Topographic Data and Flood Map Modernization

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The United States Geological Survey (USGS) is the federal agency that historically has been the custodian of our nationwide elevation data sets. In the 40s, USGS began developing a series of maps called the USGS topographic maps[1]. These maps have become the standard base maps for developing floodplain maps. Drainage areas are[2] defined using them, distances between cross section are determined by scaling off of them, runoff coefficients are determined using the land use information on them, the average slope of the watershed was derived using the contours on them. The engineer draws lines on the topo maps to show the surveyors where to survey cross sections. And when the modeling is completed and the elevations have been generated - the contours on the USGS topo map are used to define the extent of flooding and the high velocity conveyance area - the floodway.

Contours are shown on USGS Topographic Maps as brown lines of different widths. Each contour is a line of equal elevation; therefore contours never cross. The elevation difference between adjacent contours, called the contour interval, is selected to best show the general shape of the terrain. A map of a relatively flat area may have a contour interval of 10 foot or less. Maps in mountainous areas may have contour intervals of 100 feet or more. To meet National Map Accuracy Standards contour maps need to be accurate to within ½ the contour interval (e.g. 10 foot contour have an accuracy of +/- 5 feet. Topographic data is expensive to collect and does not change as fast of some of the other information on USGS's Topographic Map series. Therefore, the date of the topographic information is usually the date of the first topographic map for that area. When USGS updates these maps the "topo separate" is usually not updated.

When collecting elevation data, the vertical accuracy is directly related to the height of the camera. Analytical StereoPlotters were developed that allowed the operator to look at 2 overlapping aerial photographs and see them in 3D. The Photogrammetrist would hold what in his view scope would appear to be a floating dot on the ground and trace contour lines onto sheets of Mylar called separates[3]. Most of the topographic data on USGS's Topographic Map series were collected in this manner.

Computer technology prompted the need for digital elevation data. Due to file size issues, it wasn't deemed feasible at the time to digitally capture and store the lines themselves. Instead, a process was developed to capture a sampling of elevation points from the contour lines. The smallest sampling spacing selected (due to file size

[1] The USGS have several different sets of topographic maps. The series that covers 7 and 1/2 minutes of longitude (the 7 and 1/2 minute quadrangle maps) are the most accurate set within the series.

[2] The present tense is used and the statement is not qualified, because while local more accurate data would of course, be used in lieu of a nationwide set and computer routines have automated some processes these aberrations do not yet have a period of record that compares to the 30+ years that USGS topo maps have been deemed the base map for floodplain map development.

[3] It is assumed that these sheets were called separates because each of the layers that made up a USGS Topographic Map (Roads, buildings, streams and lakes, topography, etc, etc.) were displayed separately on a set of Mylar

sheets.
limitations at the time) was 30 meters. A grid was placed over the contour data and an elevation extracted every 30 meters (every 90 or so 100 feet). This data set is the USGS 30 meter DEM. Due to the fact that a relatively small number of samples are collected from the contour data, this sampling of data will not accurately represent any abrupt changes in terrain (stream banks, levees, ice ridges, floodplain shelf, etc.).

Today, in order to sample elevation values to generate the 30 meter DEMs; the topo separates are first scanned and vectorized. The vectors are then "tagged" with the elevation associated with that contour. The Tagged Vector Contours are converted to a Triangular Irregular Network (TIN) and an automated process is used to extract elevations every 30 meters. If a contractor develops Tagged Vector Contours as part of their process, they must provide them to USGS as part of their deliverables. USGS presently does not have a process for distributing these data to people interesting in using the data.

In order to help make the USGS Topographic Maps more useful in a digital environment, USGS has scanned the 7 and ½ minute quadrangle maps and has georeferenced these images. USGS calls this product Digital Raster Graphics (DRGs). DRGs can be displayed in a Geographic Information System, however they cannot be used in automated H&H (Hydrology & Hydraulics) tools. If all of the colors on the DRG except the brown contour lines are turned transparent, the contours on the DRGs can be viewed over other GIS data (e.g. draft floodplain boundaries). "Image catalogs" have been developed in GIS software that link all of the DRGs for an area or region. In addition, in some cases the software can make the collars on the USGS Topographic Maps transparent so that users can seamlessly view USGS Topographic Maps without having the collars obscure adjacent map panels.

Finally, it is important to recognize the relationship between the USGS's aerial photography and USGS's elevation data. The contour lines from the USGS Topographic Maps are one of the source data sets used in the development of USGS's DOQQs. Aerial photographs need to be processed to remove relief displacement. USGS uses the brown lines from the USGS Topographic Maps as the source information to create the Digital Terrain Model needed to remove the relief displacement when developing the USGS DOQQs.

Topographic Data Suitability for Flood Map Modernization Projects

Topographic Data Source	Suitability
Detailed Terrain	Acceptable for hydraulic modeling and floodplain mapping
USGS Quads	Not acceptable for detailed studies. Acceptable for approximate hydraulic modeling and floodplain mapping. Also useful for QA/QCing data conversion and redelineation projects where the original source topographic data was not detailed and no detailed terrain data is available.
USGS DEM	If it is hydro-enforced, it is acceptable for hydrologic modeling. It is not suitable for hydraulic computations, mapping or redelineation.

Definitions

Breaklines -A linear feature that describes a change in the smoothness or continuity of a surface. (ASPRS)

Contour lines - Lines of equal elevation on a surface. An imaginary line on the ground, all points of which are at the same elevation above or below a specified reference surface (vertical datum). (ASPRS)

DRG – Digital Raster Graphic. The name USGS has given its scanned Topographic Maps.

DEM - A digital elevation model is a digital cartographic representation of the elevation of the land. As used by the U.S. Geological Survey, a DEM is the digital cartographic representation of the elevation of the land at regularly spaced intervals in x and y directions, using z values referenced to a common vertical datum. (ASPRS)

Digital Orthophoto (also DOP) - A digital orthophoto is the digital version of a rectified (corrected) aerial photograph. (see also DOQQ)

DOQQ - Digital Orthophoto Quarter Quad – a digital orthophoto that is one quarter the size (3.75-minute) of a typical 7.5-minute (1:24,000 scale) quadrangle map.

DTM - A digital terrain model is similar to a digital elevation model (DEM). However, as used in this report, DTMs may be similar to DEMs, but they may also incorporate the elevating of significant topographic features on the land and mass points and breaklines that are irregularly spaced to better characterize the true shape of the bare earth terrain.

GIS - Geographic Information Systems include hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth.

Hydro-enforced - A DEM, TIN or topographic contour dataset with elevations removed from the tops of selected drainage structures (such as bridges and culverts) so as to depict the terrain under those structures. Hydro-enforced DEMs utilize drainage information to lower the elevations of selected grid cells. (ASPRS)

Hydrography - The graphical representation of water features such as streams, rivers, and lakes in map form. In a digital environment, hydrography may be encoded through a number of different data structures from simple graphics through complex relationships such as parent stream, flow direction, etc.
Mass Points - Mass points are elevation points that supplement break lines when creating a TIN. The TIN is in turn used to generate contours.

Mean Sea Level - The average location of the interface between ocean and atmosphere, over a period of time sufficiently long so that all random and periodic variations of short duration average to zero. (ASPRS)

NED -The National Elevation Dataset provides elevation data coverage of the continental United States, Alaska, Hawaii, and the island territories in a seamless format with a consistent projection, resolution, elevation units, and horizontal and vertical datums.

Photogrammetry -The science of deducing the physical three-dimensional measurements of objects from measurements on stereo photographs that photograph an area from two different perspectives. (ASPRS)

Raster Data - An abstraction of the real world; where spatial data is expressed as a matrix of cells or pixels; with spatial position implicit in the ordering of the pixels. With the raster data model, spatial data is not continuous but divided into discrete units. This makes raster data particularly suitable for certain types of spatial operation, for example overlays or area calculations. Unlike vector data however, there are no implicit topological relationship. (AGI GIS dictionary)

Raster Matrix - A regular (evenly spaced) pattern of lines that forms a uniform grid.

Triangulated Irregular Network (TIN) - A set of adjacent, non-overlapping triangles computer from irregularly spaced points with x,y coordinates and z-values. The TIN data structure is based on irregularly spaced point, line, and polygon data interpreted as mass points and breaklines and stores the topological relationship between triangles and their adjacent neighbors. The TIN model may be preferable to a DEM when it is critical to preserve the precise location of narrow or small surface features, such as levees, ditch or stream centerlines, isolated peaks or pits in the data model.

Vector data - An abstraction of the real world where positional data is represented in the form of x,y coordinates. In vector data, the basic units of spatial information are points, lines and polygons. Each of these units is composed simply as a series of one or more coordinate points, for example, a line is a collection of related points, and a polygon is a collection of related lines.

Many of the items in this Glossary were obtained from “Geodetic Program Needs of Louisiana and Wisconsin – Report to Congress”, August, 2001, 38 pp. (See www.ngs.noaa.gov)

Definitions labeled ASPRS are from Maune, 2001.

Author - Alan Lulloff with contributions from David Maune