Flood-Flow Frequency of Ungaged Streams in New Hampshire

Introduction

Safe, efficient, and evironmentally sensitive design of roads, bridges, culverts, dams and other infrastructure in the riverine environment requires estimates of the magnitude of floods at 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals. Often, flood frequency estimates are determined from historical peak-streamflow data collected at USGS streamgages. However, it is impractical to gage all streams in New Hampshire and in most instances, the streamflow data required for flood-frequency analyses is not available. In such instances, techniques are commonly applied to estimate flood frequency and magnitude based on data collected on gaged streams in a similar hydrologic region—a technique referred to as regionalization.

Flooding on the Isinglass River in May 2006

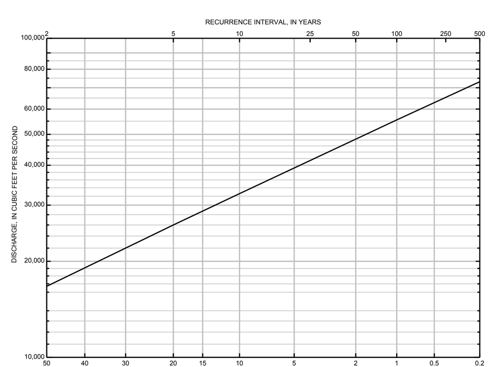
Regionalization involves finding statistical relations between flood frequency data determined at multiple gages in a region and the physical and climatic characteristics of the watershed upstream of the gages using regression techniques. The result is a set of regression equations for estimating flood frequency and magnitude that may use several explanatory variables, including, but not limited to drainage area, basin slope, channel slope, elevation, percentage of waterbodies or wetlands, or rainfall characteristics.

The USGS, in cooperation with the New Hampshire Department of Transportation, is developing equations for estimating flow frequency. The equations will be incorporated into StreamStats. StreamStats is a web-based tool that will allow users choose locations on an interactive map, obtain the basin and climatic characteristics that are required by the regression equations, and solve the equations.

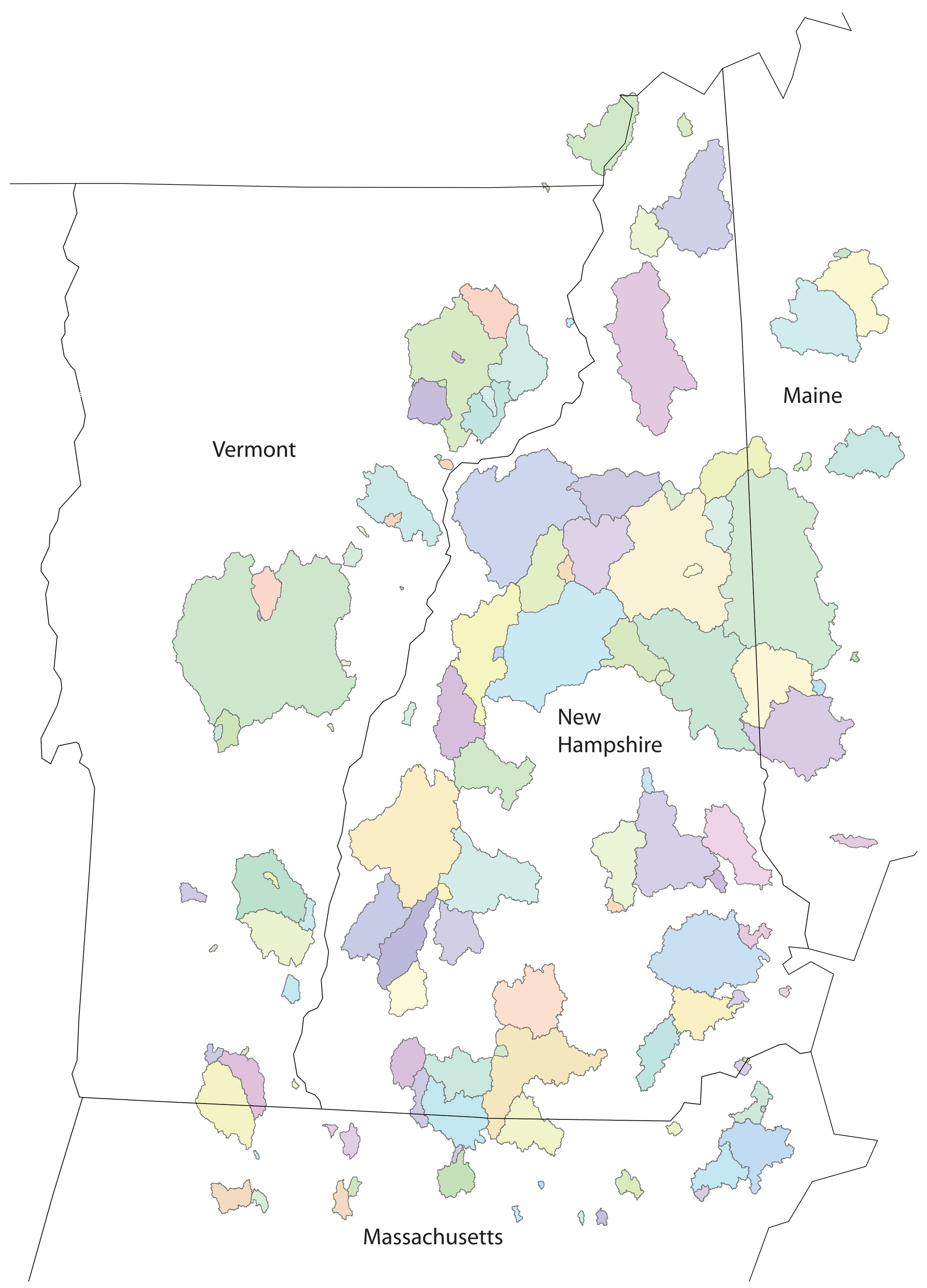
STEP 1: Determine Flood-Flow Frequency at Gaged Sites

All available streamflow records from active and discontinued streamgages on unregulated, rural streams in New Hampshire and adjacent, physiographically similar areas of Maine, Vermont, Massachusetts, and Canada will be assessed for suitability in the investigation. The figure to the right shows basins with peak-streamflow records that will potentially be utilized.

Flow-frequency curves, such as the one shown below, will be computed for all suitable gaged streamgages with at least 10 years of record using procedures outlined in the Interagency Advisory Committee on Water Data Bulletin 17B (1982).



Flow-frequency curve for Saco River near Conway, NH



Gaged basins with peak-streamflow records that may be used to develop the regression equations

STEP 2: Determine Basin Characteristics at Gaged Basins

More than a hundred basin characteristics for each streamgaging station used in this study will be determined. All basin characteristics will be determined using a GIS with currently available datasets. The basin characteristics will range from physographic characteristics, such as drainage area or channel slope, to climatic characteristics, such as the average snowfall or the 2-year, 24-hour rainfall.

Examples of various basin characteristics at gaged sites that will be determined by use of GIS methods.

Digital Elevation Model data:
- Drainage area
- Mean basin slope
- Mean elevation
- Percent of basin above 1,000 feet
- Percent of basin facing north
- Compactness or elongation ratio

Shown at right: Colorized, shaded-relief map derived from computer processing of 1:24,000-scale Digital Elevation Model (DEM) data. Blue is lower and white is higher relief. From USGS National Elevation Database.

Drainage and hydrography:
- Main channel length
- Channel sinuosity
- Area of surface-water bodies
- Channel slope
- Wetland area
- Strahler Stream order characteristics

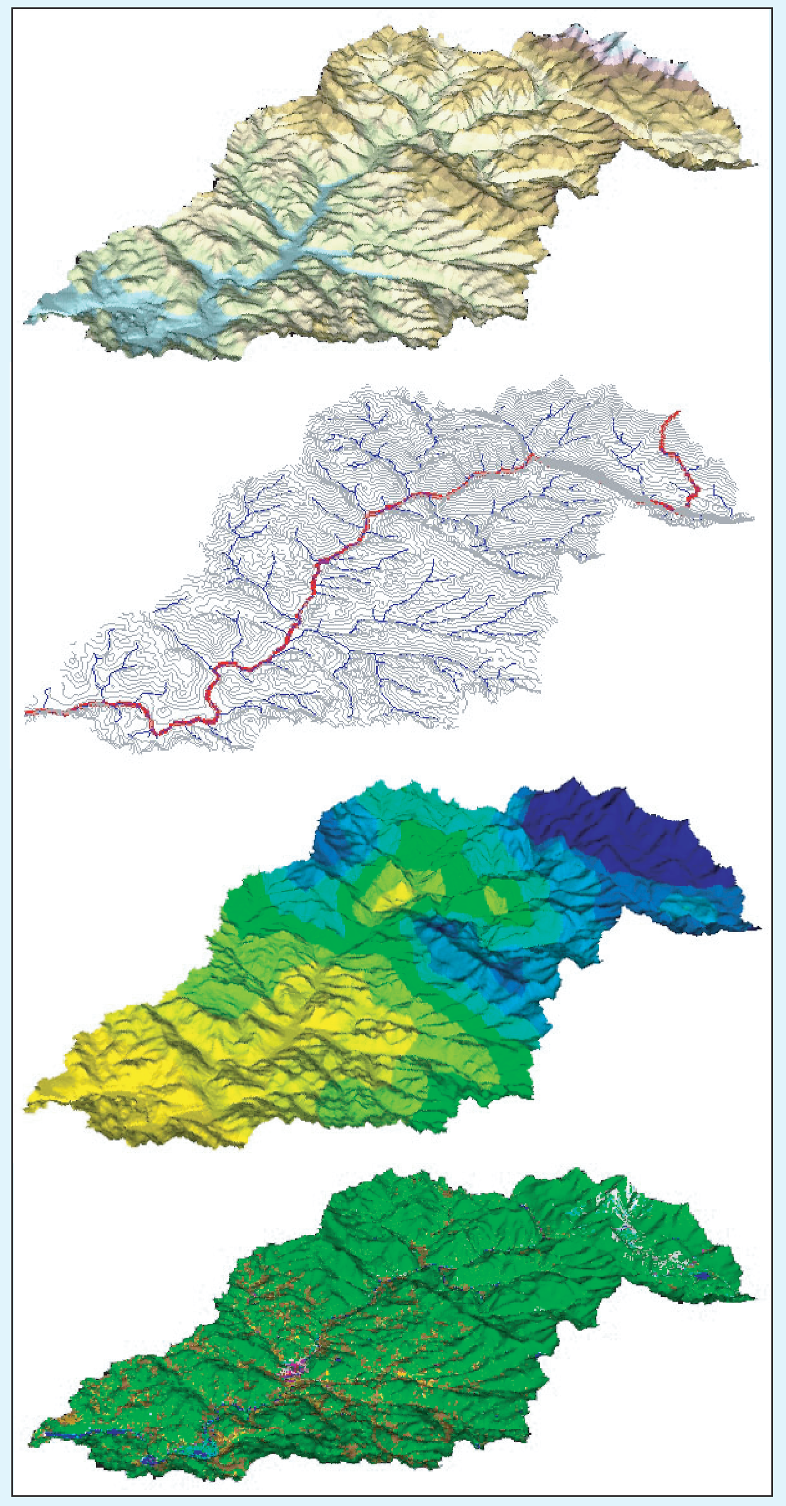
Shown at right: Watershed showing contour lines and hydrography. The main channel is shown in red, tributaries in blue.

Climate:
- Annual, seasonal, or monthly temperature
- Annual, seasonal, or monthly precipitation
- Snowfall
- Maximum temperature
- Minimum temperature
- 2-year, 24-hour rainfall

Shown at right: Watershed showing mean annual precipitation from 1960-1991. Yellow is lower and blue is higher precipitation.

Land cover, surficial geology, and soils data:
- Percent urban area
- Percent agricultural area
- Percent forested area
- Surficial geology characteristics
- Soil drainage characteristics
- Permeability

Shown at right: Land cover/land use shown from the National Land Cover Dataset (NLCD).



STEP 3: Develop Equations for Estimating Flood-Flow Frequency

Multiple regression techniques, employing generlized least squares (Tasker and others, 1986), will be utilized to define relations between basin characteristics found in Step 2 and flood peaks at the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval found in Step 1. The wide range of basin characteristics will be tested as predictive variables in order to determine which variables best explain flood-flow frequency and minimize the standard error of prediction. A Scientific Investigations Report explaining the equations in detail will be published in 2008.

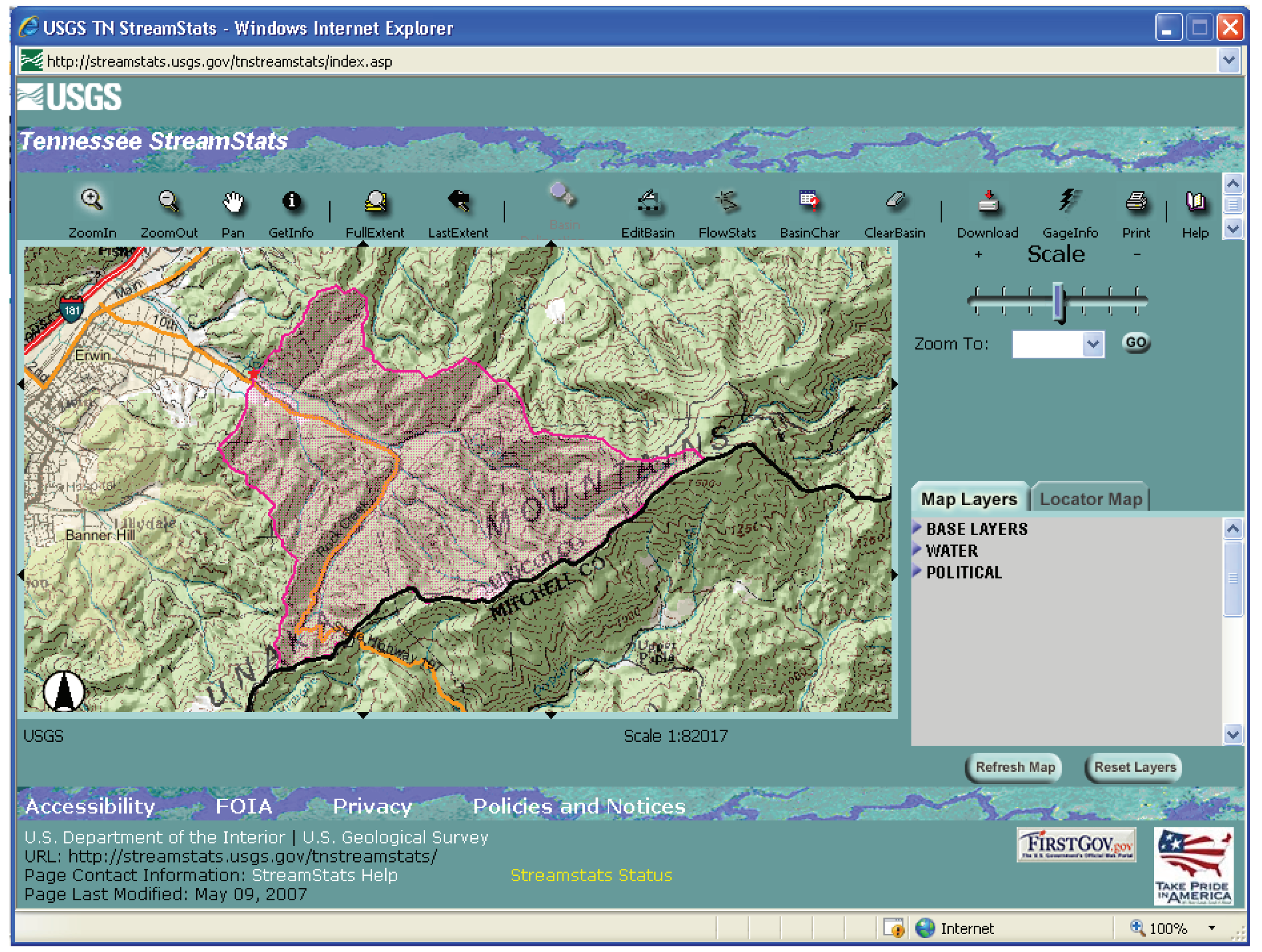
Regression equations for estimating flow-frequency characteristics in ungaged areas will be developed by relating peak-flow frequency to selected basin characteristics.

Q (flow frequency) = Function of drainage area + slope + elevation + stream length + precipitation + storage + degree of forest cover or other factors to be determined

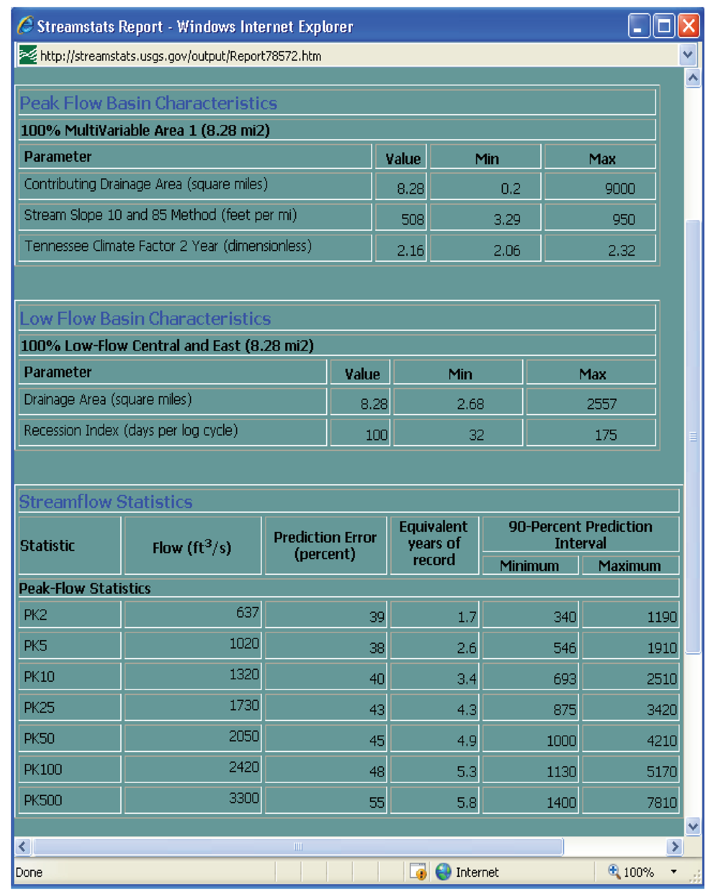
The regression equations will take the general form $Y_i = b_0 + b_1X_1 + b_2X_2 + ... + b_nX_n + \varepsilon_i$, where Y_i is the estimate of the dependent variable (peak flow estimate), for site *i*, X_1 to X_n are the *n* independent variables (basin characteristics), b_0 to b_n are the regression model coefficients, and ε_i is the residual error for site *i*.

STEP 4: Incorporate equations into StreamStats

The equations will be incorporated into streamstats. StreamStats is a internet browser based GIS application which will allow the user to interactively select a point on the stream. The application will delineate the drainage basin above the point of interest and determine the basin characteristics necessary to solve the regression equations for estimating flood-flow frequency.



Screenshot of the interactive map of the StreamStats application



Screenshot of the results window of the StreamStats application

REFERENCES

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17B of the Hydrology Subcommittee, Office of Water Data Coordination, U.S. Geological Survey, Reston, VA.

Tasker, G.D., Eychaner, J.H., and Stedinger, J.R., 1986, Application of generalized least squares in hydrologic regression analysis. In: Selected Papers in the Hydrologic Sciences. U.S. Geological Survey, Water Supply Paper 2310: 107-115.