How much water is in your dam?

By Peter Gibbings[1] and Steven Raine[2]

Accurately measuring the volume of water in on-farm storages is an important first step to planning the area of crop to be planted and assessing irrigation management options. Changes in the depth of water over time are commonly used to estimate the volume of water that has been captured as either overland flow or tail-water recycling.

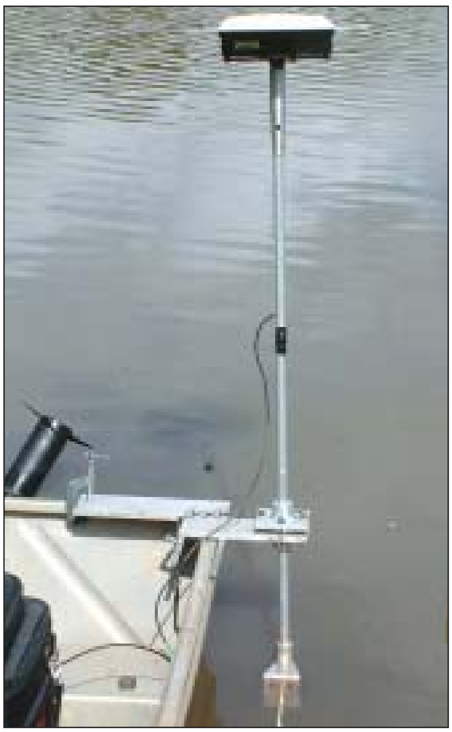
The change in storage water level is also often used to estimate the volume of water applied to fields and as an input in calculating water use efficiencies. But in many cases, both the depth to volume storage relationship and the total volumetric capacity of the constructed storage are substantially different to the original storage design specifications.

Accurate measurements of the constructed storage volume have traditionally been obtained using standard surveying techniques which require the storage to be empty. But recent research at the University of Southern Queensland has demonstrated that it is possible, using low-cost hydrographic mapping techniques, to obtain these measurements more rapidly and cheaply when the storage has water in it.

Hydrographic measurements

The hydrographic technique involves the use of a GPS and low-cost external depth sounder mounted on a boat (see photo). The depth sounder is calibrated on site to overcome the impact of water quality differences between storages.

The boat is navigated around the walls of the storage and then in transects across the storage with a series of depth soundings recorded at fixed time and/or spatial intervals. For each sounding, the three-dimensional position of the dam floor is measured using the GPS position, the offset distance between the GPS antenna and depth sensor, and the depth obtained from the sounder.



GPS antenna mounted above the electronic depth sounder.

Digital elevation model of the dam.

Validation

Validation of the hydrographic mapping technique was conducted on a newly constructed, 132 ML storage located at Stanthorpe. Three independent sets of measurements were taken at different transect spacings and different point spacings:

- Ten metre transect spacing and five metre point spacings along the transect lines;
- Twenty metre transect spacing and 10 metre point spacings along the transect lines; and,
- Twenty metre transect spacing and 20 metre point spacings along the transect lines.

Total volume (Table 1) and depth-volume relationships (Figure 1) derived using the hydrographic method were compared with data obtained using conventional RTK GPS surveying measurements taken just before the dam was filled. For the storage assessed, the maximum volumetric error measured at any water depth was less than two ML.

Additional validation was undertaken using weighted lead line depth measurements at regular intervals across the dam. The average deviation between the lead line point measurements and the hydrographic model ranged from nine to 107 mm.

A digital elevation model (DEM) of the

TABLE 1: Effect of point density on accuracy of storage volumes measured using the hydrographic method

Transect spacing (m)	Point spacing along transect (m)	Volume measured (m^3)	Variation from RTK GPS measured volume	Average difference between point and hydrographic measured depth (mm)
10	5	132144	+0.13%	9
20	10	130058	–1.4%	107
20	20	130615	–1.0%	64

storage was constructed (see photo) and the differences in volume for each transect spacing calculated (Table 1). In all cases, the difference in total volume measured using the hydrographic and conventional RTK methods varied by less than 1.5 per cent.

The results suggest that the accuracy of volume measurement is a function of the point density. The closer the points are together, the better the accuracy as the DEM joins adjacent points with a flat surface. But increasing the measured point density increases the data collection and processing requirements.

A major source of error is encountered around the edge of the storages where the wall and floor surfaces are concave. So for larger storages as used in the cotton industry, it is expected that the volumetric error due to decreasing point density will be smaller because these edge volumes represent a smaller proportion of the total volume. But further work is required to identify the optimum point spacing and transect widths for a range of dam sizes.

FIGURE 1: Dam volume versus water depth

Future work with larger storages

The results show that the volume of on-farm dams can be accurately measured (less than 0.2 per cent error depending on point density) without the need for the dam to be empty. Further work is required to confirm the accuracy of the hydrographic measurements on larger storages and to refine the computational and analytical interfaces.

It is envisaged that this technology will be able to be integrated with automated storage depth measurements to enable the accurate assessment of changes in stored water volumes. This package should enable the real-time measurement of storage inflows, evaporation and seepage losses as well as water usage.

For further information on the hydrographic measurement of on-farm storages contact Erik Schmidt at the National Centre for Engineering for Agriculture on 07 4631 1347.

1. Faculty of Engineering and Surveying, University of Southern Queensland.
2. National Centre for Engineering in Agriculture, USQ