STORMWATER POND SURVEYING: WHY PROBE WHEN YOU CAN PING

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ABSTRACT

A new method of bathymetric surveying of stormwater ponds is saving time, increasing data quality and reducing health and safety risks for field staff. It involves driving a remote controlled Q-boat around stormwater ponds with an Acoustic Doppler Current Profiler (ADCP) and collecting accurate bathymetric and position data, which can be used for multiple purposes.

Auckland Council manages nearly 500 stormwater ponds across the Auckland region, so maintenance works do present a significant cost. To provide a means to prioritise pond maintenance, Pattle Delamore Partners (PDP) and Auckland Council are using this new methodology to calculate sediment accumulation volumes, comparing the ADCP results to as-built drawings of when the pond was built or last maintained. This information is useful to determine whether the stormwater pond is functioning efficiently, whether dredging maintenance is required, and where greatest sedimentation is occurring within the pond. The data can also provide an indication of dredging costs based on the sediment volume that requires removal.

There are numerous advantages that the Q-boat and ADCP methodology has over the traditional manual probe surveying method including: faster data collection; greater data accuracy; and reduced health and safety risks. In addition, comparative evidence between the two methods suggests that the manual probe surveying method may actually be compromising the integrity of the pond.

In this paper, the field techniques used to collect ADCP data and the post field data processing techniques will be explained, and the potential uses of data outputs explored. The benefits and shortfalls of this method compared to the manual probe surveying method will also be discussed with examples given.

KEYWORDS

Pond Surveying, Acoustic Current Doppler Profiler, Pond Dredging.

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Guido Budding and Dylan Visser are engineering students from the Netherlands. They were interns at Auckland Council in 2016 and worked alongside PDP staff to develop the pond surveying method and carry out data collection.

1 INTRODUCTION

Auckland Council currently own 487 stormwater treatment ponds within the Auckland region (342 are wet ponds/wetlands, 145 are dry ponds) (Auckland Council, 2014). Approximately every 20 to 30 years, stormwater treatment ponds require major renewal works; commonly to remove sediment captured as part of their water quality treatment function.

To provide prioritisation for ponds that are nearing remedial works, Auckland Council requires bathymetric surveys to be undertaken to assess sedimentation accumulation volumes. The method that had been used by Auckland Council to obtain this information in the past was the manual probe method. A new methodology using an Acoustic Doppler Current Profiler (ADCP) mounted within a Q-boat was proposed by Pattle Delamore Partners (PDP) and trialed as part of this project. The method had previously been utilised by PDP in 2015 with success.

An ADCP uses the principle of sound waves called the Doppler effect. The ADCP works by transmitting "pings" of sound at a constant known frequency into the water, which are reflected back to the device by particles of sediment. The ADCP uses the return signal to calculate the depth of the pond. The depth profile of the pond is then plotted, and can be compared to as built bathymetry to calculate the volume of accumulated sediment.

The trial of the methodology was a success, and the method is currently being used to carry out further stormwater pond surveys for Auckland Council. This paper will explain field techniques used to collect ADCP data and the post field data processing. The potential uses and applications of data outputs will be explored, and the benefits and shortfalls of this method compared to the manual probe surveying method will also be discussed.

2 METHOD

2.1 FIELD PROCEDURE

The field procedure is the highlight of the methodology. This is where the majority of the method's advantages are seen over alternative methods. The field procedure is time efficient, accurate, and safe for the field staff operating the equipment. The basic steps involving set-up and data collection are outlined in this section, along with some common problems that arise and how they are overcome.

2.1.1 EQUIPMENT

The set up required to undertake pond surveys consists of a Oceanscience Q-boat 1800 D (Q-boat), SonTek HydroSurveyor-M9 (ADCP), GPS, Laptop or tablet, remote control and a vehicle to transport the equipment to site. Similar equipment from other manufacturers could be substituted based on preference and availability.

The Q-boat used in this method is a remotely-operated electric boat designed to make safe, unmanned measurements of bathymetry with an ADCP (Oceanscience, 2011). It can be customized with a number of different types of environmental equipment, based on its intended purpose.

The ADCP is a system designed to collect bathymetric, water column velocity profile, and acoustic bottom tracking data as part of a hydrographic survey. The two key components of the system are the HydroSurveyor Acoustic Doppler Profiler platform, and the data collection software called "HydroSurveyor" (SonTek, 2012). The ADCP is used to measure bathymetry in this methodology. An in-built GPS is also attached to the boat and connected wirelessly to the laptop, allowing the location of each measurement to be recorded.

2.1.2 ASSEMBLY

Once arriving on site, set up is relatively quick. The best place to park and the best point to launch the boat is scoped on foot. This is usually provided by maintenance access ways which are pathways built into pond designs to allow for machinery to access the pond for dredging.

The boat is assembled near the launch point into the pond. This requires attaching the propellers to the rear of the boat, connecting and strapping in the boat batteries, positioning the ADCP into the holder in the centre of the boat, and connecting the cables to the Program Control Module (PCM), radio and GPS. Once set up, the boat can be heavy to lift and usually requires two people to carry it. Photograph 1 below shows the boat once assembled and deployed.

Photograph 1: The Q-boat set up with the propellers and GPS, ready to survey.

2.1.3 CALIBRATION AND CONNECTION

Calibration of the compass is carried out using RiverSurveyor software on the laptop or tablet. This should be done away from any magnetic interference such as a bridge or steel posts (Mueller, 2012). Two 360 degree rotations of the boat are made, while simulating the pitch and roll of the boat that is expected while surveying the pond.

Once calibration is passed, HydroSurveyor software is used to undertake the survey of the pond. A new project is created for each new pond surveyed, with the survey area added onto the appropriate point on the map. The first time a survey is carried out, the appropriate measurements and offsets in relation to a central reference point (CRP) need to be entered to ensure the correct boat set up is provided to Hydrosurveyor. However for subsequent ponds, previous surveys can be used as a template to save time.

The ADCP and GPS must be connected through HydroSurveyor and within range before surveying can commence.

2.1.4 COLLECTING DATA

The boat is then lifted and placed into the water near the edge of the pond. The remote control is turned on, then the lid of the boat is opened and the ignition turned on the boat. The propellers will now be operational.

In HydroSurveyor, data collection is started, and the boat is driven around the pond using the remote control. On the laptop, the path the boat has taken will be shown, alongside the depth soundings and the interpolated bathymetry. Although the boat is capable of travelling at speeds of up to 1.8 m/s, the boat should not be driven at full speed. A sounding is obtained every second, therefore if the boat is driven too quickly, less data is collected.

A methodical path should be taken to cover the pond, starting with the perimeter of the pond, and then filling in the centre with vertical and horizontal lines. Post survey data processing will interpolate between the points and fill in any gaps that were not surveyed, so it is not essential to cover the entire pond surface. An example of acceptable coverage of a pond is shown in Figure 1 below. The blue lines represent the path of the boat.

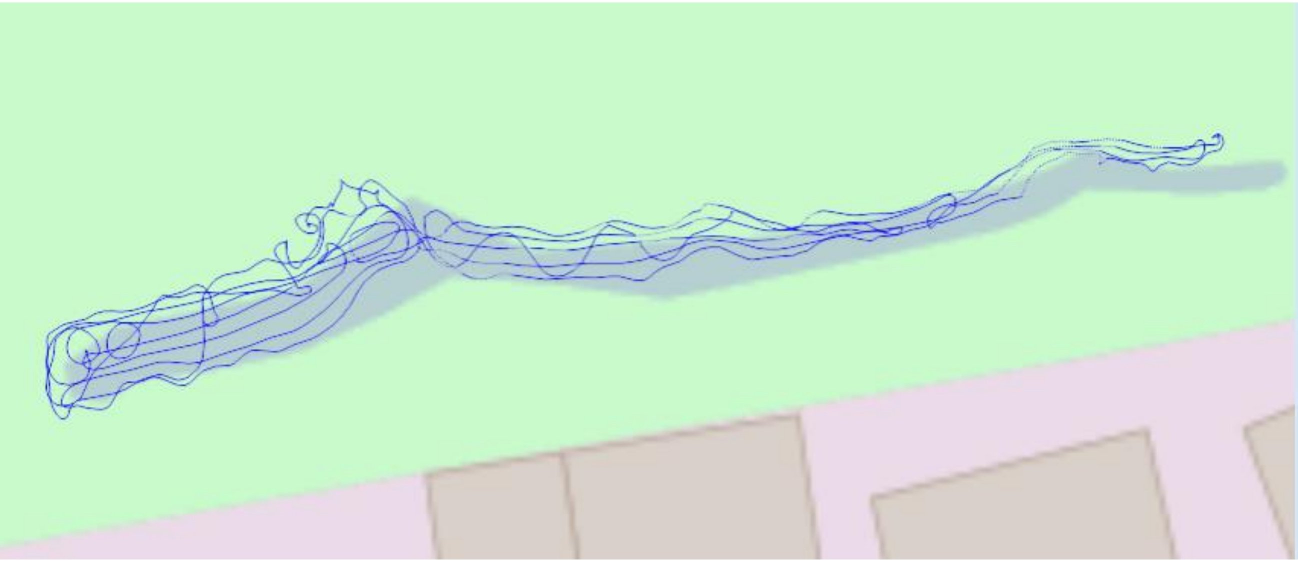

Figure 1: The boat track for a stormwater pond survey, showing appropriate coverage to achieve a good bathymetry profile.

Along with the ADCP survey, measurements should be taken at the time of surveying to ascertain the water level of the pond. This is important because depth measurements are taken relative to the water level as that is the height at which the boat sits. Inlets or outlets provide the best reference point to measure the water level against, as they remain at a constant height and details are often included for inlet and outlet heights on pond as-builts. ADCP surveying should only be carried out on days with fine weather so that there is a stable water level during the survey.

2.1.5 FIELD TROUBLESHOOTING

Some of the most common issues faced during the field procedure are; being unable to connect devices, batteries running low and propellers getting clogged.

Sometimes there can be difficulty in getting the laptop to recognize and connect with devices. This can be resolved by double checking the settings and cable connections.

There is a range limit between the devices and the laptop of 200m; however this is rarely exceeded as most ponds are not large enough. If the connection between the boat and the laptop starts to cut out, the overall boat status on the laptop will flash red instead of green. The field staff operating the laptop will need to move along the pond bank nearer to where the boat is surveying until the status lights flash green in order to overcome this.

As all components of the equipment set up rely on battery power, there can be issues with power consumption when surveying several ponds in one day. Spare batteries and/or chargers should be taken into the field to avoid data loss mid survey

Some ponds have surface weed which can get tangled in the propeller as the boat drives over it. Photograph 2 below shows a propeller that has been clogged with weed from the pond. When this happens the boat ignition needs to be turned off, and the weed untangled from the propellers using a screwdriver or scissors. Continuing to operate the boat while the propeller is clogged can strain the motor of the boat and cause the batteries to overheat.

Photograph 2: One of the Q-boat propellers clogged with weed from a pond. The weed had to be removed before sampling could continue.

Sometimes ponds contain too much weed for the ADCP methodology to be considered suitable. An example of a weedy pond is shown in Photograph 3 below. The extent of weed growth in this pond would have meant that the propellers would have been clogged almost instantly. With the large size of some ponds, untangling and re-deploying each time they become clogged would not be feasible. In addition to this, the density of the weed growth beneath the surface could cause the sound waves to be blocked, resulting in spikes within the depth measurements. For a pond such as the one below, the ADCP method is not recommended, and a manual survey should be carried out.

Photograph 3: A stormwater pond in Auckland with extensive weed growth present.

2.1.6 DATA PROCESSING

Data is processed using Surfer software. The data is exported from HydroSurveyor, as an Excel file containing X, Y and Z coordinates. The X and Y are the eastings and northings from the GPS, and Z is the elevation in metres from the water level to the base of the pond as measured by the ADCP.

Inlet and outlet measurements taken can be used to convert the Z coordinates to Reduced Level (RL). This is only possible for surveys where an as-built is provided for the pond, and details for the RL height of inlets and outlets are included.

The survey data is then plotted in Surfer, and various calculations can be made. If the aim is to calculate sediment accumulation since the last as built was produced, the as-built will be digitized and also plotted into Surfer. The two layers (both now in RL) can then be compared to identify areas of cut and fill, and produce an overall volume of sediment accumulation or erosion.

For a pre and post dredging survey, the water level at the time of each survey must be accounted for so that they are comparable. In order to calculate the volume of sediment removed, the post dredging survey is subtracted from the pre dredging survey.

2.2 DISCUSSION

2.2.1 APPLICATIONS OF DATA

There are a number of different applications of the bathymetry data. The most common use of data is calculating the quantity and location of sediment deposition since an as-built was last produced (i.e. when the pond was built or last maintained).

The other way data is commonly used is for pre and post dredging surveys in order to establish the quantity of sediment that was removed.

There could be several other uses of bathymetry data collected using this method in stormwater ponds, such as; to calculate treatment volumes, to provide information about a pond where no as-built is available, and to assess pond function and performance for redesign purposes.

2.2.2 UTILISATION BY AUCKLAND COUNCIL

The Auckland Council project has and continues to utilise the data collected in several ways. The main aim at the initiation of the project was to create a priority list of ponds urgently requiring maintenance. As there are so many stormwater ponds within Auckland, it is critical to understand which ponds should be prioritized over others that may not yet require maintenance. By using the ADCP method, Auckland Council is able to obtain accurate data about the state of their assets over a much shorter time period than if they were to manually survey each pond.

Calculating the amount of sediment that has accumulated since a pond was last maintained can also be useful to determine how well ponds are functioning. If a pond was recently maintained but has high sediment build up, then consideration can be made to the pond design.

Auckland Council is also using sediment accumulation volumes to estimate the expected cost of pond dredging, as the cost of this is based on the volume of sediment to be removed. The survey can also be used for audit purposes, by carrying out pre and post dredging surveys to quantify that the difference in volume of sediment matches that removed by the contractor.

2.2.3 COMPARISON TO MANUAL PROBE METHOD

The most commonly used alternative method to measure sediment build up in ponds in New Zealand is the manual probing method. There are variations of this, however the basic principle is that the operator moves around the pond in a flotation device of some sort, and at various points within the pond takes manual readings of the depth using a rod or staff. A measurement is taken where the rod first feels resistance, which is assumed to be the top of the sediment layer. The rod is then pushed further into the sediment until it is thought that the base of the pond is reached.

There are a number of issues with this method. Safety of operators is one of the biggest concerns, as it requires the use of a boat or kayak and travelling throughout the pond (NZTA, 2010). It is easy for the operator to lose balance while taking depth measurements, and fall into the pond. Some ponds can be very deep in parts, and also full of weeds and thick sediment which could elevate the health and safety risk. In comparison, the Q-boat and HydroSurveyor methodology does not require the operator to enter the pond at all, and all measurements can be taken from the safety of the pond bank. The greatest safety risk posed by the ADCP method is that of the moving propellers on the Q-boat. However by ensuring the appropriate method is followed, with the ignition of the boat only turned on once it is in the water, the risk of injury occurring is considered to be low.

Another issue is the accuracy of the manual probe method. Sediment build-up readings can be inconsistent and at times not reliable as it can be very difficult to feel where exactly the top of sediment begins. In addition to this, pushing the rod deep into the sediment to determine when the base of the pond is reached is an estimate only (NZTA, 2010). Several case studies were carried out during the trial phase of the project, where ponds were surveyed using both methods to compare them. The results showed there was a 15-37% difference between the sediment accumulation volumes calculated, with the manual probing method consistently overestimating the sediment volume. This is a significant issue as a dredge operator could be expecting more sediment than what is actually present, therefore the potential to damage the pond base increases.

Human error can also impact measurements made using the manual probe method. This is because the manual method is based on the amount of pressure that comes from pushing the rod into the sediment. Each person is likely to have differing strength and judgement, so consequently different pressure could be applied to determine sediment depth. This error is the likely reason that the manual survey overestimated sediment accumulation when compared to the ADCP survey methodology.

A further concern with the manual probe method is that it can cause damage to the pond itself. While pushing the survey rod down to reach the base of the pond, sometimes the operator may push too far, and go beyond the as built level of the pond. This could cause an overestimation of sediment accumulation, and cause breakages in the lining of the pond. If the pond lining is breached, the integrity of the pond could be compromised and potential releases of contaminated sediment and water to the underlying soil and groundwater aquifers could occur.

A final concern is that the manual probe method is very slow and time consuming. Although it is faster to set up than the Q-boat, obtaining data can take a lot longer. The manual method can provide approximately 30 to 60 data points per pond, with coverage of 150 m^2 per data point. The ADCP can record approximately 10,000 data points in a small pond, providing a depth measurement approximately every second. This equates to around 5 data points per $1m^2$, which provides a more accurate overview of pond bathymetry.

The manual probing method does serve a purpose, and provides an alternative for ponds where the Q-boat and HydroSurveyor methodology is not appropriate (such as very weedy ponds). It is still considered to be a suitable method of providing an estimate of sediment build up within storm water ponds, however where possible it is recommended that the Q-boat method be used in order to enhance accuracy, increase time efficiency and reduce health and safety risks for operators.

3 CONCLUSIONS

The ADCP and Q-boat method is proving to be an excellent new way to obtain data about stormwater ponds. The manual probing method comes with many limitations and safety risks for field staff, which are overcome by the ADCP method. Field staff are able to survey ponds from the safety of the bank, and are able to collect more data points with high accuracy in a reduced amount of time.

The method has provided Auckland Council with valuable information about its many assets which has allowed prioritisation of maintenance works to commence. The method is currently being utilized by Auckland Council to determine whether maintenance of a pond is required, and to provide pre and post dredging surveys that allow the volume of sediment removed to be calculated.

There are a range of other potential applications of data, such as to calculate treatment volumes, to provide information about a pond where no as built is available, and to assess pond function and performance for redesign purposes.

It really does raise the question; why probe when you can ping?

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REFERENCES

Auckland Council Stormwater Department. (2014). Auckland Council Stormwater

Department Strategic Direction. Auckland Council Internal report.

Mueller, D.S. (2012) Best Practice for Calibrating SonTek RiverSurveyor M9/S5 Compass. Online: https://hydroacoustics.usgs.gov/movingboat/pdfs/Best_Practice_for_Calibrating_SonTek_RiverSurveyor.pdf (Accessed 20/02/17)

NZTA (2010) Sediment Accumulation Monitoring Techniques. Auckland Motorways, New Zealand Transport Agency, NZ.

Oceanscience (2011) The Oceanscience Group: Q Boat 1800 User Guide. V2.1.0. Teledyne Oceanscience

SonTek (2012) SonTek FAQ Guide: HydroSurveyor System. Online: http://ysi.actonsoftware.com/acton/attachment/1253/f-00a7/1/-/-/-/-/HydroSurveyor%20FAQs.pdf (Accessed 21/02/17)