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StreamStats: A U.S. Geological Survey Web Application for Stream Information

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Introduction

The U.S. Geological Survey (USGS) provides streamflow and other stream-related information needed to protect people and property from floods, to plan and manage water resources, and to protect water quality. Streamflow statistics provided by the USGS, such as the 100-year flood, the annual mean flow, and the 7-day 10-year low flow (7Q10), frequently are used by engineers, land managers, biologists, and many others to help guide decisions in their everyday work. For example, streamflow statistics are used for flood-plain mapping, which is used as the basis for setting insurance rates and zoning land use. Streamflow statistics also are used for dam, bridge, and culvert design; water-supply planning and management, and water-use appropriations and permitting; wastewater and industrial discharge permitting; hydropower facility design and regulation; and habitat preservation for protection of endangered species. In addition, researchers, planners, regulators, and others often need to know the physical and climatic characteristics (basin characteristics) of the drainage basins upstream from locations of interest to help them understand the mechanisms that control water availability and water quality at these locations.

Streamflow statistics can be needed at any location along a stream. Commonly, the statistics are computed from available data when they are needed at the locations of USGS data-collection stations, which include streamgaging stations, where streamflow data are collected continuously; partial-record stations, where streamflow measurements
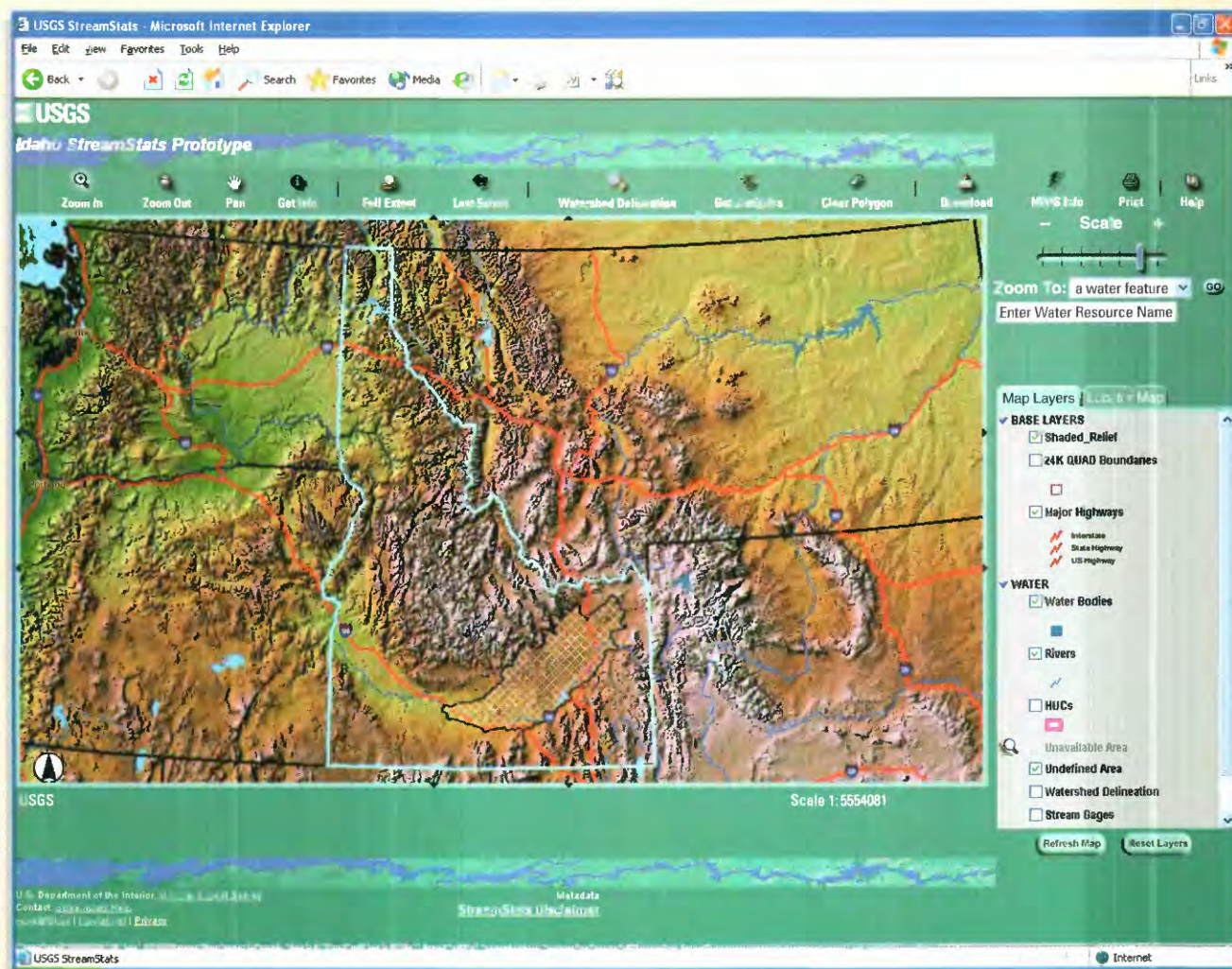

Figure 1. View of the StreamStats user interface zoomed in to Idaho.

are collected systematically over a period of years to estimate peak-flow or low-flow statistics; and miscellaneous-measurement stations, where streamflow measurements usually are collected for specific hydrologic studies with various objectives. More often, however, the statistics are needed at ungaged sites, where no observed data are available to compute the statistics.

StreamStats is a map-based Web application that makes it easy for users to obtain streamflow statistics, basin characteristics, and other information for user-selected USGS data-collection stations and ungaged sites of interest. If a user selects the location of a data-collection station, StreamStats will provide previously published information for the station from a database. If a user selects a location where no data are available (an ungaged site), StreamStats will run a Geographic Information System (GIS) program to measure basin characteristics and estimate streamflow statistics for the site. These estimates assume that natural flow conditions exist at the ungaged site. In the past, it could take an experienced person more than a day to determine the estimates. StreamStats reduces the effort to only a few minutes.

StreamStats was developed cooperatively by the USGS and the Environmental Systems Research Institute, Inc. (ESRI, at Web page *http://www.esri.com*), and was designed for national implementation. The application consists of five major components: (1) a user interface that displays maps and allows users to select stream locations where they want streamflow statistics information (fig. 1), (2) a database that contains previously published streamflow statistics and descriptive information for USGS data-collection stations, (3) an automated GIS process that determines drainage boundaries for user-selected ungaged sites and measures the basin characteristics for those sites, (4) a GIS database that stores base-map data needed for users to locate sites of interest and other map data needed for measuring basin characteristics, and (5) an automated process that takes the measured basin characteristics for ungaged sites as input, solves regression equations to estimate various streamflow statistics, and outputs the estimates for display to the user in a Web browser window. Each of these components are described below and guidance for using the application is provided.

StreamStats User Interface

The StreamStats user interface (fig. 1) allows users to navigate to areas of the map and select gaged and ungaged sites of interest. The largest part of the user interface consists of the Map Frame, which displays default and selected map layers. The Map Layers Frame, located to the right of the Map Frame, shows the layers that are or can be displayed on the Map Frame, and allows users to change the layers that are displayed. Above the Map Frame is a series of buttons that allow navigation by zooming in and out (going to a larger or smaller scale view while the map is centered on the same position), panning (moving the center of view in any direction), or returning to the previous or original map extent. Additional buttons allow the user to query for information on features in selected map layers, delineate drainage boundaries for ungaged sites, get streamflow statistics for ungaged sites, clear drainage boundaries, download drainage boundaries to a file, print the views shown in the Map Frame, retrieve information for USGS data-collection site stations from the National Water Information System (NWIS) database, and get help on using StreamStats. A "Zoom To" pull-down menu above the Map Layers Frame allows users to zoom to a named place, a water feature, an address, or a specified latitude and longitude.

The user interface is accessed initially through a Web page *(http://streamstats.usgs.gov)* that briefly describes StreamStats, provides links to documentation, and presents a map of the United States that indicates where StreamStats has been implemented. Clicking on a highlighted State on the map will take users to the user interface for that State. The initial homepage also includes a map that indicates where cooperative studies are underway to implement StreamStats for additional States.

Streamflow Statistics for Data-Collection Stations

The USGS periodically computes and publishes streamflow statistics and basin characteristics for its streamflow data-collection stations. This information typically is published in data reports prepared annually by each of the 48 USGS District offices, or in reports that are

products of statewide or regional studies done in cooperation with State and local agencies. Because available streamflow statistics and basin characteristics for a given area commonly are scattered among many reports, and many older reports may not be readily available to the public, users of this information often find it difficult to obtain the information they need. StreamStats provides convenient access to a database, StreamStatsDB, that contains previously published information for data-collection stations.

The different types of data-collection stations are shown on the map in the user interface by different symbol shapes and colors. Clicking on the location of a station gives access to the available information for that station. The available information varies by station type and by the needs of local cooperators, who may have shared in the cost of computing the statistics. The information is entered into StreamStatsDB and is quality-assured by scientists in the USGS District offices where the data were collected.

StreamStats output for data-collection stations includes descriptive information, any streamflow statistics and basin characteristics that are available for the stations, and links to the homepages for the stations in NWISWeb *(http://waterdata.usgs.gov/usa/nwis/nwis)*, the online database that contains data collected for all USGS data-collection stations. Descriptive information in StreamStatsDB includes: USGS station identification number, station name, station type, period of record, latitude, longitude, hydrologic unit code, major drainage basin name, county name, U.S. Census Bureau Minor Civil Division (MCD) name, directions to locate the station, and remarks indicating any effects of human impacts or other pertinent information about the stations.

More than 165 different basin characteristics are available in StreamStatsDB, though typically there are less than one dozen available for most stations. Drainage area is the most commonly available basin characteristic. Some other widely available characteristics include stream slope, mean annual precipitation, and area of surface-water storage (lakes, ponds, and wetlands).

About 500 different streamflow statistics are available in StreamStatsDB, including peak-flow and low-flow frequencies, annual and monthly means, medians, and flow-duration percentiles.

Most stations, however, have only a small number of statistics available. Data from NWISWeb were used to determine the statistics. Though there is some overlap in the information contained in NWISWeb and StreamStatsDB, NWISWeb was not designed to store most of the streamflow statistics and many of the basin characteristics contained in StreamStatsDB.

All streamflow statistics and basin characteristics for stations in StreamStatsDB were published in previous reports, and citations for those reports are provided in the StreamStats output. Methods used to determine the information are described in the reports. A link from the StreamStats homepage provides definitions of the streamflow statistics and basin characteristics in the database.

Streamflow Statistics for Ungaged Sites

The USGS has developed numerous equations that can be used to estimate various streamflow statistics for locations on ungaged streams throughout the Nation. The equations were obtained by use of regression analysis to statistically relate the streamflow statistics to the basin characteristics of the drainage basins for a group of data-collection stations. The basin characteristics can be measured for an ungaged site and inserted into the regression equations to obtain estimates of the streamflow statistics under natural flow conditions for the site. (See box on p. 4)

Use of the regression equations has been limited in the past because measuring the basin characteristics was difficult and time-consuming, and the equations sometimes are difficult to calculate. Historically, most physical characteristics were measured by hand from various maps. This process could take from an hour to a few days to complete for a single site, depending on the size of the basin and the characteristics measured. In addition, many of the maps were not widely circulated, and many potential users did not possess the equipment or expertise necessary to measure the values from the maps. StreamStats eliminates these problems by automatically defining the drainage boundary, measuring the basin characteristics, and solving the regression equations to obtain estimates of streamflow statistics for user-selected ungaged sites in a process that takes only a few minutes. Users simply select the location of interest from the map displayed in the user interface, and StreamStats does the rest.

StreamStats determines the drainage-basin boundary for a selected site using a Digital Elevation Model (DEM), which is a regularly spaced grid of elevation points, and a digital representation of the stream network. When a user selects a site along the digital stream network, the site location is transferred to a point in the DEM, which is then used to determine the drainage boundary for the site. Usually the DEM used for delineation has been enhanced by a process that makes it conform to the stream network and a data set of pre-existing drainage boundaries. As a result, delineations obtained from StreamStats usually are of greater accuracy than delineations obtained from a standard DEM (fig. 2).

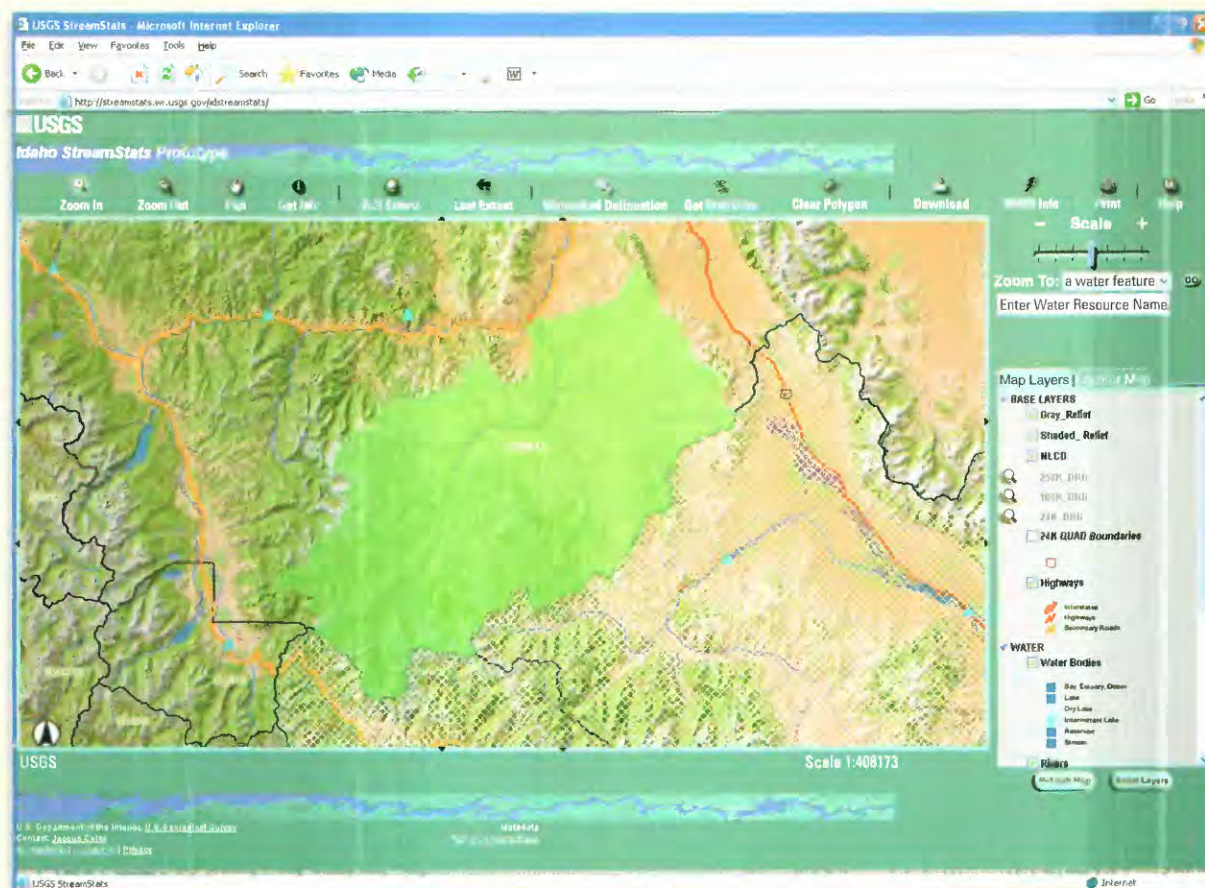StreamStats was designed to allow use of data sets at various scales so that

Figure 2. Drainage basin delineation for an ungaged site using StreamStats.

Regression Equations

The USGS has developed equations to estimate peak-flow frequency statistics, such as the 100-year flood, for ungaged sites in every State. Regression equations also have been developed to estimate other types of streamflow statistics for many States. As an example, the equation for estimating the 100-year flood for ungaged sites in part of northern Idaho is:

$$Q_{100} = 5.39 \, A^{0.874} (E/1{,}000)^{-1.13} \, P^{1.18}$$

where

Q_{100} is the peak flow that occurs, on average, once in 100 years (1-percent chance of occurrence in any year), in cubic feet per second;

A is the drainage area, in square miles;

E is the mean basin elevation, in feet; and

P is the mean annual precipitation, in inches.

Reference

Berenbrock, Charles, 2002, Estimating the magnitude of peak flows at selected recurrence intervals for streams in Idaho: U.S. Geological Survey Water-Resources Investigations Report 02-4170, 59 p.

Streamstats Report - Microsoft Internet Explorer
File Edit View Favorites Tools Help

StreamStats

Streamflow Statistics Report

Date: Thu Oct 14 2004 12:19:03
Site Location: Idaho
Latitude: 44.2672
Longitude: -114.3257
Drainage Area: 551 mi2

Peak Flow Basin Characteristics
100% Peak FLow Region 6 (551 mi2)

Parameter	Value	Min	Max
Drainage Area (mi2)	551	4	6236.7
Mean Annual Precipitation (in)	25.7	15.26	31.98

Low Flow Basin Characteristics
100% Low Flow Region 6 (551 mi2)

Parameter	Value	Min	Max
Drainage Area (mi2)	551	6.4	6236.7
Mean Basin Slope from 30m DEM (percent)	38	8.6	66.2
Percent Forest (percent)	31.1	14.5	80.2
Mean Basin Elevation (ft)	8060	6258.1	9461
Relief (ft)	6420	3015.2	9419.7

Streamflow Statistics

Statistic	Flow (ft³/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval Minimum	Maximum
Peak-Flow Statistics					
Q1.5	1610	63		609	4250
Q2	2010	62		773	5250
Q2.33	2120	60		835	5400
Q5	2790	56		1160	6740
Q10	3250	56		1360	7780
Q25	3830	56		1590	9220
Q50	4260	57		1750	10400
Q100	4690	58		1900	11600
Q200	5010	60		1990	12600
Q500	5630	62		2180	14500

Figure 3. Partial output from StreamStats for an ungaged site.

the best available local data can be used to determine drainage boundaries and to measure basin characteristics. The local USGS District offices determine the source and scale of the data layers used.

StreamStats determines what regression equations are available in the region in which the ungaged site is located, and what basin characteristics are needed to solve them. StreamStats then measures the basin characteristics and inserts them into the National Flood Frequency (NFF) program, which solves the equations. The estimated streamflow statistics, indicators of the errors associated with the estimates, and the basin characteristics for the site appear in a pop-up Web browser window (fig. 3). Documentation of the equations in NFF and the methods used to develop them is provided through links for each State on the NFF Web page at *http://water.usgs.gov/software/nff.html.*

Limitations

StreamStats provides estimates of streamflow statistics for ungaged sites

assuming natural flow conditions. If human activities such as dam regulation and water withdrawals substantially affect the timing, magnitude, or duration of flows at a selected site, the estimates provided by StreamStats should be adjusted by the user to account for those activities. StreamStats can be used to obtain regression-equation-based estimates of streamflow statistics for USGS data-collection stations that are affected by human activities. Users should not assume, however, that the differences between the data-based estimates for the stations and the regression equation-based estimates are equivalent to the effects of the human activities on streamflow at the stations because there are errors associated with both sets of estimates. When StreamStats is used to obtain estimates for sites with basin characteristics outside the ranges of the basin characteristics for the sites used to develop the regression equations, the estimates are extrapolated, and the errors associated with the estimates are unknown. StreamStats provides a warning when extrapolation occurs.
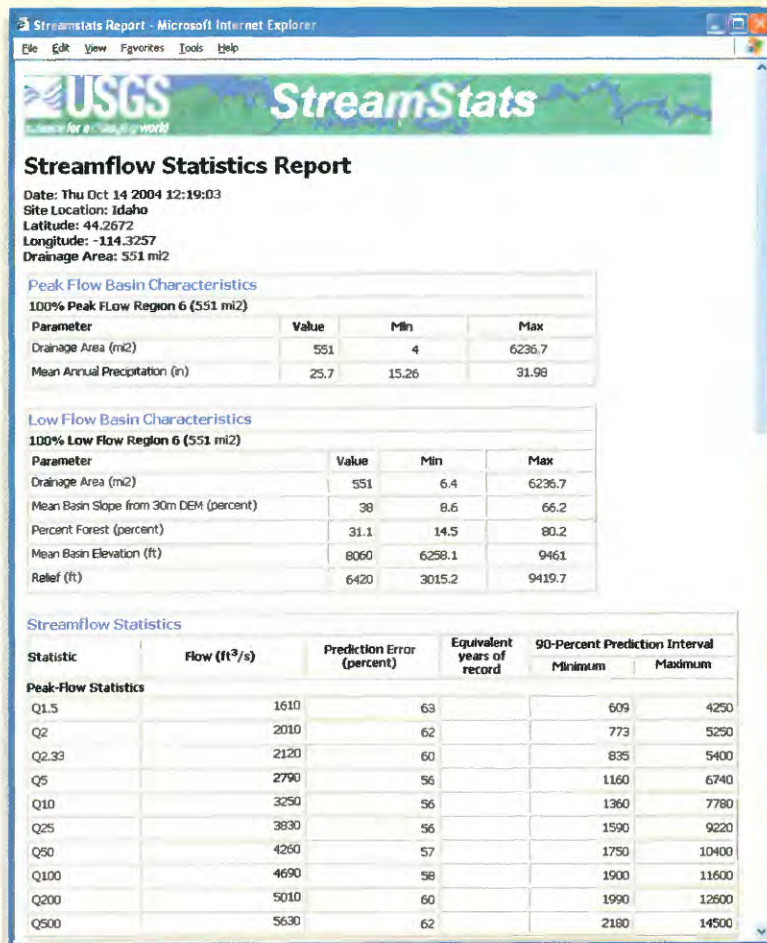
Additional Information

For further information, please contact:
Director
USGS MD-DE-DC Water Science Center
8987 Yellow Brick Road
Baltimore, Maryland 21237
http://md.water.usgs.gov
(410-238-4200)

or visit the USGS Office of Surface Water StreamStats Program homepage at:
http://water.usgs.gov/osw/programs/streamstats.html

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