ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Hierarchical Framework for Wadeable Stream Management and Conservation: Annual Report 2014

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Annual Summary Report 2014

Project Title:
Hierarchical Framework for Wadeable Stream Management and Conservation.

Project Number: T-75-R-001

Contractor information:

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Annual Reporting Period: 1 May 2014—30 April 2015

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Goals/ Objectives: (1) Develop Ecological Drainage Units for Illinois Streams; (2) Define Aquatic Ecological Systems for Illinois Streams; (3) Develop and Classify Illinois' Stream Valley Segments; (4) Define Natural Community Types for Illinois Streams; and (5) Develop and submit a list of candidate sites for INAI listing under Category I (High Quality and Significant Natural Communities) and revised Category VI (Unusual Concentrations of Fauna) criteria for streams.

Project Title:
Hierarchical Framework for Wadeable Stream Management and Conservation.

Narrative:

Work focused on integrating existing data for biological assemblages with new GIS infrastructure and existing classification efforts within Illinois (e.g., National Fish Habitat Partnership [Esselman et al. 2011]; Upper Mississippi River Basin Assessment [Khoury et al. 2011]). Updated fish and mussel data were prepared for application within Ecological Drainage Units (EDU) and summarization with Aquatic Ecological System (AES) being developed during this reporting period. We have also incorporated an expanded taxonomic resolution by adding information from the Illinois Natural History Survey (INHS) collections database, and IEPA macroinvertebrate surveys for aquatic macroinvertebrates (Ephemeroptera, Plecoptera, and Trichoptera or collectively EPT) throughout Illinois.

Work on this project was mainly conducted by one part time research scientist for the majority of the reporting period due to delays in obtaining completed summarizes for the IDNR update GIS infrastructure. While EDU, AES, and VSTs were initially developed using the previous version their integration with the new system has been more difficult than anticipated and effectively delayed work on defining Natural Community Types (Job 5) which requires their use. This project will produce attributed GIS feature classes that describe a series of nested classification units that can be used for conservation and management planning for stream systems at a variety of landscape scales. A request for a second one year no-cost extension was accepted for the project during this reporting period.

Job 1: Compile and update databases.

Compilation and integration of biological assemblage data with hydrologic, geomorphic, and geologic data within our existing GIS system was completed for data available through 2012. However, we initiated work with staff associated with the Statewide Streams Application (SSA, T-60-D-1) to assure that outputs from our project would transfer to their finer resolution GIS application (1:24,000 stream linework, 10m DEM). These efforts have delayed the final attribution of our framework until the spatial structure of SSA has been completed. Integration of these data with the new system is ongoing.

Job 2: Develop Ecological Drainage Units (EDUs).

EDUs have been defined using drainage affinity and presence of fish and mussel species and are ready for review by the working group (Figure 1). The eleven EDUs we have defined for Illinois differ only slightly from the EDUs currently being used by the National

Fish Habitat Partnership. However, we believe that these refinements better reflect existing and historical patterns of ecological connectivity. These EDUs have been incorporated as formal part of Statewide Streams Application (T-60-D-1) and are being used as natural processing units for stream flow direction and attribution. This job has been completed.

Job 3: Define Aquatic Ecological Systems (AES).

AES polygons were developed from 30-meter DEM local watersheds within the 1:100,000 stream arc coverage for Illinois. A total of 1,195 AES polygons were delineated for watersheds draining to Illinois rivers and streams. Attribution of bedrock and surficial geology, soils, landform, and groundwater potential based on a model describing potential subsurface water movement (Baker et al. 2003) for each AES polygon has completed and used to distinguish AES types. We used a cluster analysis (MDS and CLUSTER, Primer v6; Clarke & Gorlev 2006) to group hydrologic units sharing similar percentages of selected physical variables (geology, soils, landform, groundwater inputs) into AES types. However, integration of AES polygons with the new GIS system has proved to be complicated because watershed boundary polygons developed with the 1:100,000 streamlines and those from the 1:24,000 map scales do not consistently overlap. We are currently redeveloping the AES polygons using the finer resolution data. This work is ongoing.

Job 4: Classify stream segments as valley segment types (VSTs).

Based on earlier efforts to describe summer water temperatures, stream size, and low flow water yield in Illinois we used characterizations of stream arcs with the Valley Segment Affinity Search Technique (VAST; Brenden et al. 2008) to delineate valley segments by joining similar stream arcs. We used catchment area, link number, catchment slope, and two surficial geology summaries (bedrock, coarse sand) associated with different expectations for infiltration and runoff in developing this valley segment delineation. Stream arcs were then attributed with unique valley segment identifiers throughout the state. We then developed polygons for characterization of each valley segment defined with VAST. To determine if these physically based VSTs were associated with specific native fish assemblages we performed cluster analysis (MDS and CLUSTER, Primer v6; Clarke & Gorlev 2006) of VSTs and fish assemblages within each EDU. The resulting data matrix (species presence by stream segment) was used as the input data for a series of multivariate analyses that assessed the relative similarity of fish and mussel assemblages among VSTs within an EDU. However, integration of these valley segment delineations with the finer resolution data has been problematic. GIS summaries of stream segment watershed characteristics are not directly applicable to the 1:24,000 stream linework. Summaries of the 1:24,000 based stream segments are currently being compiled and this analysis will be redeveloped. This work is ongoing.

Job 5: Define Natural Community Types (NCTs).

We continued investigating the use of species richness levels, and the range of species collected during individual sampling events, to index regional biodiversity. We assembled information on fish, mussels, and aquatic insects to help define natural community types in Illinois streams and summarized these for EDUs.

We also examined the potential use of NatureServe subnational (state) rankings of fish and mussel species for defining Category I or Category VI INAI sites. Unfortunately, while this approach has promise the Illinois NatureServe rankings have not been updated since they were initially developed (< 1997) and are painfully out of date. Information from other projects (e.g., T-68, T-55, T-82) could be used to update the state S rankings but this is beyond the scope of our current project.

This work has been put on hold until our spatial units have been integrated with the refined stream network. Further work on Category I guidelines have been delayed until the completion of AES and VST integration and typing and associated analysis (see Job 3 and Job 4).

Job 6: Produce a list of candidate sites for INAI using existing data.

We continued our investigations into the use of fish and mussel richness for Category VI. We mapped locations that would qualify as INAI sites based on high mussel species richness (Figure 2), presence of threatened or endangered mussel species (Figure 3), and high fish IBI scores (Figure 4) associated with existing criteria. This work is ongoing but has been put on hold until the revised stream network is available.

Job 7: Prepare manuscripts and reports.

This annual performance report was prepared and submitted. To date total of three presentations of this work have been delivered (40^{th} Natural Areas Conference in Chicago, and the 51^{st} and 52^{nd} Annual Meetings of the Illinois Chapter of the American Fisheries Society). No other work was scheduled for this Job.

Literature Cited:

Baker, M.E., M.J. Wiley, M.L. Carlson, and P.W. Seelbach. 2003. A GIS Model of Subsurface Water Potential for Aquatic Resource Inventory, Assessment, and Environmental Management. Environmental Management 32(6): 706-719.

Brenden, T.O., L. Wang, P.W. Seelbach, R.D. Clark Jr., M.J. Wiley, B.L. Sparks-Jackson. 2008. A Spatially constrained clustering program for river valley segment delineation from GIS digital river networks. Environmental Modelling & Software 23: 638-649.

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Khoury, M., J. Higgins and R. Weitzell. 2011. A freshwater conservation assessment of the Upper Mississippi River basin using a coarse- and fine-filter approach. Freshwater Biology 56: 162-179.

T-60-D-1. State Wildlife Action Plan: Development and Expansion Needs of Existing Information Systems. Illinois Department of Natural Resources State Wildlife Grant T-60-D-1.

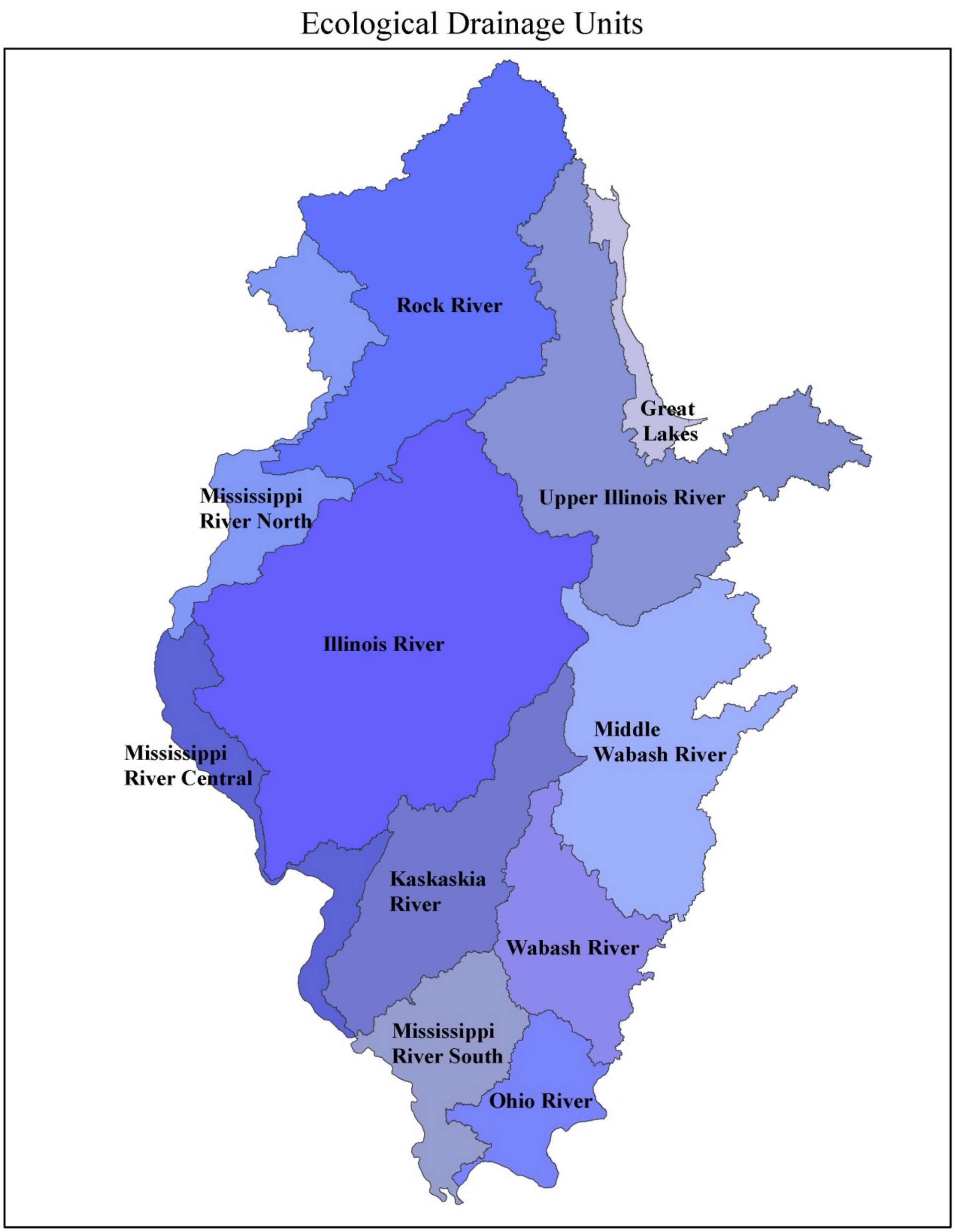


Figure 1. Ecological Drainage Units (EDUs) for Illinois were derived using drainages and HUC8s with relatively similar fish and mussel species assemblages.

Mussel Survey 2008-2012 sites that
meet or exceed criterion for INAI Category VI

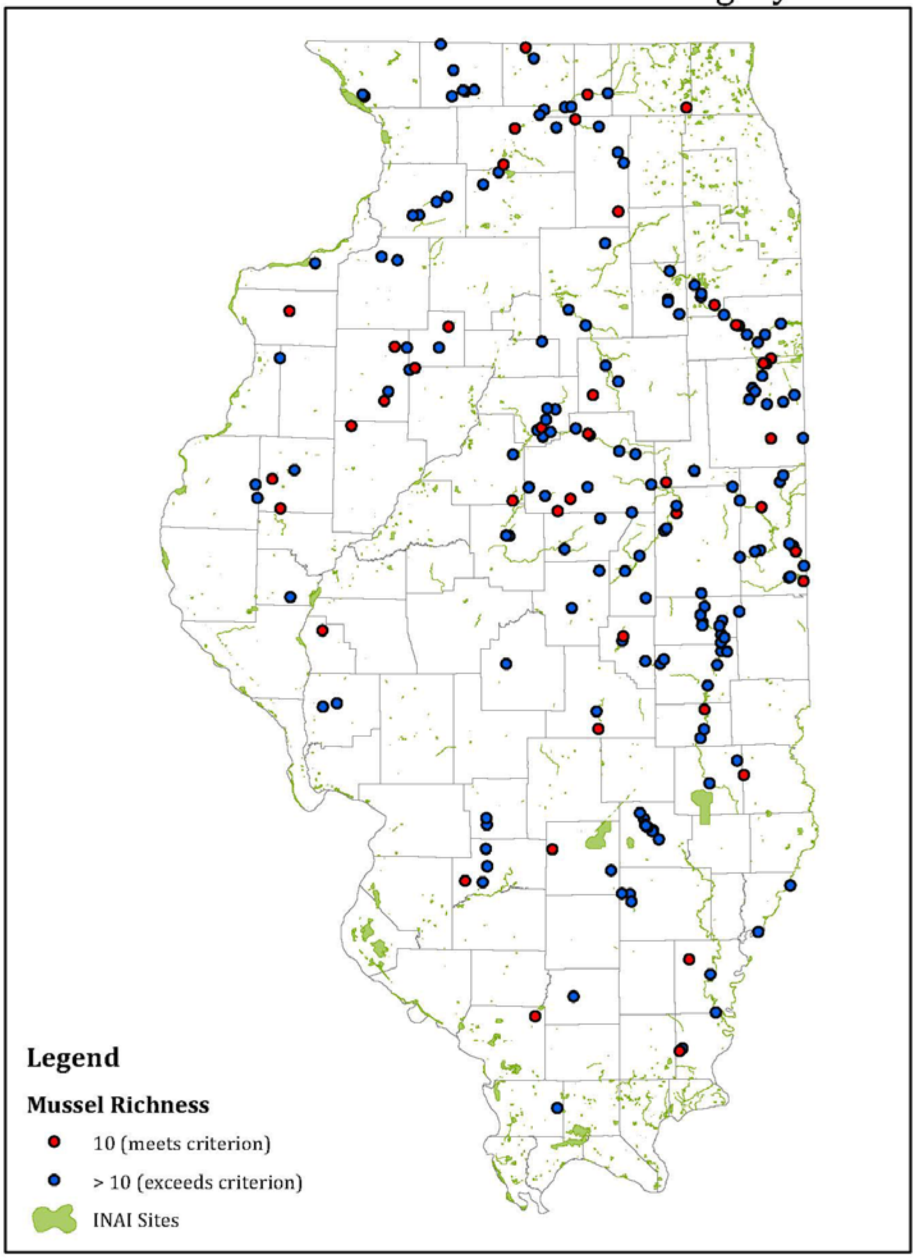


Figure 2. Locations of stations with mussel species richness that meet or exceed the existing INAI Category VI criteria ("unusual concentrations of flora or fauna"). Richness values based on recent statewide community mussel sampling.

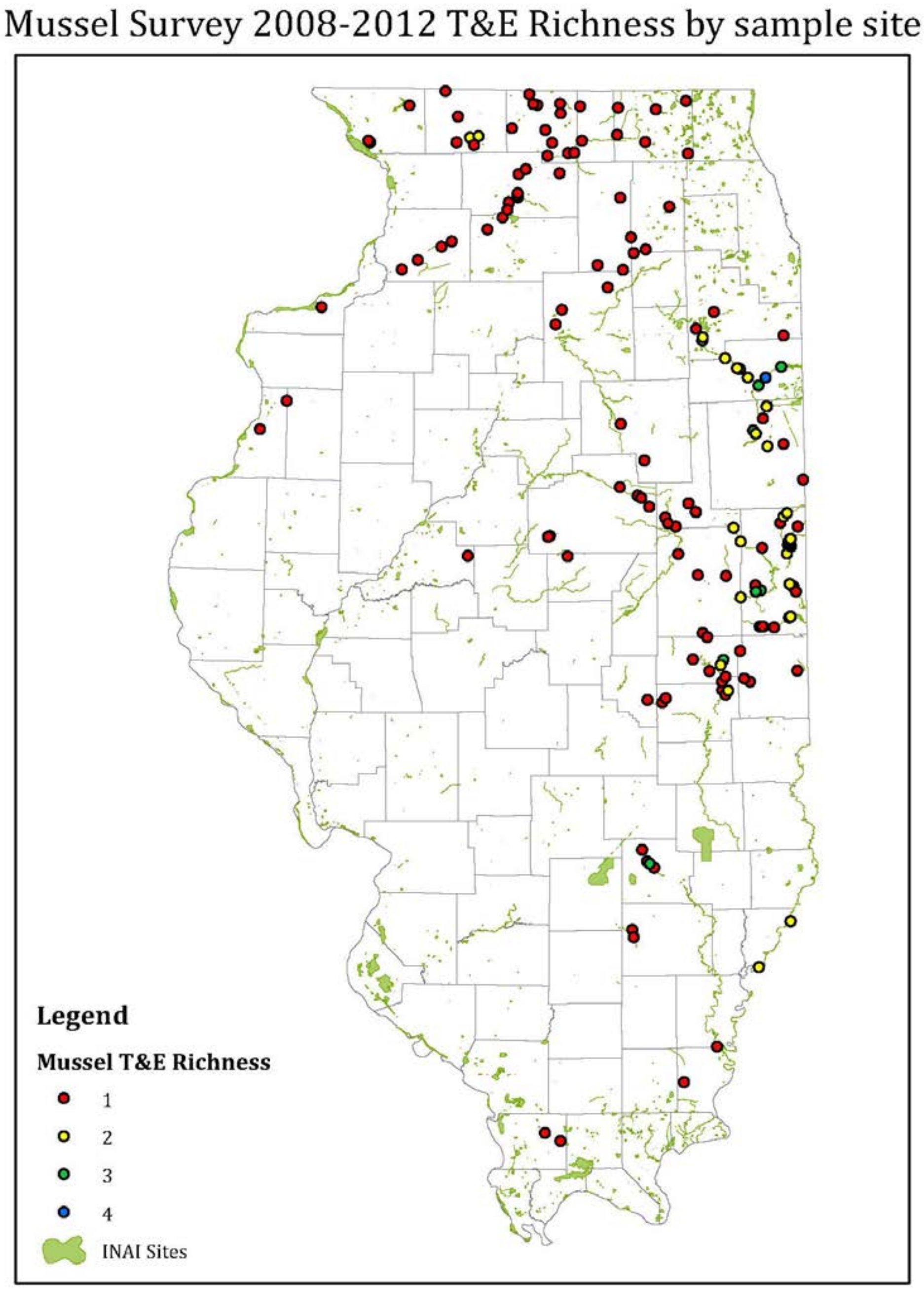


Figure 3. Locations of stations with threatened or endangered mussel species based on recent statewide mussel community sampling.

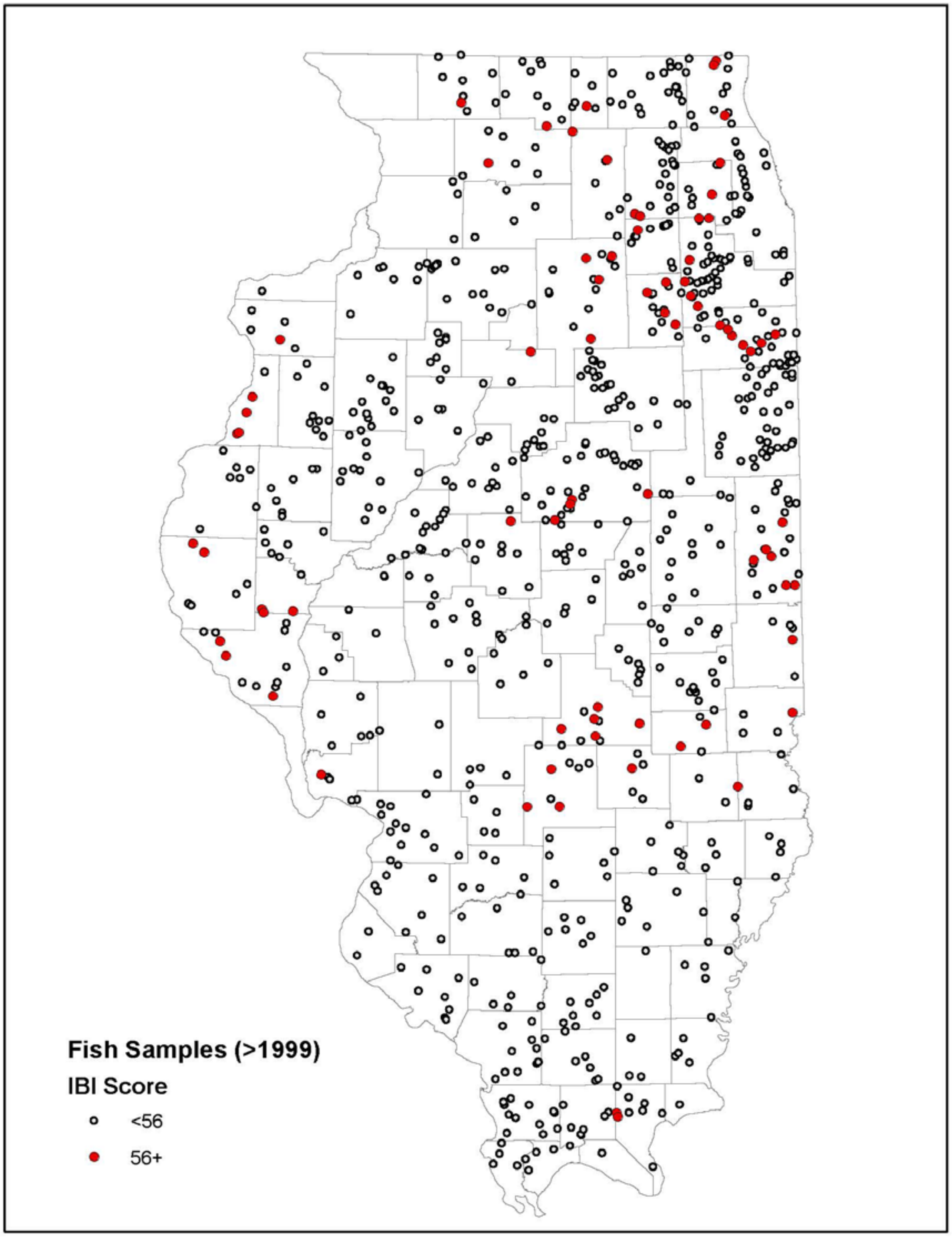


Figure 4. Locations of stations with Fish Index of Biotic Integrity scores that meet or exceed the INAI Category VI criteria for "Unusual concentration of flora or fauna" based on all IDNR fish samples collected during the period 2000-2012.

Appendix I

Examples of Differences from original Illinois Digital Stream Network

Figure A1. Original digital stream network developed for Illinois Streams in 2005 based on NHD 1:100,000 linework (red) and 2014 stream network developed with staff from T-60-D-1 (blue). The 2014 stream network also expands the coverage to include portions of the Middle Wabash River EDU that drain into Illinois.

Figure A2. Original digital stream network developed for Illinois Streams in 2005 based on NHD 1:100,000 linework (red) and 2014 stream network developed with staff from T-60-D-1 (blue) for a portion of the Wabash River EDU showing detail of additional stream lines in the 2014 stream network.

Aqueduct. We defined Aqueducts as portions of the digital stream network that flow over other stream segments in man-made structures.

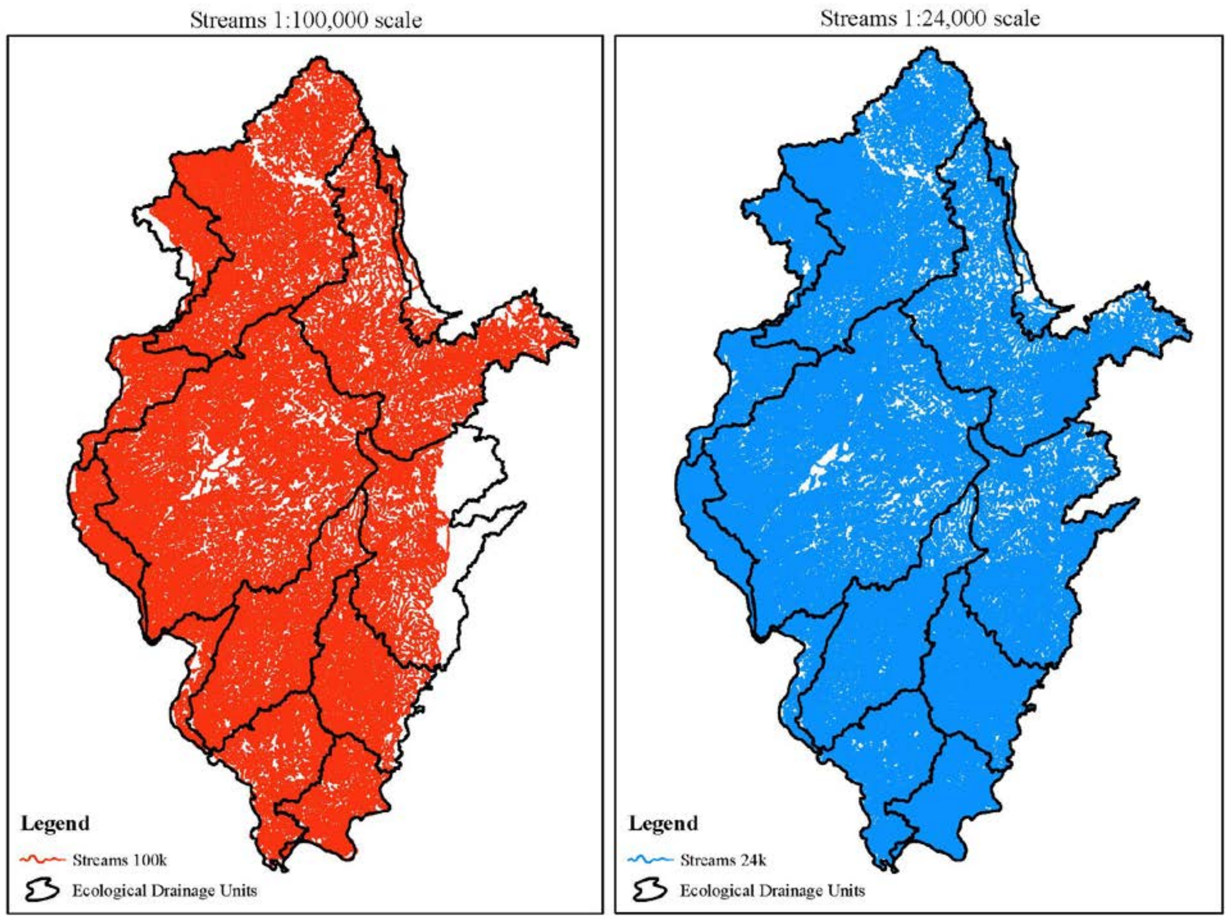
Culvert. We defined culverts as portions of the digital stream network that flow through levees.

Flow Split. We defined flow splits as portions of the digital stream network where water from a single channel flows into two separate channels.

Sinks. We defined sinks as points, or polygons, with drainages that are disconnected from any portion of the stream network that eventually flows out of the EDU.

Siphon. We defined siphons as portions of the digital stream network that cross under other stream segments through a pipe.

Strip mines. Surface mining and associated post-mining restoration activities form complicated and often novel landscapes, which may not reflect previous conditions.



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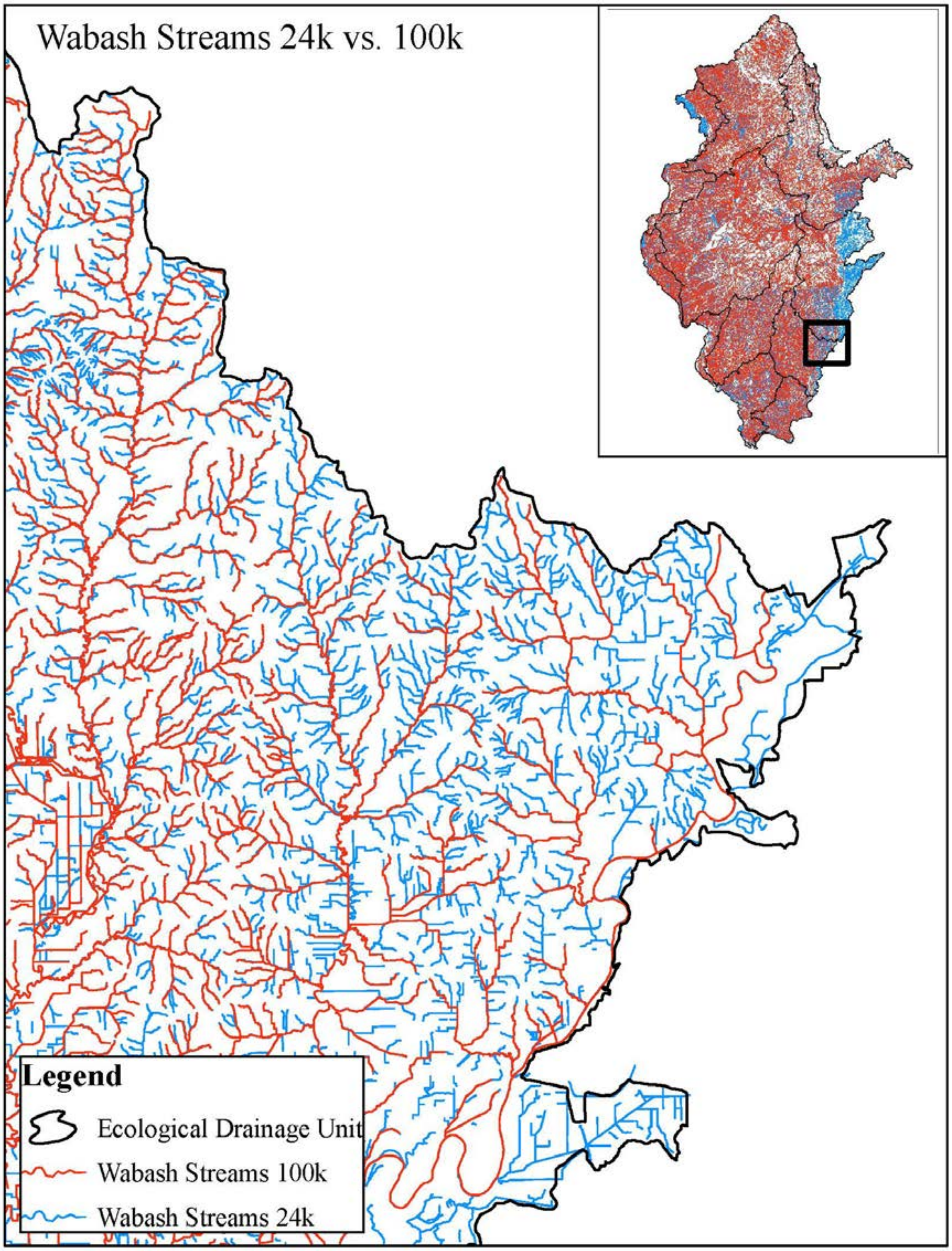
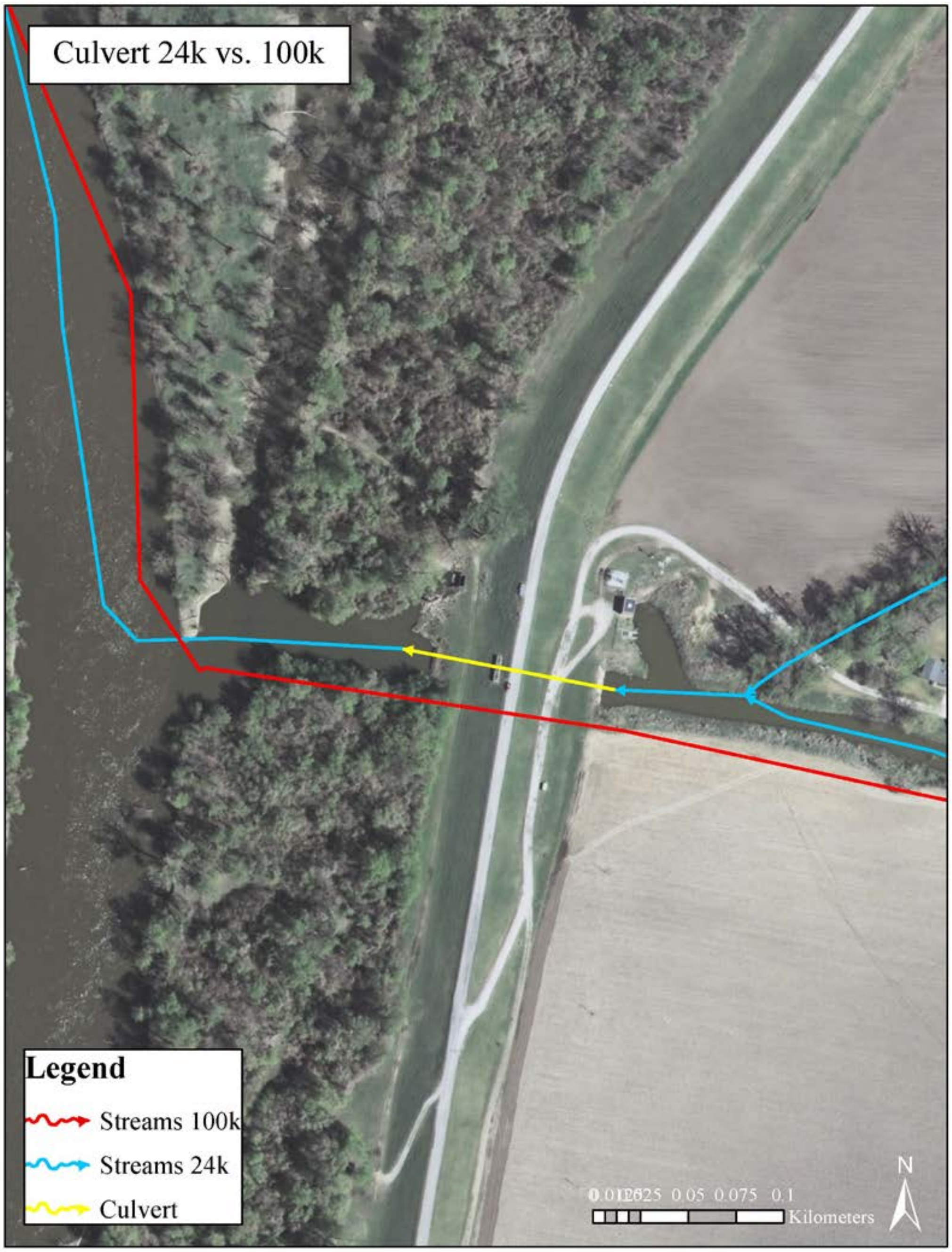
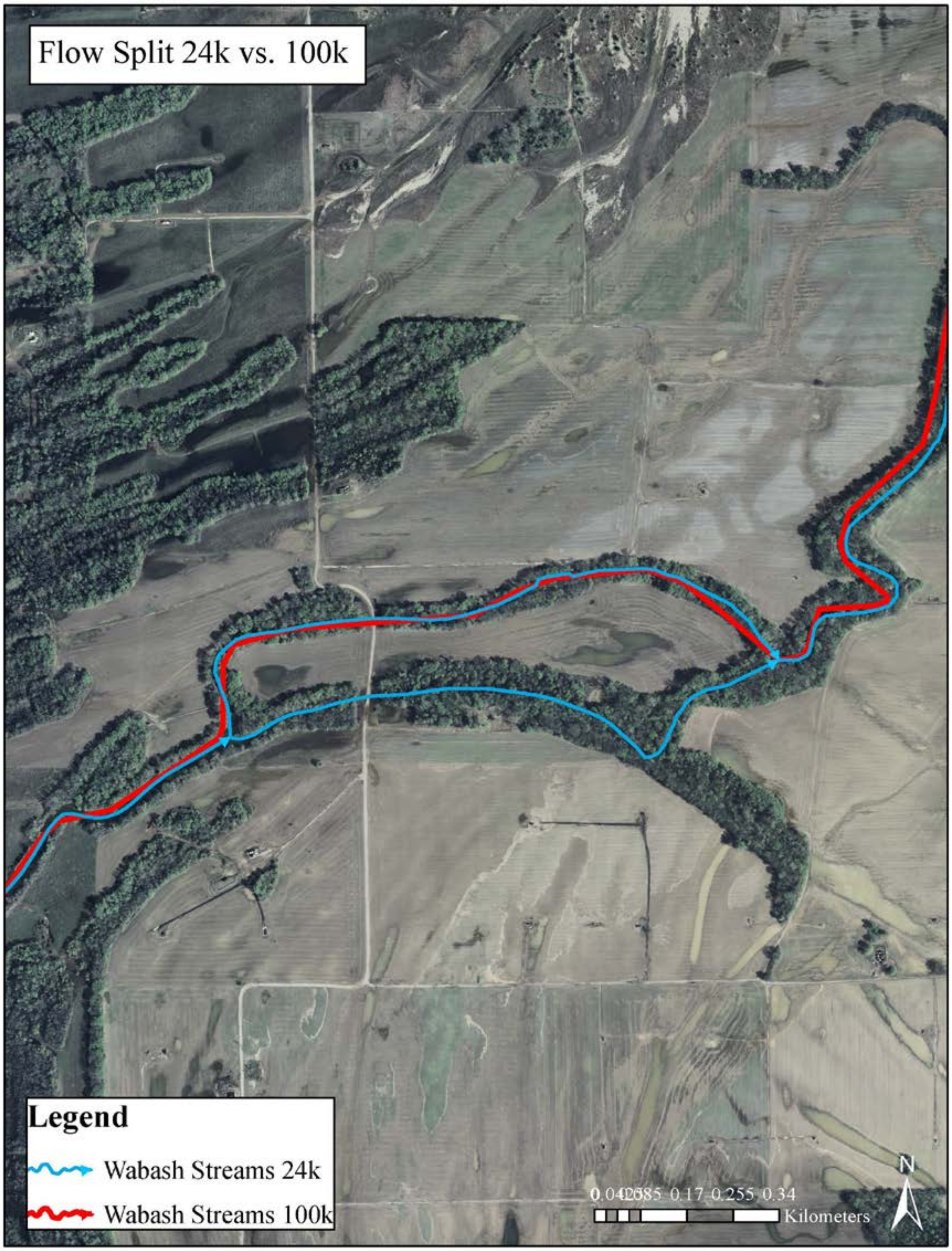


Figure A2. Original digital stream network developed for Illinois Streams in 2005 based on NHD 1:100,000 linework (red) and 2014 stream network developed with staff from T-60-D-1 (blue) for a portion of the Wabash River EDU showing detail of additional stream lines in the 2014 stream network.

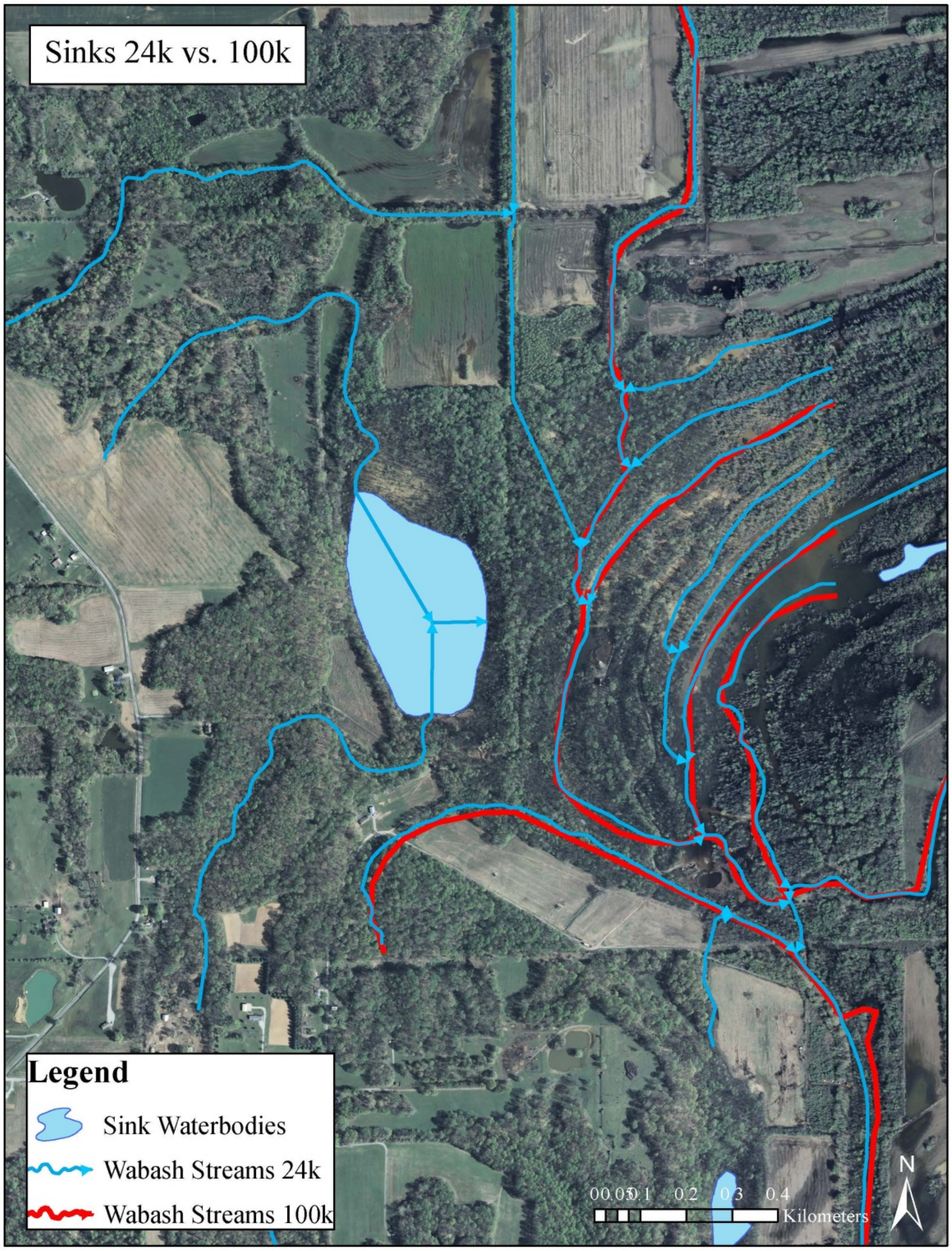
Aqueduct. We defined Aqueducts as portions of the digital stream network that flow over other stream segments in man-made structures. The 2005 stream network (red lines) merged the streams at their apparent confluence. However, there is no confluence on the landscape. Instead, the canal flows over the stream in an aqueduct (yellow line) while the other channel continues uninterrupted as reflected in the 2014 stream network (blue lines).



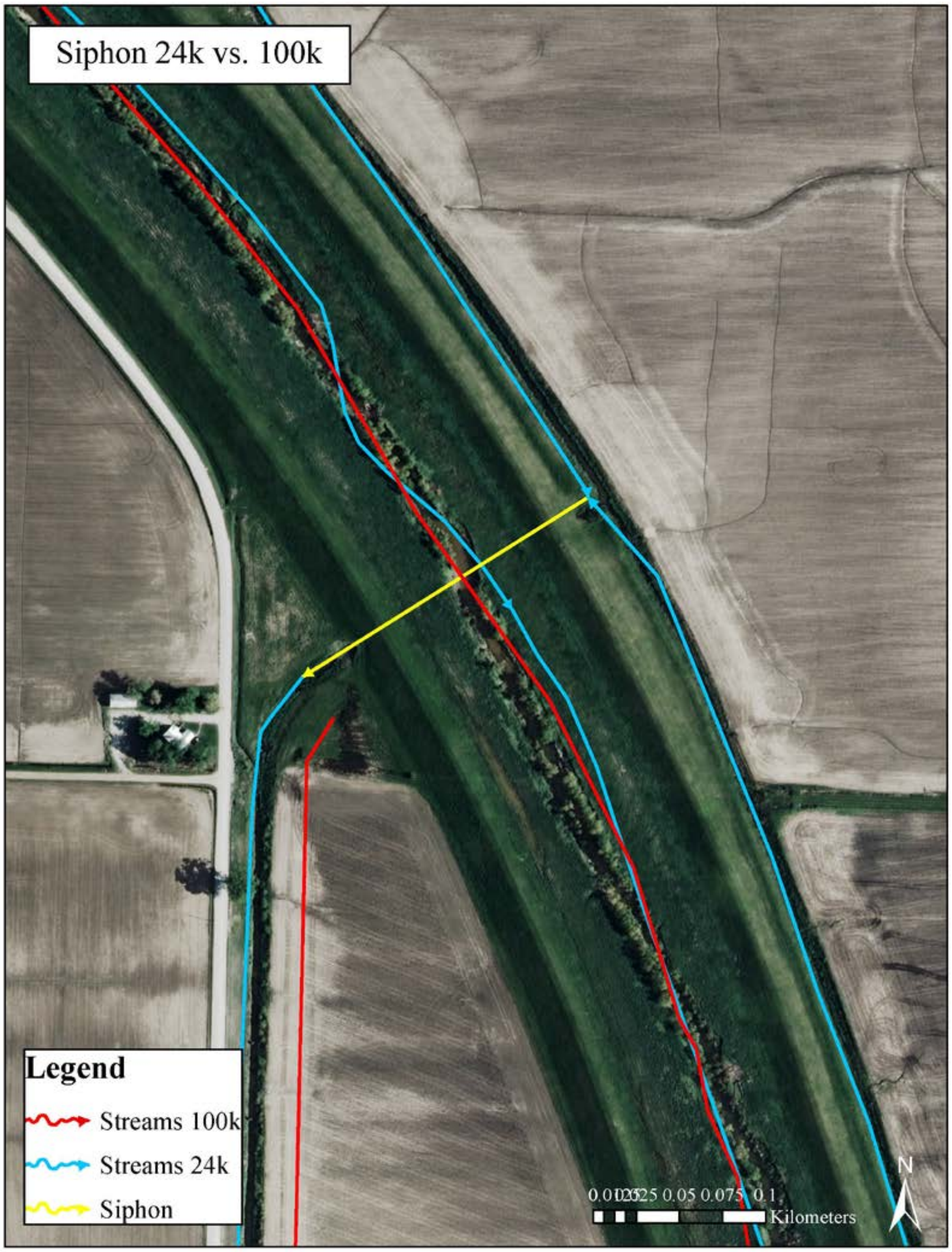
Culvert. We defined culverts as portions of the digital stream network that flow through levees. In cases where the stream network crossed over levees water would need to flow uphill based on the digital elevation map (DEM). What we observe on the ground is water flowing under the levee through a culvert. The 2005 stream network (red lines) essentially ignored these inconsistencies with the DEM or removed these connections. The 2014 stream network (blue lines) maintains these connections and allows ArcHydro to function normally in its use of the DEM.



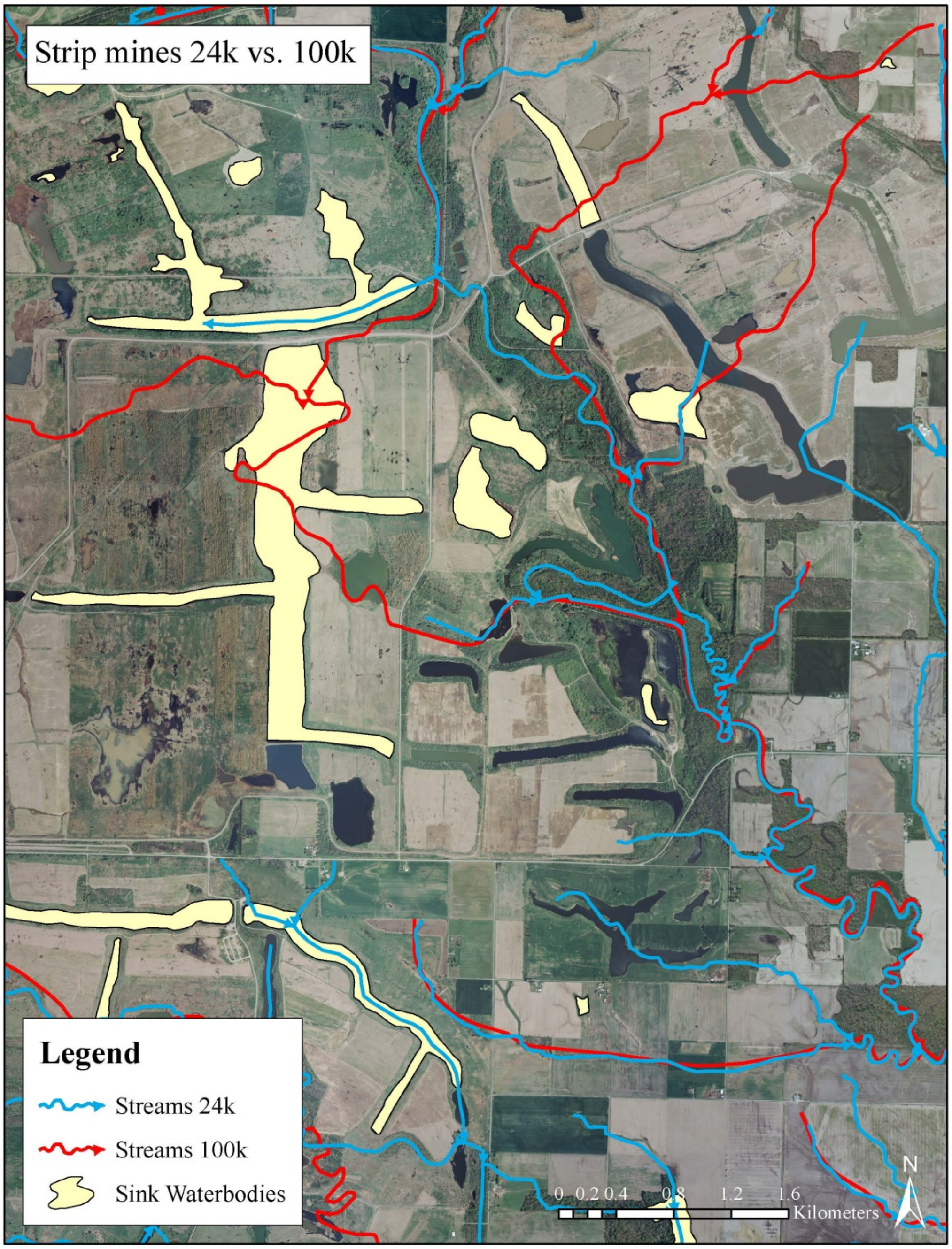
Flow Split. We defined flow splits as portions of the digital stream network where water from a single channel flows into two separate channels. The 2005 stream network (red lines) required water to flow along a single path necessitating the removal of some existing stream connections. With the switch to an ArcHydro framework we were able to include these existing connections in the 2014 digital stream network (blue lines).



Sinks. We defined sinks as points, or polygons, with drainages that are disconnected from any portion of the stream network that eventually flows out of the EDU. These are essentially isolated drainages. The 2005 stream network filled all sinks so that water would contribute directly to the stream network (red lines). The 2014 digital stream network (blue lines) has isolated drainages, such as the sink waterbody shown here, that do not contribute to adjacent drainages.



Siphon. We defined siphons as portions of the digital stream network that cross under other stream segments through a pipe. The 2005 stream network (red lines) did not contain these types of connections. Although rare, the 2014 revised stream network (blue lines) contains situations such as the one shown here where there is a connection underneath a channel running between two levees.



Strip mines. Surface mining and associated post-mining restoration activities form complicated and often novel landscapes which may not reflect previous conditions. The 2005 digital stream network (red lines) was based in large part on an interpretation of USGS topographical maps that rarely match the currently existing landscape in areas of Illinois with a history of surface mining. The 2014 revised stream network (blue lines) now better reflects existing drainage including changes in surface flow patterns and the inclusion of many waterbodies that now act as sinks.