

Application of GIS to estimate the volume of the Great Johnstown Flood

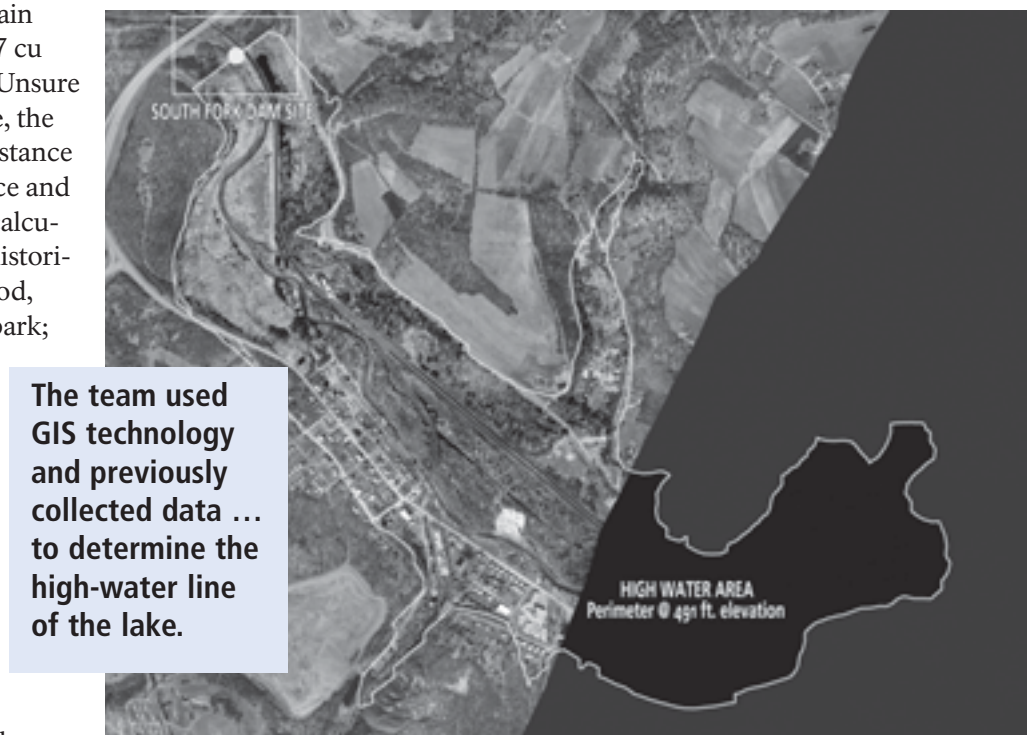
Johnstown Flood National Memorial was created in 1964 to commemorate the Great Johnstown Flood of 1889 and preserve the remnants of the South Fork Dam. The earthen dam formed a reservoir known as Conemaugh Lake on the South Fork of the Little Conemaugh River. Originally a reservoir for the Pennsylvania Mainline Canal, in the 1800s the South Fork Fishing and Hunting Club used the lake as a resort for wealthy industrialists. Following heavy rains, the dam broke on 31 May 1889, killing 2,209 people in the flood.

Historical documents presented conflicting information regarding the estimated size of the lake and the amount of water released in the flood. An 1891 engineering report in *Transactions*, the journal of the American Society of Civil Engineers, estimated the reconstructed volume of Conemaugh Lake to be 450,000,000 cubic feet (12,744,265 cu m). However, an 1889 article in *Engineering News and American Railway Journal* estimated the lake to contain 640,000,000 cubic feet (18,125,177 cu m) of water when the dam burst. Unsure which estimate was more accurate, the park staff requested technical assistance from the Northeast Regional Office and the Water Resources Division to calculate the estimated volume of the historical Conemaugh Lake. Kathy Penrod, natural resource specialist at the park; Alan Ellsworth, Northeast Region hydrologist; and James Farrell, Northeast Region GIS specialist, conducted a study to assess the historical estimates of the volume of water held by the dam when it burst.

The team used GIS technology and previously collected data from the State of Pennsylvania and the National Park Service to determine the high-water line of the lake. A high-resolution, geo-rectified aerial photograph (all points on the photo correspond to real-world coordinates) served as a background base image of the South Fork Dam region (fig. 1). A digital elevation model (indicating vertical dimensions over the area) yielded 1-foot (0.3-m) contours. This information and the known elevation of the top of the dam gave us a boundary of Conemaugh Lake

before the dam breach. Placing this high-water line over the aerial photo revealed an immediate and accurate depiction of the basin. The high-water level lined up with houses and other structures known to have been situated just above the flood area. The high-water level and elevation values within the space that had been the lake enabled the team, using ArcGIS 3D Analyst software, to determine the volume of water in the lake when the dam was breached.

The GIS study produced a lake volume of 449,093,200 cubic feet (12,716,900 cu m), which supports the estimate from the American Society of Civil Engineers' report as the more accurate of the two historical estimates. This volume is approximately equal to 780 American football fields under 10 feet (3 m) of water. The park can now use the confirmed volume in its interpretive exhibits with confidence. The GIS study may also lead to a new exhibit at the park; the park now has a GIS model of the former lake and images of the estimated lake boundary overlaid on modern aerial photography and topographic maps showing present-day towns and villages.



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Figure 1. This high-resolution aerial photograph of the Johnstown, Pennsylvania, area is overlaid with the high-water line of former Conemaugh Lake at the time of the catastrophic flood in 1889. Using GIS technology coupled with topographic data, the National Park Service was able to determine the lake's perimeter, calculate the volume of the tremendous flood, and compare the results to historical volume estimates. NPS NORTHEAST REGION

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