Lake Bathymetry Mapping with a Raspberry Pi and Open-Source Software

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Introduction

Fisheries Biologist

15-year NCWRC

Ubuntu Linux User

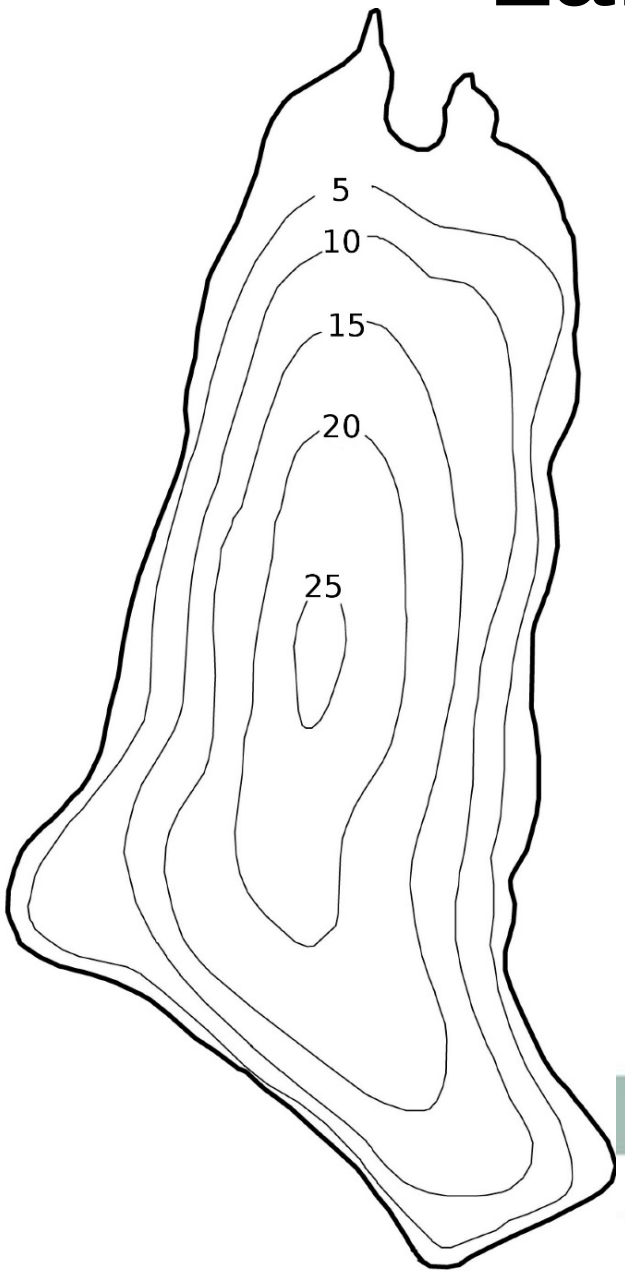
8 years

ThinkPad T530

GIS Skills Level:

Field Biologist

Lake Bathymetry



Helpful for Fishery Management

Typically Unknown

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Fish Finders

Modern Fish Finders

- 3-D Images
- Proprietary File Formats
- Proprietary Software

NMEA 0183

- Networks Boat Sensors
- Serial Connection
- 1 Observation / Second

gpsd

- Linux program
- reads NMEA 0183

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NMEA 0183 Sentences

```
$SDDBT,13.4,f,4.08,M,2.23,F*3F
$GPGGA,141151,3531.4671,N,08258.5126,W,2,10,0.6,791.7,M,-32.8,M,,*7E
$SDDBT,13.2,f,4.04,M,2.21,F*37
$GPGGA,141152,3531.4670,N,08258.5142,W,2,10,0.6,791.6,M,-32.8,M,,*7F
$SDDBT,13.7,f,4.19,M,2.29,F*36
$GPGGA,141153,3531.4670,N,08258.5160,W,2,10,0.6,791.5,M,-32.8,M,,*7D
$SDDBT,9.8,f,3.00,M,1.64,F*07
$GPGGA,141154,3531.4669,N,08258.5178,W,2,10,0.6,791.6,M,-32.8,M,,*78
$SDDBT,7.9,f,2.42,M,1.32,F*0C
$GPGGA,141155,3531.4668,N,08258.5196,W,2,10,0.6,791.6,M,-32.8,M,,*78
$SDDBT,7.3,f,2.24,M,1.22,F*07
$GPGGA,141156,3531.4667,N,08258.5213,W,2,10,0.6,791.5,M,-32.8,M,,*79
```

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NMEA 0183 Sentences

```
$SDDBT,13.4,f,4.08,M,2.23,F*3F
$GPGGA,141151,3531.4671,N,08258.5126,W,2,10,0.6,791.7,M,-32.8,M,,*7E
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```

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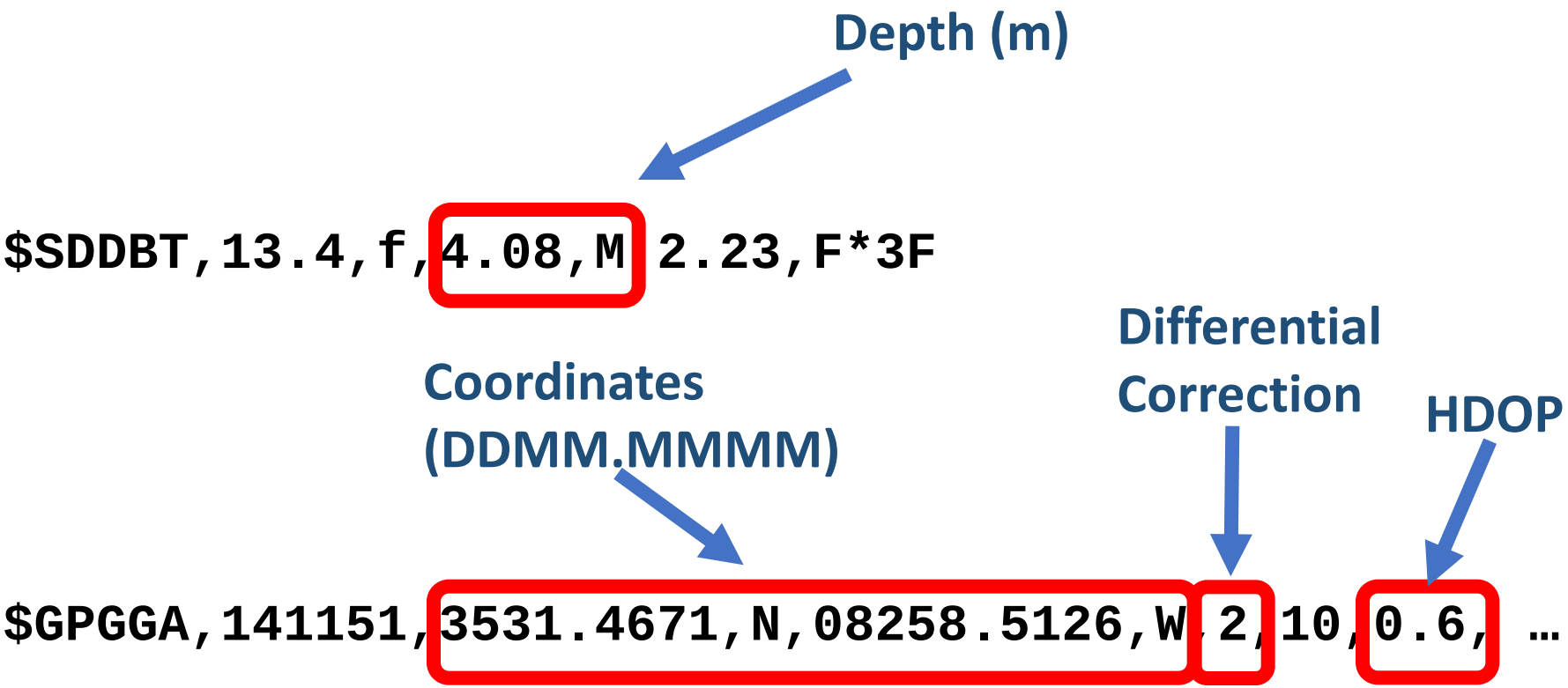
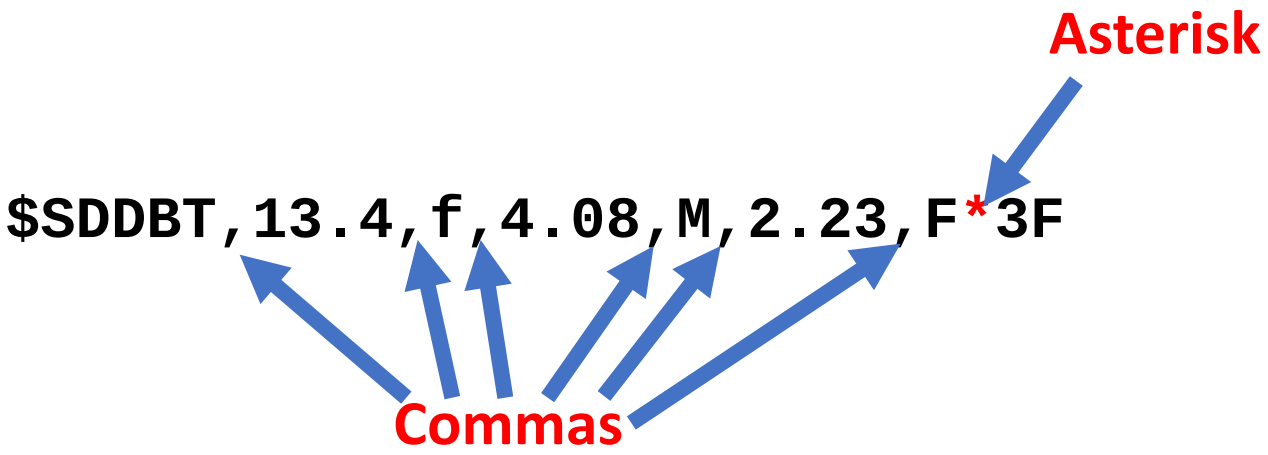
NMEA 0183 Sentences



NMEA 0183 Sentences



$GPGGA,141151,3531.4671,N,08258.5126,W,2,10,0.6, …

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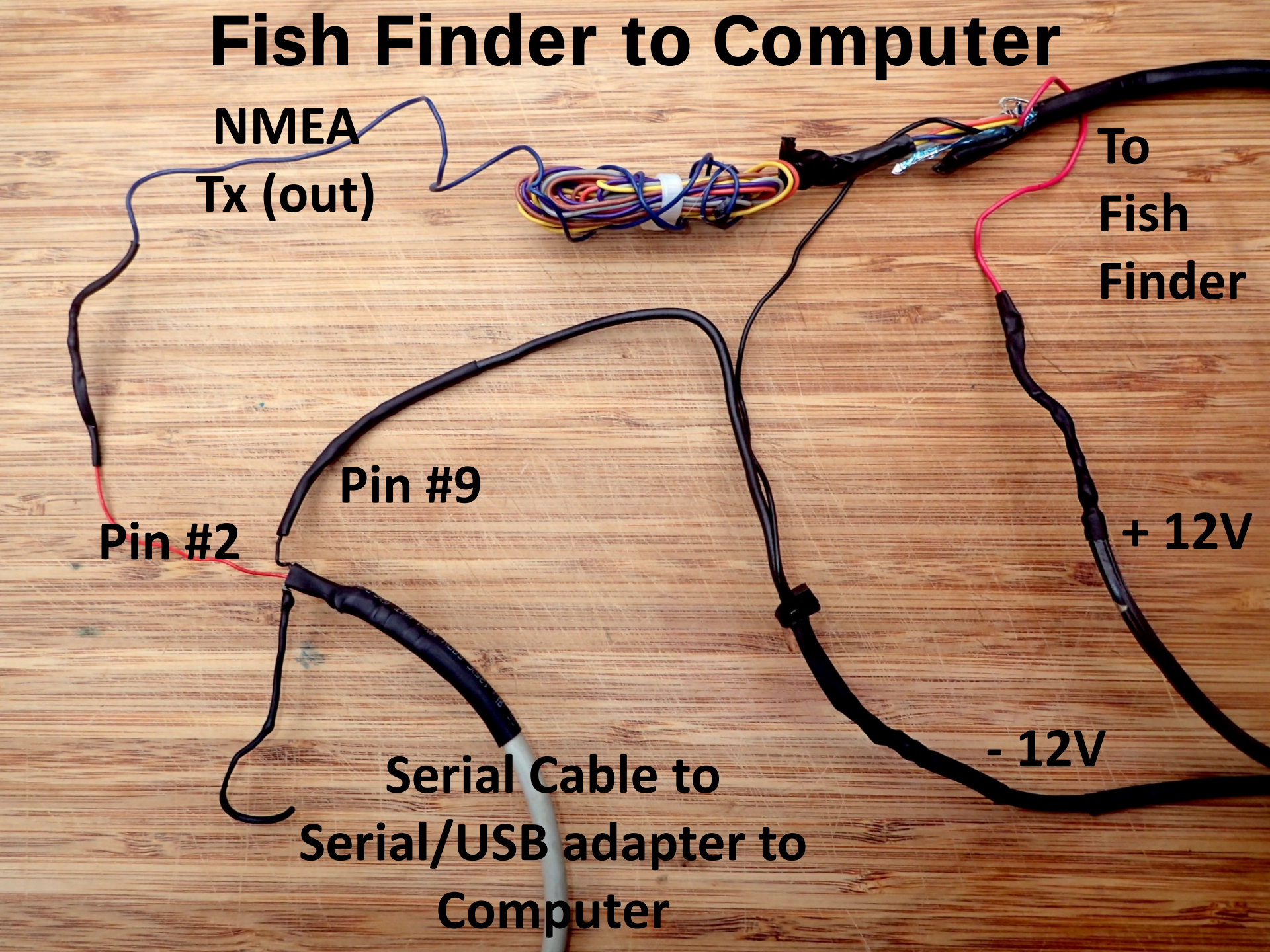
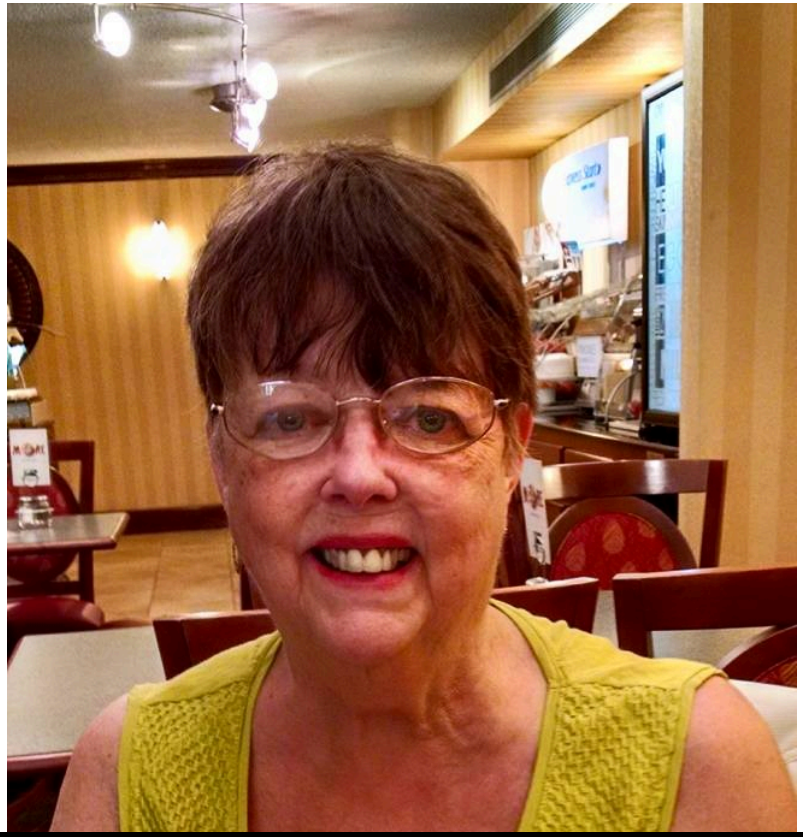

Fish Finder to Computer
NMEA
Tx (out)
To
Fish
Finder
Pin #9
Pin #2
+ 12V
- 12V
Serial Cable to
Serial/USB adapter to
Computer

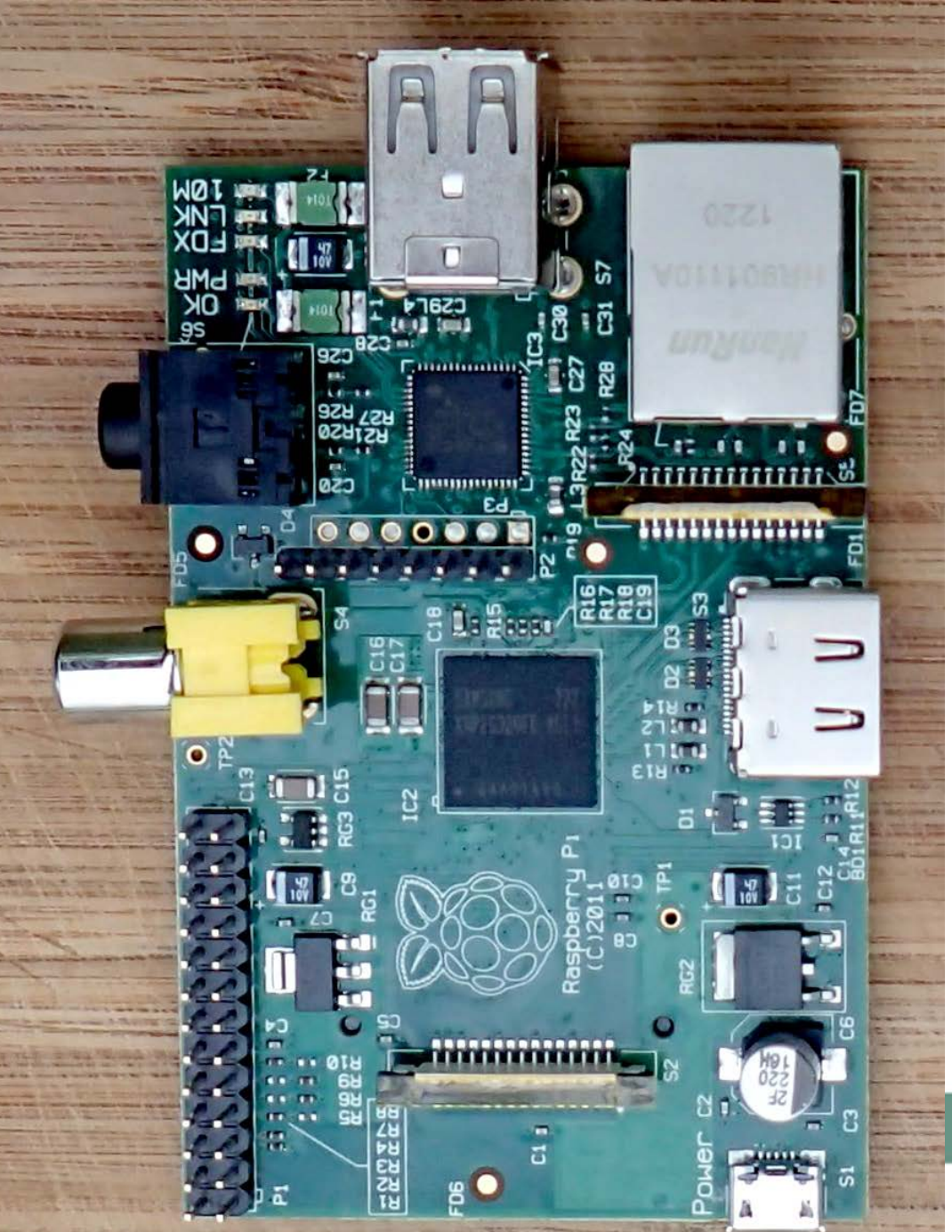
Streaming to Computer

Success!

Streaming to Computer



“Couldn't you just use a Raspberry Pi?”



Gen 1 Model B (2012)

Raspberry Pi

Credit Card-Sized Computer

Cell Phone CPU

Linux

Advantages over Laptop:

Inexpensive (~$30)

Easy to Power on Boat

“Weather-proof”

Lake Junaluska

200 Acres
1913 Hydropower
Volume ?
Berm ?

Goal and Objective

Goal:

Develop a simple and inexpensive hardware and software solutions to collect and display lake bathymetry data

Objective:

Create a bathymetry map of Lake Junaluska with a Raspberry Pi and Free/OSS that can:

a.) Resolve underwater features

b.) Estimate total lake volume

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Methods: Raspberry Pi

OS: Raspbian Jessie Lite

Software: gpsd and gpsd-clients

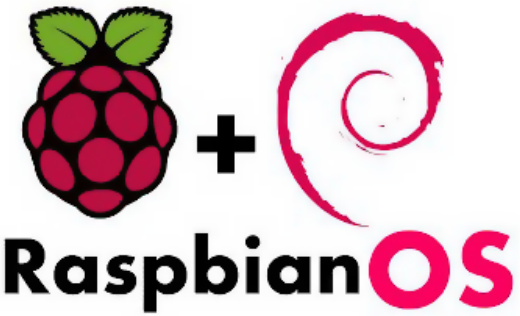
Edit /etc/default/gpsd

```
START DAEMON="true"
DEVICES="/dev/GPS0"
```

Edit /etc/rc.local

```
gpsd /dev/ttyUSB0
sleep 60
gpspipe –T "%H%M%S," –r –d –l –o /data/gpspipe.out.nmea
```

"Just Works"



Methods: Boat

Garmin echoMap 50s

GLONASS

WAAS

Methods: Boat Data

Linux Command Line

Replace the asterisk with a comma

```
sed -i 's/*/,/g' gpspipe.out.nmea
```

Split output into separate csv files by sentence type

```
cat gpspipe.out.nmea | grep 'GPGGA' > GPGGA.csv
cat gpspipe.out.nmea | grep 'SDDBT' > SDDBT.csv
```

[R]

Merged files back together using time stamps

General data clean-up

Methods: Kayak

Garmin GPSmap 64

Recorded Perimeter

GPX -> shapefiles

Imported shapefiles into [R]

- **Polygon**
  - **Lake Outline**
- **Points**
  - **Depth = Zero**

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Methods: Data Analysis

ArcMap

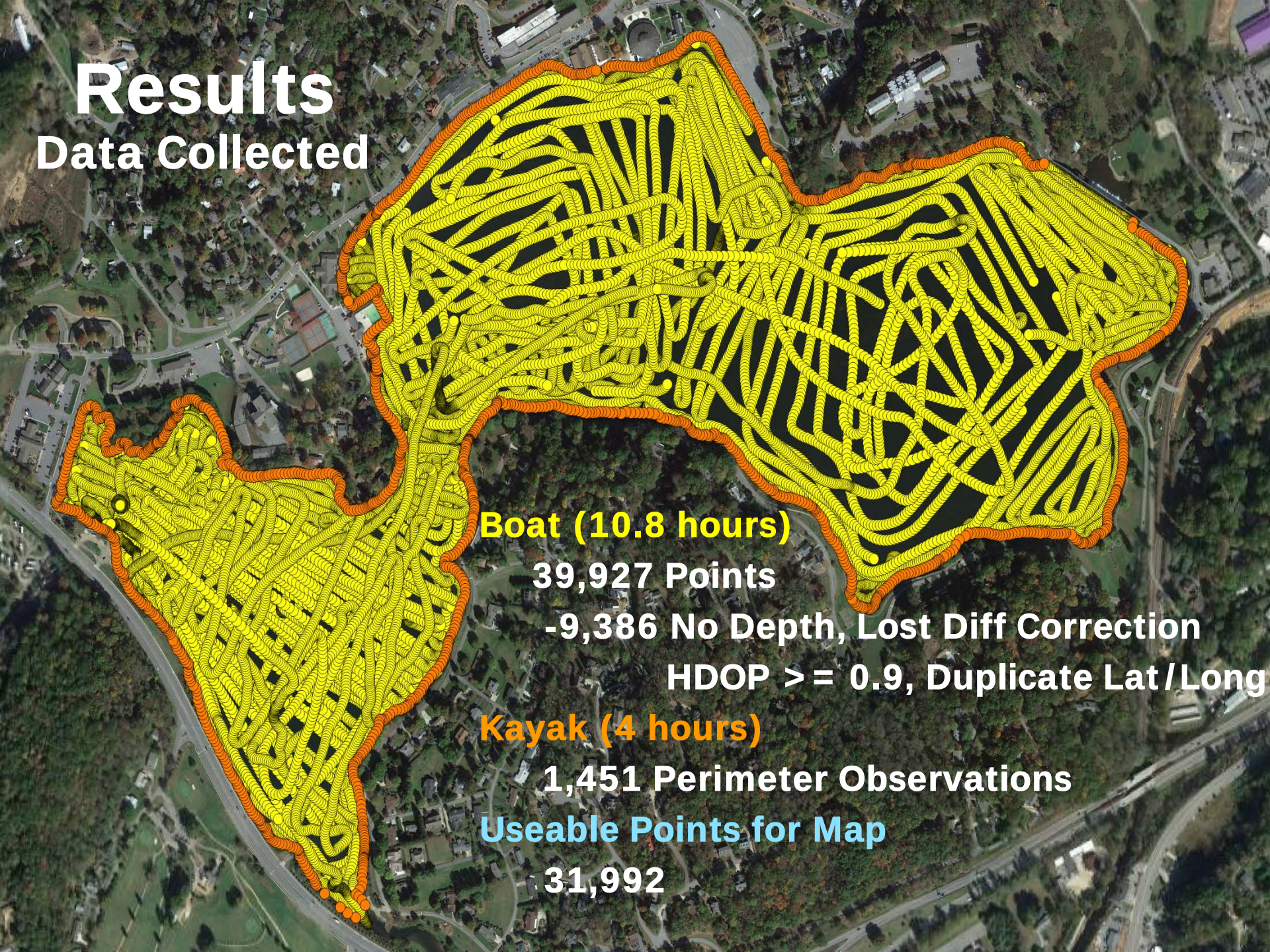
- **License Restrictions**

QGIS

- **Intuitive, Easy to Google Problems**

Results

Data Collected



Boat (10.8 hours)

39,927 Points

-9,386 No Depth, Lost Diff Correction

HDOP >= 0.9, Duplicate Lat/Long

Kayak (4 hours)

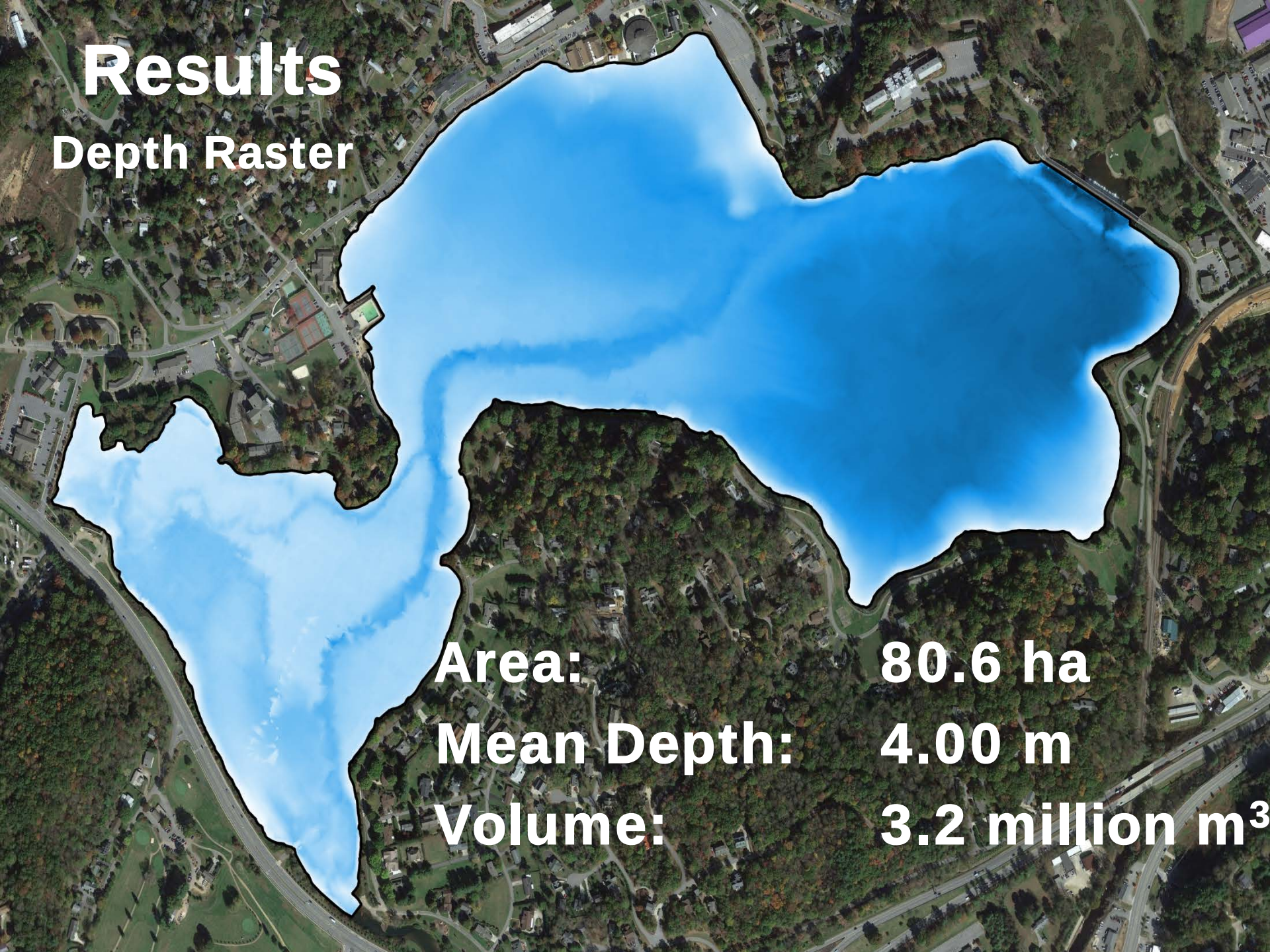
1,451 Perimeter Observations

Useable Points for Map

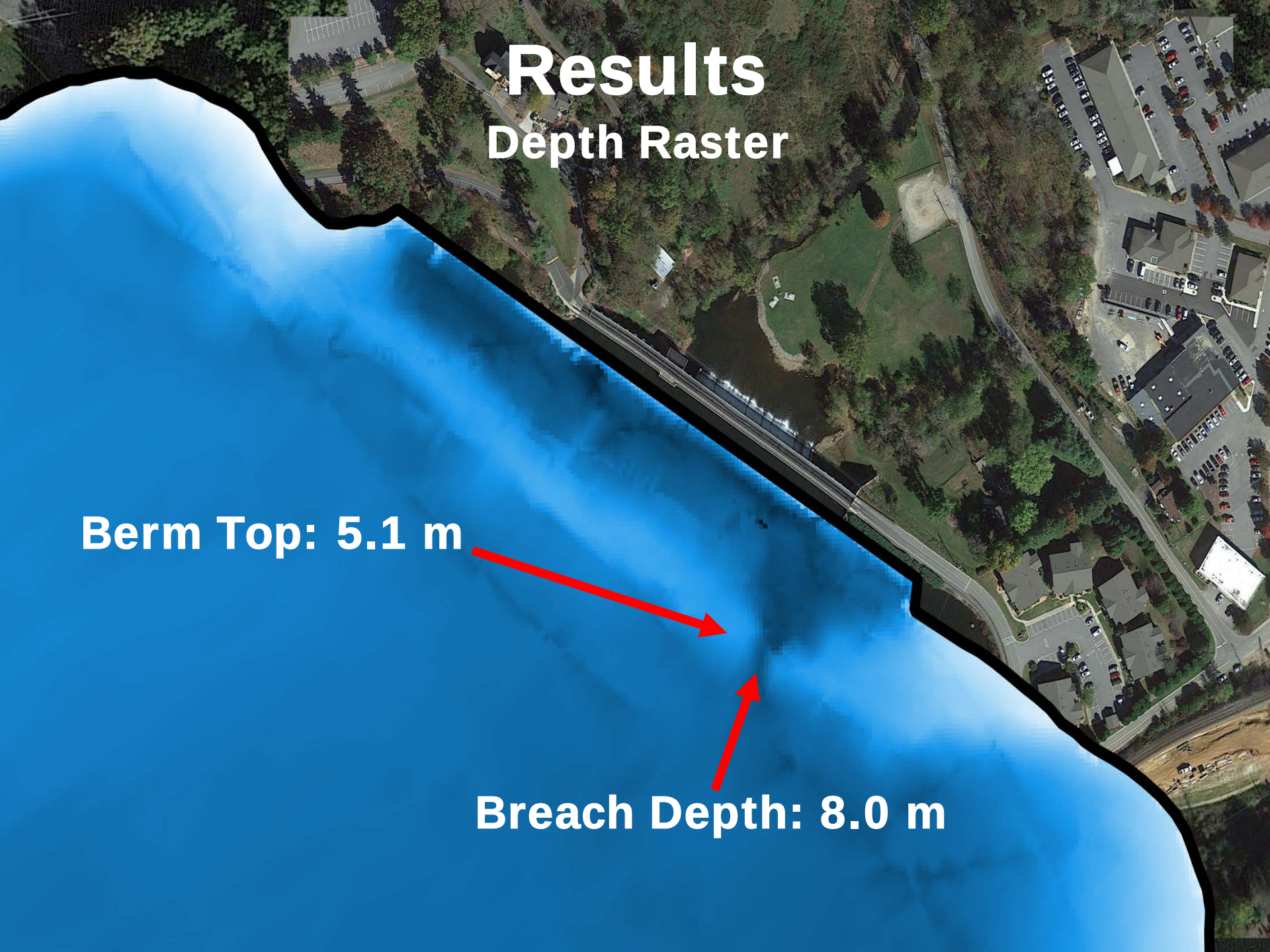
31,992

Results

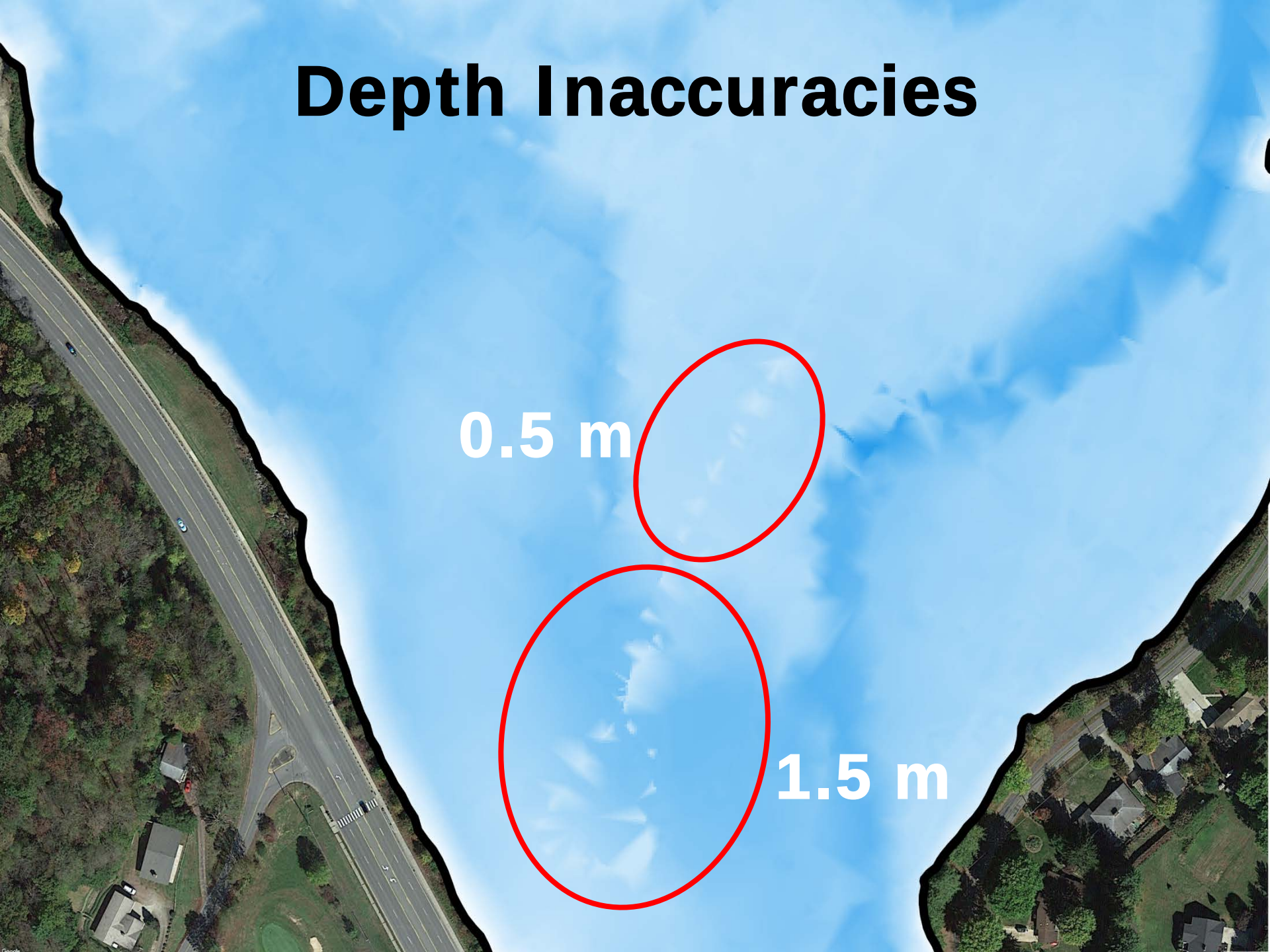
Depth Raster



Area:	80.6 ha
Mean Depth:	4.00 m
Volume:	3.2 million m^3

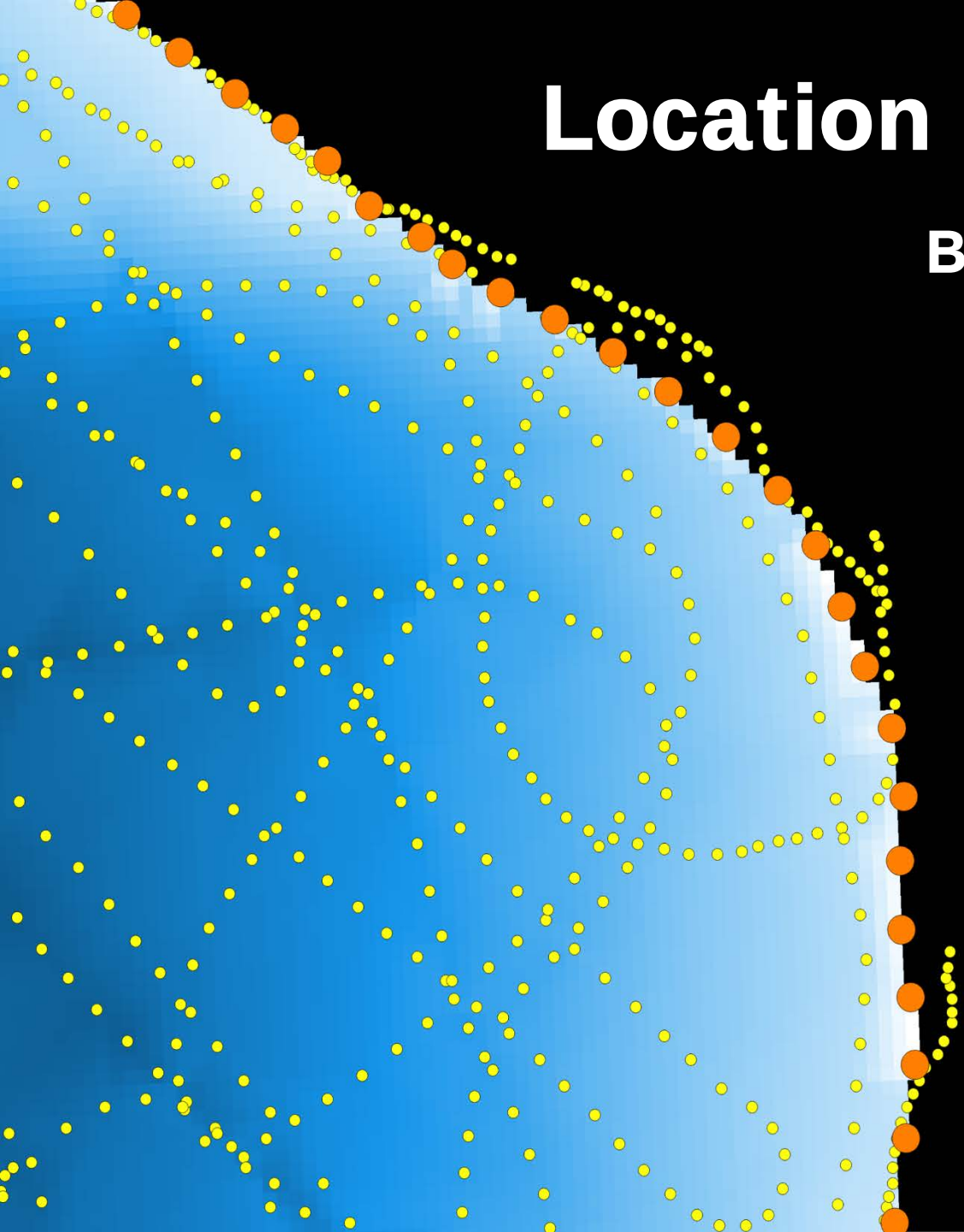

Results
Depth Raster
Berm Top: 5.1 m
Breach Depth: 8.0 m

Depth Inaccuracies



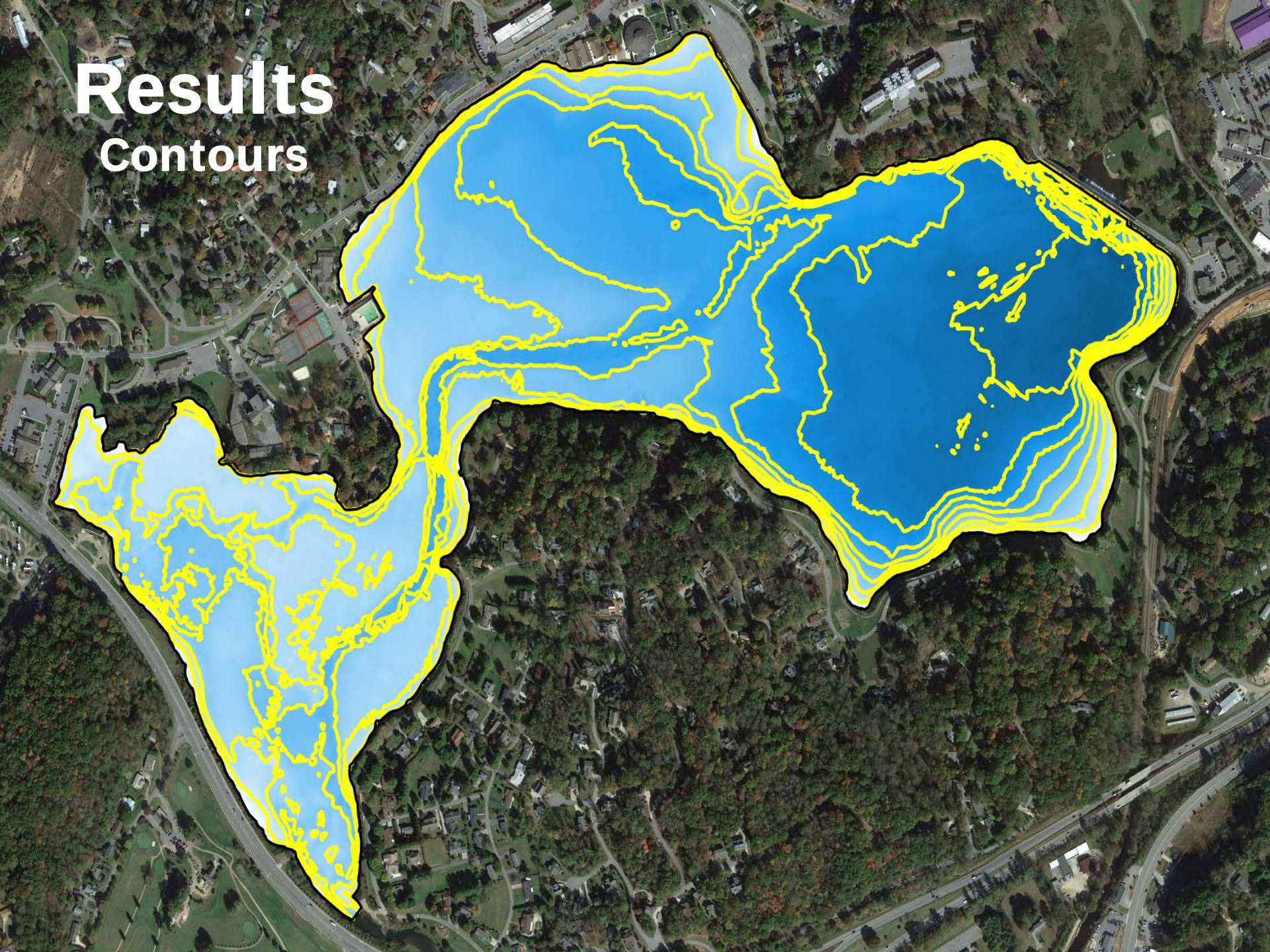
Location Inaccuracies

Boat v/s Kayak



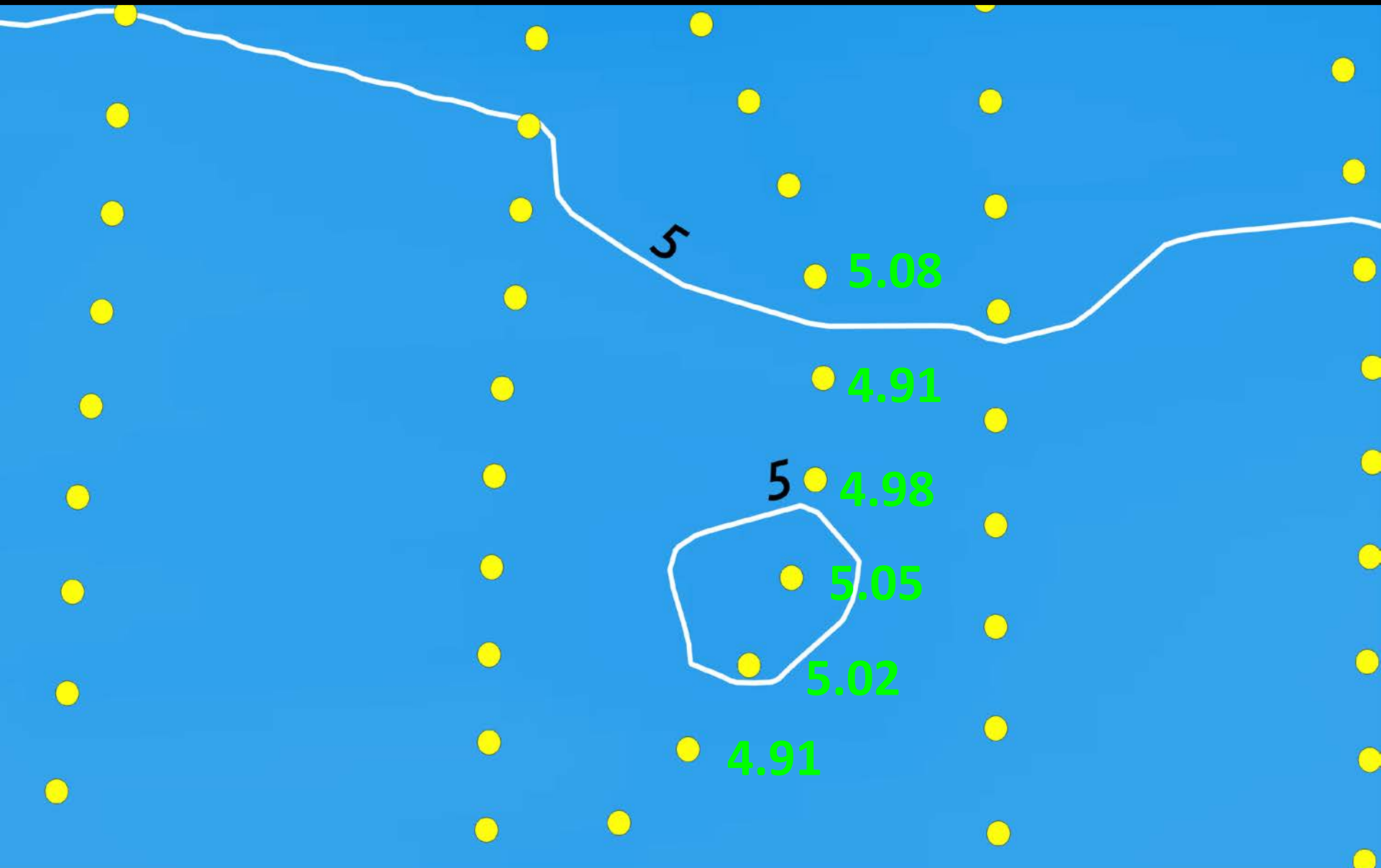
Results

Contours



Influential Data Points

Influential Data Points



Conclusions

Objectives:

- **Good overview of lake bathymetry**
- **Estimated lake volume**

Goal: Inexpensive

- **$30 Raspberry Pi**
- **$0 Software: QGIS, [R], gpsd, gpspipe, Ubuntu, Raspbian**

Goal: Simple data collection

- **No Linux knowledge required**

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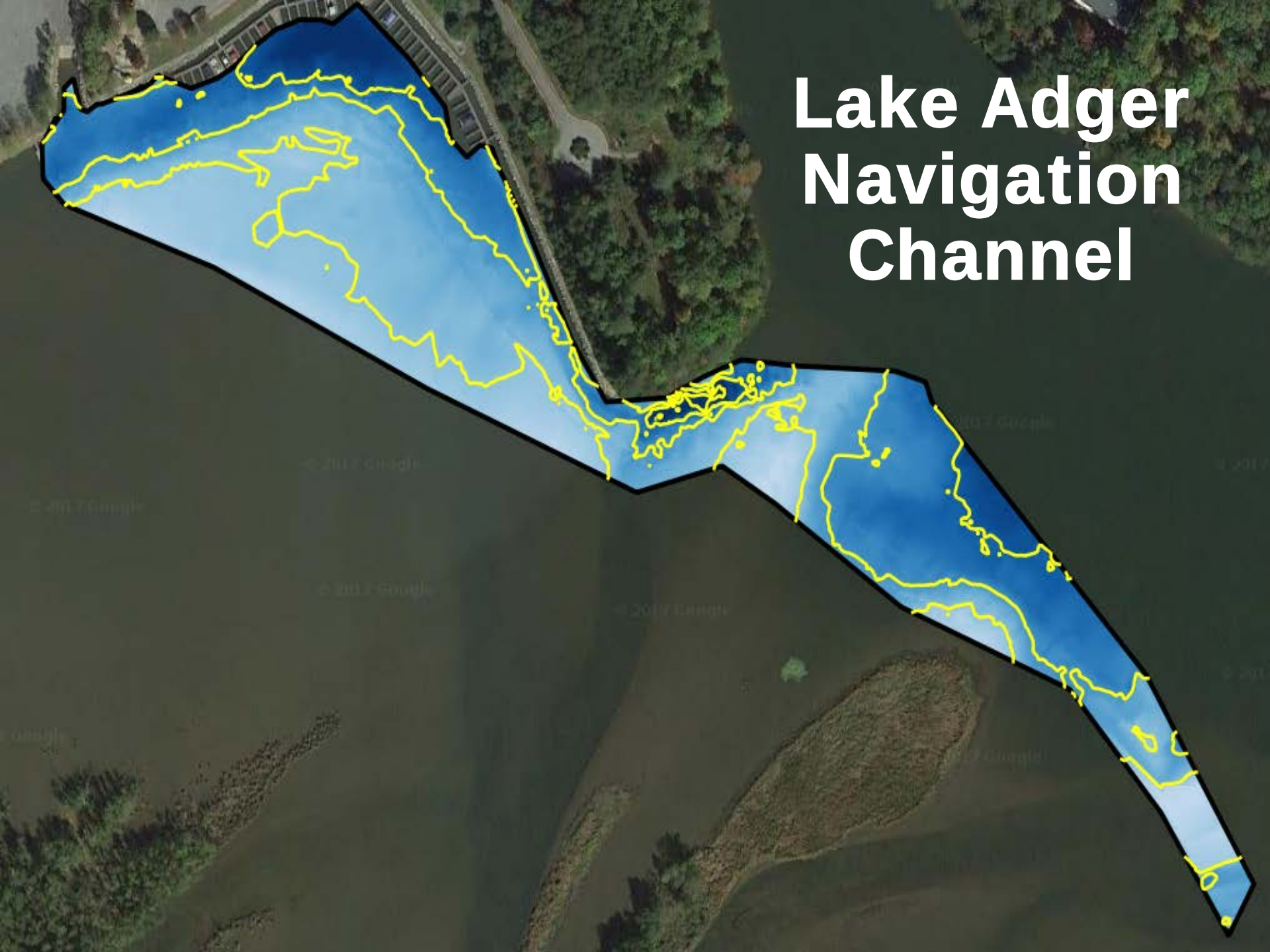
Engineering Applications


Lake Adger
Navigation
Channel

Future Plans

Goal: Eliminate Noise

Better GPS locations

- **Install a better antenna on boat**

Better depth reading

- **Study relationship between boat speed and depth**
- **Start recording boat velocity (GPVTG)**

Software solutions

- **Round depth values**
- **Data thinning (systematic, random, spThin)**

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Thanks

Lake Junaluska Assembly

Sport Fish Restoration

Mrs. Burn

Trail of Bread Crumbs…

Capture NMEA Sentences with a Raspberry Pi

http://www.instructables.com/id/Raspberry-Pi-3-GPS-Data-Logger/

Decode NMEA Sentences

http://catb.org/gpsd/NMEA.html

Convert DDMM.MMMM to DD.DDDDDD in R

http://stackoverflow.com/questions/8335146/

Create a polygon in QGIS from points with Points2One plugin

https://pvanb.wordpress.com/2013/01/17/point-to-polygon-part-i/

Interpolate Data in QGIS (Lake Bathymetry Example!)

http://www.qgistutorials.com/en/pdf/interpolating_point_data_letter.pdf

Serious QGIS Glitch That I Often Encountered and a Work-Around

https://gis.stackexchange.com/questions/228457/qgis-clipping-raster-layer

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Questions?
Thoughts?
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