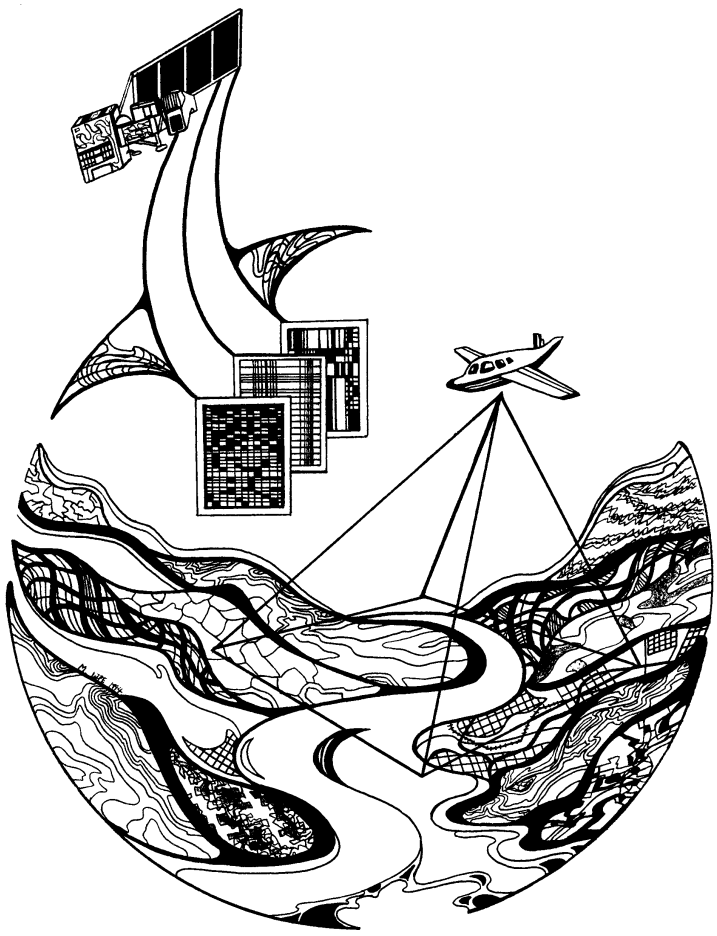
Long Term Resource Monitoring Program

Program Report
98-P003

Spatial Query Tool for Long Term Resource Monitoring Program Component Data: A User's Guide



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Spatial Query Tool for Long Term Resource Monitoring Program Component Data: A User's Guide

by

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March 1998

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Contents

Page

Preface v

Abstract 1

Introduction 1

About the Query Tool 1

Application Structure 2

Stratified Random Sampling 2

Water Quality Monitoring 4

Macroinvertebrate Monitoring 5

Fisheries Monitoring 5

Using the Query Tool 6

References 6

Appendix. Fields Included in Database Tables by Component A-1

Figures

Figure 1. Geographic information system layers and database table for Pool 8 fisheries theme 3

Figure 2. Results of logical selection for section of Pool 8 fisheries theme 4

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared under Goal 2, Task 2.3.1.2, Work Unit A—*Integration of Component Data with GIS (Multicomponent Synthesis)* of the Operating Plan (USFWS 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

Spatial Query Tool for Long Term Resource Monitoring Program Component Data: A User's Guide

by

Douglas A. Olsen

Abstract

Using the personal computer-based geographic information systems software ArcView, a graphical application has been developed to spatially query the Long Term Resource Monitoring Program (LTRMP) component database and to display the selected data in conjunction with other spatial data for viewing, plotting, and analysis. One of the important features of the LTRMP Decision Support System - Component Database Module is the ability to define an area spatially, then extract the LTRMP trend data for that area. Selected information can be summarized within ArcView, or exported in a format compatible with statistical analysis programs.

Introduction

Long Term Resource Monitoring Program (LTRMP) staff collect fisheries, water quality, vegetation, invertebrate, and other biological and physical long-term resource trend data on the Upper Mississippi River System (UMRS). These data are stored in a database management system. Spatial data such as land cover/use, bathymetry, water control infrastructure, transportation, political boundaries, and other information are also collected and maintained. Scientists and river managers regularly need to view and analyze trend data in conjunction with other spatial data. The LTRMP Component Database Spatial Query Tool for ArcView (Query Tool), a geographic information system (GIS) application, was developed in response to this need. As an analysis aid, the Query Tool facilitates the integration of the trend data with other spatial data and enables the user to query spatial and subset trend data.

Vegetation, land use, hydrology, and geomorphic characteristics vary significantly over the UMRS study area. When integrated with monitoring data, spatial databases will assist scientists in determining ecological status and trends and help explain causal relations. The sheer magnitude of this effort, however, requires automated tools to support such analyses.

About the Query Tool

The Query Tool is a graphical application, intended to be easy-to-use, developed using ArcView, a personal computer (PC)-based GIS. The Query Tool is used to spatially query the LTRMP component database and display the selected data in conjunction with other spatial data for viewing, plotting, and analysis. An important feature of the Query Tool is the ability to define an area spatially, then extract the LTRMP trend data for that area. Selected information can be summarized within ArcView, or exported in a format compatible with statistical analysis programs such as Statistical Analysis System (Statistical Analysis Systems Institute Inc., Cary, North Carolina).

The Query Tool allows the user to select a study pool, a base map, and resource component, enlarge the area of interest, then create a spatial subset by graphically selecting sampling sites. Base maps of land/water, terrestrial land cover, major roads, and control structures can be displayed. The user can submit a database

query to the selected subset of sampling sites and display the sites meeting query criteria over the selected base data or write the tabular data to an ASCII file for use with other programs.

The Query Tool takes advantage of the intuitive graphical user interface, functionality, and ease-of-use of the ArcView GIS, and requires only basic knowledge of GIS concepts. Proper use of this tool does, however, require familiarity with ArcView 3, basic relational database theory, and an understanding of the LTRMP component database structure and sampling methodologies. These topics are not covered in this user's guide. ArcView 3 is shipped with an extensive on-line help system as well as the book *Using ArcView*, which catalogs the many capabilities of ArcView 3. For a detailed description of the LTRMP component database structure and sampling methodologies, see LTRMP Program Report 95-P002 (National Biological Service 1995).

Application Structure

The Query Tool comprises six ArcView projects, one for each LTRMP study pool. Each project contains three views: fisheries, water quality, and invertebrates. Each view contains point themes for stratified random sampling for 1993–96. Background polygon themes for land or water and terrestrial vegetation and linear themes for major roads and water control structures are included (Figure 1). All component sampling themes have a predefined database table containing site and sampled data. The Appendix has a description of the fields included in the database tables for each component. The Query Tool uses data downloaded from the relational database management system (RDBMS) used by the Environmental Management Technical Center (EMTC) to store component data. The EMTC trend database is a dynamic system with continual updates and corrections. The Query Tool is a snapshot of the trend database at one point in time. The intent of the Query Tool is to provide the user with a subset of the LTRMP trend database in an easy-to-use format (Figure 2). The Query Tool is not a copy of the EMTC RDBMS. The Query Tool is updated annually and the revision date is accessible through the Help menu by selecting the **About the Query Tool** option.

Stratified Random Sampling

Stratified random sampling is a method for allocating sampling resources more efficiently by sampling different strata with different sampling intensity. This prevents the over or under sampling from generating random samples evenly over the entire study area. The LTRMP strata are based on aquatic area types. Each component has slightly different strata as listed below:

Fisheries:

- Backwater, offshore
- Backwater, shoreline
- Main channel border, unstructured
- Main channel border, wing dam
- Impounded, offshore
- Side channel border
- Tailwater zone (fixed sites only)
- Main channel trough (optional only)

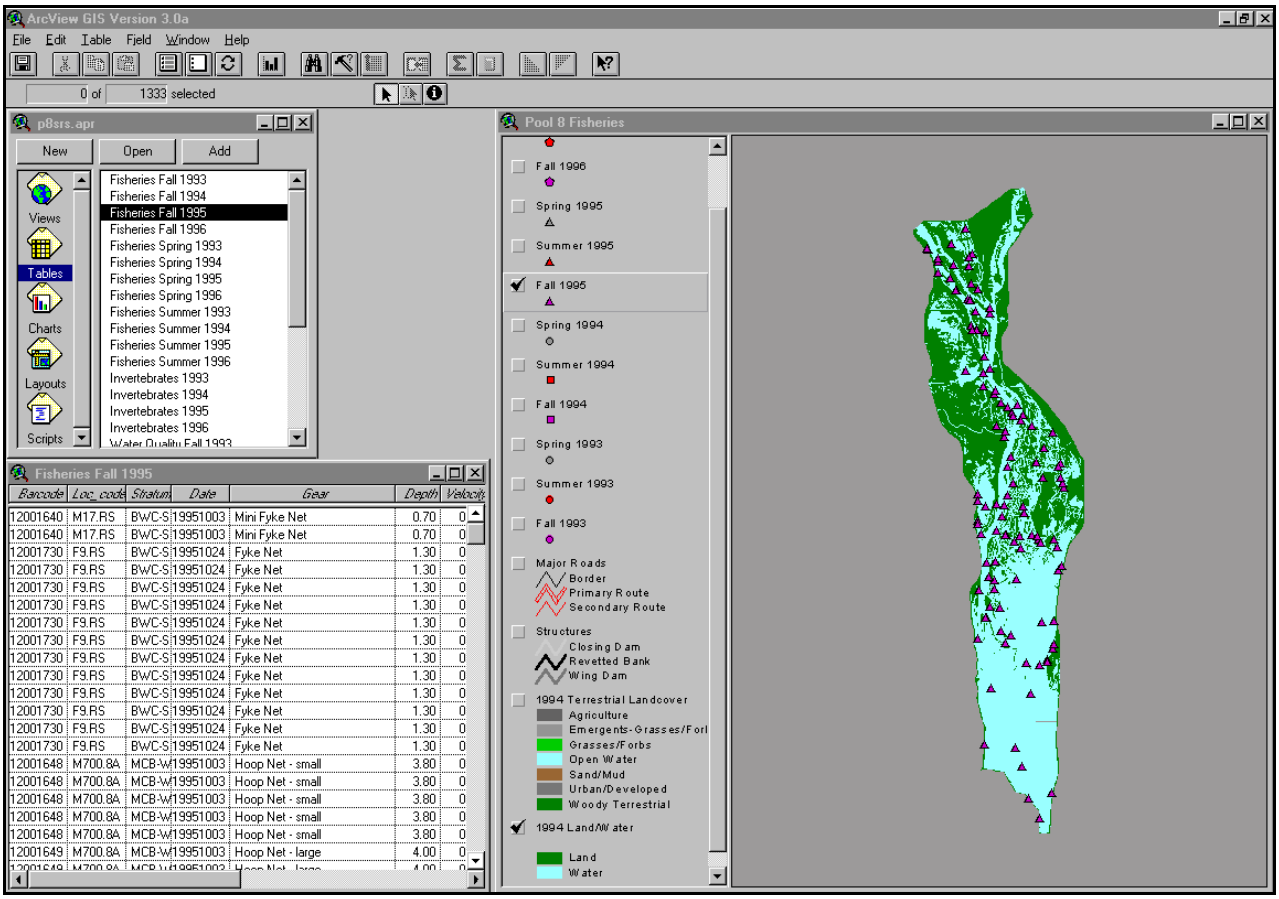

Figure 1. Geographic information system layers and database table for Pool 8 fisheries theme.

Water Quality
- Main channel
- Side channel
- Backwater contiguous
- Lake Pepin/Swan Lake
- Impounded
- Isolated

Invertebrates
- Main channel border
- Impounded
- Side channel
- Backwater contiguous
- Lake Pepin

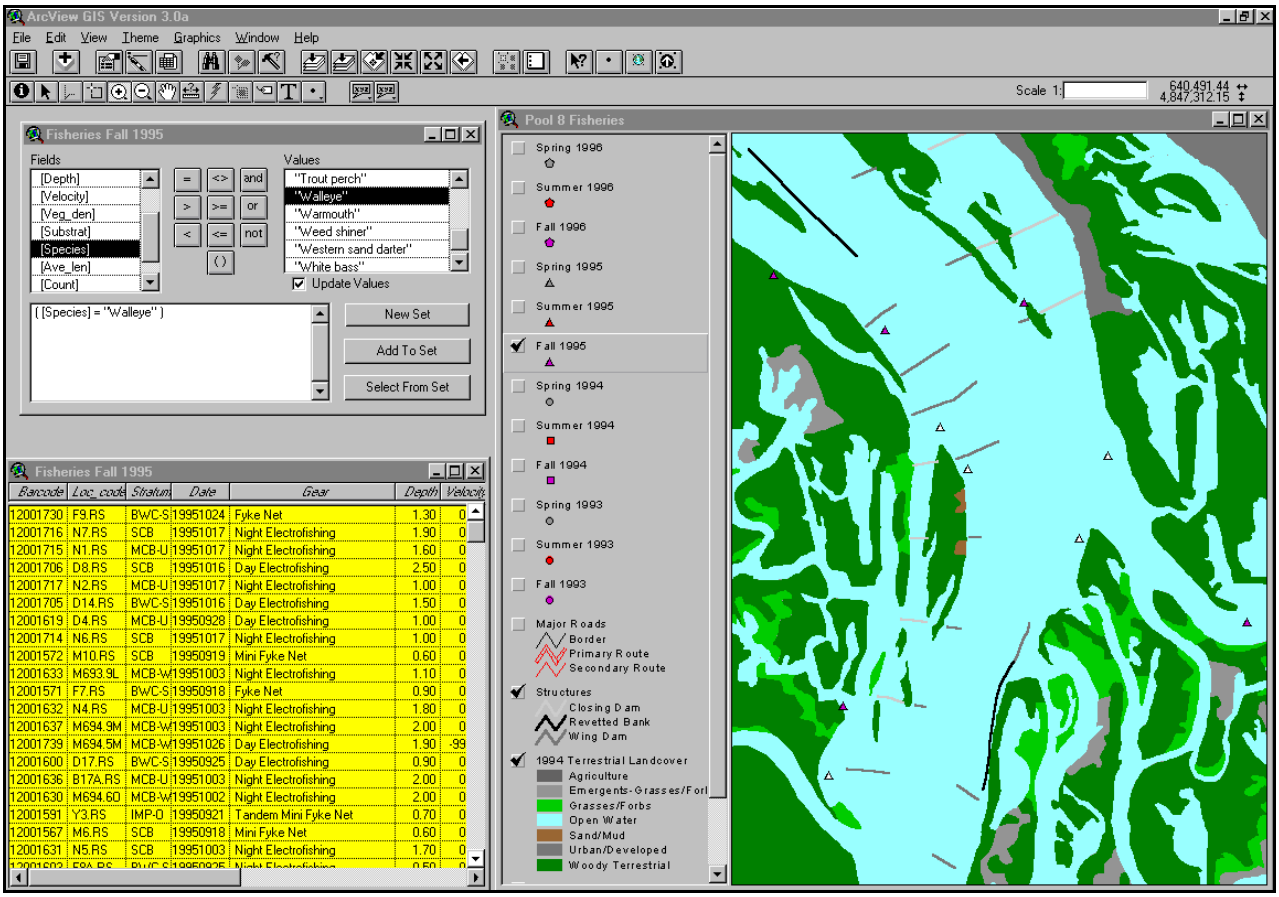

Figure 2. Results of logical selection for section of Pool 8 fisheries theme.

Staff at the EMTC have developed an automated system for generating random sampling field maps. The random samples are generated based on the desired sampling allocation and produces map and coordinate files printable with the PC-based GIS software EPPL7. Map and coordinate files are sent by electronic mail to the field stations and printed using their local copies of EPPL7. The maps are used by the field crews to navigate to the randomly generated sites. Positional accuracy in navigating is affected by a number of parameters, including real-time differential correction for Global Positioning System readings and proximity to shorelines or other landmarks that can aid in navigation.

Water Quality Monitoring

The following passage was taken from an unpublished LTRMP report on water quality monitoring.

> LTRMP water quality monitoring emphasizes basic limnological characteristics that pertain to the suitability of habitat for aquatic organisms and the movement of sediment and materials within the system (cf. Hynes 1970). Because of logistic limitations, the LTRMP monitors only a small subset of important limnological variables, and parameters of importance primarily for human consumptive uses are not measured. Standard methods are used in all data collection

efforts and, because the program strives to document long-term trends, long-term consistency is maintained to the extent possible (David Soballe, Environmental Management Technical Center, Onalaska, Wisconsin, unpublished report).

The water quality component has four sampling episodes per year: winter, spring, summer, and fall. The Query Tool contains only surface sample data from the LTRMP trend database.

The Appendix contains a listing and description of fields included in the water quality database tables.

Macroinvertebrate Monitoring

The following passage was taken from LTRMP Program Report 95-P002-2, Long Term Resource Monitoring Program Procedures: Macroinvertebrate Monitoring.

> Macroinvertebrates are an important component of the UMRS. They are a significant food source for fish, waterfowl, and furbearing animals. Macroinvertebrates also perform an important ecological function by digesting organic material and recycling nutrients.
>
> Relative to fish and other aquatic organisms, most benthic macroinvertebrates have very limited mobility, are less able to avoid unfavorable environmental conditions, and are sensitive to many environmental stressors. Consequently, they respond quickly to environmental changes. The presence, absence, or dominance of tolerant or sensitive species can provide a useful tool for inferring where environmental problems exist.
>
> Trend analysis of macroinvertebrates is needed to assess spatial and temporal changes in the abundance of benthic populations and to suggest potential mechanisms causing variance. Measuring macroinvertebrate populations and communities assists researchers evaluating the condition of the UMRS. Quantitative sampling techniques are employed to obtain information on population density and diversity (Thiel and Sauer 1995).

Invertebrate sampling has a single sampling episode per year. The Appendix contains a listing and description of fields included in the macroinvertebrate database tables.

Fisheries Monitoring

The following passage was taken from an LTRMP program report on fish monitoring (Gutreuter et al. 1995).

> Trend analysis under the LTRMP emphasizes two attributes of the UMRS fishery resource: community and population structure.
>
> Fish community structure refers to the relative abundance of fishes of each species within a multi-species assemblage of fishes (Carline 1986). Relative abundance is traditionally measured by catch in numbers per unit of sampling effort, but measures based on weight are also commonly used. A "fish community" theoretically includes all of the fish that use a defined area over a given period of time. The best overall method for measuring fish community structure is the one that is most effective (samples the largest number of specimens) and least selective (captures species in proportion to their occurrence in the sampled area). Given commonly

available levels of time and personnel, no single method routinely satisfies both criteria (Starrett and Barnikol 1955; Funk 1957; Hayes 1983; Hubert 1983) For this reason, the trend analysis procedure for fish community structure in a given aquatic area includes use of several sampling gears. Comparisons of collections between habitat categories are made with caution and with the full understanding that results are probably affected by habitat-related differences in gear efficiency.

Population structure refers to the distribution of individuals of a single species among size or age groups. Fishery biologists often recommend that analyses of population structure be based on large numbers (>200) of specimens. Data on population structure are obtained from routine LTRMP sampling efforts.

The fisheries component has three sampling episodes per year: spring, summer, and fall.

The fisheries component has a slightly different database structure than the water quality or invertebrate components. Because each sample can contain many individual fish of many species, the database structure has a one-to-many feature of record relations. This relation requires that the attribute table be linked to a second table containing the site and sampled data. This means that for a given sample point there will be many records in the linked database table. The table structure is organized so that there will be a record for each species in an individual sample. The fields for average length (ave_len), number of each species (count), and catch per unit of effort (catch_eff; Fisheries, Appendix) will contain values per species per sample. When using the Query Tool, this one-to-many relation will require that you query the linked table and not the theme. The link is bidirectional, meaning that selecting points from the theme graphically will select the records in the related table, and querying the table logically will select the points from the theme. Because of this linked table structure, the **Identify** tool will not be particularly useful. It will only return the record from the attribute table, not from the related table where the site and sampled data reside. Open the desired database table and use the **Select Feature** tool instead of the **Identify** tool to list records for graphically selected sampling sites.

The Appendix contains a listing and description of fields included in the fisheries database tables.

Using the Query Tool

The functionality of this tool is directly related to the users familiarity with ArcView 3. The included data sets provide the foundation for the spatial querying of the LTRMP component database and for the integration of component data with other layers of spatial data. The powerful functionality of ArcView makes it possible to perform a wide variety of mapping and analytical tasks. Users can easily modify the included projects by adding themes that are pertinent to their application of the Query Tool. This is the first in a series of tools that will facilitate the full integration of LTRMP monitoring databases with the wealth of spatial data now available for the Upper Mississippi River floodplain.

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Appendix. Fields Included in Database Tables by Component

Fisheries

Grid_code

Modified and concatenated Universal Transverse Mercator (UTM) coordinate pair used to generalize site locations within a 50-m^2 area. Set to not visible by default.

Barcode

Unique number for each sample taken.

Loc_code

Alphanumeric code having the format *nnnnn.nnnnn*. For randomly selected sites, the format is *nnnn.RS*, where *nnnn* is the site number from the sampling map or site list. From permanently fixed sites, the format is *rmmm.ma*, where *r* designates the river (M = Mississippi and I = Illinois), *mmm.m* is the river mile (recorded to the nearest 0.1 mi), and *a* is an alphabetic code for the relative lateral position across the floodplain. (Note: The fisheries component fixed sampling sites that fall within the random sampling periods are included. Use the format of the location code field to determine which sites are fixed.)

Stratum

LTRMP habitat class description where:

BWC-O = Backwater, offshore
BWC-S = Backwater, shoreline
MCB-U = Main channel border, unstructured
MCB-W = Main channel border, wing dam
IMP-O = Impounded, offshore
SCB = Side channel border
TWZ = Tailwater zone (fixed sites only)
CTR = Main channel trough (optional only)

Date

Date on which gear collection was initiated (e.g., the date on which a net was set).

Gear_i, Gear

Integer and character fields for gear type where:

GEAR_I	GEAR
1	Day Electrofishing
2	Fyke Net
3	Gill Net

4 Gill Net - parallel
5 Gill Net - perpendicular
6 Hoop Net - large
7 Hoop Net - small
8 Mini Fyke Net
9 Night Electrofishing
10 Seining
11 Trawling
12 Trammel Net - anchored
13 Trammel Net - float/drift
14 Plankton Trawling
15 Tandem Fyke Net
16 Tandem Mini Fyke Net

Gear_i set to not visible by default.

Depth

Water depth at the sampling site at the time the sample was taken. Measured to the nearest 0.1 m.

Velocity

Water velocity at the sampling site at the time the sample was taken. Measured to the nearest 0.1 m/s.

Veg_den_i, Veg_den

Qualitative estimate of density of both emergent and submersed aquatic vegetation within a 100-m radius, based on visual observation. Values are as follows:

Veg_den_i

Veg_den

0 None
1 Sparse (<10 stems/m^2)
2 Dense (>10 stems/m^2)

Veg_den_i set to not visible by default.

Substrat_i, Substrat

Qualitative observation of sediments based on visual and tactile observation. Values are as follows:

Substrat_i Substrat

1 Silt
2 Silt/Clay/Little sand
3 Sand/Mostly sand
4 Gravel/Rock/Hard clay

Substrat_i set to not visible by default.

Structures

Eight byte field where the value (0,1) of each byte indicates absence or presence of the following:

Species_i, Species

American Fisheries Society-accepted common names.

Ave_len

Average length of each species for a given catch.

Count

Total number of each species for a given catch.

Catch_eff

Catch per unit effort for each species of a given catch expressed in hours. Not calculated for seining or trawling gear types.

Water Quality

Grid_code

Modified and concatenated UTM coordinate pair used to generalize site locations within a 50-m^2 area. Set to not visible by default.

Barcode

Unique number for each sample taken.

Loc_code

Alphanumeric code having the format *yyfennn* where *yy* is the calendar year (e.g., 97), *f* is the field station identifier, *e* is the seasonal episode (1=spring, 2=summer, 3=summer, 4=winter), and *nnn* is the sequence number as originally assigned on the sampling maps.

Date

Sampling date.

Time

Sampling time using military (24 hour) time.

Stratum_i, Stratum_c

LTRMP habitat class description where:

Stratum_i Stratum

1 Main Channel
2 Side Channel
3 Backwater Contiguous
4 Lake Pepin/Swan Lake
5 Impounded
6 Isolated

Stratum_i set to not visible by default.

Samp_depth

Depth at which sample was taken. Measured to the nearest 0.1 m.

Dis_oxygen

Dissolved oxygen measured to the nearest 0.1 mg/L.

Temp

Water temperature measured to the nearest 0.1 EC.

pH

pH measured to the nearest 0.1 unit.

Cond

Conductivity measured to the nearest microseimen per centimeter (FS/cm).

Turbidity

Turbidity measured to the nearest nephelometric turbidity unit (NTU).

Secchi

Secchi disk transparency measured to the nearest centimeter. Measurements where the disk is visible on the bottom are preceded by a negative sign.

Velocity

Water velocity measured to the nearest 0.01 m/s.

Invertebrates

Grid_code

Modified and concatenated UTM coordinate pair used to generalize site locations within a 50-m^2 area. Set to not visible by default.

Barcode

Unique number for each sample taken.

Date

Date sample was taken.

Samp_grid

Secondary unique site identifier. Set to not visible by default.

Subsamp

Code indicating if a subsample was used during fingernail clam enumeration. Subsamples are used when the number of fingernail clams in the Ponar wash tray is estimated to be > 1,000.

Subsample codes are as follows:

N = No
A = 268 cm^2
B = 162 cm^2

Stratum

LTRMP habitat class description wherein

MCB = Main Channel Border
TDL = Tributary Delta Lake (Lake Pepin)
IMP = Impounded
SC = Side Channel
BWC = Backwater Contiguous

Depth

Water depth to the nearest 0.1 m.

Pct_veg

Subjective visual measurement of submersed and floating-leaf vegetation based on the column of water and sediment the Ponar fall through.

Pct_open

Percentage of open water within a 15-m radius from the boat.

Pct_sub

Percentage of submergent vegetation within a 15-m radius of the boat.

Pct_float

Percentage of floating-leaf vegetation within a 15-m radius of the boat.

Pct_emert

Percentage of emergent vegetation within a 15-m radius of the boat.

Pct_shells

Percentage of dead shells in the sample wash frame.

Pct_detrit

Percentage of detritus (fibrous material on the surface and within the sediment) in the sample wash frame.

Fine_org

Code (Y or N) indicating presence or absence of fine organic material in the sample.

Substrat

Predominant substrate based on visual and tactile observation. Possible values are as follows:

Hard clay
Silt/Clay
Mostly silt/Clay with sand
Mostly sand with silt/Clay
Sand
Gravel rock

Mayflies

Number of mayflies in sample.

Fgnl_clams

Number of fingernail clams in sample.

Corbicula

Number of *Corbicula* in sample.

Midges

Number of midges in sample.

Zebra_mus

Number of zebra mussels in sample.

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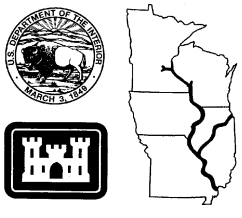
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