completewaters

USV Sonar Imaging Trials

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Company: completewaters - ROV & USV Services
Date: May 10 2022
Location: Brantford, Ontario, Canada.
Services: USV Sonar Imaging
Software: BioBase Maps

May 10 2022

Throughout the month of April, an Unmanned Surface Vessel (USV) equipped with a sonar and remote controller was used to run trial sonar imaging on various ponds in Brantford and Hamilton, Ontario.

The objective to the trials was to confirm that the use of a USV could be successfully applied to operate in parallel with the BioBase Maps software, by not requiring human occupancy on the water in means such as workboat, kayak or canoe.

Four main elements were tested and verified:

1. USV operation in manual and autonomous modes
2. Sonar transducer placement
3. Creation of surveys remotely with onsite changes made to waypoints and parameters
4. Processing of sonar logs through BioBase software

Intro

The purpose of this summary is to showcase the combination of **USV, sonar** and **software** that can be utilised to produce a range of waterbody images and maps. This is not a technical document or an exact representation of the USV summary that can be generated under contract. This document is designed to show what equipment is being used to generate a certain type of aquatic habitat imaging files.

The trials on these waterbodies were undertaken in good weather with calm marine conditions. Typical spring pond conditions were present at each site, with moderate inflows and calm to light surface winds.

Purpose

The purpose of this equipment is to create a workflow where no one has to be physically present on the water, greatly improving health and safety and efficiency. It can also allow for higher precision survey plans compared to a manned boat, with the survey plan/grid being saved for future repeat surveys. This assures the client is getting systematic and highly repeatable imagery each time. This leads to survey comparisons with the ability to predict sediment build up and depth changes.

It also allows a more cost effective option to image waterbodies, by not requiring high end sonar transducers. With advancements in software processing capabilities, a wider range of sonar transducers are able to produce quality sonar imaging representations of a waterbody.

The USV can be used in a range of waters. These include ponds, lagoons, lakes, irrigation ponds, marinas, coastlines and larger streams and rivers. The USV can be launched easily from shore or from our workboat if access is required on a larger waterbody.

Equipment used:

- NX Innovations NX100 PRO USV
- High capacity LiPo battery packs
- Lowrance 3-1 Active Imaging Sonar
- Lowrance Elite FS 7 chart plotter
- Handheld controller with single channel telemetry communications
- Equipped with HD camera (video and photo)
- Equipped with autonomous controllers
- One person deployable

USV Specs:

- 1000mm L x 700mm W x 460mm H
- Weight 16 kg
- Payload 10 kg
- 100% battery operated
- x2 350 watt brushless shrouded thrusters
- 3.8 knots max speed, 1.9 knots working speed
- Shoreline or boat launch-able
- 2-4hr run times, field swappable batteries
- Autonomous & RC controlled
- Long distance autonomous transmission

NX100 Pro

3-1 Active Imaging Sonar

The sonar is mounted in between the catamaran hulls and can be adjusted in height to depths to suit your requirements and water conditions.

The USV can be operated in two modes. Firstly, in RC mode, piloted manually by the onshore USV Operator. Secondly, operated autonomously by a predetermined survey grid/plan. This autonomous survey plan is uploaded to the USVs onboard controllers.

The USV only has to carry out a single trip in order to produce all of the below imagery in the BioBase software. This makes for a very efficient workflow both in the field and post processing, allowing a more cost effective USV sonar imaging package.

The USV is constructed from tough GRP, is light weight and can be deployed in a range of environments. Propelled by two brushless shrouded thrusters and with a payload of 10 kg, the USV surveys at a controlled speed set by the operator. The max speed is 2m/s. Survey speeds can vary but in trials we have found 1m/s an average speed for smooth detailed lines of travel.

Onboard, in secure weather sealed hatches, are long endurance Lithium Polymer (LiPo) batteries, PX4 autopilot and Herelink controller units, onboard HD camera and a custom fabricated sonar transducer adjustable pole and bracket.

Mounted to the USV is a 3-1 Active Imaging sonar transducer with CHIRP, Side Scan and Down Scan. With the ability to choose low and high frequencies, we are able to set the required 200 kHz for mapping. This creates an effective imaging option that is designed to work through aquatic vegetation and in shallow water.

The USV is piloted using a Herelink controller which is an integrated remote controller, ground station and wireless digital transmission system, paired with a PX4 auto pilot system for unmanned vehicles. This integrated controller and auto pilot allows for autonomous and RC control, 1080 HD Video and telemetry data to be transmitted simultaneously on one channel which allows for a small working foot print.

The controller is loaded with a ground control software that allows for mission planning and configuration as well as mission map display showing the USV position, tracking, waypoints and USV instruments. Live video streaming is also viewed.

The USV auto pilot software can be programmed by the USV Pilot to follow a systematic grid or circular pattern, with lines of travel set to certain distances apart to achieve a thorough and extensive coverage of the water.

Sonar data logs from the survey area are recorded to the onboard SD card and downloaded to run through the aquatic habitat imaging software to create the following imagery.

BioBase Maps.

BioBase Maps software is a unique cloud based software that allows the generation of a wide range of aquatic habitat maps from one single USV trip, taking the .sl2 or .sl3 sonar logs from the Lowrance unit and processes them through sophisticated automated algorithms based on cloud servers.
The analytical tools allow us to create polygons around an area of interest and generate local statistics for water volume or aquatic vegetation cover.

BioBase creates the following files:

- Aquatic Vegetation(Presence/Absence & full BioVolume)
- Bottom Hardness
- Bathymetry
- Vegetation data reports
- Google Earth layering
- Water Body Statistics

The BioBase images and reports can be delivered to the end user in a range of formats including .png, .jpeg, .pdf and .html. Access can be given to the cloud version for more detailed analysis of results. The software does not allow for use with AutoCAD programs or files as the aim is for aquatic habitat imaging research, not civil engineering.

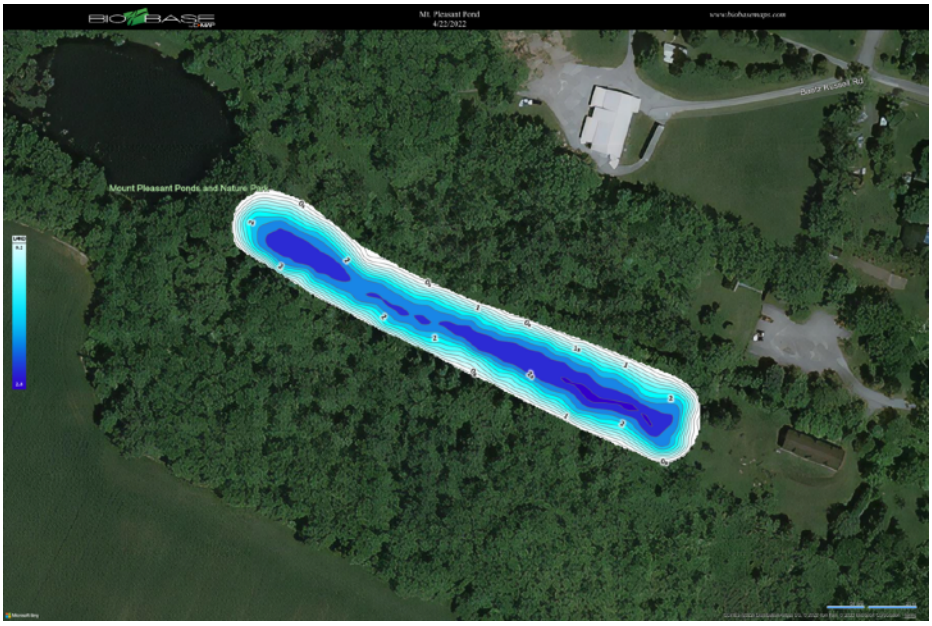
Locations

Imaging Dates: April 2022
Services: USV Sonar Imaging
USV Pilots: Blake & Jess Spittle

The **Mount Pleasant Ponds** are located on the southern edge of the Mt. Pleasant village and provide a place of leisure and recreation including nature walks and fishing. There are three ponds in series at this location. For this trial, the eastern most pond due to its long narrow lagoon like topography was used in this trial, to test the USVs ability to capture a waterbody through long transect lines.

The **Anderson Rd SWM** ponds are located on The City of Brantford's southern residential developments. The ponds are in an open area with surrounding grass and wetland areas. Two ponds sit together here. For this trial it was used as a different pond layout and relatively new SWM pond system.

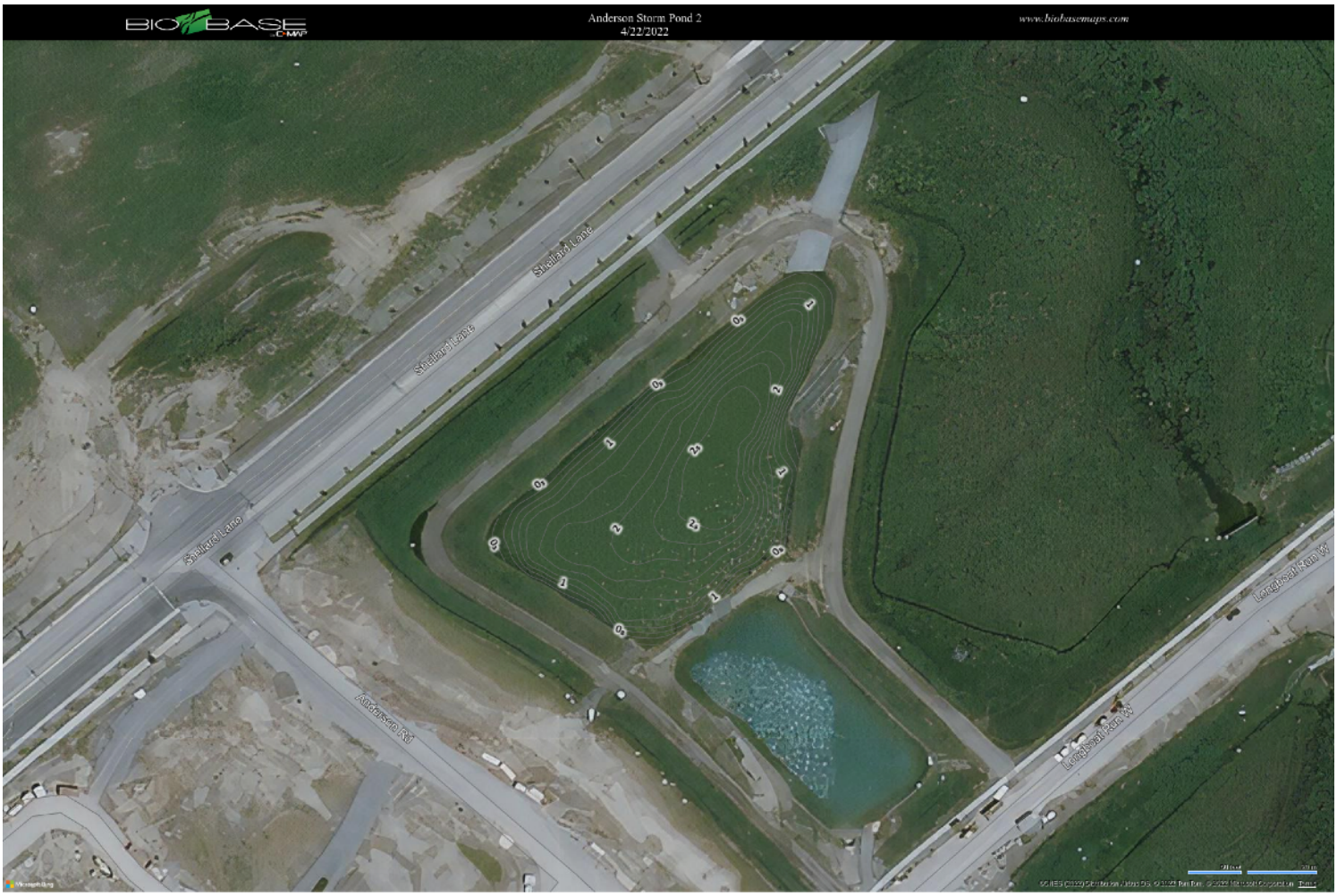
The **Sawmill Pond** in the Dundas Valley Conservation Authority is located close to Governors Rd on the West side of the township of Dundas, Ontario. This pond is surrounded by forested areas and sits by itself. For this trial it was used for multiple trips to refine system parameters.



1.0
Bathymetry

The bathymetry maps show the depths and contours of the waterbody. These maps help the user to understand the depth characteristics of the waterbody. These can be used to reference against original as built engineering drawings to identify areas of depth changes signifying failures in normal water operating conditions. Repeat surveys can also be sat side by side to each other and comparisons made to determine gradual or rapid changes in the aquatic environment.

Depths are displayed with typical bathymetry contour lines and colour palettes. The side left depth bar shows the colour representation of the different depths.

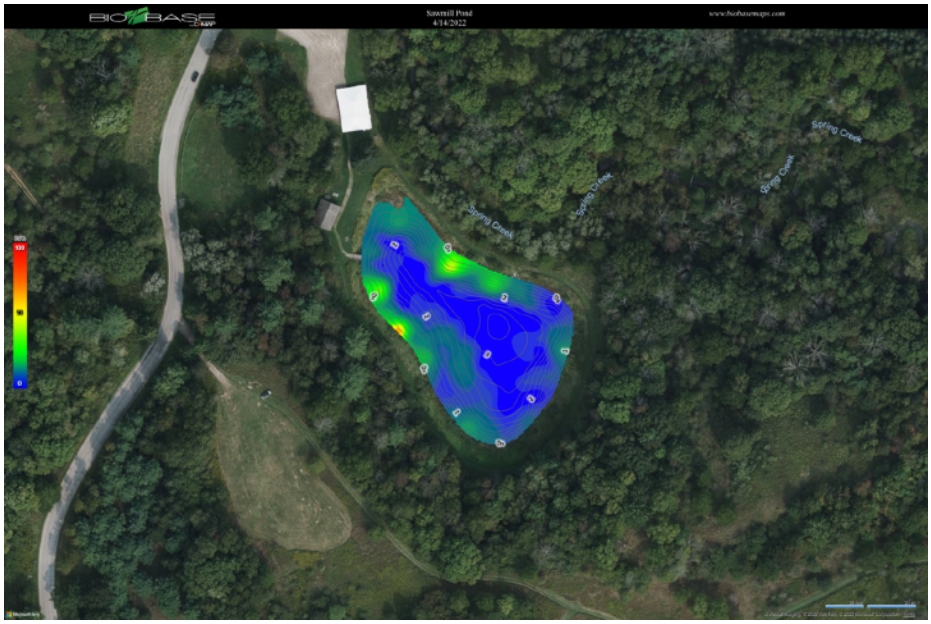


Depths can also be displayed with this map with no colour palette added.

2.0
Bottom Hardness (sediment)

The bottom hardness maps show the areas of soft and hard sediment. These maps help the user understand where soft and hard sediment lays on the waterbody floor, and can help identify where the best areas are for aerator placement or areas to focus fish habitat structure or dredge operations. As with the bathymetry maps, these can be sat side by side against as built engineering drawings of the waterbody or to repeat surveys to identify waterbody issues, specifically areas of sediment build ups.

Bottom Hardness is displayed in the colour palette that illustrates the difference between hard and soft sediment coverage on the waterbody floor. The side left colour bar shows the varying colours that represent the sediment characteristics.



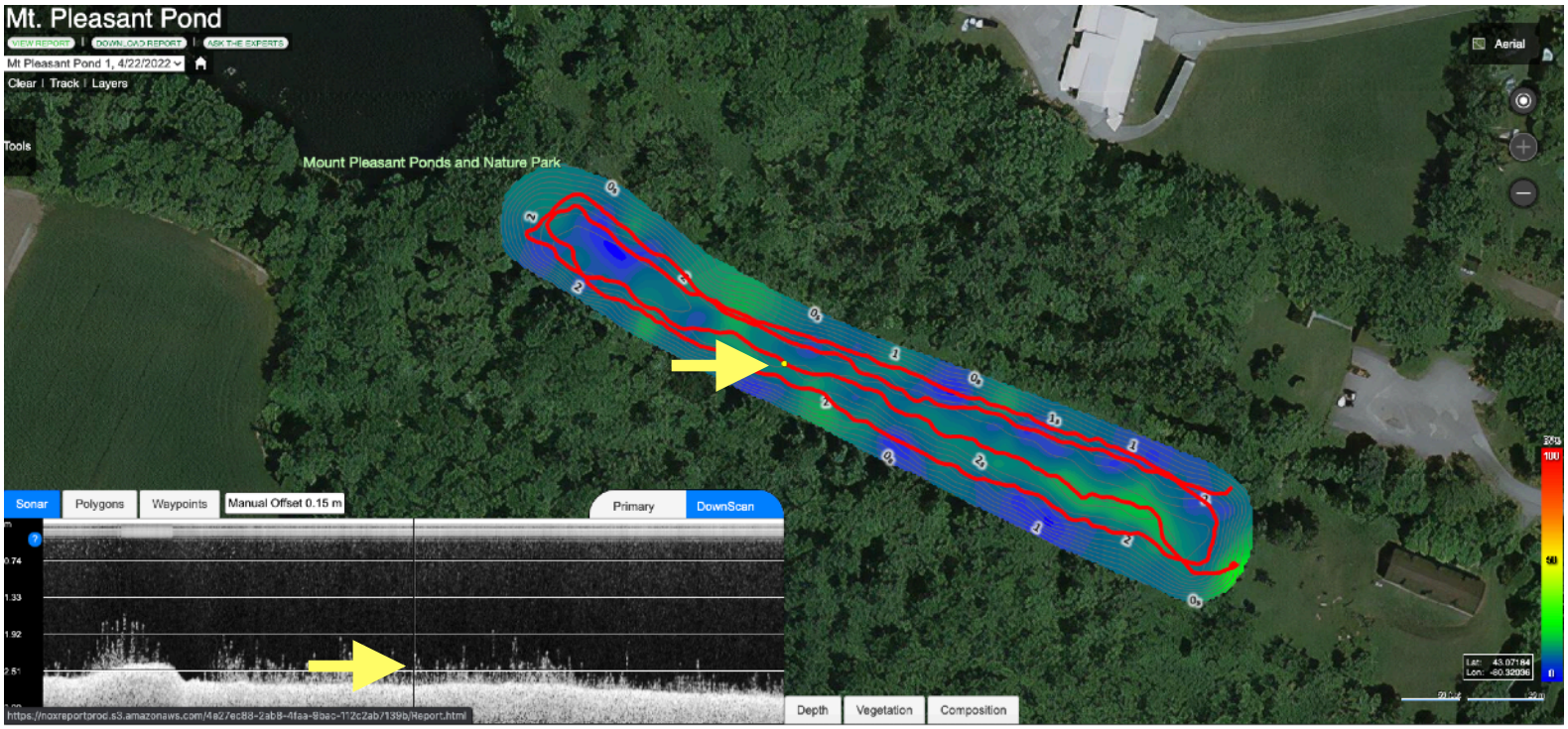
3.0
Aquatic Vegetation BioVolume

This map shows the aquatic vegetation coverage, displayed as a ‘heat map’. This map helps the user to understand the coverage of aquatic vegetation and the volume or concentration of vegetation across the waterbody. Track and monitor aquatic vegetation growth and coverages over time with simple repeat surveys and map overlays. This can also be used as a tool to make informed marine herbicide application decisions.

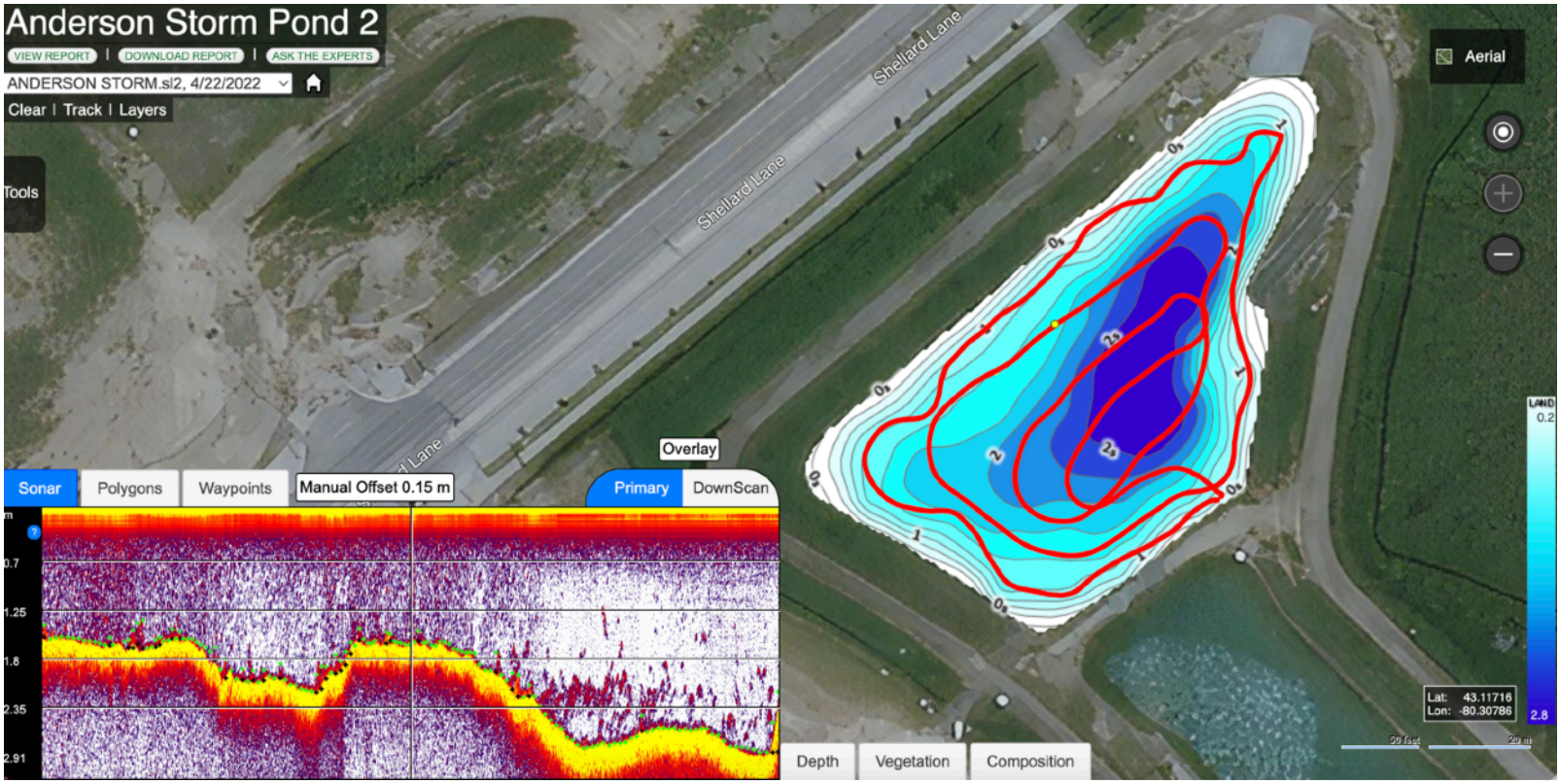
Aquatic Vegetation BioVolume is displayed in this coloured map with the colour palette representation on the side left colour bar. This map illustrates the coverage and densities of the aquatic vegetation in the waterbody.

4.0
Aquatic vegetation with DownScan bottom Profile

This map shows the aquatic vegetation coverage with the USV ‘track’ overlaid. The DownScan image is also shown in the bottom left, with the point of the waterbody floor represented by the yellow dot on the USV track. This type of imagery can pull up any GPS point along the USV’s line of travel and show the user a bottom profile image.



Another step further to the previous detail, is represented in the image below. The sonar bottom tracking shows small green and black dots. These dots are tracking with the floor of the waterbody and the aquatic vegetation. This helps to understand and confirm the contour of the waterbody floor as well as the aquatic vegetation growth. In areas of aquatic vegetation growth, this can be useful in determining vegetation height.



Waterbody Analysis Reports

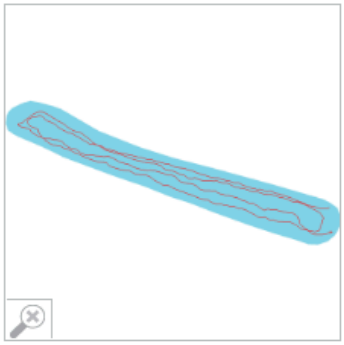
Along with imagery, analysis reports are generated from the survey, through the sonar logs recorded. This report can be viewed as an .html link or via .pdf as apart of the end deliverable package. This information can be used in your reporting and water management plan, giving the end user data on volumes, depths, temperatures, hectares, surface areas, survey settings and GPS coordinates.

BIOBASE

VEGETATION ANALYSIS REPORT

Mt. Pleasant Pond, Brant Ontario

Report Time Stamp: 2022 April 22 - 23:12 (UTC) ... REPORT LINK



Survey Metadata

Data Collector:	Blake Spittle
Survey Time Stamp (UTC):	2022 April 22 - 17:52
Starting Location:	43.070956, -80.316634
Ending Location:	43.070772, -80.316634
Distance	0.793 km

Survey Statistics

Average Water Temperature:	15.1 °C
Survey Area:	0.682 ha
Survey Volume:	12032.971 cu. m
Percent of Waterbody Surveyed:	100.0%
Waterbody Area:	0.682 ha
Estimated Waterbody Volume	12037.358 cu. m

Survey Settings

Includes Edited Data:	No
Track Buffer:	25 m
BV Grid Cell Size:	5 m
BV Minimum Detection - Percent:	5.0%
BV Minimum Detection - Depth:	0.701 m
BV Maximum Detection - Depth:	6.096 m
BV Sonar Channel:	Primary

Quality Control

Reviewer:	Valley, Ray
Comments:	We have reviewed this trip. Please use the "ASK THE EXPERTS" button for this trip if you have any questions.

Survey Summary

Type ?	PAC ?	Avg BVp ?	SD BVp ?	Avg BVw ?	SD BVw ?	Depth Range	Depth Avg	No. Depth Records
Point	62.3%	10.5%	± 8.0%	6.5%	± 7.0%	0.70 - 2.90 m	2.239 m	825
Grid	66.0%	8.5%	± 3.0%	5.6%	± 4.7%	0.12 - 2.79 m	1.764 m	508

Biovolume Analysis by Quintiles

Type ?	0 - 20%	20 - 40%	40 - 60%	60 - 80%	80 - 100%
Point	95.9%	3.9%	0%	0%	0.1%
Grid	99.4%	0.6%	0%	0%	0%

Biovolume Analysis by Depth

Type ?	Depth	Count	PAC ?	Avg BVp ?	SD BVp ?	Avg BVw ?	SD BVw ?
Point	0 - 1 m	0	0%	0%	± 0%	0%	± 0%
	1 - 2 m	128	61.0%	10.2%	± 9.2%	6.2%	± 8.3%
	2 - 3 m	378	62.8%	10.6%	± 7.6%	6.7%	± 6.5%
	3 - 4 m	0	0%	0%	± 0%	0%	± 0%
	4 - 5 m	0	0%	0%	± 0%	0%	± 0%
	5 - 6 m	0	0%	0%	± 0%	0%	± 0%
	6 - 7 m	0	0%	0%	± 0%	0%	± 0%
	7 - 8 m	0	0%	0%	± 0%	0%	± 0%
	8 - 9 m	0	0%	0%	± 0%	0%	± 0%
	9 m +	0	0%	0%	± 0%	0%	± 0%
Grid	0 - 1 m	105	69.8%	8.8%	± 4.1%	6.2%	± 5.3%
	1 - 2 m	165	60.2%	8.2%	± 2.7%	4.9%	± 4.5%
	2 - 3 m	238	68.4%	8.5%	± 2.6%	5.8%	± 4.5%
	3 - 4 m	0	0%	0%	± 0%	0%	± 0%
	4 - 5 m	0	0%	0%	± 0%	0%	± 0%
	5 - 6 m	0	0%	0%	± 0%	0%	± 0%
	6 - 7 m	0	0%	0%	± 0%	0%	± 0%
	7 - 8 m	0	0%	0%	± 0%	0%	± 0%

This report has a focus on Vegetation BioVolume. Any manual changes made to the survey will also show on this report. The above Analysis data columns represent the following:

- **BVp *Biovolume (Plant):*** Refers to the percentage of the water column taken up by vegetation when vegetation exists.Areas that do not have any vegetation are not taken into consideration for this calculation.
- **BVw *Biovolume (All water):*** Refers to the average percentage of the water column taken up by vegetation regardless of whether vegetation exists.In areas where no vegetation exists, a zero value is entered into the calculation, thus reducing the overall biovolume of the entire area covered by the survey.
- **PAC *Percent Area Covered:*** Refers to the overall surface area that has vegetation growing.
- **Grid *Geostatistical Interpolated Grid:*** Interpolated and evenly spaced values representing kriged (smoothed) output of aggregated data points.The gridded data is most accurate summary of individual survey areas.
- **Point *Individual Coordinate Point:*** A single point represents a summary of sonar pings and the derived bottom and canopy depths.Individual point data create an irregularity spaced data set that may have overlaps and/or gaps in the data resulting in a increased potential for error.

Imagery Options

Further imagery options are available, generated by the same trips as the above imagery and reports. These can be used for a variety of reasons. The below image shows the measurement and monitoring of pond sedimentation by comparing bathymetric profiles.

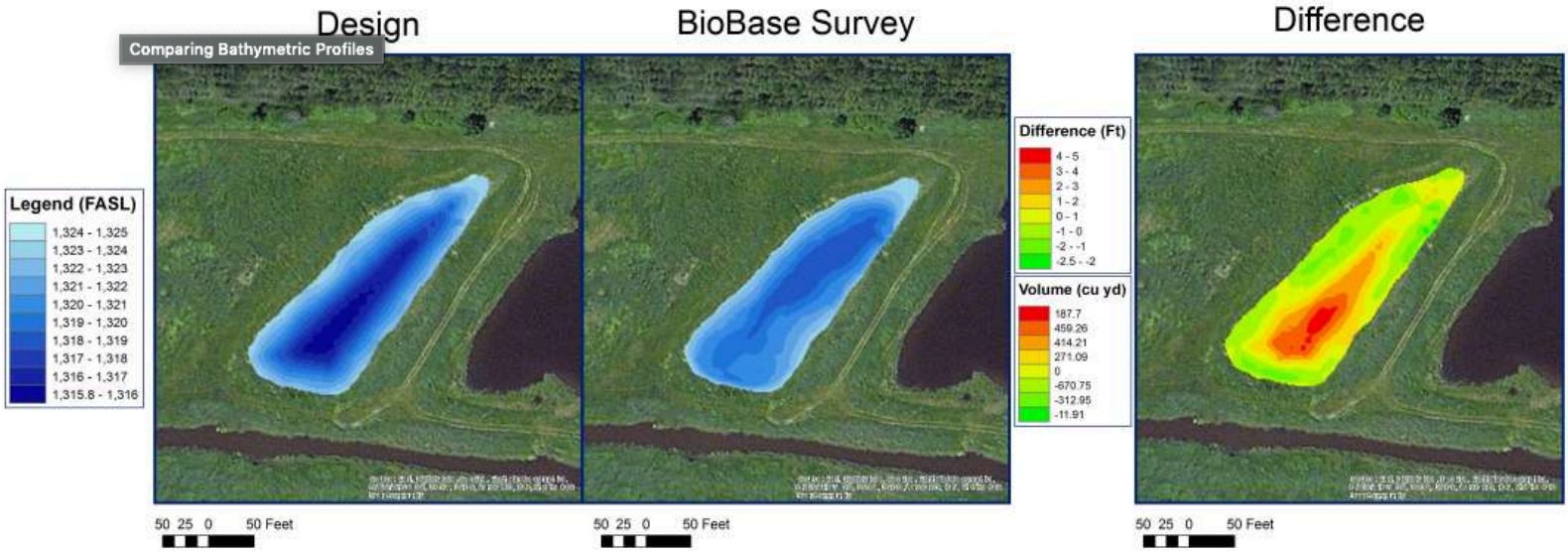


Image credit BioBase Maps

Packages

completewaters offers two packages to suit the needs of our clients.
The basic package is designed to give three detailed aquatic habitat images without the requirement for vegetation reports.
The advanced package is designed to give a detailed visual representation of the waterbody as well as aquatic vegetation reports.

	Basic Package	Advanced Package
Bathymetry (Bottom Depths) Map	✓	✓
Bottom Hardness Map	✓	✓
Vegetation Map (Presence/Absence and full BioVolume)	✓	✓
Water Body Statistics		✓
Vegetation Data Reports		✓
Google Earth Layer		✓
Bottom Tracking		✓

Summary

The USV is an open concept build, meaning it can integrate a range of sonar or sonde units, specific to the required outputs needed.

The USV has performed excellent with the current sonar set up. The BioBase technical support team have verified the USV and sonar placement in the water as a sound way to map these waterbodies. Each trip had been QC by the BioBase software technical team and have determined the surveys as competent with the softwares requirements.

It was observed on the first trip that the sonar was picking up the USV's hull and creating slight noise on the sonar logs. This was remedied by lowering the sonar further below the hull. The sonar level below the water surface is measured and added into the parameters as an offset.

A USV is a safe option. It allows for complete onshore operation and eliminates the need for a work boat on small waters. In autonomous mode, it also creates a survey system that is highly accurate to what is needed to be covered on water and highly repeatable. The survey grid pattern can be saved and repeated in future surveys, giving the end user sound data sets.

Please contact us if you have any questions.

Sincerely,

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