Ambient Water-Quality Monitoring in Missouri

--Emitt C. Witt, III and John Ford

Recreational use, North Fork River, Missouri.

Agricultural use, Spring Creek,Basin, Missouri (Photograph courtesy of Rebecca Inman, U.S. Geological Survey).

Urban runoff, Kansas City, Missouri (Photograph courtesy of Don Wilkison, U.S. Geological Survey).

Introduction

During the last 31 years, the Missouri Department of Natural Resources (MoDNR) and the U.S. Geological Survey (USGS) have cooperated on a program to monitor the quality of the Stateís streams, springs, and rivers (hereafter referred to as surface water). This program is referred to as the Ambient Water-Quality Monitoring Network (hereafter referred to as Ambient Network) and was established to detect changes and determine trends in the quality of Missouriís streams and to provide the regulatory community with baseline data needed to enforce environmental law.

Although the level of funding and the number of monitoring stations have changed with time, the program has always focused on monitoring the present status of the Stateís surface water by using the most representative data-collection techniques and quality-assured laboratory procedures. Missouri has more than 21,978 miles of rivers that support recreation, agriculture, industry, transportation, and public utilities. The 1998 Missouri Water-Quality Report, published by the MoDNR, identified approximately 10,000 stream miles that are adversely affected by various physical changes or chemical contaminants. Because nearly one-half of the surface-water resources in Missouri are currently (2001) being affected, a major effort is needed to maintain the remaining resources and to improve the affected resources.

Urbanization, intensive agriculture, recreation, and the manufacturing industry are affecting water quality throughout the United States. In the U.S. Environmental Protection Agencyís (USEPA) 1998 report to Congress, 35 percent of the assessed streams and rivers in the United States are impaired beyond their ability to support designated uses (U.S. Environmental Protection Agency, 1999; 2000). Uses typically include drinking water, aquatic life support, fish consumption, recreational contact, and agriculture. In Missouri, nearly one-third of the surface water in the north and western regions support less than 20 percent of the designated uses. Also, more than 5 percent of aquatic species are at risk within the southeastern and southwestern regions (U.S. Environmental Protection Agency, 1998).

Missouri's population grew by more than 7 percent from 1980 to 1990 and by another 6.3 percent from 1990 to 1998 (U.S. Census Bureau, 1999). This growth has a substantial effect on Missouriís water resources. For example, the city of Springfield, although located over a substantial potable aquifer, must also use surface water from the James River and three reservoirs on the Sac and Little Sac Rivers to meet the cityís demand for drinking water. The population increase in the city of Nevada has placed such a demand on the ground-water supply that salinewater is being pumped from the deeper aquifer to the shallow aquifer that has supplied the water for the city.

The future of Missouri is linked to the future quality of its water resources. Without an adequate water supply, population growth will be limited, agriculture will be hampered, and the recreational industry will suffer. Therefore, a system that monitors the changing quality of the surface-water resources is necessary, and the Ambient Network has and will continue to serve this purpose in Missouri.

The Network

Ambient water-quality monitoring began in Missouri in 1969 with 18 sampling stations. By 1979 the network had increased by only two stations. From 1980 to 1986, the network increased to 41 stations. However, by 1991 funding had been reduced so that only 5 stations remained in the network. Realizing the need for an increase in baseline data, the MoDNR began reestablishing the network in 1993, and by the end of 1994, 34 stations had been added to the network. In October 1999, funds were allocated for an additional 24 stations, and Federal funds became available to support 2 more stations, which increased the total network to 65 stations (fig. 1).

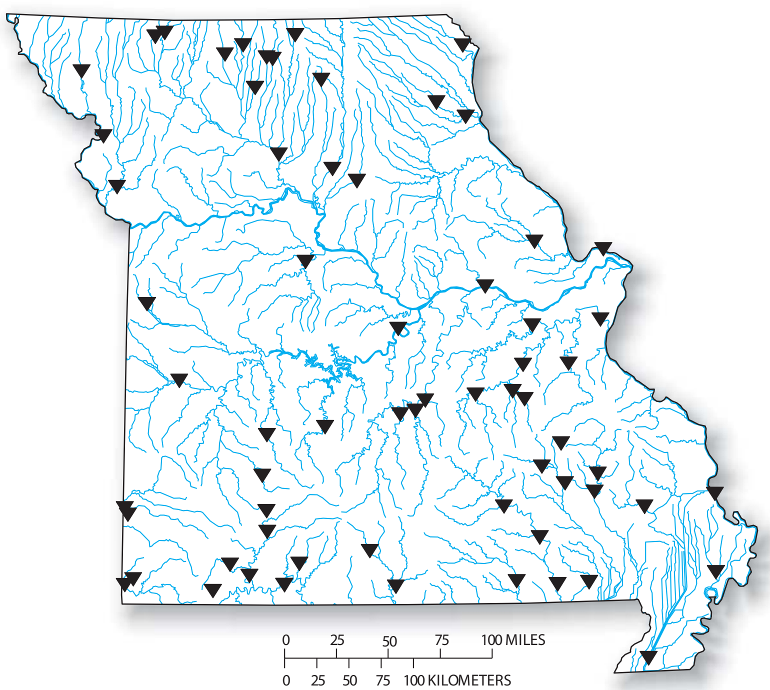

Figure 1. Location of stations in the Ambient Water-Quality Monitoring Network.

A committee composed of representatives from the MoDNR and the USGS is responsible for the selection of stations for the Ambient Network. Criteria for inclusion in the network are:

1. Moderate size surface waters that represent typical land use in a specific physiographic province or aquatic ecoregion.
2. Surface waters with substantial land-use change occurring within their drainage basin, such as those affected by growing industry, expanding or changing agricultural practices, and urban development.
3. Surface waters with known water-quality concerns, such as those with point source inputs of contaminants.
4. Surface waters listed in the Missouri Water-Quality Standards as 'Outstanding Natural Resource Waters'.
5. Surface waters of special interest requiring the establishment of an initial data set.

The Ambient Network is a large effort that requires substantial financial support to operate. Labor associated with data collection and laboratory costs account for more than 51 and 18 percent of the total funding. The remaining expenses include vehicle rental, overnight travel, miscellaneous supply purchases, and sample shipping.

The Ambient Network is supported by three major sources of funding. The first is from a share of the funds the State collects from judgements and settlements of water pollution enforcement cases, the second is from the USGS cooperative program, and the third is the Clean Water Act funding from the USEPA. These funds support a group of eight field technicians and one quality-assurance officer who sample and validate data collected from Missouriís surface waters.

Sample Collection

Samples are collected at stations in the network at varying frequencies. Of the 65 stations in the Ambient Network, 1 is sampled 4 times per year, 38 are sampled 6 times, 3 are sampled 9 times, and the remaining 23 are sampled 12 times. Sampling frequency is determined by a number of factors that include the drainage basin size, potential effects from cultural activity, history of chemical change, the need for short-term data, and cost. Lower sampling frequency helps to reduce the cost of the overall network by lowering costs for each station. With lower costs per station, more stations can be added to the network and provide wider coverage of the Stateís stream resources with a constant level of funding.

Methods used by the USGS for collecting representative water-quality samples are presented in detail in several publications (Ward and Harr, 1990; Wilde and others, 1998). In summary, there are two techniques to collect samples from a stream, the Equal Width Increment (EWI) and the Equal Discharge Increment (EDI). The EWI method requires the collection of subsamples within a cross section of the stream at equal distances apart (fig. 2). This method typically is used for streams with relatively even depth and flow. Water depths between sampling subsections generally do not vary by more than 10 percent.

The EDI method is based on equal discharge for each cross section of the river. More samples are collected in the deeper part of the river channel where most of the water is flowing (fig. 2). The EDI method is used for large rivers where shipping channels have deepened the streambed near its center. The EDI method is exclusively used for sample collection at Mississippi and Missouri River stations.

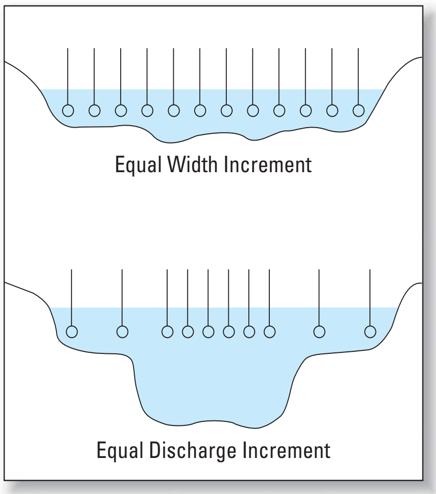

Figure 2. Methods for collecting samples in a cross section of a stream with shallow even flow and deep channelized flow.

Sample collection using either of the methods requires the use of a sampling device that maintains the representative chemistry of the water and collects a representative parcel of water. Because materials used to construct sampling equipment can directly affect sample chemistry, relatively inert materials are used that will not contribute to or remove constituents from the sample. The material currently used is Teflon[1].

A sampler also must collect a representative volume of water within a subsection without any flow-disturbing effects from the body of the sampler. Water flowing into the sampler must represent the water within the area of the sampler opening. The term given to such a sampling device is 'isokinetic sampler'. Two types of Teflon isokinetic samplers are used in the Ambient Network: the D-77, modified for use with a Teflon bag (collapsible bag sampler) and the DH-81 hand-held sampler. The collapsible bag sampler typically is used where flow and depth conditions are too extreme to wade within the cross section. This sampler is suspended by a cable from either a bridge deck or a boat and lowered into the water at a constant rate (fig. 3). This 'transit rate' is calculated based on the depth and velocity of streamflow and the size of the nozzle attached to the sampler. The DH-81 sampler is used for small streams and during low-flow conditions where wading a cross section is safe. A transit rate is determined before sampling begins.

[1]The use of brand names in this fact sheet is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Figure 3. Use of a collapsible bag sampler on the Mississippi River at Thebes, Illinois.

Samples collected from each subsection of the cross section are composited in a common vessel during the sampling process, which ensures that the sample sent to the laboratory for chemical analysis is a representative sample. The time required to complete sampling of a cross section is from 2 to 4 hours, depending on the size of the stream, flow conditions, accessibility, and weather.

Constituents Measured

The composite sample is processed onsite in a USGS mobile field laboratory within 1 hour of collection. Aliquots of sample are removed from the common vessel and analyzed for pH and alkalinity. Temperature, dissolved oxygen, and specific conductance are measured instream at the centroid of flow during the sample collection process. Indicator bacteria are processed from a grab sample collected at the centroid of flow. Additional aliquots of sample are processed using filtration and chemical preservatives for shipment to the USGS National Water Quality Laboratory in Denver, Colorado. Constituents measured in the laboratory include nitrogen and phosphorus species, major ions, chemical oxygen demand, trace metals, suspended solids, dissolved solids, organic carbon, and 47 pesticide compounds. Laboratory procedures meet quality-assurance procedures by the USGS and generally exceed the detection levels of similar analyses required for compliance purposes by the USEPA (Fishman and Friedman, 1989; Faires, 1993; Zaugg and others, 1995).

The USGS follows procedures to ensure the physical properties of the stream can be linked to the chemical composition of the sample collected. Therefore, before sample collection, the USGS technician either measures the flow in the stream or records it from an existing gaging station. In either case, the procedures for obtaining a flow value are given in Rantz and others (1982). Flow data in conjunction with a water-quality sample are useful during the data validation and interpretation process. Flow data permit scientists to calculate loads of various chemicals in surface water, determine the effects of dilution on surface-water chemistry, and determine the time it will take for contaminants to travel downstream. Twenty-four of the 65 Ambient Network stations have a permanently installed stream gage where a stage discharge relation has been established for the continuous calculation of flow. At the remaining stations, flow is measured using a current meter and appropriate techniques to provide an instantaneous measurement.

Uses for the Data

The USGS has many uses for the data it collects, but the most important use is for answering environmental quality questions on a National level. Specific uses of water-quality data include characterizing the quality of streams within different physiographic plateaus and geohydrologic regimes; determining and understanding the changes in chemistry with time and defining trends as they relate to land use and water use change; establishing control points for smaller, site-specific environmental projects; and providing a source of unbiased data for use by State and Federal regulators, as well as research scientists in the public, private, and academic sectors.

The MoDNR uses the data to characterize ëambientí water quality within and between aquatic ecoregions in Missouri; characterize diurnal, seasonal, and flow-related effects on water quality; characterize water-quality effects of specific point or nonpoint source areas; analyze data for long-term trends; and check for compliance with State water-quality standards.

Data Availability

All data collected for the Ambient Network and other USGS water-quality projects are stored in the National Water Information System (NWIS) data base. Before data are committed to the data base, they are carefully screened for transmission errors, analytical anomalies, and balance with other data collected from the same sample. Data collection, processing, and validation procedures are described in the Quality Assurance Project Plan (QAPP) developed for the network annually. The QAPP is an unpublished document, but it may be reviewed by contacting the Missouri Water-Quality Specialist (573-308-3829 or jdavis@usgs.gov). Following validation, the data are available for use by the public.

Data contained in the NWIS data base were transferred to the USEPA STORET data base annually until March 1999. Future data will not be transferred to STORET until the compatibility concerns between NWIS and STORET are resolved.

The Missouri District Water-Quality Specialist is available to assist with data retrievals from the NWIS data base. Historical data from 1995 to the current year are available in Adobe Acrobat Portable Document Format on the Missouri homepage http://missouri.usgs.gov. All historical data are available on the National USGS web page http://water.usgs.gov/nwis.

In addition to the availability of data on the Web, data are published annually in ì Water Resources Data for Missouriî . This hydrologic-data report for Missouri is one of a series of annual reports that document hydrologic data collected from USGS surface- and ground-water data collection networks in each State, Puerto Rico, and the Trust Territories. Copies of the annual report may be obtained by contacting the District Chief of Missouri (573-308-3664) or sending an email request to cpepmill@usgs.gov.

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For more information contact any of the following:

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