Implementation of the U.S. Geological Survey’s *StreamStats* Program in Kansas—A Web Application for Streamflow Statistics and Basin Characteristics

Prepared by: May 2011

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# Problem

Streamflow statistics are used by government agencies, engineers, scientists, water resources managers and environmental groups, for purposes of water management, permitting, and design. The primary source of streamflow data are streamflow-gaging stations operated by the USGS for numerous State, Federal and Local agencies. Limited streamflow statistics for flows recorded at USGS streamflow gaging stations are published in an annual water resources report. Streamflow-gaging stations that have been discontinued are not included in the report and streamflow statistics for those sites are not readily available for planners and managers. Location and information concerning the discontinued streamflow-gaging stations are also not presently on any digital Geographic Information System (GIS) database assessable to the general public. The need exists to distribute to users critical streamflow data that have been collected in Kansas since 1895.

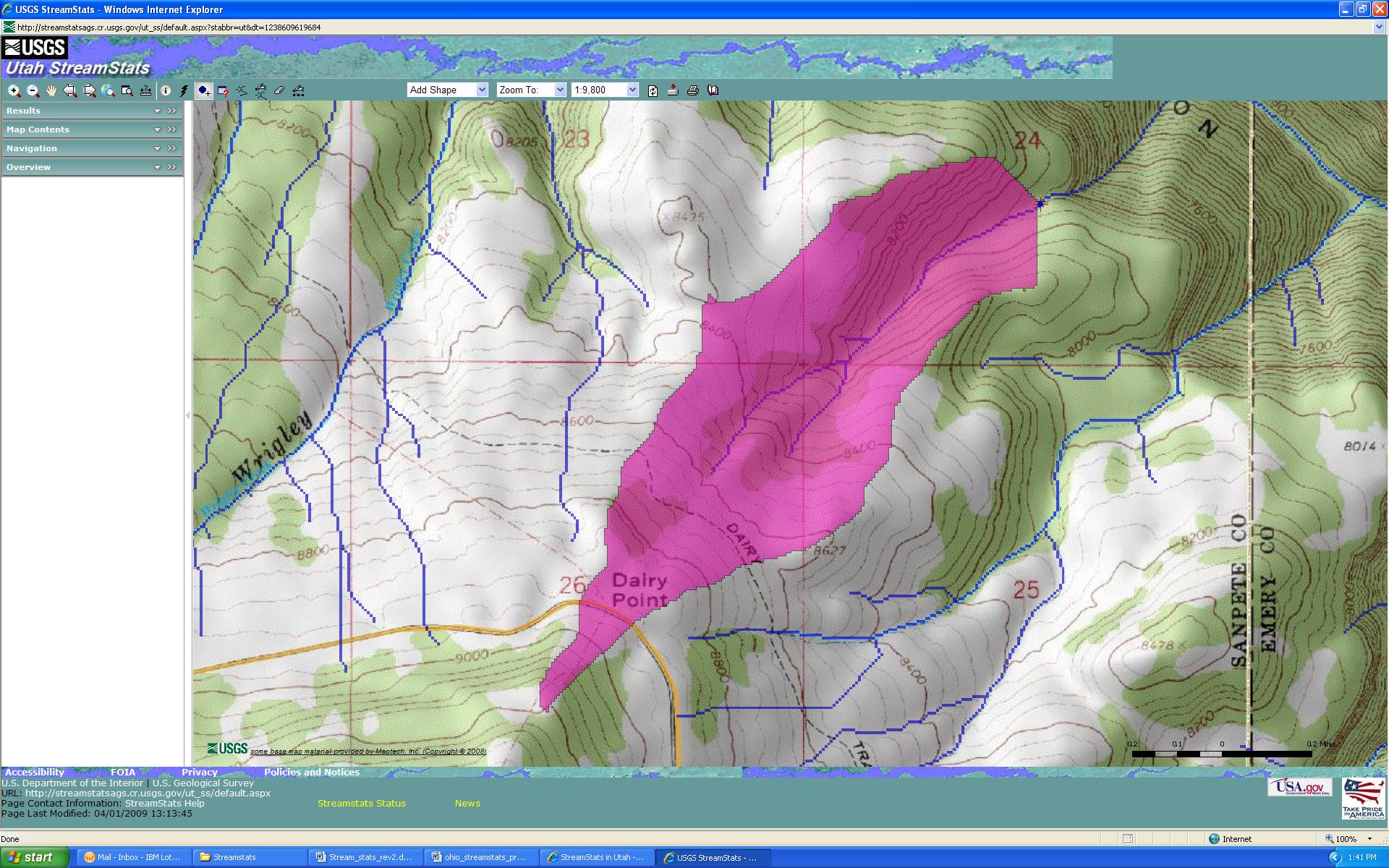
Estimates of streamflow statistics are needed at ungaged sites where no observed flow data are available. Estimates of streamflow statistics for ungaged sites can be made by using regional flow equations developed from data collected at continuous-record streamflow gaging stations that are physiographically similar to the ungaged streams. To determine estimates of flow at ungaged streams, basin characteristics that are used as explanatory variables in the equations are computed using maps or GIS databases and inserted into the regional flow equations.

Computation of required basin characteristics is problematic for many potential users needing streamflow information. Manual methods for determining basin characteristics from paper maps are difficult for multiple reasons. Manual methods are slow and labor intensive. Results may not be reproducible because of differing map scales, subjective interpretations of maps, and varying skill levels of users. Digital computations of basin characteristics are not feasible for many users due to the high costs of computer software and hardware and the investment in the training of personnel to correctly compile and manipulate GIS data using proper techniques.

To address the needs of entities requiring streamflow information, the USGS has developed a Web-based application called StreamStats that serves published streamflow statistics to the public and facilitates the estimation of streamflow statistics for ungaged sites on streams. StreamStats is an integrated web-based GIS application that uses ArcGIS Server technology and the ArcHydro Tools to make the process of computing streamflow statistics much faster, more accurate, and more consistent than previous methods. StreamStats allows a user to select any point on a stream via a web-based GIS interface, and then determines and displays the area contributing drainage to that point (fig. 1). Once the user confirms the drainage boundary, StreamStats determines the basin characteristics required and which regional equations are available for the location (and provides an option to download a shapefile of the drainage boundary that can be imported into a local GIS). The basin characteristic values and appropriate regional equations are then used to compute the stream flow statistics and a report showing the computed basin-characteristic values and streamflow statistics is provided.

Implementation of StreamStats in Kansas will provide planners and managers with an efficient, consistent, and accurate means of obtaining streamflow statistics at gaged stations and estimated streamflow statistics at ungaged stream sites. StreamStats is a dynamic application that can be easily updated to serve new or more current statistics as they become available. The application can be updated to contain new GIS data layers, basin characteristics, and regression equations at a later date. The URL for the StreamStats home page is: <http://streamstats.usgs.gov>. Currently (2011) StreamStats has the following capabilities (Ries and others, 2008):

* Exhibits a range of base map features such as roads, streams, and political boundaries;
* Map may be re-centered on a user-specified point;
* Zoom in or out based on user-specified area or point information;
* Identify feature on map layers;
* Access previously published streamflow statistics, basin characteristics and other information for streamflow gaging stations, and link to the USGS National Water Information System (NWIS) Web site;
* Delineate the drainage-basin boundary for a user-selected site;
* Measure pre-defined basin characteristics;
* Estimate streamflow statistics and provide confidence intervals and other indicators of potential errors;
* Edit computer generated basin boundary and basin characteristics, if desired;
* Search upstream and downstream from a site to identify critical features;
* Download basin boundary for other uses;
* Print displayed maps.



**Figure 1.** Drainage basin delineation using the web application StreamStats in Utah.

# Objective

This project will implement the USGS StreamStats web application in Kansas. The StreamStats application will provide scientists, engineers, managers, environmental groups and the general public, with access to over 100 years of USGS stream gaging records collected in Kansas and a means to estimate basin characteristics and stream flow statistics at ungaged sites.

# Relevance and Benefits

The StreamStats application has been developed by the USGS to further its mission of providing hydrologic information needed by others to achieve the best use of the Nation’s water resources. Development of Kansas geospatial data needed to implement StreamStats will contribute to a national database to advance the understanding of regional and temporal variations in climatic and hydrologic conditions. The application can be utilized to provide information for developing strategies to mitigate property losses from natural events, for the design of infrastructure near or crossing streams, and for assessing and maintaining aquatic habit.

The proposed steps will provide essential streamflow information in one data base for discontinued and active streamflow gaging stations throughout the State of Kansas. These statistics will be readily accessible from the StreamStats web site for the management and planning of the State’s water resources. The tool will be useful for the design of highway structures, for the management of water control structures, for addressing water quality issues, and for assessments of fish and wildlife habitats.

# Approach

The USGS Kansas Water Science Center will compile available streamflow statistics, predictive equations, and appropriate GIS layers for use in the web application and will test and verify the data entry and performance of the web applications. Implementation will be accomplished in several steps including:

1. **Update national database:** Update and entry of previously published information for USGS data-collection stations into a national database: Existing descriptive information, streamflow statistics, and basin characteristics in the database for Kansas data-collection stations will be reviewed and updated, where necessary, to include all current and relevant published streamflow statistics and basin characteristics for the stations.
2. **Geospatial data preparation:** Process and provide to the StreamStats development team Kansas’ portion of the National Elevation Dataset (NED), a 10-meter Digital Elevation Model (DEM), to assure that drainage-boundary delineations obtained conform to known watershed boundaries and stream networks. Prepare additional datasets in the format needed for base maps in StreamStats and to measure the basin characteristics used as variables in the regional regression equations for Kansas. These include the National Hydrography Dataset (NHD), Elevation Derivatives for National Applications Dataset (EDNA), National Land Cover Dataset (NLCD), Watershed Boundary Dataset (WBD), Parameter-elevation Regressions on Independent Slopes Model Dataset (PRISM), State Soil Geographic Database (STATSGO), and Surficial Geology of Kansas dataset;
3. **Validation:** After the StreamStats development team sets up a test site, it will run the Kansas StreamStats program under all conceivable scenarios and within all of the 8-digit hydrologic units within the state to establish the accuracy of results. If necessary, methods measuring basin characteristics will be modified to ensure the accuracy of the regression equation results.
4. **Documentation:** Prepare a factsheet and web page to describe the availability and uses of the StreamStats applications for Kansas users.

# Compilation and Input of Data for Data-Collection Stations into a National Database

The USGS has created the StreamStats database to contain descriptive information, streamflow statistics, and basin characteristics for data-collection stations. Information from this database is served by the StreamStats Web application. The database was populated initially from a similar database that was retired from use in the late 1990s, thus most information in the database is a decade or more old. The data in StreamStats database will be reviewed and updated as part of the StreamStats implementation process. Descriptive information, such as station type (continuous-record; low-flow, partial-record; peak-flow partial-record, etc.), whether or not the station is affected by flow regulation or diversions, remarks, and so forth, will be input or updated for stations in the database and information for stations not already in the database will be added. In addition, a thorough review of relevant USGS reports for Kansas will be completed to identify published streamflow statistics, basin characteristics, or other information that should be included in the database, and that information will be added. This step should be completed in the first 6 months of the project and the updated data could be made available through the national StreamStats application for data-collection stations at <http://streamstats.usgs.gov/gages/index.htm>. In this way, the public would have access to the data-collection station information while other work on the Kansas StreamStats application is ongoing.

# Acquisition, Preparation, and Testing of Spatial Data

Accurate and efficient computation of basin characteristics within the StreamStats application is highly dependent on preprocessing of the GIS data layers. In particular, the DEM and high-resolution National Hydrography Datasets (NHD) (U.S. Geological Survey, 2009) datasets require substantial work to ensure high-quality drainage-area delineations and stream-network navigation. Additional datasets will need to be acquired and processed using the ArcHydro Tools to allow measurement of basin characteristics needed to solve the regression equations, and to allow users to locate sites of interest in the StreamStats user interface.

The USGS will use the most recent digital elevation data for the proposed study. The State of Kansas has a 10-meter Level 2 DEM completed. The processing of the DEM requires three important steps. The first step involves forcing the DEM to conform to digitized drainage-basin boundaries from the Watershed Boundary Dataset (WBD) (U.S. Department of Agriculture Natural Resources Conservation Service, 2008). This process is called “walling” of the DEM. The second step involves the filling of sinks within the DEM. The flow accumulation grid is produced after the DEM is filled and no areas exist that have no outlet for overland flow. The grid must be developed to enable a user to determine basin characteristics for any location. The third step involves the “burning in” of streams into the DEM using medium-resolution NHD. The “burning in” process forces the DEM to recognize the NHD streamlines as truth and the result is a single dendritic network for the DEM.

After GIS data preparation is complete, the Kansas Water Science Center (WSC) will deliver the data to the national StreamStats development team, which will set up a test application for verification. Kansas WSC personnel will then test the application by obtaining basin characteristics and estimates of streamflow statistics at the locations of streamflow-gaging stations that were used to develop the regression equations. Values provided in the StreamStats outputs will be compared to values taken from the reports that contain the regional equations to determine if there are any statistically significant differences between the values. In some cases, adjustments to the StreamStats methods for measuring the basin characteristics may be needed to assure that the values provided by StreamStats are statistically equivalent to the published values. Infrequently, simple adjustments to the measurement methods are not adequate to achieve statistically equivalent values from StreamStats. In such cases, which are most likely to occur when attempting to implement old regional equations that were developed using basin characteristics that were not obtained from a GIS, it may be necessary to recalibrate the regional equations to the basin characteristics measured by StreamStats.

# Streamflow Information

One of the most critical elements necessary for implementing a successful StreamStats application in Kansas is the continual process of gathering streamflow information statewide. Without a backbone network of streamflow-gaging stations in the State, compilation of streamflow and subsequent statistical analyses would not be possible.

# Documentation

The documentation for this study will be a Fact Sheet to document the data, capabilities, and changes to existing equations in the application of the StreamStats web application. Training will be made available to all cooperator(s) on the use of the web application.

# Timetable

Table 2 presents the projected timeline to implement the USGS StreamStats program in Kansas. The project will begin September 1, 2009 and all final data will be delivered to the cooperator(s) by September 30, 2012. These dates are contingent upon the USGS and cooperator(s) signing a cooperative project agreement on or before September 1, 2009.

**Table 2.** Timeline of study steps.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Fiscal Year** | **2012** | | | | **2013** | | | | **2014** | | | |
| **Step / Fiscal Year Quarter** | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Training |  |  |  |  |  |  |  |  |  |  |  |  |
| Update national database |  |  |  |  |  |  |  |  |  |  |  |  |
| Geospatial data preparation |  |  |  |  |  |  |  |  |  |  |  |  |
| Validation |  |  |  |  |  |  |  |  |  |  |  |  |
| Documentation |  |  |  |  |  |  |  |  |  |  |  |  |

# Project Budget

The total funding required to implement the StreamStats program in Kansas is $315,000. Table 3 presents a breakdown of needed funding by Federal fiscal year (Oct. 1 – Sept. 10) and the steps necessary to implement the program. In view of the fact that multiple agencies and private citizens across Kansas will utilize this program, it would be inequitable and cost prohibitive to have one agency completely fund implementation of the StreamStats program in Kansas.

**Table 3.** StreamStats funding breakdown by year and step.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Steps / Year** | **2012** | **2013** | **2014** | ***Total*** |
| Training | $10,000 |  |  | ***$10,000*** |
| Update national database | $50,000 | $0 | $0 | ***$50,000*** |
| Geospatial data preparation | $50,000 | $115,000 | $0 | ***$165,000*** |
| Validation | $0 | $0 | $34,500 | ***$34,500*** |
| Documentation | $0 | $0 | $69,500 | ***$69,500*** |
| ***Cost per Year:*** | ***$110,000*** | ***$115,000*** | ***$86,000*** | ***$329,000*** |

# Delivery of Study Materials

The USGS will complete the world wide web application of StreamStats for Kansas and document the limitations and use of the application in a web page and Fact Sheet by September 30, 2014.

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