IOWA'S WATER
Ambient Monitoring Program

REMAP
A Probabilistic Survey of Iowa's Perennial Rivers and Streams

The U.S. Environmental Protection Agency's (EPA) Regional Environmental Monitoring and Assessment Program (REMAP) provides assistance to States and other entities that share responsibility for assessing the condition of the Nation's lakes, rivers, streams, and wetlands. In 2002, with funding and technical assistance from EPA, the Iowa Department of Natural Resources (IDNR) began a five-year REMAP survey of Iowa's perennial rivers and streams. Sampling was completed in 2006, and the data will now be used to report on the ecological status of Iowa's rivers and streams. Specifically, the REMAP project is designed to determine how many of Iowa's streams support healthy aquatic communities, and how many suffer from stressors such as habitat alteration, nutrient enrichment, sedimentation, and chemical contamination.

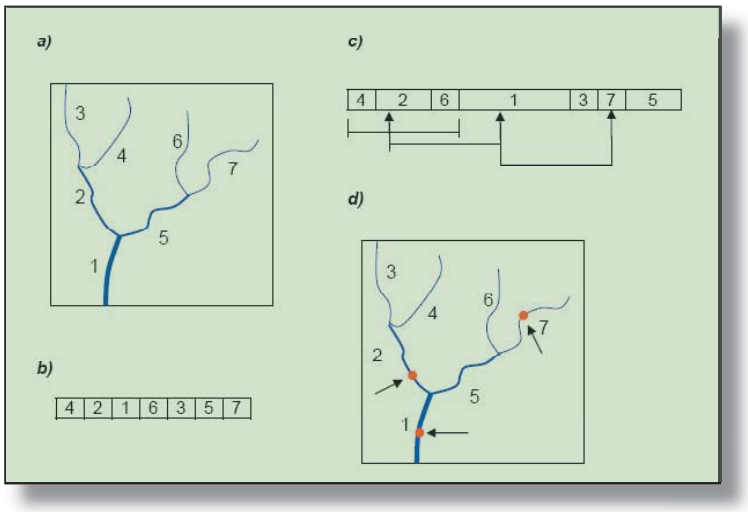

Figure 1. REMAP *random site selection process. a) Each segment is assigned a unique address code. b) Segments are randomly arranged on a line. c) Segment widths are adjusted to ensure representation within desired strata or sub-populations (e.g., large streams). A fixed interval is obtained based on the number of sites needed and adjusted total segment length. The first site is selected at a random point within the interval. The next site is added by moving right one interval. d) Site addresses are translated into* UTM (*lat./long.*) *coordinates.*

Survey Design

Randomized site selection is a key part of Iowa's probabilistic stream survey. A probabilistic survey assures that each sample site has a known probability of inclusion in the survey and represents a known proportion of the targeted population (i.e., perennial rivers and streams). This type of survey provides statistically valid estimates of resource conditions with known confidence levels. The random site selection was done by the EPA's Health and Environmental Effects Research Laboratory in Corvallis, Oregon. Figure 1 shows a simplified example of the site selection process, referred to as Generalized Random Tessellation Stratified (GRTS) (Stevens and Olsen, 2004). The main advantage of GRTS over

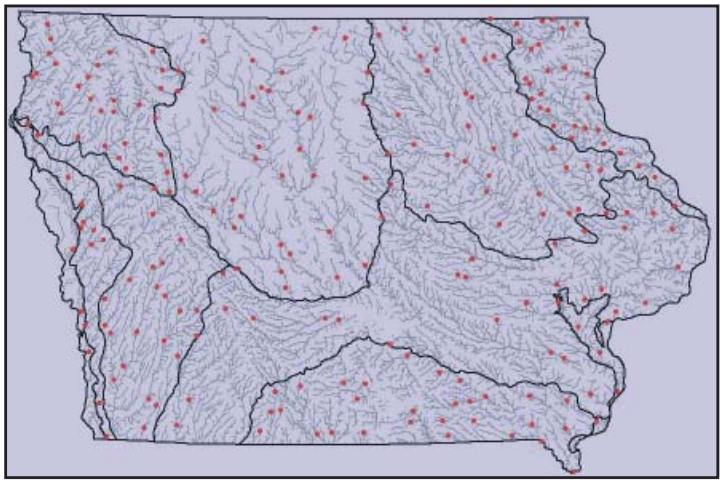

Figure 2. 2002-2006 REMAP *random stream sampling sites and ecoregion boundaries.*

simple random selection is its ability to produce a spatially balanced random sample that can be easily customized to meet individual project needs.

Stratification of Iowa's stream REMAP design was used to ensure adequate coverage within seven major ecological regions (30 sites each) and three stream size / warmwater aquatic life use categories (minimum of 30 each). It also ensured at least 15 sites in designated coldwater streams. This survey design provided a regionally balanced distribution of approximately 45 random sites per year, with the statewide goal of 225 sites reached in 2006 (Figure 2).

Sampling

Standard sampling procedures were used throughout the survey to ensure data comparability across sites and years. The main sampling elements include benthic macroinvertebrates; fish; diurnal dissolved oxygen and temperature; physical habitat; and fish tissue, sediment, and water contaminants. Since the number of samples collected at any given site was small (typically from 1-3), sampling parameters that are good integrators of changing stream conditions were emphasized. This sampling design is best suited for drawing conclusions about the statewide or regional status of streams rather than characterizing conditions in any given stream.

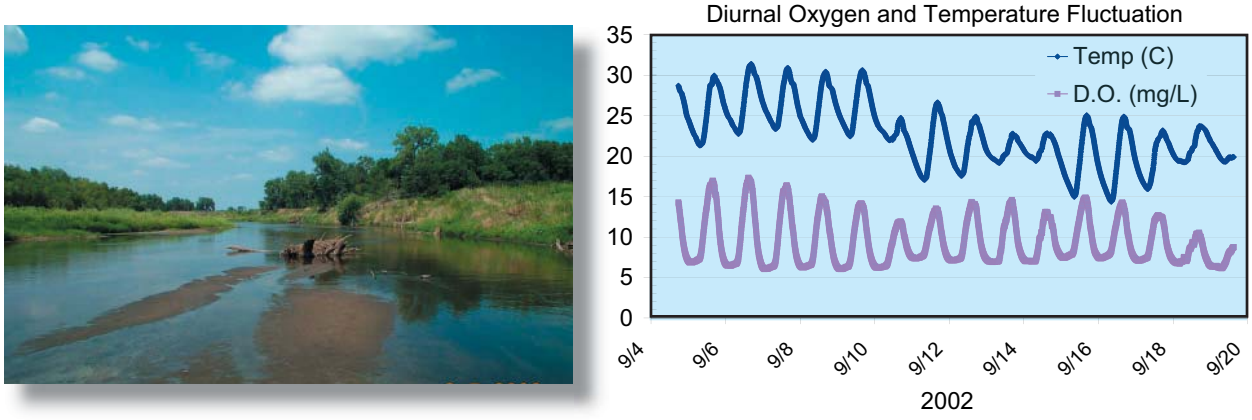

Figure 3. *Daily fluctuations in dissolved oxygen concentration and water temperature in the East Nishnabotna River (Cass Co.), September 2002. Large daily swings in dissolved oxygen like those seen above are indicative of high rates of algae growth.*

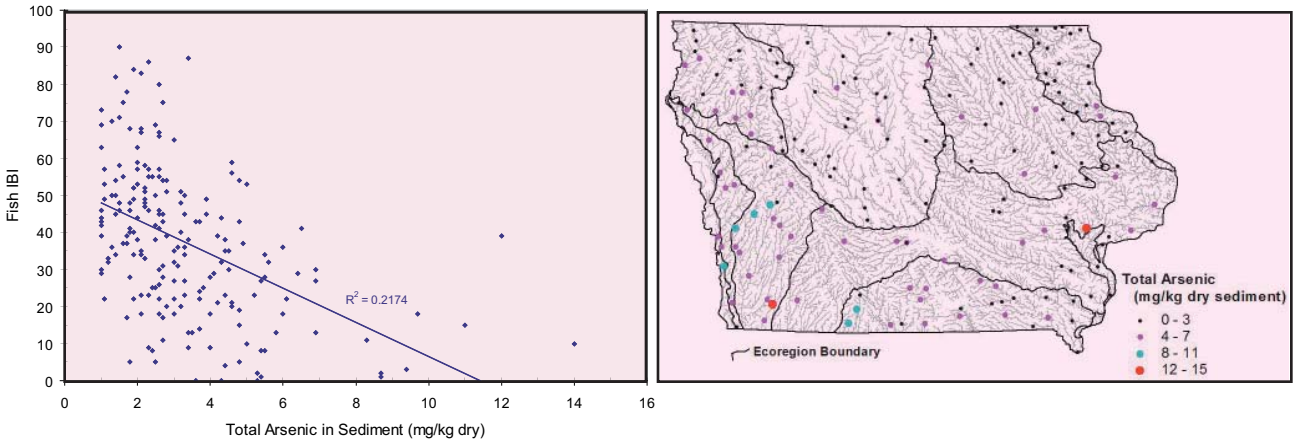

***Figure* 4.** *Left*: REMAP *Fish Index of Biotic Integrity* (IBI) *scores and total arsenic levels in stream sediments* 2002-2005. *Right*: *Geographic distribution of sediment total arsenic concentrations*.

Preliminary Highlights

Data summarization and analysis are still in the early stages; however, several preliminary highlights and observations are worth mentioning. The REMAP project includes a sub-component that consists of researching relationships among stream fish assemblages, physical habitat characteristics, and watershed characteristics. This research has important implications for future stream management and restoration efforts. The diurnal dissolved oxygen and temperature sampling component (Figure 3) has already proven useful for understanding nutrient enrichment issues in Iowa's streams. Sampling results have documented a wide range of primary production (photosynthetic) responses across varying nutrient concentrations. The data suggest that factors such as channel shape, shade, and stream flow can greatly influence the degree to which nutrients contribute to adverse habitat and water quality conditions associated with excessive algae or plant growth. Prior to the REMAP project, statewide sampling of sediment contaminants in Iowa streams had not been done. Preliminary results indicate an inverse relationship between biotic index scores (benthic macroinvertebrates and fish) and levels of sediment-bound metals such as arsenic (Figure 4), copper, chromium, and lead. Approximately 4% of samples from 2002-2005 exceed the arsenic Toxicity Reference Value (TRV) (Jones et al., 1997) of 8.2 mg/kg for screening potential effects to sediment associated biota. A total of 88% of Fish IBI scores for sites with sediment arsenic levels above the TRV are considered poor. More investigation of this correlative relationship is needed. Arsenic is a naturally occurring element widely distributed in soil and rock materials. Industrial sources include wood preservatives, agricultural pesticides, and coal-fired power plants. Elevated stream sediment levels mostly occur in western and southern Iowa (Figure 4).

A major benefit of the probabilistic survey design is the ability to extrapolate sampling results to make accurate statements about the condition of all perennial rivers and streams. In Figure 5, a Cumulative Distribution Function (CDF) is used to graph the proportion of stream miles meeting or exceeding varying levels of the Benthic Macroinvertebrate Index of Biotic Integrity. The probabilistic design also allows 95% confidence bounds above and below the CDF to be added. The confidence bounds are useful for evaluating the comparability of another data set. For example, the black line in Figure 5 depicts the CDF for non-REMAP targeted bioassessment sites. The data represent a mixture of refer-

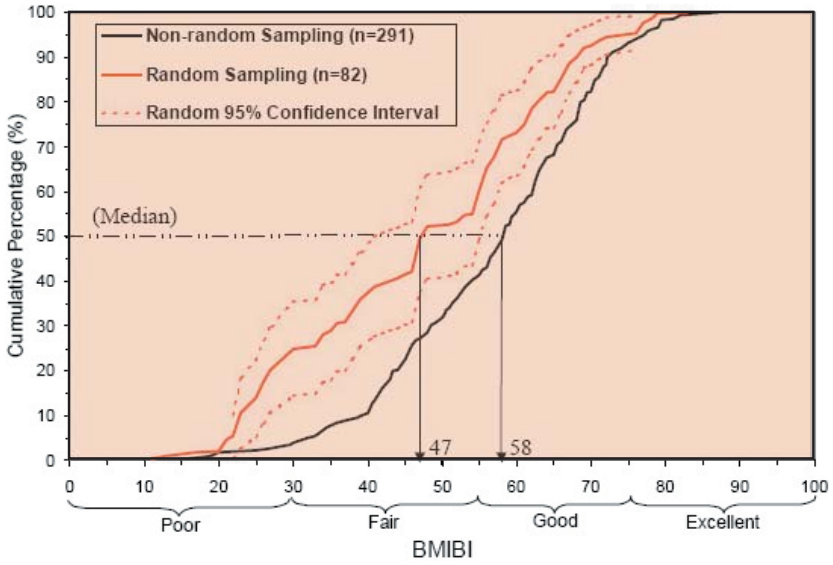

Figure 5. *Cumulative Distribution Function* (CDF) *of Benthic Macroinvertebrate Index of Biotic Integrity* (BMIBI) *for* 2002-2003 *random* (REMAP) *sites* (*orange*) *and* 1994-2002 *targeted* (*non-random*) *stream bioassessment sites* (*black*).

ence sites and other targeted sampling sites. There is little overlap of the targeted sample data set with the REMAP 95% confidence bounds. The targeted data set has approximately 66% reference sites, which apparently skews the distribution toward higher BMIBI scores. Due to the statistically defensible sampling design, the REMAP CDF probably represents a more accurate portrayal of biological conditions in Iowa's perennial streams.

Summary

Following the completion of the five-year sampling project in 2006, the main tasks in 2007 are preparing for and conducting the REMAP data analysis. The focus of data analysis will be to answer the primary questions asked at the beginning of the project. Another important task will be to determine in what capacity to continue the REMAP survey. The REMAP survey design can potentially serve as a useful trend monitoring tool for determining whether Iowa's streams are improving, holding steady, or getting worse.

References

Jones, D.S., G.W. Suter, and R.N. Hull. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota*: 1997 Revision. Oak Ridge National Lab. ES/ER/TM-95/R4, Oak Ridge National Lab., Oak Ridge, TN.

Stevens, D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistics Association*. March 2004, Vol. 99, No. 465, Theory and Methods: 262-278.

Acknowledgements

DNR recognizes the University Hygienic Laboratory for sample collection, fish and invertebrate identification, and chemical sample analysis; the USGS Fish and Wildlife Cooperative Research Unit, Iowa State University for collection of stream habitat data and researching fish assemblage and habitat relationships; the U.S. Environmental Protection Agency for providing administrative support, funding, and technical assistance; and last but not least, the many private landowners who provided stream access, without which this project would not have been possible.

Funding

Water monitoring activities of the Iowa Department of Natural Resources are funded by Iowa Infrastructure - Environment First Fund appropriations, as well as grants provided by the U.S. Environmental Protection Agency from Sections 106 and 319 of the Clean Water Act and the Regional Environmental Monitoring and Assessment Program.

Iowa Watershed Monitoring and Assessment Program Web Site – wqm.igsb.uiowa.edu

Prepared by
Iowa Department of Natural Resources, Geological Survey
109 Trowbridge Hall, Iowa City, IA 52242-1319

Printed on Recycled Paper