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Presented by:

Toronto and Region Conservation Authority

In association with:

Lake Simcoe Region conservation authority

Credit Valley Conservation – inspired by nature

Measuring SWMP volumes: A comparison of sonar vs differential GPS survey using disk and rod

Source to Stream

March 22, 2023

Chandler Eves (LSRCA)
William Dainty (Ecometrix Inc.)

Lake Simcoe Region conservation authority

Stormwater Pond Sediment Accumulation Assessment

- Requirement of the new CLI ECA
- Important to get accurate, repeatable measurements of pond volume and sediment accumulation
- Document accumulation rates and develop long term pond clean-out schedules (10 to 20 year plans) and associated costs
- Confirm as-builts or set benchmark on current condition
- Two common methods of assessing pond volume are using sonar or differential GPS disk and rod (but which to choose?)

Background – Bathymetry Study

- Comparison of measuring SMWP volume calculation and associated sediment accumulation within the same pond during the same year:
  - Effort comparison:
    - Time of data collection
    - Equipment cost
    - Post-processing time/method
  - Method comparison, pros & cons, best practices

Background - Bathymetry Study

- What is the difference between two main bathymetric methods?
- Pond RH1-4
  - 0.5ha quantity control pond, constructed in 2005
- Measurements conducted on same pond
  - Sonar – May 2022
  - Disk and Rod – November 2022

LSRCA Equipment Overview

Sontek RiverSurveyor M9

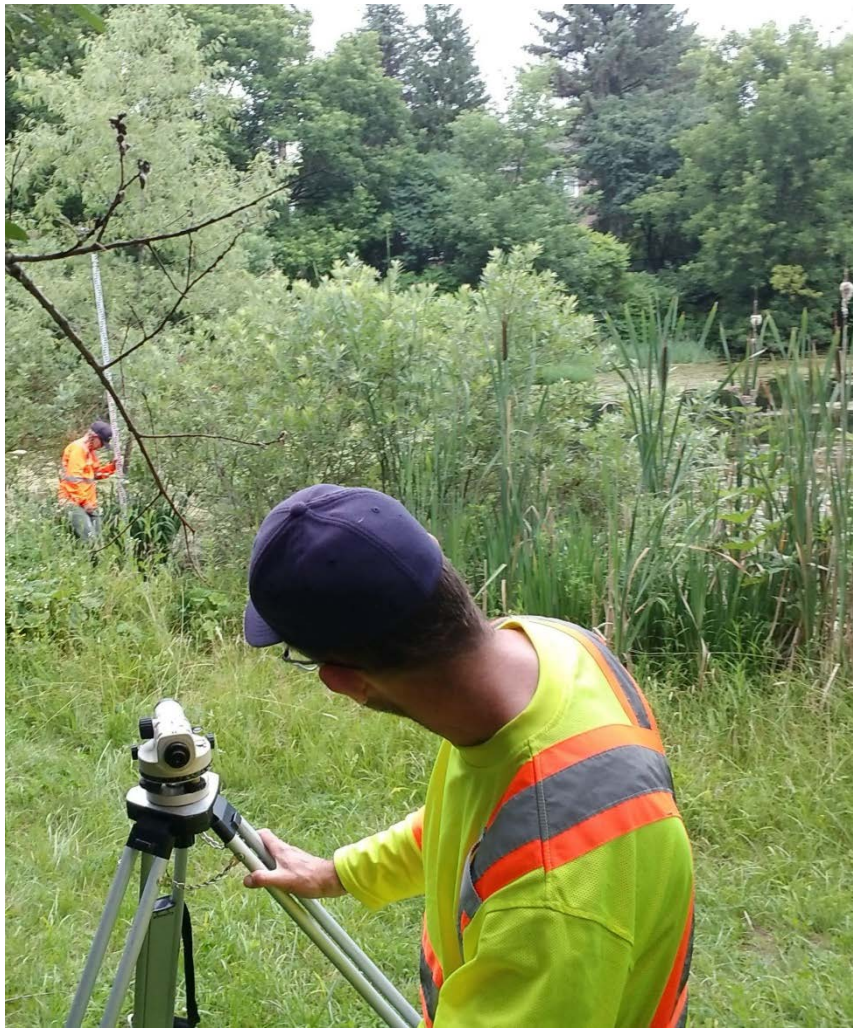
- 9 transducers (5 providing depth at a rate of 1 sample/second)
- Beam frequency range from 0.5 MHz to 3.0 MHz/1.0 MHz
- Depth range: 0.20m to 80m
- Resolution: 0.001m
- Accuracy: 1%
- RTK GPS with horizontal accuracy of <0.04m
- Price: $98,000 (Bottom Tracking/RTK unit with boat)

LSRCA Survey Method

- Collect physical measurement of depth (disk and rod)
- Kayak wetted edge of pond
- Kayak a 5m x 5m grid
- Walk edge with M9 to delineate true wetted border of pond

LSRCA Survey Method (continued)

- Survey water level using survey level and stadia rod against a known benchmark (e.g. invert of inlet pipe)
- Surveyed water level will be used as a potential correction value



Data Post Processing

- All data (wetted edge, grid, border) are exported as a point shapefile for analysis in ArcMap
- Correction value calculated from survey of water, applied to all M9 water level points (if required)
- The merged shapefiles are interpolated using Kriging analyst tool in ArcMap and a pond volume is calculated

RH1-4 2022-05-19

Volume = 5771.07 m3
Corrected to observed NWL: 289.04 masl
Subtracted 0.295 m

0 4 8 16 24 32 Metres

N

Sonar Method: Pros & Cons

Pros

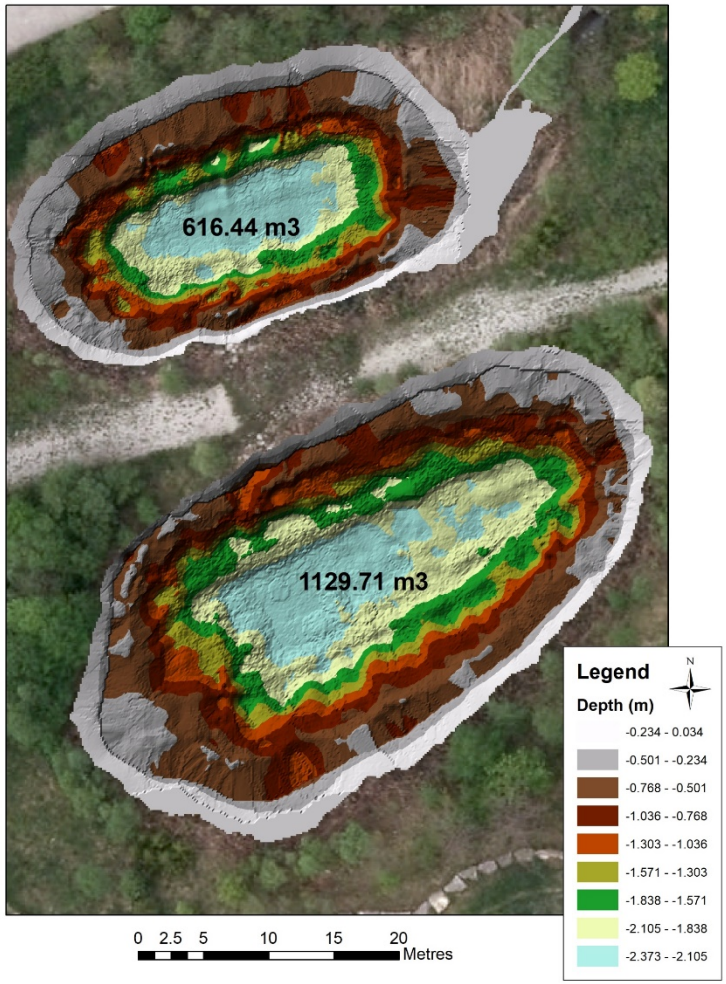
- High accuracy
- Relatively quick
- Consistent depth measurement
- Generates detailed bathymetric surface (a lot of points!)
- Excellent coverage of submerged features (berm)

Cons

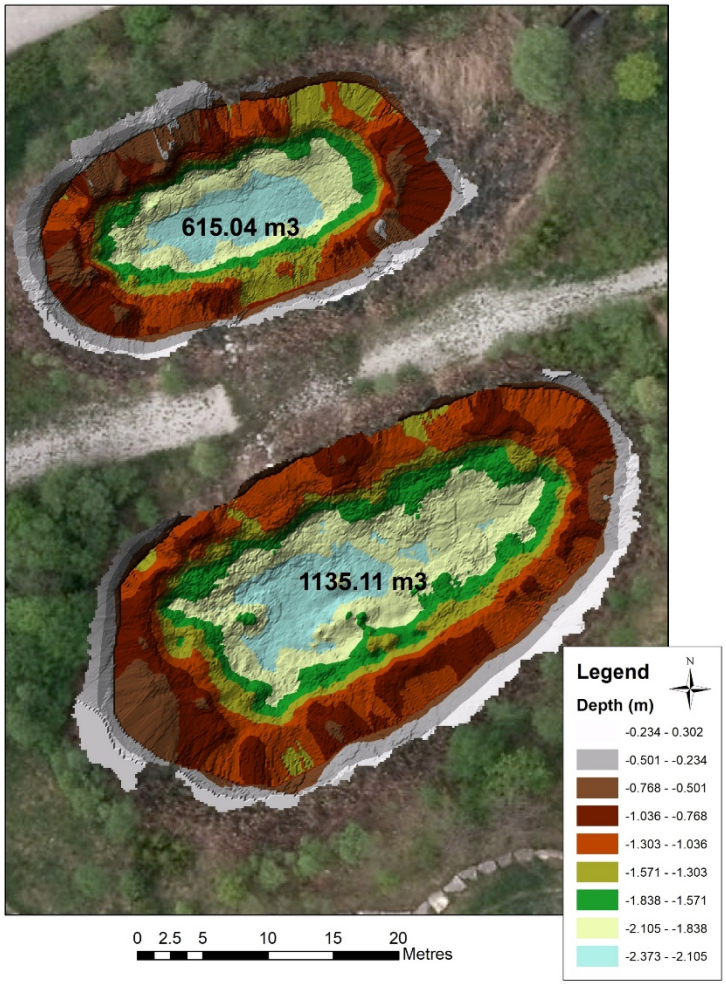
- Equipment cost
- X,Y of GPS can drift (but easy to post correct)
- Relies on design drawings to calculate final sediment volume
- Submerged plants can interfere with sonar

Limitations - LSRCA

NSW18-2017-04-27



NSW18-2017-11-07



LSRCA Method – Best Practices

- Conduct survey from ice-off to end of May to limit plant interference
- Correct to NWL: provides a meaningful volume that can be compared to design volume, assuming as-built volume is correct
- Manual measurements taken throughout pond to verify M9
  - Also used to validate as-builts
  - Can be used to explain why calculated pond volumes are greater than design volume

Ecometrix

Boat Work (Ice-Off Conditions)

- Health and Safety
- Differential GPS System
- Carbon Fibre Rod
- Sediment Foot
- Boat – 10’ to 12' Flat Bottom
- Electric Motor and Paddles
- 2 People
- Price: $50,000

Ecometrix

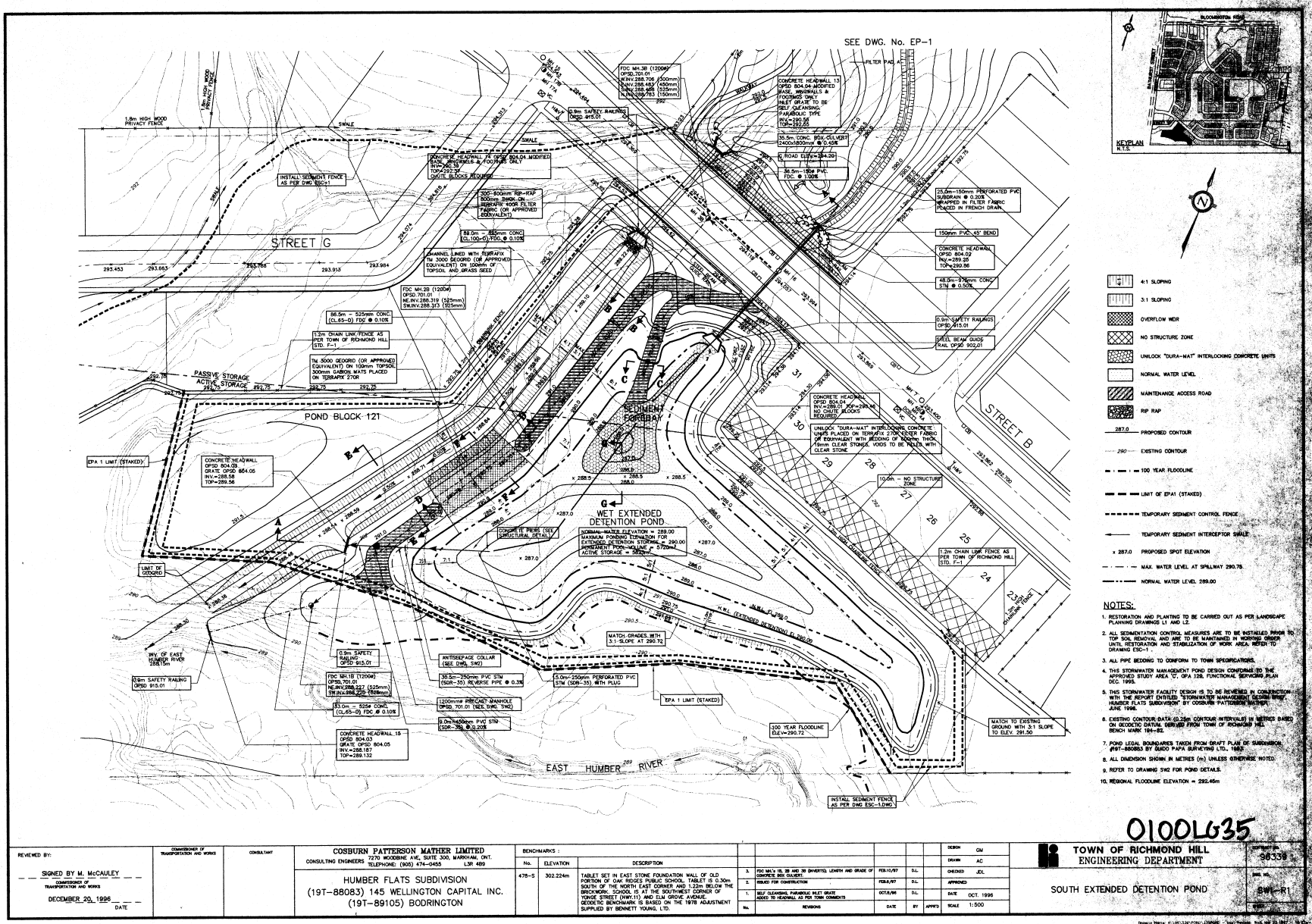
Survey method:

1. Survey the Pond Perimeter. Pick up visible infrastructure.
2. Walk in with hip waders where possible for side slope shots
3. Boat work. Accelerate between shots and try to stop the boat as much as possible. Boat operator controls the GPS system. Low wind conditions is critical.
4. The GPS is affixed to the top of the rod, so each shot is geo-referenced.

Ecometrix

Data Analysis:

- Data collector is downloaded at the office and data points are put into an Autocad file
- The historic bathymetry is developed from whatever is available (i.e. As-Constructed Drawings, SWM Report Figures, As-Constructed Surveys, Historic Clean-out Surveys)
- Quantities and cross-sections are developed using TIN (Triangular Irregular Method) through Autocad.



NOTES:

1. RESTORATION AND PLANTING TO BE CARRIED OUT AS PER LANDSCAPE PLANNING DRAWINGS L1 AND L2.
2. ALL SEDIMENTATION CONTROL MEASURES ARE TO BE INSTALLED PRIOR TO TOP SOIL REMOVAL AND ARE TO BE MAINTAINED IN WORKING ORDER UNTIL RESTORATION AND STABILIZATION OF WORK AREA. REFER TO DRAWING ESC-1.
3. ALL PIPE BEDDING TO CONFORM TO TOWN SPECIFICATIONS.
4. THIS STORMWATER MANAGEMENT POND DESIGN CONFORMS TO THE APPROVED STUDY AREA 'C', OPA 128, FUNCTIONAL SERVICING PLAN DEC. 1995.
5. THIS STORMWATER FACILITY DESIGN IS TO BE REVIEWED IN CONJUNCTION WITH THE REPORT ENTITLED "STORMWATER MANAGEMENT DESIGN BRIEF, HUMBER FLATS SUBDIVISION" BY COSBURN PATTERSON MATHER, JUNE 1996.
6. EXISTING CONTOUR DATA (0.25m CONTOUR INTERVALS) IN METRES BASED ON GEODETIC DATUM DERIVED FROM TOWN OF RICHMOND HILL BENCH MARK 194-82.
7. POND LEGAL BOUNDARIES TAKEN FROM DRAFT PLAN OF SUBDIVISION #19T-88083 BY GUIDO PAPA SURVEYING LTD., 1987.
8. ALL DIMENSION SHOWN IN METRES (m) UNLESS OTHERWISE NOTED.
9. REFER TO DRAWING SW2 FOR POND DETAILS.
10. REGIONAL FLOODLINE ELEVATION = 292.45m

0100L635

REVIEWED BY:

SIGNED BY M. McCAULEY
COMMISSIONER OF TRANSPORTATION AND WORKS

DECEMBER 20, 1996
DATE

COMMISSIONER OF TRANSPORTATION AND WORKS

CONSULTANT

COSBURN PATTERSON MATHER LIMITED
CONSULTING ENGINEERS 7270 WOODBINE AVE, SUITE 300, MARKHAM, ONT.
TELEPHONE: (905) 474-0455 L3R 4B9

HUMBER FLATS SUBDIVISION
(19T-88083) 145 WELLINGTON CAPITAL INC.
(19T-89105) BODRINGTON

BENCHMARKS :

No.	ELEVATION	DESCRIPTION
478-S	302.224m	TABLET SET IN EAST STONE FOUNDATION WALL OF OLD PORTION OF OAK RIDGES PUBLIC SCHOOL. TABLET IS 0.30m SOUTH OF THE NORTH EAST CORNER AND 1.22m BELOW THE BRICKWORK. SCHOOL IS AT THE SOUTHWEST CORNER OF YONGE STREET (HWY.11) AND ELM GROVE AVENUE. GEODETIC BENCHMARK IS BASED ON THE 1978 ADJUSTMENT SUPPLIED BY BENNETT YOUNG, LTD.

No.	REVISIONS	DATE	BY	APP'D
3.	FDC MH's 1B, 2B AND 3B (INVERTS), LENGTH AND GRADE OF CONCRETE BOX CULVERT.	FEB.10/97	D.L.	
2.	ISSUED FOR CONSTRUCTION	FEB.6/97	D.L.	
1.	SELF CLEANSING, PARABOLIC INLET GRATE ADDED TO HEADWALL AS PER TOWN COMMENTS	OCT.8/96	D.L.	

DESIGN GM
DRAWN AC
CHECKED JDL
APPROVED
DATE OCT. 1996
SCALE 1:500

TOWN OF RICHMOND HILL
ENGINEERING DEPARTMENT

SOUTH EXTENDED DETENTION POND

DRAWING NO. 98338
DWG. NO. SWM-R1

RH1-4 Consultant Data (November 2022)

Volume = 6665 m3
No Correction

0 4 8 16 24 32
Metres

N

Disk and Rod Method: Pros & Cons

Pros

- Accurate X,Y and Z with survey grade GPS
- Fast method when done on ice
- Equipment readily available
- Limited training required for a typical surveyor

Cons

- Not enough points on a submerged feature (berm) or irregular surface (low detail)
- Climate change narrowing ice-on window
- Need to use consistent disk size and rod weight
- Penetration depends on sediment material and rod holder

Ecometrix

Best Practices:

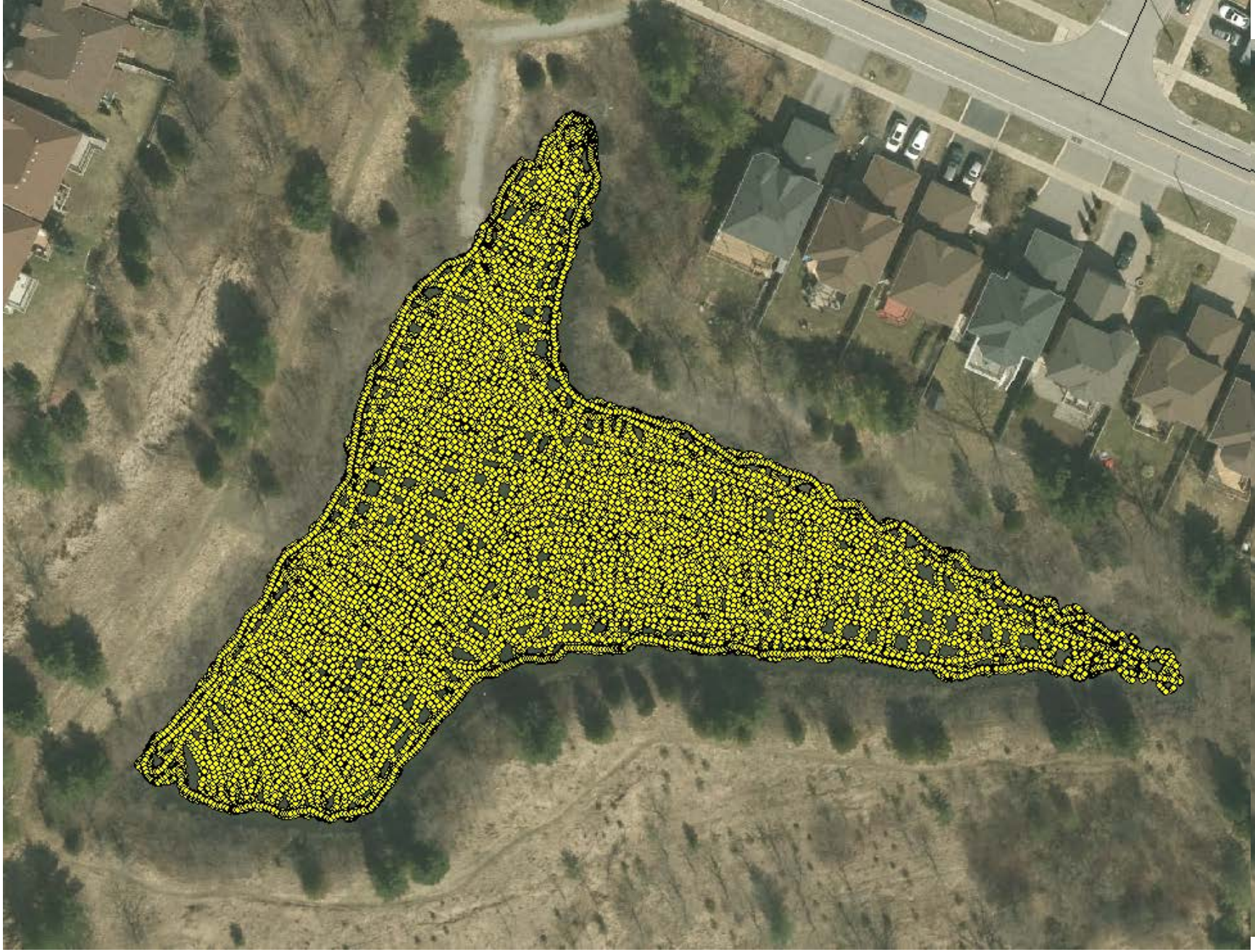
1. Consistent foot size (100mm?).
2. Consistent weight of the rod/GPS (Carbon Fibre).
3. Consistent XYZ coordinates. Use of a differential GPS system.
4. Operator training. Consistent rod placement is critical for reproduceable results.
5. Competent boat operator.

Survey Method Effort Comparison

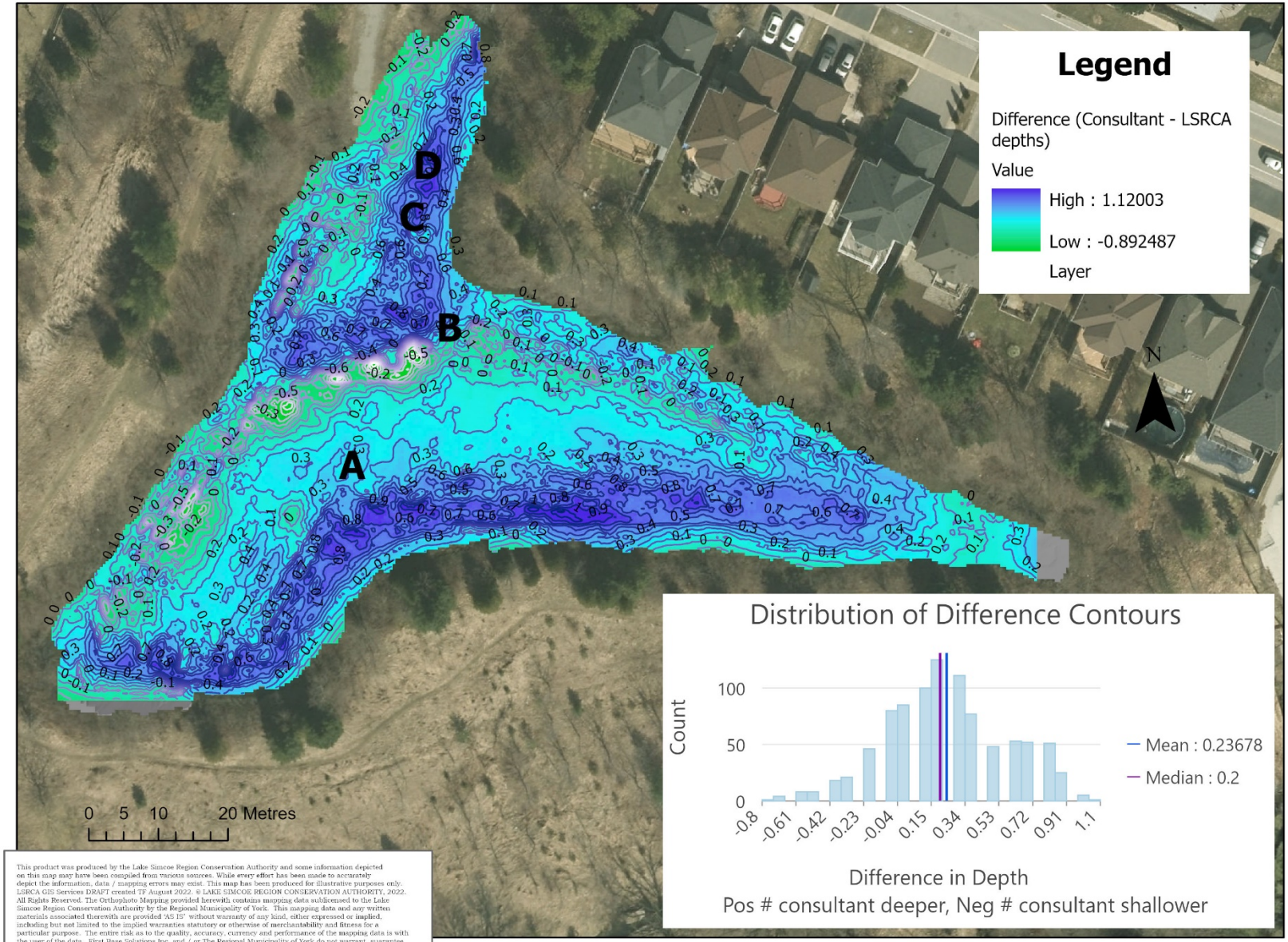
	Field Data Collection (hr)	Data Export/Correction (hr)	GIS Data Processing (hr)	Total (hr)
LSRCA	4	1	6.5	11.5
Ecometrix	3	1	6.5	10.5

LSRCA Data Points	Ecometrix Data Points
41,026	298

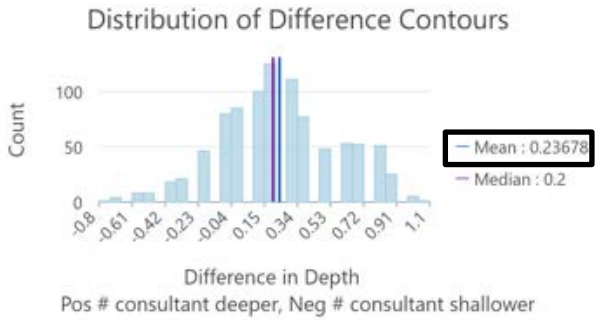
Design Volume (m3)	LSRCA Volume (m3)	Ecometrix Volume (m3)
6,408	5,771	6,665



Depth Difference RH 1-4



Depth Difference: Field Investigation



Location	Depth RH Foot (m)	Depth Survey Flat (m)	Depth Survey Point (m)	Depth M9 (m)	Diff. RH Foot to M9 (m)	Diff. Survey Foot to M9 (m)	Diff. Survey Point to M9 (m)
A-H1	2.60	2.65	2.67	2.56	0.04	0.09	0.11
C-H1	1.39	-	1.47	1.17	0.22	-	0.30
C-H2	1.23	-	1.27	0.98	0.25	-	0.29

Method Conclusions

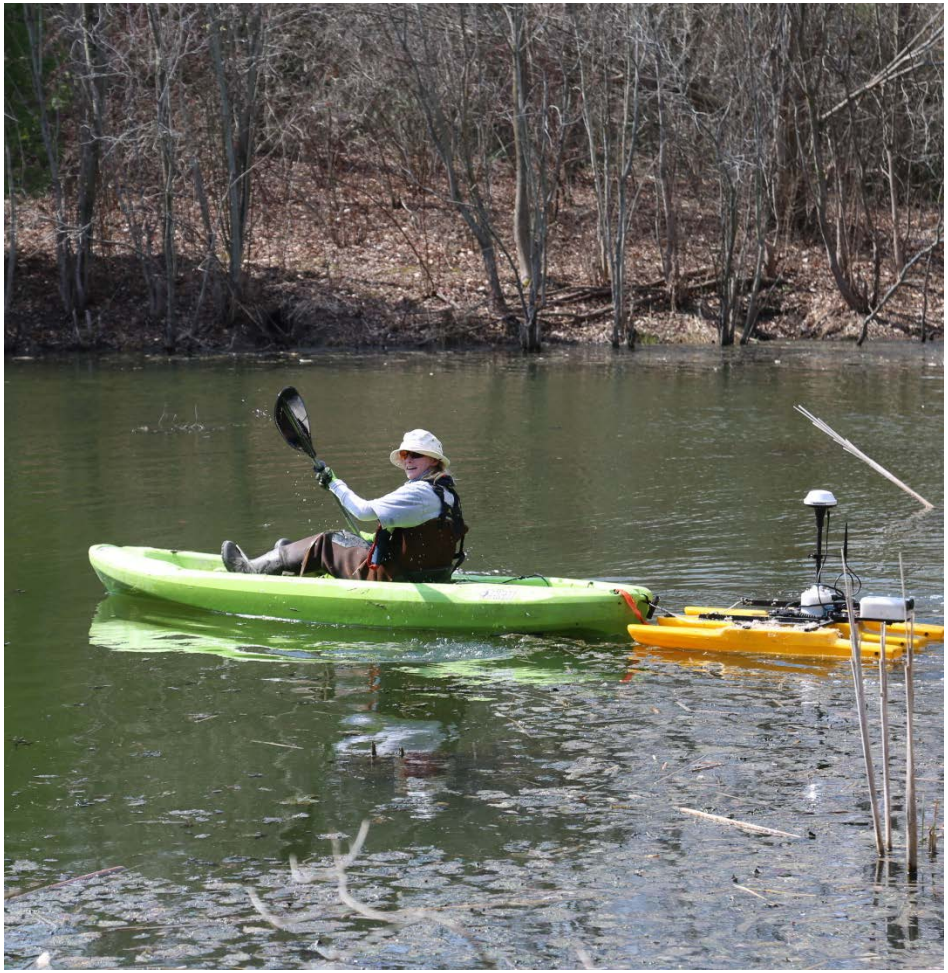
- Approx. 15% difference between methods
- Higher resolution provides better delineation of pond bottom / submerged features
- Sonar bias shallower depths / less volume, disk and rod bias deeper depths / greater volume
- Equipment cost – slightly more for sonar
- Labour is comparable

Best Practice Recommendations

- Conduct survey upon assumption so a baseline can be set and verify design to as-built (or ASAP to get baseline – this assists in better sediment accumulation rates)
- “Show your work!”/ set reporting standards for survey
- Consistent survey and analysis (GIS) method each time for better comparability
- Set equipment standards (disk size), sonar frequency
- Set benchmarks at ponds for repeatability

Thank you

- City of Richmond Hill for pond access and support
- MECP for supporting bathymetric survey methods investigation
- LSRCA Colleagues: Field efforts – K. Pellerin, D. Lembcke, R. Wilson, K. Read, S. Auger; GIS efforts – T. Fleischaker & D. Campbell



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