CONDUCTING SIMPLE SEDIMENT SURVEYS USING MODERN GPS, SONAR, AND GIS TECHNOLOGY

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Abstract Procedures for measuring the volume of sediment in a reservoir were established by the Soil Conservation Service, now the Natural Resources Conservation Service, in 1935 in connection with a nationwide study of reservoir sedimentation. Many of these procedures, with some modification, are still used by NRCS and other federal agencies today.
The primary purpose of a reservoir sedimentation survey is to determine the volume and weight of sediment accumulated between surveys, or during the recorded period of storage. Information obtained from reservoir sedimentation surveys may be used to:

Estimate sediment yield for a given watershed,
Evaluate sediment damages,
Provide basic data for planning and designing reservoirs,
Evaluate the effects of watershed protection measures,
Determine the distribution of sediment in a reservoir, and/or
Predict a reservoir's sediment storage life expectancy, or period of useful operation.

For accuracy, NRCS has long used the range-cable survey or contour methods for small reservoirs. The range-cable method involves stretching aircraft cable across the reservoir and collecting depth measurements using a fathom line lowered from a john boat with a center well. The end points of each line were surveyed back to a benchmark, usually the structure monument. By measuring the distance along the line each data point could be located with some degree of accuracy. Typically, 10 ranges, equally spaced along the length of the reservoir and parallel to the dam, were run with 10 data points per range. Back at the office, each range was drawn as a cross section and divided into polygons. The area between the polygons was calculated and multiplied by the distance between 2 ranges to calculate a volume. The sum of the volumes equaled the total reservoir volume. If the original reservoir volume was accurately calculated and documented in the as-built plan, a simple sediment survey could be achieved by subtracting the calculated volume from as-built volume. This method required approximately 1 week in the field, in addition to the hours of tedious office work. The contour method involved measuring depths at random locations across the reservoir, plotting the elevations on a map, contouring them and using a planimeter, measure area of each contour to calculate the volume. The problem with this method was accurately locating the data points. Detailed procedures for the range method and contour method can be found in the NRCS National Engineering Handbook, Section 3, Chapter 7 - Field Investigations and Surveys [NEH3-7]. These reservoir sedimentation surveys followed the guidance outlined in NEH3-7for the contour method, using modern location and sounding equipment.

Using modern technology, simple sediment surveys can be completed in a fraction of the time required using these older methods and with a higher degree of accuracy. Between May 11 and May 14, 2009, the authors conducted five sediment surveys by randomly collecting horizontal

data points (lat-long coordinates) and corresponding water depths. A 16-ft flat bottom shallow draft boat with a well in the middle was used as a basis from which to take measurements. Horizontal data points were collected using a Topcon GMS-2 GIS mapping GPS receiver. This device has a kinematic accuracy of 10mm. Water depth measurements were taken with the use of a Garmin GPSMap 535s duel frequency chartplotter. The 535s has a transducer capable of emitting 50kHz and 200kHz wave frequencies simultaneously or individually. The higher frequency is less likely to penetrate the sediment surface. A hand held fathometer device, capable of emitting 400kHz sonar frequency, was also used. Calibrations to ascertain keel offset of the 535s transducer were calculated prior to recording the water depth measurements. The GMS-2 GPS was set to collect a waypoint every 10 seconds, giving both an audible and visual signal. When the unit indicated that a waypoint was collected, the depth displayed on the chartplotter was recorded with the corresponding waypoint number. If the chartplotter was not responding, which sometimes occurred in water depths of less than 2 feet, the handheld fathometer was used. Data points were collected in this manner while moving the boat at a slow and constant speed around the perimeter and then in transects across the width and the length of the reservoir. Between 450 and 560 data points were collected for each survey. The average time spent collecting data for each survey was about 2 hours.

The measurements were processed by downloading the waypoints from the GPS receiver to a computer in an Excel format. Corresponding depths were entered manually to complete the data set. The data set and a GIS generated outline of the reservoir were imported into Civil 3D, a CAD program, which was used to create a contour map of the reservoir bottom and calculate the volume. It should be noted that these surveys were conducted as preliminary investigations. As such, the current water volume, as calculated in each report, was compared to the original sediment storage capacity. The difference between the two becomes the total amount of sediment accumulation. If the results of a preliminary investigation indicated excessive sediment accumulation, then a second reservoir sedimentation survey would be conducted to determine actual sediment depth and distribution in preparation for sediment removal.