restore and/or protect mainstem to tributary connectivity, where appropriate, to maintain fish mobility and community structure.
8. Reduce unnatural peak discharge along the Tenmile Creek mainstem and tributaries to the extent possible with a subjective target of a 2-3% reduction for the 2- to 5-year recurrence storm events by 2023. The basinwide target is to reduce peak discharge 20% over the long term.
9. Reduce the incidence of low-water stress to aquatic organisms in the Tenmile Creek system by increasing base flows. The basinwide goal for tributary streams is to increase base flows 50%.
10. Ensure protection of exposed pipelines by in-stream geo- and biotechnical means or negotiation with pipeline owners for reasonable settlement between economic and public interests.
11. Maintain full-use support for aquatic life in all surface waters with Tenmile Creek watershed, as defined in 303(d) of the Clean Water Act. Achieve full-use support for all waters in the Tenmile Creek watershed by 2055.
12. Encourage remediation of contaminated sites that affect habitat.
13. Achieve USEPA nutrient standards by 2025, following standards put in place by the USEPA by 2008.
14. Work with the USACE and the State of Illinois (IDNR) to identify beneficial uses of sediments.
	1. **Preliminary Evaluation of Alternatives**

Section 519 of WRDA 2000 specifies that if an ILRB restoration project will produce independent, immediate, and substantial restoration, preservation, and protection benefits, the USACE shall facilitate project implementation. Restoration projects generally recommended in this document are preliminary and would require further feasibility study, however.

The stream channel is influenced by the glacial history of the watershed, surficial materials, and by combined dynamic processes, including climate, drainage modifications, land-use changes, etc. Unstable channel and near channel areas are demarcated (Figure 51) and recommended for environmental restoration and naturalization such that energy is dissipated and quasi-equilibrium is restored to the channel system. Restoration techniques that could be used in the watershed and stream system include bioengineered streambank and streambed stabilization; bioengineering techniques with low-intensity structural controls such as naturalized riffle and pool construction, placement of lunker structures or stream barbs; riparian zone expansion and management; upland and floodplain wetland restoration; woodland structure and understory management in forested bluff areas; stabilization of mass wasting sites; and traditional upland conservation treatments.

 Figure 4000. Reaches identified for possible ecosystem restoration activities.

Based on this analysis, four reaches along the Tenmile Creek mainstem are relatively unstable (Figures 37 and 51) and should be considered as priorities. Further investigations may improve upon predictive capabilities. Investigations initially focused on the Tenmile Creek mainstem, but it became clear early on that tributaries such as Wolf Creek, Spring Creek, and (Figure 24) deliver considerable sediment to the mainstem. Additional work has shown that these tributaries also are high-priority candidates for restoration. Practices in the upper watershed and in sloping forested areas also require further consideration.

***[Suggestion: Start general description of targeted reaches (though they’ve already been described above), such as total number of sites, length of reaches for additional study, how there are some long reaches with many problem sites but there are also problem sites outside of those reaches… Then break out Mainstem, Tributary Channels (lumped, unless you can think of a geological or process reason to separate them), Forested Lands, Agricultural Lands. Then continue the evaluation based on processes, e.g., Channel incision and widening (grade control, riffle/pool, Lunker…), Channel bank erosion (as part of intrinsic meandering…why do anything?), Mass Wasting of valley walls, etc. The relative costs and constraints of treating each process would be more easily discussed in that structure. The locations of particular sites or practices could then be identified on a figure. ]***

* + 1. **Tenmile Creek Mainstem**

Eight problem sites initially were identified from recent GPS tracked aerial flights along the assessed portion of the mainstem. An additional 49 potential problem areas were identified along the mainstem by carefully reviewing recently acquired aerial videotapes. Another 18 potential problem areas were identified from review of contemporary and historic panchromatic still aerial photos (Table 3). An additional four sites of concern were identified from in-channel field work and will require engineering surveys before proceeding further with project design.

The upper target reach is approximately a mile long (Figure 44). Only existing panchromatic still aerial photos were available for this area.

The next target reach is approximately 3.5 miles long. Recommended treatments primarily include grade control and habitat enhancement by constructing riffle and pool structures (Figure 51). Where the channelized segment ends in upper reaches of the mainstem, bedrock is exposed in the channel bed. The channel was less stable and stability and habitat indices were poor just below this point. Bedrock was considered to be a good place to anchor potential upper end multi-objective riffle and pool structures. Some severely eroded stream reaches may require installation of lunker structures and associated bioengineered techniques in combination with riffle and pool grade/habitat structures.

The third target reach is 3.9 miles long. Recommended treatments here also include grade control and habitat enhancement with riffle and pool structures, possibly combined with bioengineered techniques and lunker structures.

The fourth and lowest reach is 2.3 miles long, and 11 potential project sites were identified from aerial reconnaissance. This complex area is generally aggrading but exhibits channel degradation/incision in a few short segments where two gas pipeline segments are exposed. Riffle and pool structures may be useful to protect those gas pipelines, but relatively low bank elevations have led landowners to express concerns about flooding fields if water backs up too much.

Four sites with extensive mass wasting occur within the 3.5-mile project reach. Two more sites occur between the uppermost 1-mile and 3.5-mile project reaches, and five other sites occur near the bluff line between the 3.5-mile and lower 2.3-mile project reaches. Mass wasting occurs where the stream impinges on the base of the eastern valley walls.

Several more eroding streambanks occur at more isolated problem areas outside potential project reaches recommended in this report. Treatments within recommended reaches could have positive impacts on some of these other sites, but further study is necessary to clarify this. Appropriate stabilization of these outlier eroding streambanks also may be considered for potential individual projects, but project impacts must be considered within the context of the overall plan. Assessment of impacts to the stream channel from previously installed BMPs in uplands also needs to occur to identify additional opportunities for integrated system resource management (cf. Figure 3).

* + 1. **Spring Creek**

Creek is 8.5 miles long and has 5-6 segments that may be suitable for projects (Figures 51 and 39). The uppermost reach defined here is about a mile long and exposed tree roots indicate ongoing incision. Various restoration practices could be considered, including riffle and pool structures for grade control, oxygenation of water, aesthetics, habitat, and energy dissipation in combination with bioengineering techniques or even “hard” structures such as stone toe protection.

The next channel segment downstream has two small segments that could be combined into one reach depending upon type of restoration practices considered for further assessment in a feasibility study. When combined, the two segments are about a mile long (Figures 51 and 39). Two mass wasting sites are located along this stream segment. Restoration of mass wasting sites requires considerable effort, financial commitment, and site access from a willing landowner. The remaining three channel segments are located in the lower third of the stream. The last stream channel segment has one mass wasting site, and three other mass wasting sites are just upstream (second to last channel segment). Therefore, the four mass wasting sites are located in lowermost 2 miles of the creek. These channel segments also would benefit from bioengineering, stone toe protection and riffle and pool structures.

* + 1. **Spring Creek Tributary S4**

Creek is about 4.5 miles long, and assessment data indicated three particular reaches with channel stability problems, poor habitat, or both (Figure 40). The longest stream segment is in the middle area of Creek, the next longest is at the upper end of the channel, and the shortest segment is near the end of the channel about a quarter mile upstream of the channel mouth at the confluence with Creek. Typical restoration practices described above would also be suitable for consideration in these three reaches. No mass wasting sites were reported for this channel.

* + 1. **Wolf Creek**

Creek is about 6 miles long, and preliminary field data indicated three reaches of concern (Figure 41). An exposed gas pipeline and a lower channel segment where the channel gradient is a little steeper than in the middle portion (Figure 28), requires considerable work. This pipeline may not be active since steps had not been taken to protect it from exposure for many years. In particular, the pipeline had not been physically covered with a protective emulsion and wrapped with a polyurethane sealant. If the gas pipeline is active, then relocation of the line or armoring are common approaches to address public safety and potential pollution concerns. The gas pipeline company must be contacted to be sure this issue is addressed. Forest management also would be a major consideration in middle and upper segments. Other potential restoration practices include those provided above for other stream segments.

* + 1. **Forestland**

Much of the southwestern part of the watershed, in particular, could benefit from woodland management. Forested ravines are habitat areas of interest in the Tenmile Creek watershed for management opportunities. They include forests on interfluves, slopes, terraces, and riparian areas. Elimination of invasive plant species is highly recommended. Removal of some understory biomaterial and less desirable short story trees should be considered with overall timber stand improvement practices. Connection and structural enhancement offragmentedvegetated areas, especially riparian zones, would be of great benefit, not only for water quality but to enhance habitat for many floral and faunal species, including birds.

Most existing forest is limited to ravines because slopes are too steep for agricultural or residential development. Steep slopes also are less valuable than gentle slopes for wildlife [citation]. Opportunities for restoring additional forest acreage in low sloping upland and floodplain areas should also be investigated.

* + 1. **Agricultural Land**

Various agricultural BMPs have previously been implemented in the watershed, mainly outside channel areas (Figure 3). Traditional water management and erosion control projects (e.g. grassed waterways, terraces, ponds, WASCOBs, etc.) also have been constructed outside the channel in the Creek watershed. Those practices mainly focus on NPS sediment on agricultural lands. Agricultural BMPs are intended largely to maintain or improve productivity, but their effects on terrestrial habitat, aquatic habitat, fluvial hydrology and sediment delivery may be profound. These effects have not been well characterized in watersheds in Illinois and should be studied more thoroughly. These beyond-channel projects may alter water and sediment loadings to the Creek mainstem and can have either positive or negative effects immediately after construction. For example, without planning for compensation of flow regime changes or channel slope adjustments, sediment detention in upland areas can result in channel migration and/or channel incision, which would induce channel erosion with channel morphology changes (White et al., in review). By contrast, coordinated implementation of beyond-channel and in-channel BMPs should reduce peak discharge, increase base flow and provide a more balanced sediment regime.

* 1. **Proposed Methods for Benefit Assessment**

Monitoring stream hydrology can help determine if peak discharges have been ameliorated and if base flows have increased in summer months. “Normalizing” discharges can benefit habitat, plant and animal communities. Monitoring sediment and nutrient data combined with rainfall determinations would document changes in sediment delivery and transport in the watershed system. Continued monitoring of channel stability conditions and habitat indices as already initiated would help determine responses of the channel and habitat as long as other factors can be isolated and eliminated as causes.

1. **FEDERAL INTEREST**

Potential project features will require resources from several federal, local, and state agencies. Integrated planning and management of these resources will be instrumental in achieving significant ecosystem restoration locally in the Tenmile Creek watershed andthroughout the ILRB. Federal interest exists and will be realized specifically when project plans, designs, and resources are integrated as seamlessly as possible with those of local and state organizations. This integrated effort and funding will foster ecosystem restoration most effectively and efficiently. The challenge to integrate efforts lies not only with federal agencies but also with local and state organizations. Potential project features and required federal interests are briefly outlined (Table 16).

Table ##

|  |  |
| --- | --- |
| **Potential Project Feature** | **Appropriate Agency** |
| Traditional Upland FarmTreatment(Terraces, WASCOB’s, Grassed Waterways, No-till, etc… | USDA-NRCS USDA-FSA, IDOA, SWCD |
| In-Stream Naturalization (Riffle/Pool Stuctures, Lunker Structures, Bioengineering for Streambank Stabilization, etc… | ISWS, IDNR-ORC, USFWS, USDA-NRCS, USACOE |
| Priority Upland and Floodplain Wetland Restoration and Enhancement in Hydric Soil Areas  | USDA-NRCS, USFWS, IDNR-ORC, USACOE |
| Forested Slope and Riparian Management | USFWS, USDA-NRCS, IDNR-ORC, INHS |
| Stabilization of Select Mass Wasting Sites  | USGS, USACOE, ISGS, ISWS |

1. **RECOMMENDATIONS**

Based on study results, it is evident that various strategies could improve ecological integrity of theTenmile Creek watershed and thus address several goals within Alternative 6 of the Comprehensive Plan (USACE, 2007). Some goals of the Comprehensive Plan are applicable to restoration efforts in the Tenmile Creek watershed and are outlined in Section VE above.

Goals can be met by incorporating appropriate combinations of resource management options into a resource management plan for the entire watershed. These resource management options could include: 1) traditional erosion and sediment control BMPs outlined in standards developed for NRCS use; 2)bioengineering techniques (combined with placement of lunker structures or perhaps even “harder” structures, such as stone toe protection, stream barbs, etc. when necessary) to stabilize or naturalize streambanks and address channel equilibrium issues; 3) control of channel incision using riffle and pool structures (Newbury weirs, etc.); 4) channel re-meandering and reconnection of streams to parent floodplains; 5) wetland restoration or enhancement; 6) fish ladder placed at a large in-channel dam to promote fish passage and; 7) alternative futures planning and contemporary conservation designs for urban and rural stormwater infiltration and filtering, etc. Many of these options provide multiple benefits that enhance habitat while restoring or naturalizing flow regimes.

Traditional erosion and sediment control and water management practices and structures are recommended for additional design and construction. Innovative channel and near-channel restoration projects must be constructed to naturalize the fluvial environment and also managed to establish and sustain biologic diversity. Several unstable channel segments and near-channel areas on the mainstem identified for restoration are shown (Figure 51). Likewise, several areas were identified as potential sites for feasibility consideration. Because many factors may have contributed to these areas becoming unstable (e.g. glacial history of the watershed, surficial materials, combined dynamic processes including climate, drainage modifications, land-use changes, etc.) closer examination of causative factors and processes is recommended before implementing specific channel and slope stabilization projects. Initiating restoration projects that focus on stabilizing active degradation (e.g. knickpoints and headcuts) and regulating variability of water and sediment supply to the channel (reducing peak flow and increasing base flow) would rapidly improve habitats in the watershed, increase the likelihood of success of many other treatments, and possibly reduce long-term maintenance costs.

Application of the CEM shows that most stream reaches classified were post-Stage III. Moreover, the majority of these reaches were Stage V (Table 4), suggesting that general stability of the watershed is late-stage transitional, characterized by aggradation of the channel bed, mild mass wasting, heavy bank accretion, anastamosing channel thalweg, and diverse bank forms (Hupp, 1987). Within the CEM context, general stability of the physical habitat should trend toward improvement unless there are further extrinsic stimuli such as channel disturbances or modifications. What is not known, however, is how long observed conditions have existed. In west Tennessee where the CEM was developed, system recovery was on the order of 65 years (Hupp, 1992). Analysis in Illinois has been insufficient to document similar process-response rates, but continued data collection in this and other watersheds eventually will fill this data gap.

From Simon and Rinaldi 2000.

[“Reconnaissance in west-central Illinois and east-central and southeastern Iowa disclosed many sinuous streams with bank failures and meander extension occurring on outside bends from the growth of point bars on the opposite, inside bank. This is typical of late Stage V and Stage VI channels. Bank heights did not appear to be nearly as high as in southeast Nebraska, or western Iowa where bank heights between 8 and 11 m are common. Assuming that channel modifications occurred in west-central Illinois and east-central and southeastern Iowa at about the same time as in western Iowa, it seems that many of the eastern loess-area streams have recovered more quickly probably because (1) the initial direct disturbance to the channel (dredging and/or straightening) may not have been as extensive as in other parts of the loess area, and (2) the thinner loess cap has been penetrated by the streams, exposing an ample supply of coarser sand and gravel.”]

Forest management techniques specifically must applied within wooded bluff areas and along riparian zones in the watershed. The IRVCG, as mentioned previously, encouraged R.O.D. advancement and strongly supported its development, bringing immediate acceptance and regional project support.

Channel and near-channel sources of sediment (particularly from streambed, streambanks, and riparian areas of the Tenmile Creek mainstem, Spring Creek, Wolf Creek and other tributaries to Tenmile Creek) must be controlled and habitats must be enhanced using in-stream and riparian naturalization techniques. These techniques include variations of bioengineering, rock weir establishment, thinning of some wooded bluff areas and intense understory management. Control of invasive species, protection of Threatened and Endangered species, concentrated management and expansion of terrestrial habitat types (such as forest, prairie, and savannah) and protection and enhancement of aquatic (fish and macroinvertebrate) habitats all must be considered in a comprehensive manner with systematic programs that appropriately address systemic problems.

Implementation of solutions that effectively and efficiently address problems must be coordinated with all local, state and federal agencies proficient at handling these problems from both technical and funding perspectives. The Tenmile Creek watershed assessment was modeled after the Special Area Management Plans (SAMPs) outlined in the USACE Comprehensive Plan (USACE, 2007), but adjustments were made to accommodate assessment scaling issues between the larger ILRB and subwatershed levels. The study attempted to conduct a comprehensive review of aquatic and terrestrial resources in the entire watershed. Assessment reports help define where SAMPs or resource management plans should be developed for key watershed areas in which considerable planning and restoration activities occur or where scientific information suggests a need to target restoration. The approach to build upon this SCWA effort with a more specific feasibility effort is more environmentally sensitive than the traditional project-by-project process. The traditional approach may lead to cumulative loss of resources over time. With the SAMPs approach, potential impacts are analyzed at a watershed scale to identify priority areas for preservation, identify potential critical restoration areas and determine not only the least environmentally damaging locations for proposed projects but also the most important target areas for restoration. The goal is to achieve balance between terrestrial and aquatic resource protection and reasonable economic development. These comprehensive and complex efforts require multi-agency participation at local, state and federal levels.

Potential partners include the USDA-NRCS (CREP, Environmental Quality Incentives Program, Conservation Reserve Program, Conservation Practices Program , etc.), USDA Farm Service Administration, local SWCDs, the Illinois Department of Agriculture Streambank Stabilization Program, IDNR (e.g., Illinois portion of CREP, Acres for Wildlife, Forestry Incentives Program, etc.), USEPA and IEPA (Section 319 of the Clean Water Act, etc.) and a host of other partners and funding sources.

Restoration in the Tenmile Creek watershed is complicated because public interests control very little of the watershed. Participation in ecosystem restoration efforts by private landowners is vital for achieving ecosystem goals. Recommendations include continuation of the traditional “sign-up” programs currently in place and further incentives to private landowners to participate in construction of restoration projects outlined and targeted as potential projects in this assessment report.

In summary, several BMPs have been applied in this watershed in the past, but more work is necessary. This report describes watershed conditions, both past and present, and recommends implementation of specific restoration techniques, many targeted to specific locations. Restoration of target areas would reduce water and sediment discharge variability in the watershed, expand management of riparian zones, increase upland and floodplain wetland restoration, enhance woodland structure and understory management (particularly in bluff areas), stabilize mass wasting sites and further install traditional upland conservation treatments. Various channel and streambank treatments that could be applied include bioengineered streambank erosion control, bioengineered low-intensity structural controls such as naturalized riffle and pool construction, lunker structures, longitudinal peak stone protection, stream barbs, etc. A renewed focus should be on restoration of target areas as described in the assessment report, continued focus and interest in capabilities and funding needs of local landowners, and increased landowner incentives would maximize restoration while providing more sustainable ecological diversity.

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1. **DISCLAIMER**

**"Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the IDNR"**

1. **REFERENCES CITED**

Barbour, M. T., J. Gerritsen, B, D, Snyder, and J. B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, Periphyton, Benthic Macroinvertebrates, and Fish.* Second Edition. U.S. Environmental Protection Agency, Office of Water, EPA 841-B-99-002, Washington, D.C.

Barrows, H.H. 1910. Geography of the Middle Illinois Valley: Bulletin 15, Illinois State Geological Survey, Champaign, 128 p.

Bhowmik, N.G., W.C. Bogner, J. Slowikowski, and J.R. Adams. 1993*. Source Monitoring and Evaluation of Sediment Inputs for Peoria Lake.* Illinois Department of Energy and Natural Resources Report No. IENR/RE-WR-93/01 and Illinois State Water Survey Contract Report 514, Champaign, IL.

Biological Stream Categorization Work Group. 1993. *Biological Stream Categorization (BSC): Biological Assessment of Illinois Stream Quality through 1993.* Edited by W.A. Bertrand, R. L. Hite, and D. M. Day with the Biological Stream Categorization Work Group (W. Ettinger, W. Matsunaga, S. Kohler, J. Mick, and R. Schanzle.). Illinois Environmental Protection Agency, Springfield, IL.

Berg, R.C. 2001. Aquifer Sensitivity Classification for Illinois Using Depth to Uppermost Aquifer Material and Aquifer Thickness. Illinois State Geological Survey Circular 560, 14 p.

Berg, R.C., C.P. Weibel, A.J. Stumpf, and E.D. McKay III, 2009, Bedrock Topography of the Middle Illinois River Valley, Bureau, Marshall, Peoria, Putnam, and Woodford Counties, Illinois: Illinois State Geological Survey, Illinois Map 15, 1:62,500.

Brookes, A., 1988. Channelized Rivers: Perspectives for Environmental Management. John Wiley and Sons Ltd., Chichester , England. 326 p.

CH2MHill, 2001, City of Washington Comprehensive Plan, <http://www.washington-illinois.org/>

Changnon, S.A., J.R. Angel, K.E. Kunkel, and C.M.B. Lehmann. 2004. *Climate Atlas of Illinois.* Illinois State Water Survey, Informational/Educational Material 2004-02, Champaign, IL.

Demissie, M., R. Xia, L. Keefer, and N. Bhowmik. 2004. *The Sediment Budget of the Illinois River.* Illinois State Water Survey, Contract Report 2004-13, Champaign, IL.

Drown, S.D. 1844. The Peoria directory, for 1844: containing an account of the early discovery of the country, with a history of the town, down to the present time: an alphabetical list of the different heads of families or house-keepers, with their residences and occupations: and much other statistical information, never before published. Peoria, Illinois, Spoon River Press, reprinted 1978, 124 p.

Easterling, D.R., and T.R. Karl. 2001. Potential Consequences of Climate Variability and Change for the Midwestern United States. *Climate Change Impacts on the United States The Potential Consequences of Climate Variability and Change.* National Assessment Synthesis Team, U.S. Global Change Research Program, Chapter 6, pp. 167-188.

Evans, R.E., and D.H. Schnepper. 1977. Sources of Suspended Sediment: Spoon River, Illinois. *Proceedings of the North-Central Section of the Geological Society of America*, Peoria, IL, pp. 592-593

Federal Interagency Working Group. 1998. “Stream Corridor Restoration: Principles, Processes, and Practices.” October 1998.

Grissinger, E.H., A.J. Bowie, and J.B. Murphey. 1991. Goodwin Creek Bank Instability and Sediment Yield. *Proceedings of the Fifth Federal Interagency Sedimentation Conference.* Subcommittee on Sedimentation of the Interagency Advisory Committee on Water Data, Las Vegas, NV, pp. 5-51 to 5-60.

Hansel, A.K., and W.H. Johnson. 1996. *Wedron and Mason Groups: Lithostratigraphic Reclassification of Deposits of the Wisconsin Episode, Lake Michigan Lobe Area.* Illinois State Geological Survey, Bulletin 104, Urbana, IL.

Herricks, E.E., P. Kumar, B. L. Rhoads, J.S. Schwartz. 2004. Developing A Multi-Scale Assessment Procedure To Evaluate Subwatersheds For Ecosystem Restoration For The Rock River Ecosystem Restoration Feasibility Study. Final Report prepared under U.S. Army Corps of Engineers Contract No. DACW25-03-P-0045. Rock Island District, 171 p.

Herzog, B.L., B.J. Stiff, C.A. Chenoweth et al. 1994. *Buried Bedrock Surface of Illinois [Map].* Illinois State Geological Survey and U.S. Geological Survey, Illinois Map 5, Urbana, IL.

Hilsenhoff, W.L. 1982. *Using a Biotic Index to Evaluate Water Quality in Streams.* Wisconsin Department of Natural Resources, Technical Bulletin 132, Madison, WI.

Hite, R. L., and W.A. Bertrand. 1989. *Biological Stream Characterization (BSC): A Biological Assessment of Illinois Stream Quality. Special Report No. 13 of the State Water Plan Task Force.* IEPA/AC/89-275.

Holtrop, A.M., and M. Pegg (eds.). 2004. *Illinois River Ecosystem Restoration Monitoring and Watershed Assessment Framework. Final Report*. U.S. Army Corps of Engineers, Rock Island District, 339 p.

Hupp, C.R. 1987. Determination of Bank Widening and Accretion Rates and Vegetation Recovery along Modified West Tennessee Streams. *International Symposium on Ecological Aspects of Tree-Ring Analysis*, Tarrytown, NY, pp. 224-233.

Hupp, C.R. 1992. Riparian Vegetation Recovery Patterns Following Stream Channelization: A Geomorphic Perspective. *Ecology* **73**(4):1209-1226.

Illinois Department of Agriculture. 2009 Landcover Statistics by Watershed www.agr.state.il.us/gis/stats/landcover/mainpages/statistics\_by\_watershed.htm

Illinois Department of Natural Resources. 1998a. *The Illinois River Bluffs Area Assessment, Volume 1: Geology.* Illinois Department of Natural Resources, Office of Scientific Research and Analysis, State Geological Survey Division, Springfield, IL. <http://dnr.state.il.us/orep/pfc/assessments/IRB/pagei.htm> ).

Illinois Department of Natural Resources. 1998b. *The Illinois River Bluffs Area Assessment, Volume 2: Water Resources.* Illinois Department of Natural Resources, Office of Scientific Research and Analysis, Illinois State Water Survey Division, Springfield, IL.

Illinois Department of Natural Resources. 1998c. *The Illinois River Bluffs Area Assessment, Volume 3: Living Resources.* Illinois Department of Natural Resources, Office of Scientific Research and Analysis, Natural History Survey Division, Springfield, IL.

Illinois Department of Natural Resources. 1998d. *The Illinois River Bluffs Area Assessment, Volume 4: Soci-Economic Profile, Environmental Quality, Archaeological Resources.* Illinois Department of Natural Resources, Office of Scientific Research and Analysis, Division of Energy and Environmental Assessment, Illinois State Water Survey, Waste Management and Research Center, and Illinois State Museum Divisions, Springfield, IL.

Illinois Department of Natural Resources, 2006. *Illinois Wildlife Action Plan.* IDNR Office of Resource Conservation, Springfield, IL.

Illinois Department of Transportation, 2008, Eastern Bypass Study Kickoff Meeting handout:

 <http://www.easternbypass.com/>

Illinois Environmental Protection Agency. 2000. Median Nutrient Concentrations by Watershed in Illinois: Source Water Assessment Program (SWAP) digital data: source: Short, M.B., 1999, Baseline Loadings of Nitrogen, Phosphorus and Sediments From Illinois Watersheds, IEPA BOW/99-020, Springfield, IL.

Illinois Environmental Protection Agency. 2004. *Illinois Water Quality Report—2004, Clean Water Act Section 305(b), Water Resource Assessment Information.* IEPA Bureau of Water,Appendix A-11, p. 2 (<http://www.epa.state.il.us/water/water-quality/305b/305b-2004.pdf>, accessed ).

Illinois Environmental Protection Agency. 2006a. *Illinois Integrated Water Quality Report and Section 303(d) List—2006, Clean Water Act Sections 303(d), 305(b) and 314, Water Resource Assessment Information and Listing of Impaired Waters.* IEPA Bureau of Water, Appendix A, 201 pp. and Listed waters maps, p. 40 (<http://www.epa.state.il.us/water/tmdl/303d-list.html>, accessed ).

Illinois Environmental Protection Agency. 2006b. *State of Illinois Section 319 Biannual Report.* IEPA Bureau of Water, p. 24 (<http://www.epa.state.il.us/water/watershed/reports/biannual-319/2006/march.pdf>, accessed ).

Illinois Geospatial Data Clearinghouse. 1999. *Illinois Digital Orthophoto Quarter Quadrangle (DOQ) Data 1998-1999* (<http://www.isgs.uiuc.edu/nsdihome/webdocs/doqs>, accessed ).

Illinois Natural History Survey, 2003a, Land Cover of Illinois in the Early 1800s, vector digital data,

Champaign, IL, <http://www.inhs.uiuc.edu/cwe/maps/glo.html>, accessed December 2008.

Illinois Natural History Survey, 2003b, Illinois Natural History Survey's 1999-2000 1:100,000 Scale

Illinois Gap Analysis Land Cover Classification, raster digital data, Version 2.0, Champaign, IL, <http://www.isgs.illinois.edu/nsdihome/webdocs/landcover/gap.html>, accessed December 2008.

Illinois Natural History Survey, 2005, Illinois GAP Analysis Project: Vertebrate Modeling: digital raster

 data, , http://www.inhs.uiuc.edu/cwe/gap/vertmodeling.htm .

Johnstone, P.D. 2003. Aquifer Sensitivity Map of Tazewell County, Illinois: Open File Series 2003-6D, Illinois State Geological Survey, Champaign (map), 1:62,500 scale.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. *Assessing Biological Integrity in Running Waters: A Method and Its Rational.* Illinois Natural History Survey, Special Publication 5.

Keefer, D.A., 1995, Potential for Agricultural Contamination of Aquifers in Illinois. Illinois State Environmental Geology 148, 28 p., 5 plates, scale 1:250,000.

Keefer, L.L., White, W. P., Beardsley, J. D. 2009. DRAFT v.2, *Illinois River Basin Ecosystem Restoration Geomorphic Watershed Assessment (IRBGWA) Protocols.* Illinois State Water Survey, Institute of Natural Resource Sustainability, University of Illinois

Keefer, L.L. 2006, *Multi-scale Geomorphic Assessment Approach for Streams in the Southern Illinois Region: Case Study, Big Creek Watershed, Pulaski and Union Counties, Illinois.* Master of Science Thesis, University of Illinois, Urbana-Champaign, IL.

Kuhnle, R.A., A. Simon, and S.S. Knight, 2001. *Development Linkage Between Sediment Load and Biological Impairment for Clean Sediment TMDLs.* Wetlands Engineering & River Restoration Conference 2001, Reno, Nevada

 Kuhnle, R. A. and A. Simon, 2000. *Evaluation of Sediment Transport Data for Clean Sediment TMDLs.* Oxford, Mississippi, USDA-ARS National Sedimentation Laboratory Report No. 17, 60 p.

Killey, M. 1998. Illinois’ Ice Age Legacy. Illinois Department of Natural Resources, Illinois State Geological Survey, GeoScience Education Series 14, Champaign, IL.

Kramer, G.L., 1980, Prairie Studies at Caterpillar Tractor Co. Peoria Proving Ground, in Kucera, C.L.,

ed., Proceedings of the Seventh North American Prairie Conference, No.7, Springfield, Missouri: Southwest Missouri State University, p. 177–178.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr.

1980. Atlas of North American freshwater fishes. Publication #1980-12 of the North Carolina Biological Survey.

Lee, M.T., P. Makowski, and W. Fitzpatrick. 1982*. Assessment of Erosion, Sedimentation, and Water Quality in the Blue Creek Watershed, Pike County, Illinois*. Illinois State Water Survey Contract Report 321, Champaign, IL.

Leedy, J.B. 1979. *Observations on the Sources of Sediment in Illinois Streams*. University of Illinois, Illinois Water Information System Group, Report of Investigation No. 18, Urbana, IL.

Lineback, J.A. (compiler). 1979. *Quaternary Deposits of Illinois* [Map]: Illinois State Geological Survey, 1:500,000 scale.

Maher, B.A. 1986. Characterization of soils by mineral magnetic measurements. Physics of the Earth and Planetary Interiors v. 42, pp. 76-92.

McKay, E.D., R.C. Berg, A.J. Stumpf, and C.P. Weibel, 2009, Surficial Geology of the Middle Illinois River Valley, Bureau, Marshall, Peoria, Putnam, and Woodford Counties, Illinois: Illinois State Geological Survey, Illinois Map 17, 1:48,000.

McKay, E.D., R.C. Berg, P.D. Johnstone, A.J. Stumpf, and C.P. Weibel. In review. Surficial Geology of the Middle Illinois River Valley – Portions of Bureau, Marshall, Peoria, Putnam, and Woodford Counties, Illinois – Including Chillicothe, Lacon, Putnam, and Rome, Illinois State Geological Survey, 7.5 Minute Quadrangles: Illinois Map Series, Champaign, IL. 1:62,500 scale.

Montgomery, D.R. and J.M. Buffington 1998. Channel processes, classification, and response potential.

In: R.J. Naiman and R.E. Bilby, Editors, *River Ecology and Management*, Springer-Verlag, New York (1998), pp. 13–42.

National Atlas. 2005. National Atlas of the United States and The National Atlas of the United States of America, Registered trademarks of the United States Department of Interior. http://www.nationalatlas.gov/ and http://www.nationalatlas.gov/printable/images/pdf/congdist/IL18\_109.pdf.

Natural Resources Conservation Service. 2002. *Watershed Boundary Data - 12 digit Hydrologic Units.* U.S. Department of Agriculture, NRCS, Fort Worth, TX (<http://datagateway.nrcs.usda.gov>.

Ohio Environmental Protection Agency. 1987. *Biological Criteria for the Protection of Aquatic Life: Volume II: Users Manual for Biological Assessment of Ohio Surface Waters.* OEPA Division of Water Quality, Monitoring, and Assessment, Columbus OH (<http://www.epa.state.oh.us/dsw/bioassess/BioCriteriaProtAqLife.html>, accessed).

Ohio Environmental Protection Agency. 2006a. 2006. Updates to *Biological Criteria for the Protection of Aquatic Life: Volume II and Volume II Addendum: Users Manual for Biological Assessment of Ohio Surface Waters.* OEPA Division of Surface Water, Ecol. Assessment Section, Columbus, OH

Ohio Environmental Protection Agency. 2006b. 2006. Updates to *Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities.* OEPA Division of Surface Water, Ecol. Assessment Section, Columbus, OH

Ohio Environmental Protection Agency. 2006c. *Methods for assessing habitat in flowing waters: Using* the Qualitative Habitat Evaluation Index (QHEI)*.* Ohio EPA Tech. Bull. EAS/2006-06-1. OEPA Division of Surface Water, Ecol. Assessment Section, Columbus, OH

Olson, K.R., and R.L. Jones. 2001. Use of fly ash as time marker in soil erosion and sedimentation studies. In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds.), Sustaining the Global Farm, 10th International Soil Conservation Organization Meeting, May 24-29, Purdue University and USDA-ARS National Soil Erosion Research Laboratory, pp. 1059-1061.

Omernik, J.M. 1995. Ecoregions: a spatial framework for environmental management: In Biological

Assessment and Criteria: Tools for Water Resource Planning and Decision Making, W. Davis and T.P. Simon (eds.). Lewis Publishing, Boca Raton, FL. pp.. 49-62.

O’Neal, M.R., M.A. Nearing, R.C. Vining, J. Southworth, and R.A. Pfeiferea. 2005. Climate Change Impacts on Soil Erosion in Midwest United States with Changes in Crop Management. *Catena* **61**:165-184.

Page, L.M., K.S. Cummings, C.A. Mayer, S.L. Post, and M.E. Retzer. 1992. *Biologically Significant Illinois Streams: An Evaluation of the Streams of Illinois Based on Aquatic Biodiversity.* Illinois Department of Conservation and Illinois Department of Energy and Natural Resources, Project Completion Report: Enhancement of Biological Stream Characterization F-110-R, : 485 pages.

Phillips, A.C., B.L. Rhoads, T.J. McTighe, and C. Klaus. 2002. *Stream Dynamics Assessment, Illinois River Basin.* U.S. Army Corps of Engineers, Rock Island, Contract Report DACW25-98-D-0077, 65 p., 7 tbl., 46 figs.

Piskin, K., and R.E. Bergstrom. 1975. *Glacial Drift in Illinois: Thickness and Character.* Illinois State Geological Survey, Urbana, IL.

Rhoads, B.L., and M.A. Urban. 1997. A Human-induced Geomorphic Change in Low-energy Agricultural Stream: An Example from East-central Illinois. In S.S.Y.Wang, E.J. Langendoen, and F.D. Shields (eds.), *Management of Landscapes Disturbed by Channel Incision*, University of Mississippi, Oxford, MS, pp. 968-973.

Roseboom, D., and W.P. White. 1990. The Court Creek Restoration Project. *Proceedings of* *Erosion Control: Technology in Transition*. 21st International Erosion Control Association Conference, Washington D.C., pp. 14-17.

Soil Conservation Service. 1990. *Draft Preliminary Investigation Report: Senachwine Creek Watershed, Peoria and Marshall Counties, Illinois.* U.S. Department of Agriculture, SCS, 11 pages.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. *Incised Channels: Morphology Dynamics and Control.* Water Resources Publications, Littleton, CO.

Schwegman, J. 1973. *Comprehensive Plan for the Illinois Nature Preserves System—Part 2—The Natural Divisions of Illinois.* Prepared by the Illinois Nature Preserves Commission under guidance of the Framework Advisory Committee and in cooperation with the Illinois Department of Conservation.

Shields, F.D. Jr., S.S. Knight, and C.M. Cooper. 1997. Rehabilitation of Aquatic Habitats in Warmwater Streams Damaged by Channel Incision in Mississippi. *Hydrobiologia* **382**:63–86.

Smith, P.W. 1979. The fishes of Illinois. University of Illinois Press, Urbana.

Simon, A. 1989. A Model of Channel Response in Distributed Alluvial Channels. *Earth Surface Processes and Landforms* **14(**1):11-26.

Simon and Darby, 2002 A. Simon and S.E. Darby, Effectiveness of grade-control structures in reducing erosion along incised river channels: the case of Hotophia Creek, Mississippi, *Geomorphology* **42** (2002), pp. 229–254.

Simon, A. and P.W. Downs. 1995. An Interdisciplinary Approach to Evaluation of Potential Instability in Alluvial Channels. *Geomorphology* **12:**215-232.

Simon, A., and M. Rinaldi. 2000. Channel Instability in the Loess Area of the Midwestern United States. *Journal of American Water Resources Association* **36**(1):133-150.

Soil Survey Staff. 2006. Soil Survey Geographic (SSURGO) Database for Tazewell County, Illinois*.* U.S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, TX (<http://SoilDataMart.nrcs.usda.gov/>, accessed 9/15/2008 ).

Soil Survey Staff. 2007. Soil Survey Geographic (SSURGO) Database for Woodford County, Illinois. U.S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, TX (<http://SoilDataMart.nrcs.usda.gov/>, accessed 9/15/2008)

Soong, D.T., Ishii, A.L., Sharpe, J.B., and Avery, C.F., 2004, Estimating flood-peak discharge

magnitudes and frequencies for rural streams in Illinois: U.S. Geological Survey Scientific Investigations Report 2004-5103, 147 p.

State of Illinois. 1997. *Integrated Management Plan for the Illinois River Watershed.* Office of the Lt. Governor, Technical Report, Springfield, IL.

Ohio Environmental Protection Agency, 2006, Methods for Assessing Habitat in Flowing

Waters: Using the Qualitative Habitat Evaluation Index (QHEI), Ohio EPA Technical Bulletin EAS/2006-06-1, State of Ohio Environmental Protection Agency, Division of Surface Water, Groveport, OH. 26 p.

Straub T.D., G.P. Johnson, D.P. Roseboom, and C.S. Sierra. 2006. *Suspended-sediment Yields and Stream-channel Processes on Judy’s Branch Watershed in the St. Louis Metro East Region in Illinois.* U.S. Geological Survey, Scientific Investigations Report 2006-5016, Reston, VA.

Suloway, L., M. Joselyn, and P. Brown. 1996. *Critical Trends Assessment Phase II, Inventory of Resource Rich Areas in Illinois: An Evaluation of Ecological Resources.* Illinois Department of Natural Resources, Center for Wildlife Ecology, Illinois Natural History Survey Division, IDNR/EEA-96/08 3M/1996 (<http://www.inhs.uiuc.edu/cwe/rra/rra.html>, accessed ).

Taylor, S.J., A.C. Phillips, S.L. Post, S.E. Brown, and K.R. Robertson. In review. An Overview of Illinois’ Geological History and Landscape: In Taylor, C. (Ed.), *Canaries in the Catbird Seat*: Chapter 2, Illinois Natural History Survey, Champaign.

Tele Atlas North America, Inc., and ESRI, 2008, U.S. Census Block Centroid Populations, vector digital data, in ESRI Data & Maps, Redlands, California: ESRI.

Tri-County Regional Planning Commission, 1996, Woodford County Comprehensive Land Use Plan, Tri-

County Regional Planning Commission, <http://www.woodford-county.org/index.php?section=30>.

Tri-County Regional Planning Commission, 2004a, Tenmile Creek Watershed Restoration Plan,

Tri-County Regional Planning Commission,<http://www.tricountyrpc.org/environment-page/watershed-planning>.

Tri-County Regional Planning Commission, 2004b, Village of Germantown Hills, Illinois Comprehensive

Plan, Peroia, IL <http://www.tricountyrpc.org/community-page/germantown-hills>.

U.S. Army Corps of Engineers. 1990. *Vicksburg District Systems Approach to Watershed Analysis for Demonstration Erosion Control Project, Appendix A.* USACE, Vicksburg District, Demonstration Erosion Control Project Design Memorandum No. 54, Vicksburg, MS.

U.S. Army Corps of Engineers. 2004. *Illinois River Basin and Tributaries Ecosystem Restoration Project Management Plan (PMP).* USACE, Rock Island District.

U.S. Army Corps of Engineers. 2007. *Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment, Main Report; Public Review Draft.* USACE, Rock Island District.

U.S. Department of Agriculture, 2009, 2008 Illinois Cropland Data Layer: United States Department of

Agriculture, National Agricultural Statistics Service, digital raster data, Washington D.C., <http://datagateway.nrcs.usda.gov/>, accessed March 2009.

U.S. Geological Survey. 2009. Illinois Stream Stats. available online: <http://water.usgs.gov/osw/streamstats/illinois.html>

Urban, M.A. 2000. Conceptualizing Anthropogenic Change on the Upper Embarras River. Dissertation, University of Illinois, Champaign, IL.

Vagt, P.J. 1982. *Vertical and Horizontal Stability of Streams in Northern Illinois*. Masters Thesis, Geology Department, Northern Illinois University, DeKalb, IL.

White, W.P., M.Demissie, and L. Keefer. 2005. Illinois River Basin Assessment Framework. *Proceedings of the Governor’s Conference on the Management of the Illinois River System.* Peoria, IL (<http://ilrdss.sws.uiuc.edu/>, accessed ).

White, W.P., and L.L. Keefer. 2005. Rapid Stream Assessments of the Illinois River Watershed. *Proceedings of the World Water & Environmental Resources Congress 2005: Impacts of Global Climate Change.* Conference of the Environmental & Water Resources Institute of the American Society of Civil Engineers, Anchorage, AL, USA (accessible only with on-line subscription).

White, W.P., J. Beardsley, and S. Tomkins. 2008. “Lake Pittsfield (Blue Creek Watershed, Illinois) Section 319 National Monitoring Program Project”. *National Water Quality Group Newsletter*. North Carolina State University and the North Carolina State University Extension Service. With funding from the Illinois Environmental Protection Agency and the U. S. Environmental Protection Agency Section 319 Nonpoint Pollution Control Program of the Clean Water Act. Raleigh, NC.

Willman, H.B., E. Atherton, T.C. Buschback, C. Collinson, J. Fry, M.E. Hopkins, J. Linebeck, and J. Simon. 1975. *Handbook of Illinois Stratigraphy.* Illinois State Geological Society, Bulletin 95, Urbana, IL.

Windhorn, R.D., 2003, Tenmile and Partridge Creeks erosion and sedimentation investigation. Natural Resources Conservation Service, unpublished manuscript, 13 p.

Windhorn, R.A., 2005, Key to Illinois soils: Natural Resources Conservation Service, U.S. Department of

Agriculture, 59 p., <http://www.illinoissoils.org/Links_Files/KeySoilsSept2006.xls>.

Windhorn, R.D., and T. D’Avello, 2002, RAP-M and BATHMASTER, USDA – NRCS, available online at ftp://ftp-fc.sc.egov.usda.gov/IL/resplng/RAP-M.pdf, 71 p.

Woermann, J. W. 1902-1904. Map of the Illinois and DesPlains Rivers from Lockport, Illinois, to the

mouth of the Illinois River. US Army Corps of Engineers

Woods, A.J., J.M. Omernick, C.L. Pederson, and B.C. Moran, 2006, Level III and IV Ecoregions of

Illinois: U.S. Environmental Protection Agency, ftp://ftp.epa.gov/wed/ecoregions/il/il\_eco.zip.

Zielinski, J. 2002. Watershed Vulnerability Analysis: Center for Watershed Protection, Ellicott City, MD (<http://www.cwp.org/Vulnerability_Analysis.pdf>, accessed ).