# Surveying Above and Below the Water Line

| SURFACE TYPE | MEAN (M) | RMS (M) |
|---|---|---|
| Hard identifiable features (eg road markings, tactile paving etc) | 0,02 | 0,06 |
| Hard non-identifiable features (eg on unmarked road or pavement | 0,00 | 0,05 |
| Soft features (short) - eg short grass, typically 5cm to tip | 0,07 | 0,04 |
| Soft features (medium) - eg shin height vegetation, typically 20-25cm to tip | 0,13 | 0,09 |

Phil Mills presents a case study of Derwent Reservoir in Northeast England, looking at the accuracy of photogrammetry underwater and surrounding the reservoir and at the value of the imagery for assessing the condition of the embankment.

Occasionally there is a requirement to survey a site which has standing water present. This situation could for example occur at an old quarry where there may be a number of such areas and they could differ substantially in depth. This investigation tested whether data captured using an SUA could measure reasonable depths of water and determine at what depth the level accuracy became unacceptable. It included a general assessment of accuracies achieved on adjacent areas.

## Challenging environment

The Derwent Reservoir was chosen as a suitable location for this test because it has a known slope underwater against which to test the surveyed detail. In addition, the area has complex relief (65m height difference between highest and lowest points) providing a challenging flight environment, together with hidden/obscured detail to test the image resolution. Downstream of the dam there is a weir system leading into the River Derwent and adjacent fields often have lying water.

The survey was carried out using a QuestUAV Q200 fixed wing aircraft, capable of productive flights of over 45 minutes duration in winds of up to 35mph. An appropriate flight plan was drawn up in advance which covered the area of interest in addition to the land on the downstream side of the dam, which is owned by Northumbrian Water.

On the day of the survey the weather was calm, dry and overcast with variable visibility. A calm day had been specifically chosen for the test, so that there would be minimal rippling of the water surface and therefore the best conditions for surveying the underwater detail.

## Maintaining Control

Before flying, control markers were placed around the site and surveyed using a Trimble GPS receiver referencing an onsite base station. Repeat measurements were taken at these points to ensure accuracy and the mean position of each point was taken to be correct. These control points were used later in the process to refine an initial alignment of the photography. An additional 77 check points were taken across the site, sampling various surfaces, including roads, water level and vegetation of varying height and density. These points would act as independent checks against the final model, in order for a statistical analysis to be conducted. They played no role in the production of the final model.

## Let’s fly

During the flight, survey data was captured in the form of high resolution still photography. Over the course of the 22 minute flight 61 ha were covered, with over 600 photographs captured in the process. The flying height was 300 ft above the water. These photographs were then processed using Agisoft Photoscan, in conjunction with the ground control data, to produce accurate 3D coordinates and orthomosaics.

Once the final models had been completed the resulting point cloud was exported to a specialist survey package to compare against the ground survey check points.

## Results on land

Table 1 summarises the results of the flight, when compared to the ground survey check points. Points have been grouped into categories in order to reflect the different features to which they were related. “Identifiable” point accuracy is in XYZ, the remainder are in Z (height) only.

On soft surfaces the mean value is used to apply a generic height correction to vegetation areas.

The water level of the reservoir as recorded by the flight agreed with the surveyed level, the spread of readings being 2cm.

## Blocked drains

The survey also highlighted a number of additional aspects. The field drains downstream from the dam are clearly identifiable: they are seen as changes in grass texture and colour on the orthomosaic and as waves in the contour drawing. On the grassed downstream face of the dam the location of the uppermost drainage blanket is also clearly visible along half of the dam, again shown by changes in grass colour. Along the middle section of the dam there is no visible evidence of the blanket. In discussion with Northumbrian Water it was concluded that this is most likely to have been due to drains in that section blocking over the course of the 50 years they had been in situ.

Also present and identified, are small areas of water within the grassed area, which show as dark patches at the south end of the dam near the woodland and in the field north of the visitor centre.

## Results underwater

Whilst the underwater detail lacks clarity in the photography, Photoscan was able to produce a reasonable ground model to a water depth of around 1½m. Down to a depth of 0.4m the model was fairly smooth, after this point levels of noise in the generated surface increased substantially. Even so, by taking the lowest point in the main part of the point cloud reasonable estimates of water depth (within 15% of real depth) could be calculated to a depth in excess of 1m.

Underwater detail was only visible on vertical or near vertical images, where the effect of refraction is minimal. At oblique angles only reflections from the water surface were visible. In this sense the water acted as a ‘self-filter’. Because the underwater imagery is only present at near vertical angles, the heights calculated will never be as accurate as those of ground points.

## Conclusion

The results obtained showed that reasonable estimates can be obtained for clear water depths down to 1½m. Successful commercial use of this method would require understanding of the methods of data collection, how to extract the relevant data and the limitations to the accuracy of such data.

The survey carried out for this experiment was designed and planned in advance in order to give the best possibility of producing a good underwater model. The repeatability of these results in less than ideal conditions is unknown.

The initial requirement to test whether it is possible to calculate reasonable estimates of depths of shallow standing water from aerial photography was met.

It was also possible to identify shallow underground features, for example underground pipes/membranes as well as lying surface water. Whilst such features can be quickly identified from the aerial data, additional specialist knowledge of the site is required to interpret the results and determine their significance, possibly prior to commissioning a much more detailed investigation.

*This article was published in Geomatics World September/October 2017*