

Hydro acoustic storage volume assessment

Actualization of the storage volume and surface-volume relation.

Context

For the operation of all types of reservoirs the knowledge of the exact storage volume is a crucial information. During changing environmental conditions, like floods and draughts, but also land use changes in the catchment, the necessity for adapted operation of reservoirs can be eminent.

As a basis of such operational measures lies the actual and profound knowledge of the contained amount of water. The surface-volume relation derived from the bathymetric 3D-model of the reservoir, can tell the operator, which volume relates to which level in the reservoir. Without knowing the exact amount of available water, the vulnerability during extreme events increases significantly.

Objectives/Goals

- Assessment of actual storage volume
- High definition morphological map
- Derivation of a surface-volume curve

Method and Equipment

Initially a high resolution bathymetry was created using a WASSP F3Xi multibeam echo sounder with 160 kHz, 224 single beams and an opening angle of 120° resulting in a swath width of ca. 3 times the water depth. The multibeam was combined with a Hemisphere V123 Compass for location and heading information and with a WSP-038 IMU unit for Roll/Pitch (0.25° accuracy) and heave (5 cm accuracy) correction. The system allowed for a vertical resolution of ± 2 cm and horizontal resolution of ~ 20 cm. Since the outer beams of each multibeam system tend to produce more measurement errors than the inner beams, the driven lines are so close that the footprint of the last line is covered by 50% by the next footprint. In that manner the entire area is covered by inner beams at least once. The entire survey took ~ 50 hours on the boat (ca. 300 km of boat tracks) and created 1000 GB of data. For the post processing and creation of maps 60 hours were needed.

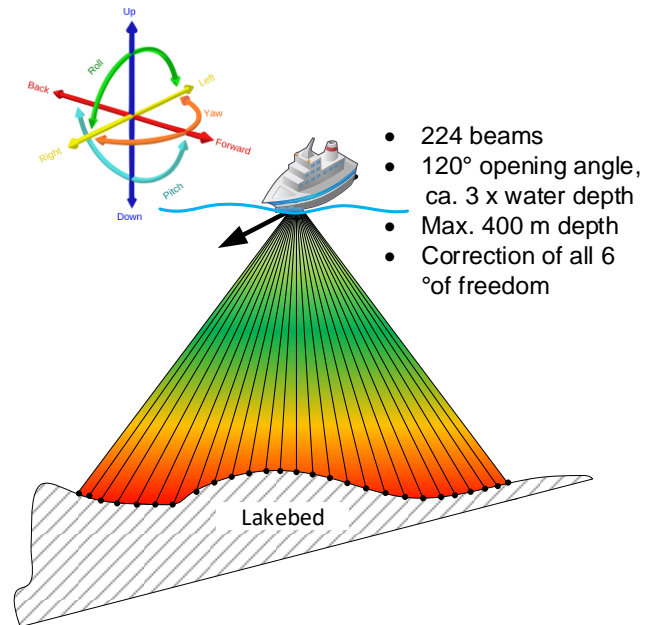


Fig. 1. Setup of the acoustic measurement system

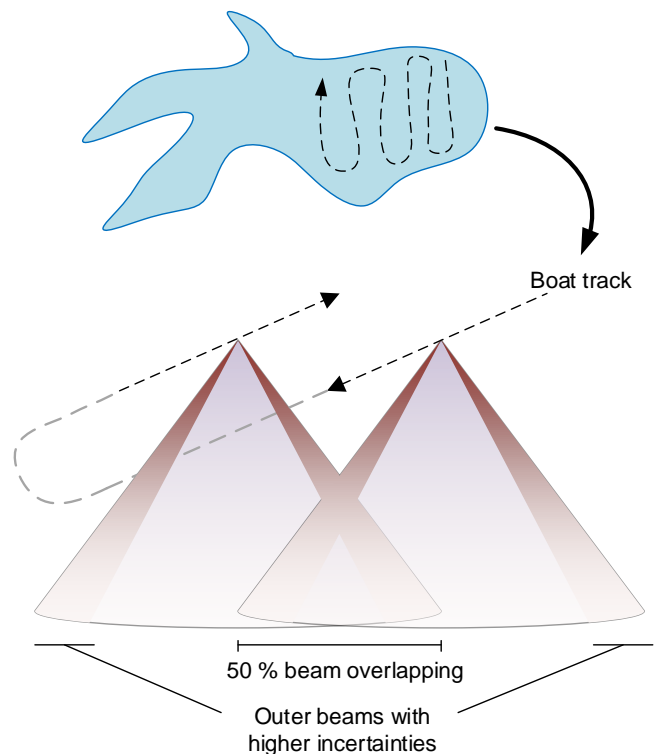


Fig. 2. Beam overlapping to increase bathymetric data quality

Results

The results of the bathymetric survey show the morphology of the actual lake bottom in high resolution (Fig. 3 & 4).

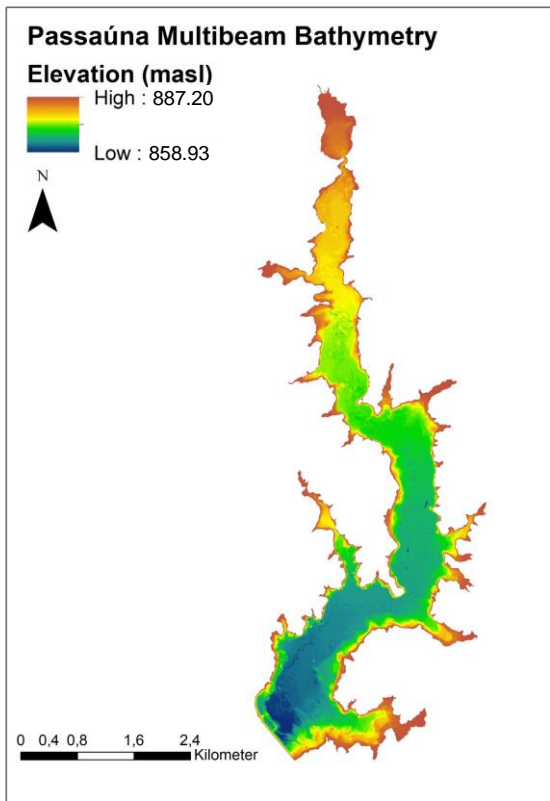


Fig. 3. Bathymetric map of Passaúna reservoir with a 20x20 cm resolution.

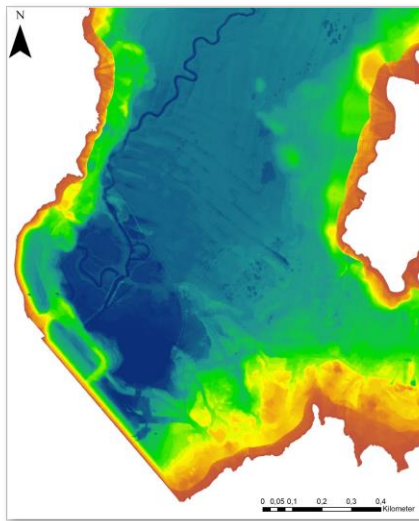


Fig. 4. High resolution map of the area in front of the Passaúna dam.

We derived a 3D model from the bathymetric measurements and calculated the water level–volume relation (WLVR) for maximum water level. The actual volume of the Passaúna reservoir is 69,248,500 m³ at a level of 887.2 masl. From the SVR you can see that with a draw down of 4 m the volume is reduced by ~42%.

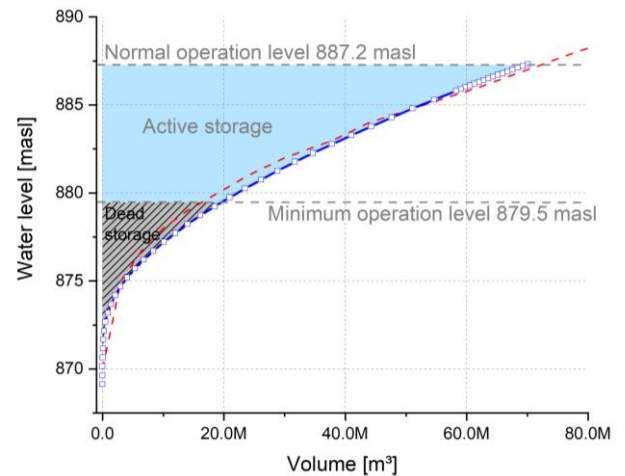


Fig. 5. Water level–Volume Relation (WLVR) for the Passaúna reservoir (blue line) in 2019. The storage volume was calculated for each 10 cm for the upper 2 m, and each 1 m for the rest of the water level (blue squares). The red lines shows the old SVR before impoundment (Source: Sanepar).

Discussion

The results show the direct value of a bathymetric multibeam survey. The morphological information might be useful for any type of sampling or construction work in the reservoir. As the actual storage volume and especially the WLVR were actualized, we recommend to use this data, which allows the operator to manage the reservoir during extreme situations. Additionally, a repeated survey or a combination with sediment detection may give valuable predictions for the life time of the reservoir (see Flyer on Sedimentation).

Innovation/Outlook

- ✓ High precision storage volume assessment.
- ✓ Basis for future siltation rate calculations.
- ✓ Secure long-term planning for the reservoir operator.

Authors Stephan Hilgert, Klajdi Sotiri and Stephan Fuchs
 Funded by Federal Ministry of Education and Research, BMBF

Contact stephan.hilgert@kit.edu
 Web www.mudak-wrm.kit.edu