USGS
science for a changing world

Surface Water

For more than a century, the USGS has provided critical information to water managers and water users so that the United States can have a well-managed surface-water system that is capable of sustaining the population, the economy, and the natural environment. In Ohio, it is our goal to provide water managers the data and tools to plan for the following areas.

Flood Protection

Water is Ohio's greatest natural hazard. Nearly every year, floods cost the State thousands or even millions of dollars in damages. Data collected by the USGS have helped reduce flood-related death and damage over the years.

By analyzing long-term streamflow records, USGS scientists have developed statistical techniques for estimating the magnitude and frequency of flooding on streams in urban and rural areas. During floods, USGS field personnel attempt to make streamflow measurements so that extreme streamflows are adequately accounted for in the record. In situations where flooding was too sudden or too severe for measurements to be made, USGS scientists occasionally examine the flooded areas after the fact to estimate peak streamflows.

The USGS Ohio Water Science Center (WSC) operates a network of about 200 streamgages, most of which are linked to satellite transmitters so that real-time stream data can be viewed by the public at *http://waterdata.usgs.gov/oh/nwis/rt*. These stream data are used in a variety of ways.

Flood alerts—Automated streamgages can provide early warning of rapid floodwater rises on major streams. These data are used by the National Weather Service, along with weather data, weather forecasts, and river forecast models to issue flood warnings. The USGS recently added and upgraded some streamgages to help provide additional flood-warning capability for the City of Findlay. The USGS also is generating flood-inundation maps for Findlay that will be used along with National Weather Service flood forecasts to help visualize the anticipated areal extent of flooding.

River forecast models—The USGS recently developed a rainfall-runoff and routing model of the Great Miami River watershed in southwestern Ohio. The model is used to forecast the magnitude and timing of peak streamflows at 14 critical locations in the watershed. To facilitate the forecasts, the USGS developed automated or computer-assisted methods to acquire and process meteorological data from the National Weather Service and developed methods to process precipitation data retrieved from Miami Conservancy District's ALERT database.

WHAT IS A STREAMGAGE?

The USGS operates a network of about 200 streamgages in Ohio. The gage enclosure generally is located beside a river and contains a device to measure and record the water level in the river. Measurements are recorded automatically every 5 minutes to an hour, depending on the gage. Water-level data sent via satellite from most of these gages are received almost immediately at the USGS office in Columbus. There, computers process the water-level data from more than 150 of the streamgages to determine streamflow, in cubic feet per second. (Streamflow is not determined at approximately 50 gages that are used only for specific needs such as flood warning—for these sites only water level, or "gage height," is reported.) Streamflow and gage-height data are made available to users over the Internet (*http://waterdata.usgs.gov/oh/nwis/rt*). At each gage where the relation between water level and streamflow is provided, field personnel visit the site periodically and during very wet or dry periods to measure the flow directly to ensure that the relation is accurate and that all equipment is operating properly.

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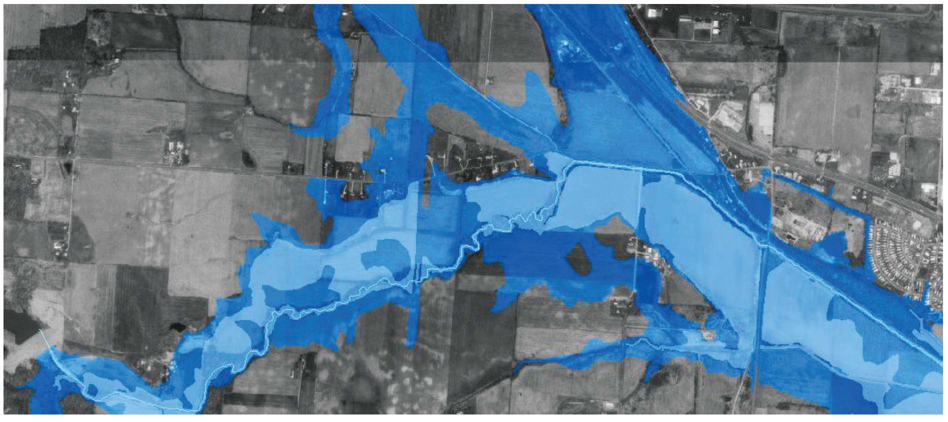
Flood profiles and flood maps—County or city planners need to know what areas should be zoned as flood plain so that they can regulate development within the flood plain. The USGS has done several Flood Insurance Studies for the Federal Emergency Management Agency addressing flooding of low-lying areas. Flood profiles and maps must be updated periodically as patterns of commercial and residential development near streams change. The USGS also has worked with the Ohio Emergency Management Agency to document the meteorological and hydrological conditions associated with several large floods that occurred in Ohio.

Dam-break analysis—The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) is currently involved in efforts to rehabilitate hydraulic structures in the Rush Creek and Upper Hocking River watersheds in southeastern Ohio. Of the nearly 50 dams present within the two watersheds, most were designed for a 50-year life span, and many are approaching the end of their design life. To aid NRCS in prioritizing their rehabilitation efforts, the USGS analyzed what would happen to downstream areas if dams were to fail. The software HEC-RAS was used to model breaches of 11 earthen dams. The resulting flood wave was routed downstream using unsteady flow equations. Areas that would be inundated in the resulting flood were digitally mapped (example shown below).



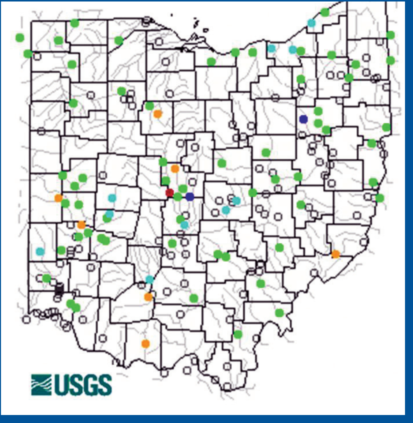
Land-Use Change

Residential and commercial development is expanding in parts of Ohio at a rapid pace. The changes in land use associated with urban development affect flooding in many ways. Removing vegetation and replacing permeable soil with impervious surfaces such as roads, parking lots, roofs, and sidewalks increases runoff to streams from rainfall and snowmelt. Building networks of drainage ditches and storm sewers decreases the distance that runoff must travel overland or through subsurface flow paths before discharging to streams and rivers. Also, flow of water through these artificial drainage features is faster than either overland or subsurface flow. As a result, the peak discharge, volume, and frequency of floods increase in nearby streams.

Statewide effects of urbanization on flood-frequency characteristics—In the 1970s, the USGS began a statewide program to collect and analyze streamflow data on urban streams to document the effects of urbanization on flood-frequency characteristics of Ohio streams. As a result of this program, equations were developed to estimate flood-peak-frequency relations, flood hydrographs, and volume-duration-frequency relations of ungaged small urban streams in Ohio; the equations were published in 1993. Explanatory variables in the equations are drainage area, average annual precipitation, and basin development factor.

RECREATIONAL PLANNING

People planning to canoe, kayak, or fish need information to avoid unsafe river conditions and to preclude costly trips to remote river locations when conditions are not suitable for recreation. Real-time stream data for Ohio sites can be found at Ohio's National Water Information System Web site *(http://waterdata.usgs.gov/oh/nwis/rt)*.



Currently, the USGS Ohio WSC is interested in further improving the ability to estimate flood frequencies of urban streams. With the advent of geographic information systems (GIS) databases, new digital data are available that could potentially be used to create more accurate equations. In addition, the 30 urban streams on which the original equations were based had drainage areas from 0.026 to 4.09 square miles, thus limiting the applicability of the equations to streams within the same range. The USGS realizes the need to collect streamflow and rainfall data from urban streams having drainage areas ranging from 5 to 30 square miles. These data could be used to develop equations to estimate flood-peak-frequency relations of urban streams in Ohio from GIS-based explanatory variables such as drainage area, main-channel slope, average annual precipitation, and an index of urbanization. Eventually, these equations could be incorporated into StreamStats (see sidebar on next page).

STREAMFLOW STATISTICS ARE A SNAP! (WELL, A CLICK)

Estimation of streamflow statistics used to be a long and tedious process, but a new Web-based tool called StreamStats reduces the effort to only a few minutes. StreamStats combines a GIS with the National Streamflow Statistics computational engine. The application permits a user to select a point on a stream and, even at an ungaged site, have returned pertinent basin characteristics as well as estimates of selected streamflow statistics indicating the range of streamflow that can be expected at the site. For more information on StreamStats, see *http://water.usgs.gov/osw/streamstats*.

County-level effects of land-use change on flood characteristics—Recent technological advances in the integration of GIS and streamflow models coupled with the availability of ample streamflow, rainfall, and GIS data in Summit County have presented a unique opportunity for the USGS to develop a state-of-the-science analytical tool to assist engineers in estimating the effects of proposed development and runoff-controlling mechanisms on the flood characteristics in basins in Summit County. The analytical tool is a calibrated streamflow-simulation model that provides detailed information on flood hydrographs. Model parameters may be adjusted to simulate the effects of proposed alterations of land use or drainage systems on flood characteristics and to test the effectiveness of design and placement of runoff-controlling mechanisms (such as detention basins) that could be used to mitigate undesirable changes in flood characteristics. The study will enable the Summit County Engineer to manage stormwater runoff in a manner that best meets the needs of the citizens in terms of effectiveness, cost, and safety.

Evaluation of Best Management Practices (BMPs) for stormwater runoff—The U.S. Environmental Protection Agency (USEPA) plans to implement various Best Management Practices (BMPs) for stormwater runoff management within the headwaters of Shepherd Creek near Mount Airy, Ohio. In order to measure the effectiveness of these BMPs, the USEPA must accurately compare streamflow data collected at selected tributaries to Shepherd Creek before and after the BMPs have been developed within the watershed. To provide these data, the USGS is using up-to-date engineering methods for instrumentation and rating development for streamflow data collection at nine sites established by the USEPA. Because the Shepherd Creek watershed is small and changes in streamflow can occur rapidly, stream data are being logged at 5-minute increments. Telemetry equipment allows real-time viewing of data at eight of the sites. Such methods will minimize error in the data so that small differences in flow can be observed.

Effects of land-use change on sediment loading rates—Daily suspended-sediment loads have been calculated from samples collected from Big Darby Creek, tributaries to Lake Erie, the Upper Auglaize River, and other Ohio streams. These loads can be used to help assess impacts from development and agricultural activities on the receiving water bodies. A high sediment load can adversely affect city water supply and can shorten the useful lifespan of harbors and lakes.

Water Supply and Waste Disposal

Estimation of reservoir storage capacity requirements—Construction of new reservoirs is one way to meet increasing water-supply demands. The USGS has provided data and methods to aid in the hydrologic design or evaluation of impounding reservoirs and side-channel reservoirs used for water supply in Ohio. Data from 117 streamgages throughout Ohio were analyzed to develop relations between reservoir storage requirements, water demand, flow duration, and frequency. The report generated from this study also presents information to help assess the effects of precipitation and evaporation on required reservoir capacities.

Determination of low-flow characteristics—Low-flow characteristics of streams are used by engineers and water-resource managers to determine the availability of water for industrial or municipal supply during times of drought, to establish waste-disposal limitations, and to assess aquatic habitats. Many agencies use low-flow characteristics as target conditions or thresholds for making regulatory decisions. Low-flow characteristics can be developed from statistical analyses of daily streamflow at long-term gages or at partial-record gages (sites that have less than 10 years of daily streamflow data or measurements of base flows) in combination with long-term gages. Currently, the USGS is collecting low-flow data at approximately 60 sites throughout Ohio.

Estimating pollutant traveltimes—Most time-of-travel studies are used to determine the time it takes a slug of water to move from one location to another. In addition, time-of-travel studies may be aimed at assessing longitudinal dispersion of a soluble contaminant. Such studies have been done on reaches of the Cuyahoga, Great Miami, Little Miami, Mad, Mahoning, Stillwater, and Tuscarawas Rivers. Observations of traveltime gained from these studies have been used by the Ohio Environmental Protection Agency and USGS to model the fate and transport of pollutants. Recently, the USGS completed a study that assessed the Ohio River's bathymetry, velocity, and cross-channel mixing characteristics in a reach of the river extending about 12 miles upstream from Cincinnati. (The above photo of a dye release is from that study.) The data collected are being used to develop a flow and transport model that will help managers protect the water supply.

Research in Support of Highway Projects

Flood-frequency characteristics—High-flow characteristics of streams are used by engineers, water-resource managers, and state and county highway departments to design hydraulic structures (dams, bridges, retention ponds, and culverts) that can accommodate high-magnitude flows, as well as roadways that will function safely during floods. Crest-stage gages are being used to economically augment peak-flow stream statistics for streams with drainage areas less than 100 square miles where no streamgage exists. Crest-stage gages are located at several stream sites throughout Ohio, covering a range of drainage-basin sizes and characteristics. High-flow data gathered at these gages will improve understanding of the magnitude and frequency of peak flows in Ohio at a considerable savings compared to the cost of operating full-scale streamgages.

Geomorphology of stable stream channels – The building of highways frequently involves relocation of streams or construction of bridges and culverts at stream crossings. Such construction can have considerable impact on the geomorphic stability of the stream. Reconstruction of stream channels to natural geomorphic dimensions can result in more stable channels, which can in turn improve the stability of the structures. A USGS study was done to improve the understanding of the relation between stream geomorphic characteristics (such as bankfull stage) and the basin characteristics that influence them. Bankfull stage is the elevation at which a stream first begins to overflow its natural banks onto the active flood plain. Regression equations were developed to estimate bankfull dimensions (width, mean depth, and cross-sectional area) and bankfull discharge from basin characteristics such as drainage area and main-channel slope. Because strong relations typically exist between peak-flow characteristics and channel-geometry characteristics, simple-regression equations also were developed to estimate 2-, 5-, 10-, 25-, 50-, and 100-year flood-peak discharges of rural, unregulated streams in Ohio from bankfull channel cross-sectional area.

Additional Information

To learn more about USGS projects in Ohio or USGS information products, please visit

http://oh.water.usgs.gov/

or contact

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