Comparison of transect spacing and GPS/Sonar equipment for fluvial lake mapping

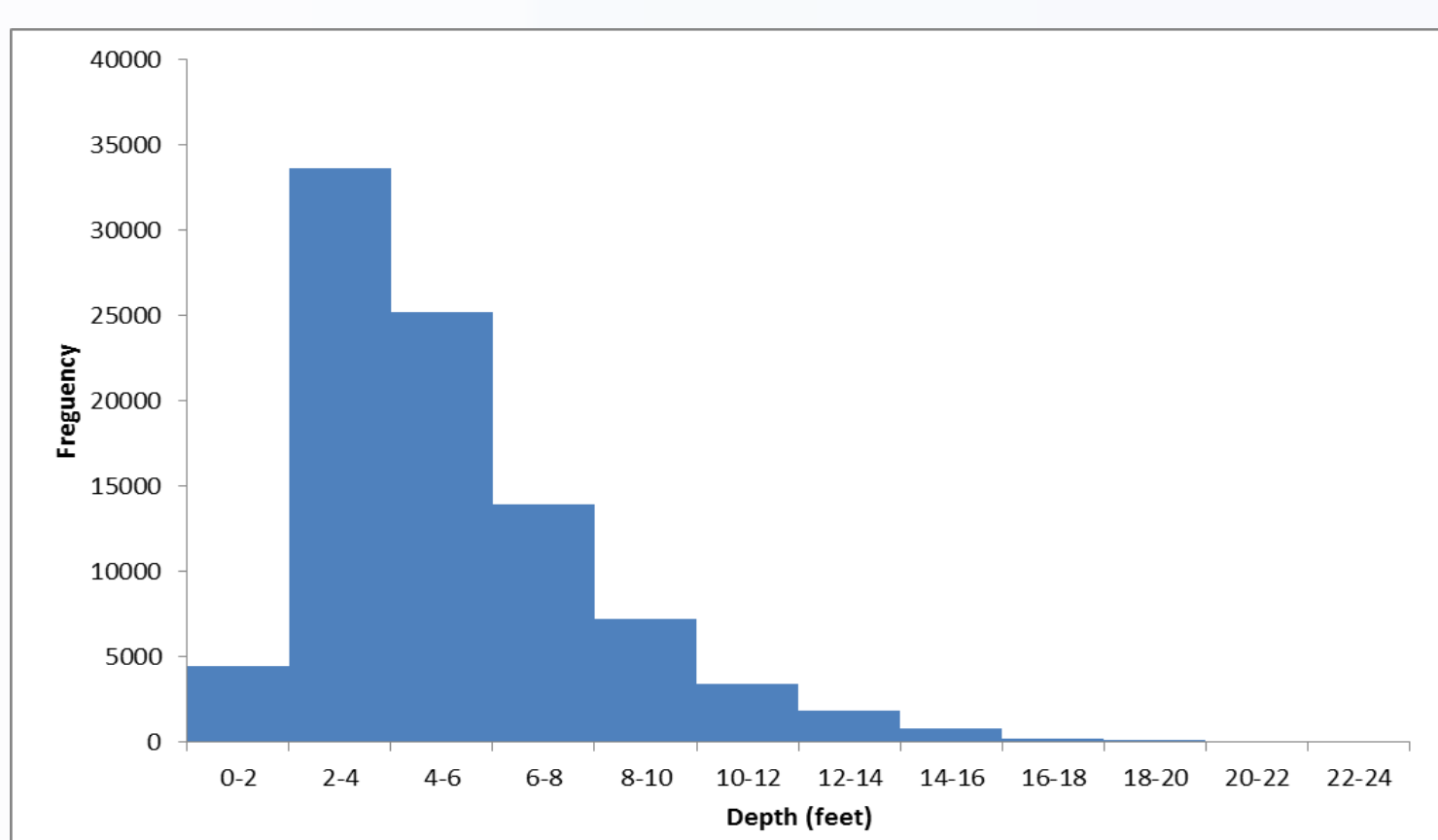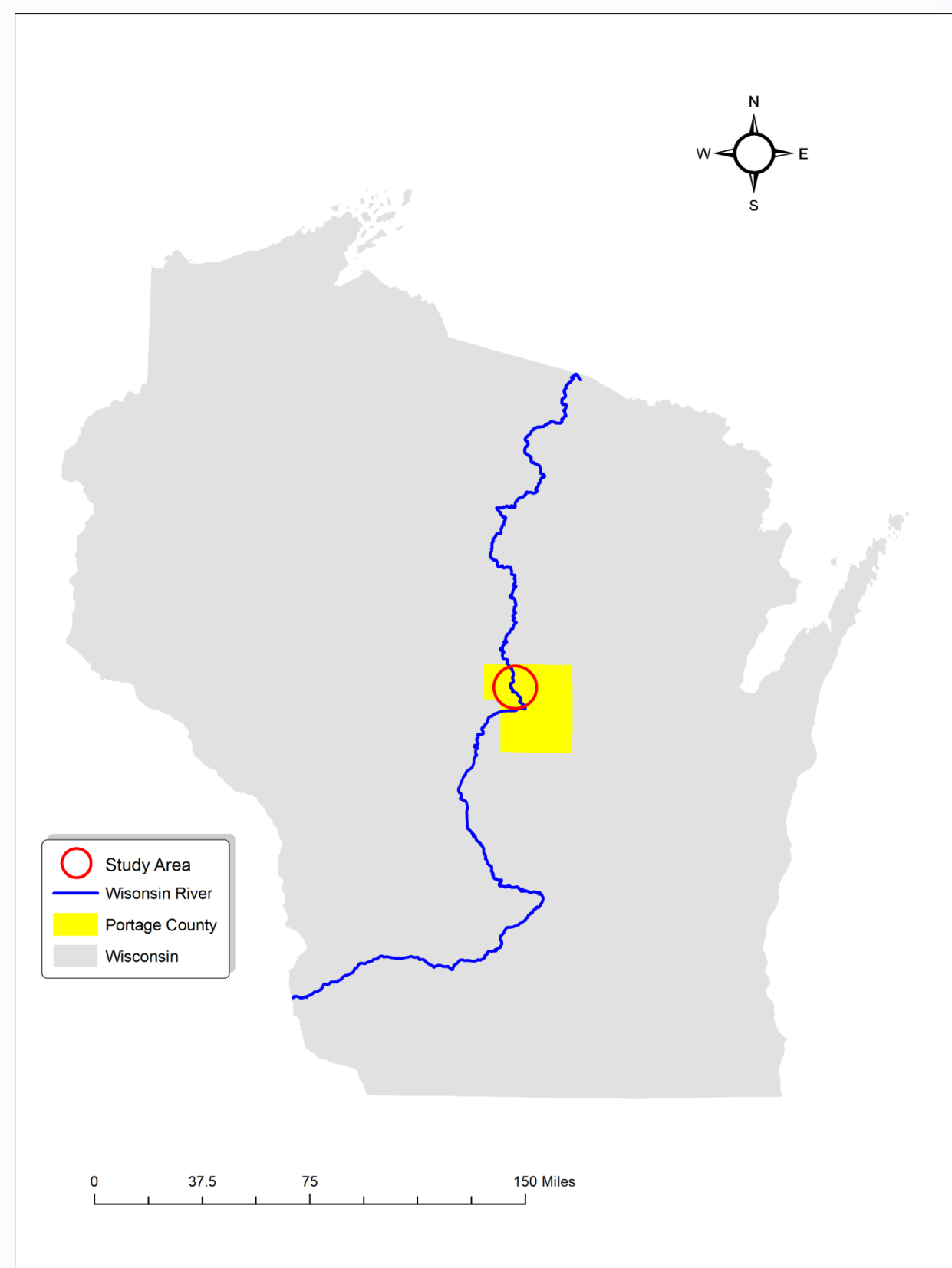Author: Mason Johnson   Advisor: Christine Koeller

ABSTRACT

Bathymetric lake mappers are inconsistently employing survey techniques and GPS/Sonar equipment. Comparing transect spacing and GPS/Sonar equipment for fluvial lake mapping is needed. A bathymetric survey was conducted on the Stevens Point Flowage in 2013 from Bukolt Park north to the Highway 10 overpass. The survey was completed with two methods including 1) a Trimble R6 GPS receiver, TSC2 data collector, Sonarmite depth sounder, cellular device with WISCORS instantaneous corrections applied and 2) a Lowrance HDS5 GPS/Sonar. Transects were initially spaced 300 feet apart running perpendicular to flow direction. Trimble and Lowrance XYZ points that occurred within 30 feet of each other were used to create separate lake models for each technique. Subsequent models were built after manually removing every other transect (600 foot spacing). Flowage models from both survey techniques and varying transect spacing scenarios were built and compared at randomly generated locations (two-way, paired t-Test(two-tailed)317 using ESRI ArcGIS 10.1 software and the Geospatial Modeling Environment tools to determine if significant differences exist between survey techniques. Pool volume differences are also evaluated.

STUDY AREA

The Stevens Point flowage is an impoundment of the Wisconsin River located in Portage County (Figure 1).

The surveyed area extends from Bukolt Park north to the Highway 10 overpass. The studied area is 2611 acres with a channel length of seven miles.

Figure 1: Stevens Point Flowage, Portage County, WI.

Graph 1: Depth distribution of XYZ locations on Stevens Point Flowage, 2013.

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INTRODUCTION

Surveyors are able to measure lake depth fairly well using modern sonars but, these types of measurements can be challenging if striving for the highest level of accuracy (Fridl 2009). Utilizing echo sounder and GPS technology to estimate lake volume requires precision for developing a representative model of the system. Bathymetric data, in essence information about the water depth and underwater topography of oceans, seas and lakes, are important in many aspects of marine and lacustrine research, administration and spatial planning of marine and coastal environments and their resources (Jakobsson 2011).
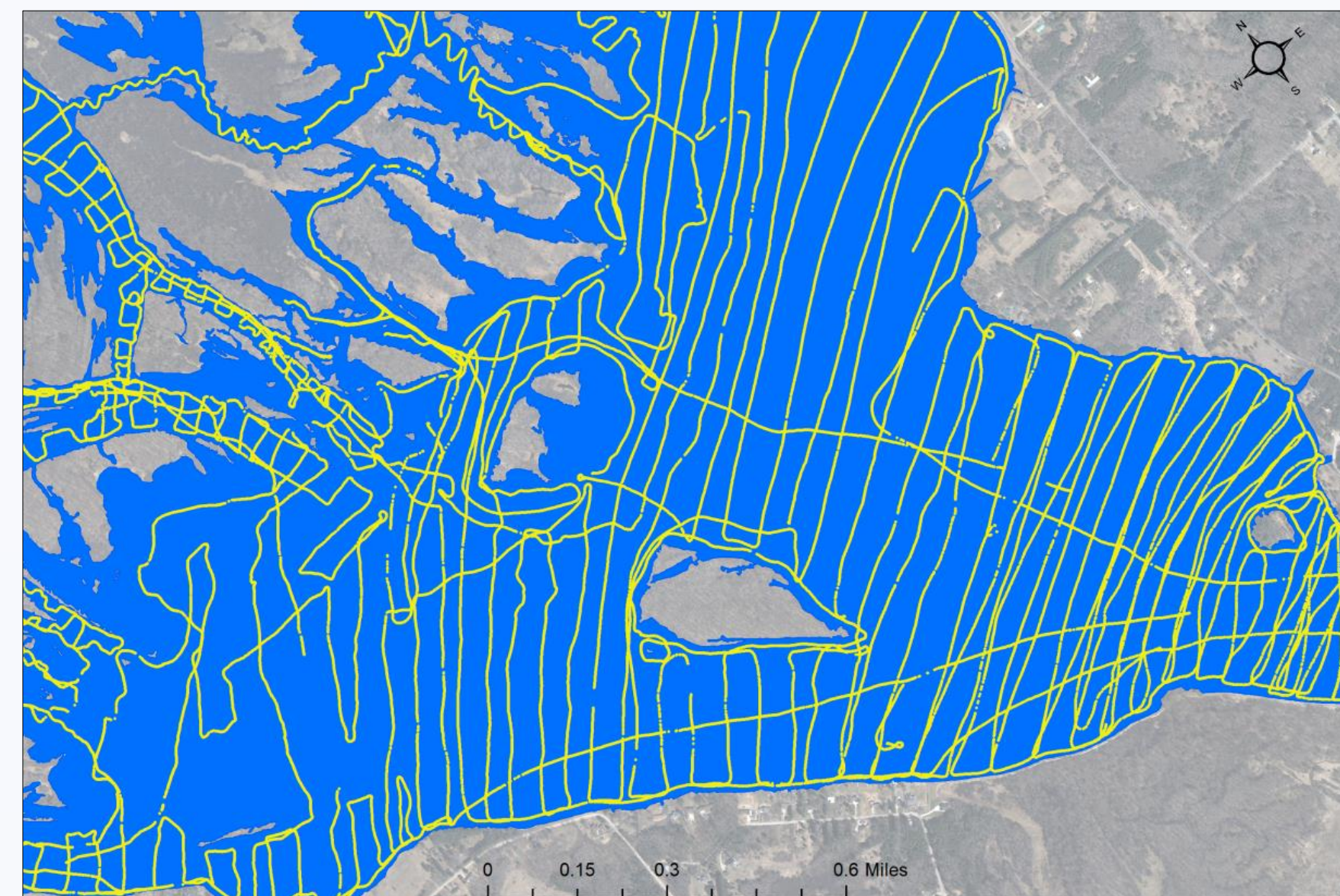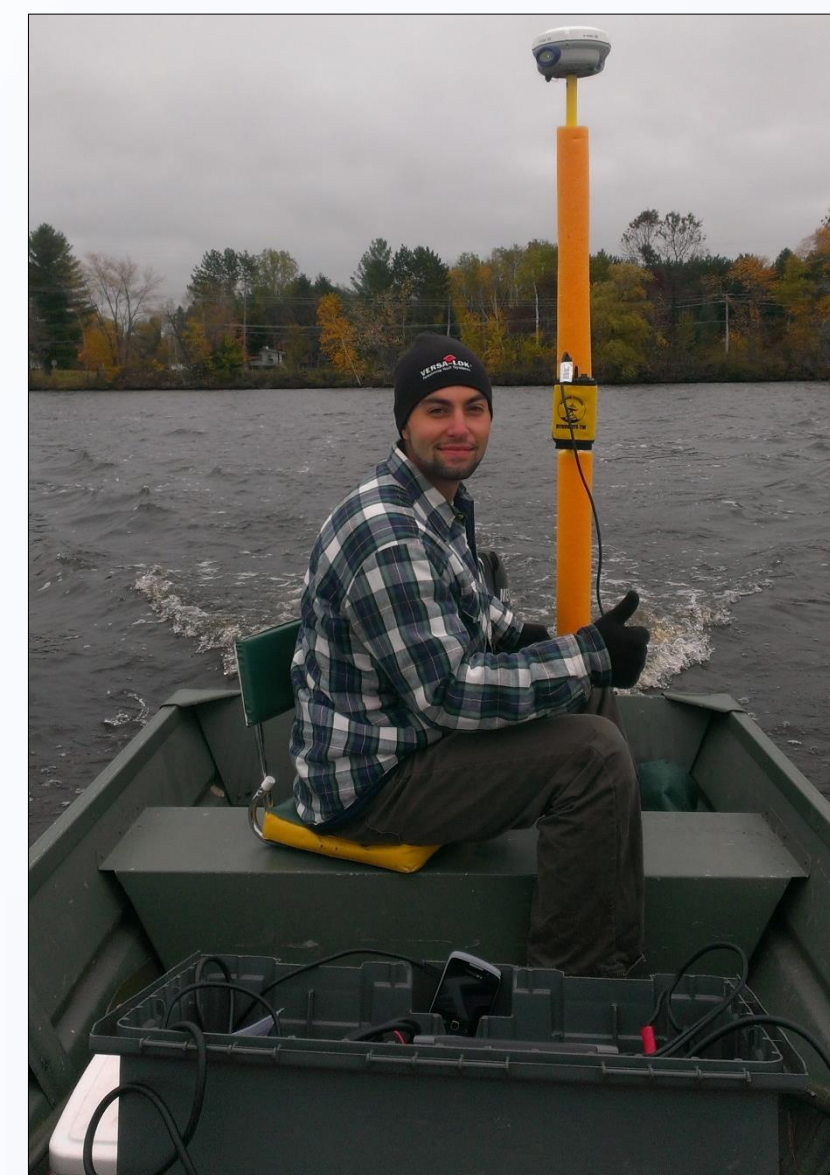
OBJECTIVES

1) Determine if significant differences exist between survey-grade (Trimble R6) and mapping-grade equipment (Lowrance HDS5).

2) Determine adequate transect spacing using survey-grade equipment for estimating lake volume. (μ T$_{300}$ = μ T$_{600}$)

METHODS

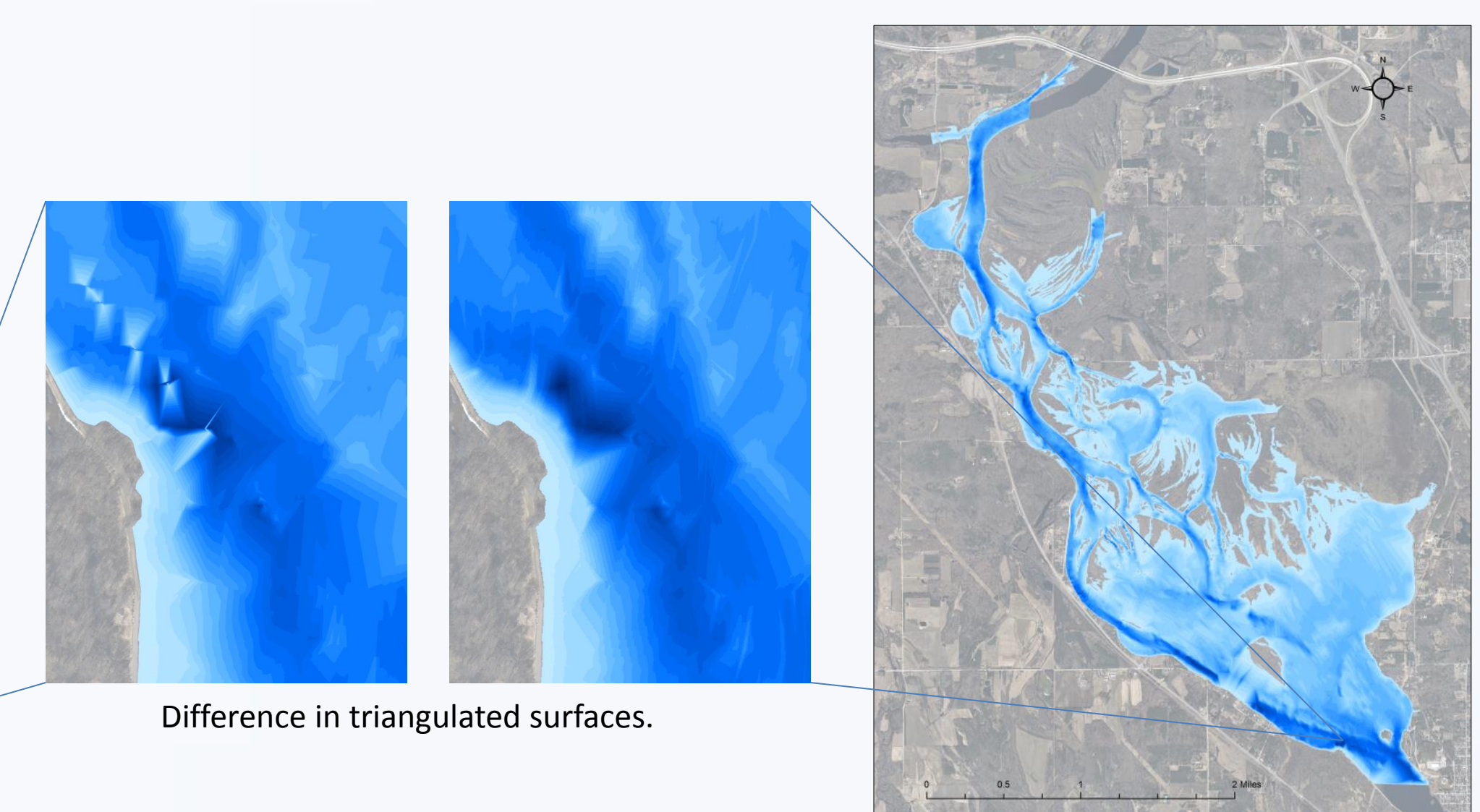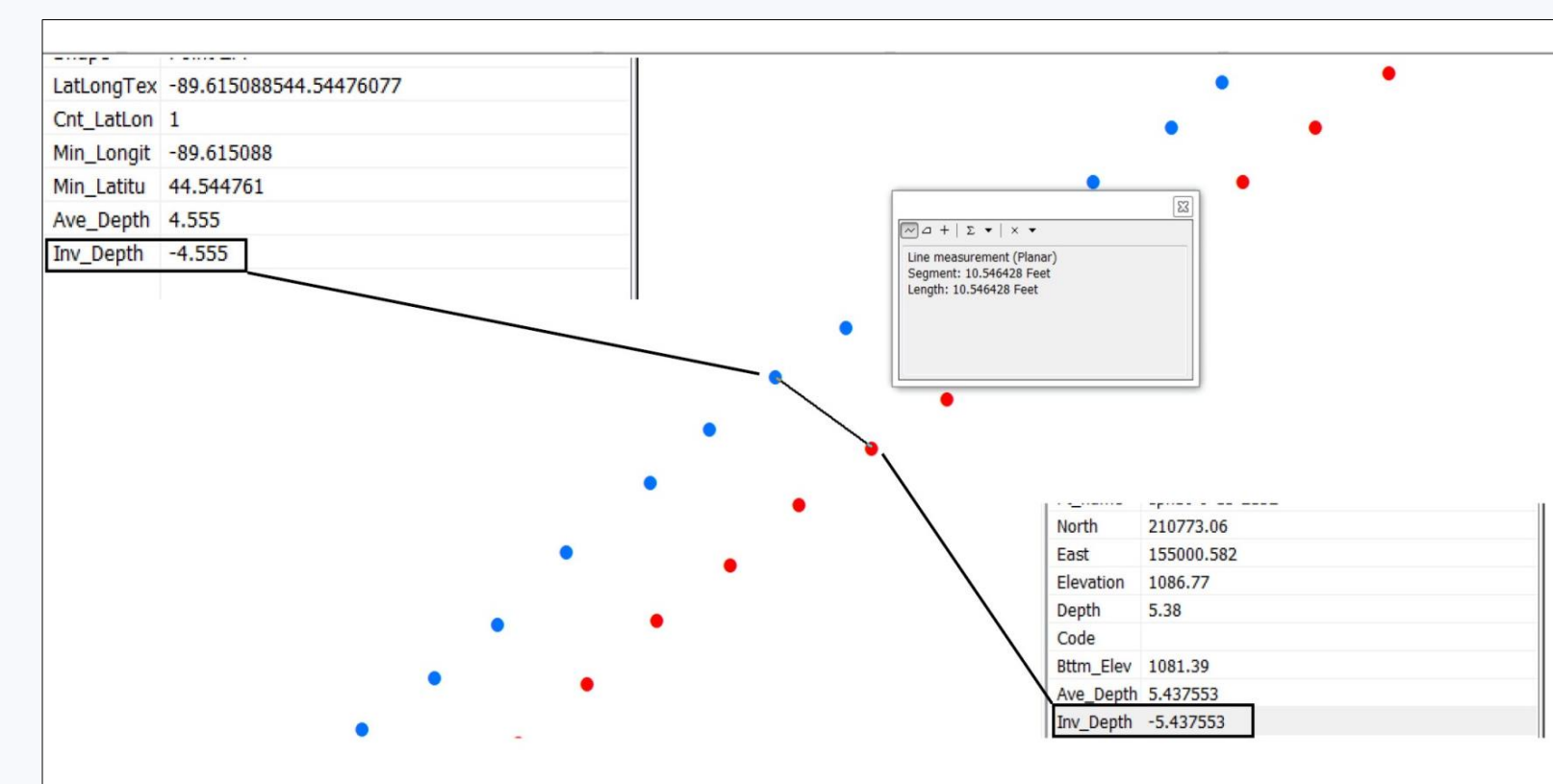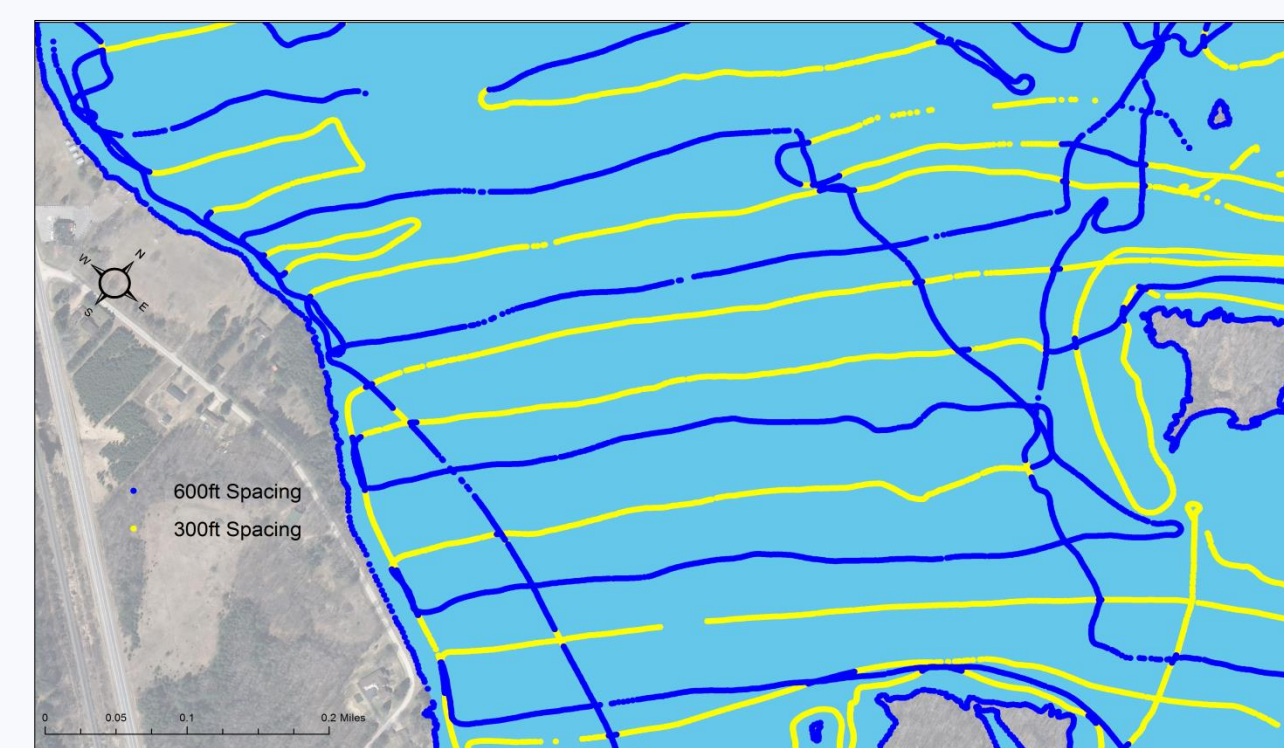*Data Acquisition for 2013 Maps*

- GPS/Sonar survey in summer-fall 2013 using survey-grade equipment (Trimble R6 GPS, Ohmex Sonarmite depth sounder) (Figure 2).
- Real-time corrections were applied to Trimble equipment via WISCORS reference station (<1 cm horizontally, ±3cm vertically).
- Grid transects were spaced 300 feet apart perpendicular to channel flow (Figure 3).
- Near shore depths were also acquired.
- XYZ positions were recorded every second.
- Lowrance survey data was collected using a similar method devoid of WISCORS differential corrections.

Figure 2: Trimble/Lowrance survey equipment attached to transform of 6hp Jon boat while surveying .

Figure 3: Grid-like transects spaced 300 feet apart and proximate shore outline, Stevens Point Flowage spring 2013.

METHODS

Construction of 2013 Trimble and Lowrance Surface Models

- Shoreline and islands were digitized from WROC 2010 aerial imagery using ArcMap 10.2 software.
- Vertices from digitized shoreline and islands were set to a depth of zero and combined with surveyed data.
- Transects spaced 300 feet apart were manually removed for comparison between 300 and 600 foot models (Figure 4).
- Triangulated Irregular Network (TIN) models were created from Trimble and Lowrance data .
- TIN models were converted to 1m raster grid (Figures 6 and 7).

Figure 4: Transects spaced 300 feet manually removed.

Figure 5: Positional and depth error of Lowrance survey data.

Figure 6: Lowrance 1m raster.

Difference in triangulated surfaces.

Figure 7: Trimble 1m raster.

METHODS

Model Comparisons

- Utilizing Geospatial Modeling Environment, one-acre grids were created (Figure 10).
- Random points were generated for each ten-acre grid.
- Depth points were extracted from each 1m raster model using generated random points.
- Paired t-Test executed to determine if any significant differences existed between Trimble and Lowrance (Table 1 and 2).
- Percent differences were calculated for survey equipment (Table 3) and Trimble transect spacing (Table 4).

RESULTS

Table 1:Percent difference of lake volumes produced by Trimble vs Lowrance depth models.

Lake Volume (Acre-feet)	
Trimble	10254.22
Lowrance	9297.64
Average	9775.93
Difference	956.58
Percent Difference	9.79

Table 2: Calculated percent difference of Trimble lake volumes with different transect spacing.

Transect Spacing (feet)	Volume (Acre-feet)
300	10254.22
600	9894.37
Average	10074.30
Difference	359.85
Percent Difference	3.57

Table 3: Paired t-Test of Lowrance and Trimble bathymetric models at random points within ten-acre grid.

Paired t-Test (α=0.05)	t Critical	P-value
Lowrance vs. Trimble t$_{(two-tail),317}$	-9.94	0

Significant difference exist (P<0.05) between Lowrance and Trimble survey equipment.

Table 4: Paired t-Test of Trimble bathymetric models using 300 foot transects.

Paired t-Test (α=0.05)	t Critical	P-value
Trimble t$_{(two-tail),317}$	-2.68	0.008

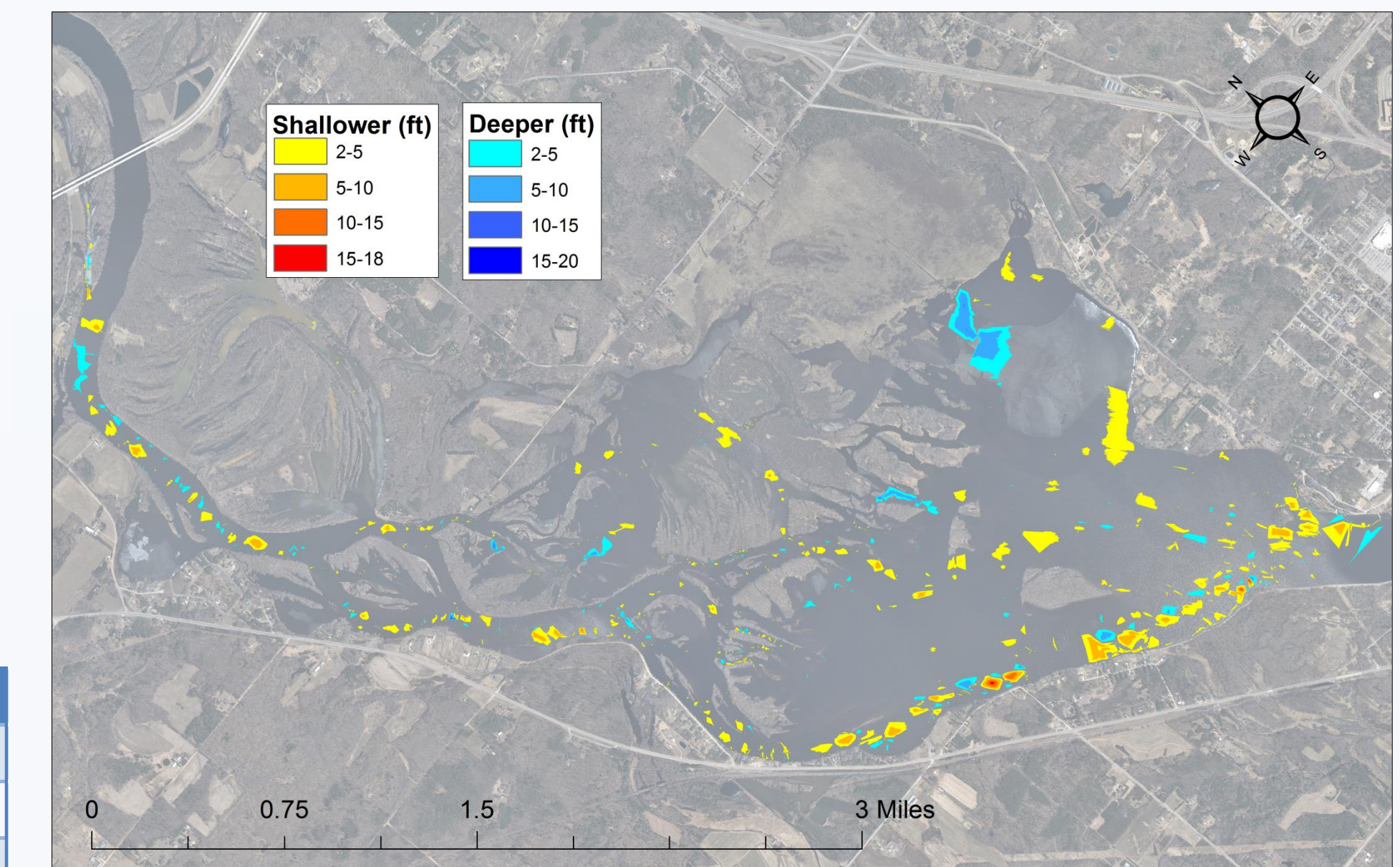Significant difference exist (P<0.05) between Trimble 300 and 600 foot transect spacing.
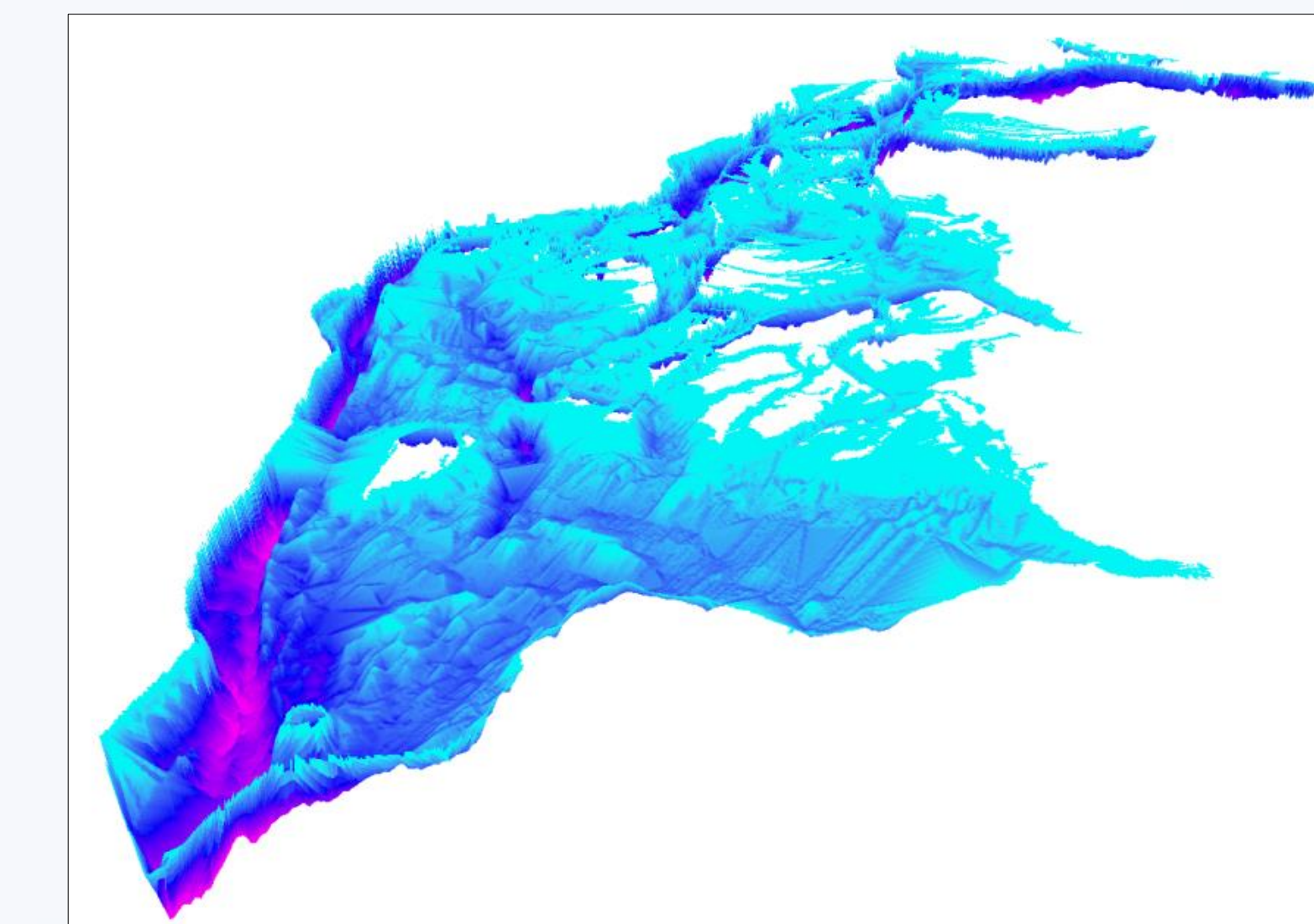
Figure 8: Depth variations of Lowrance model compared to Trimble

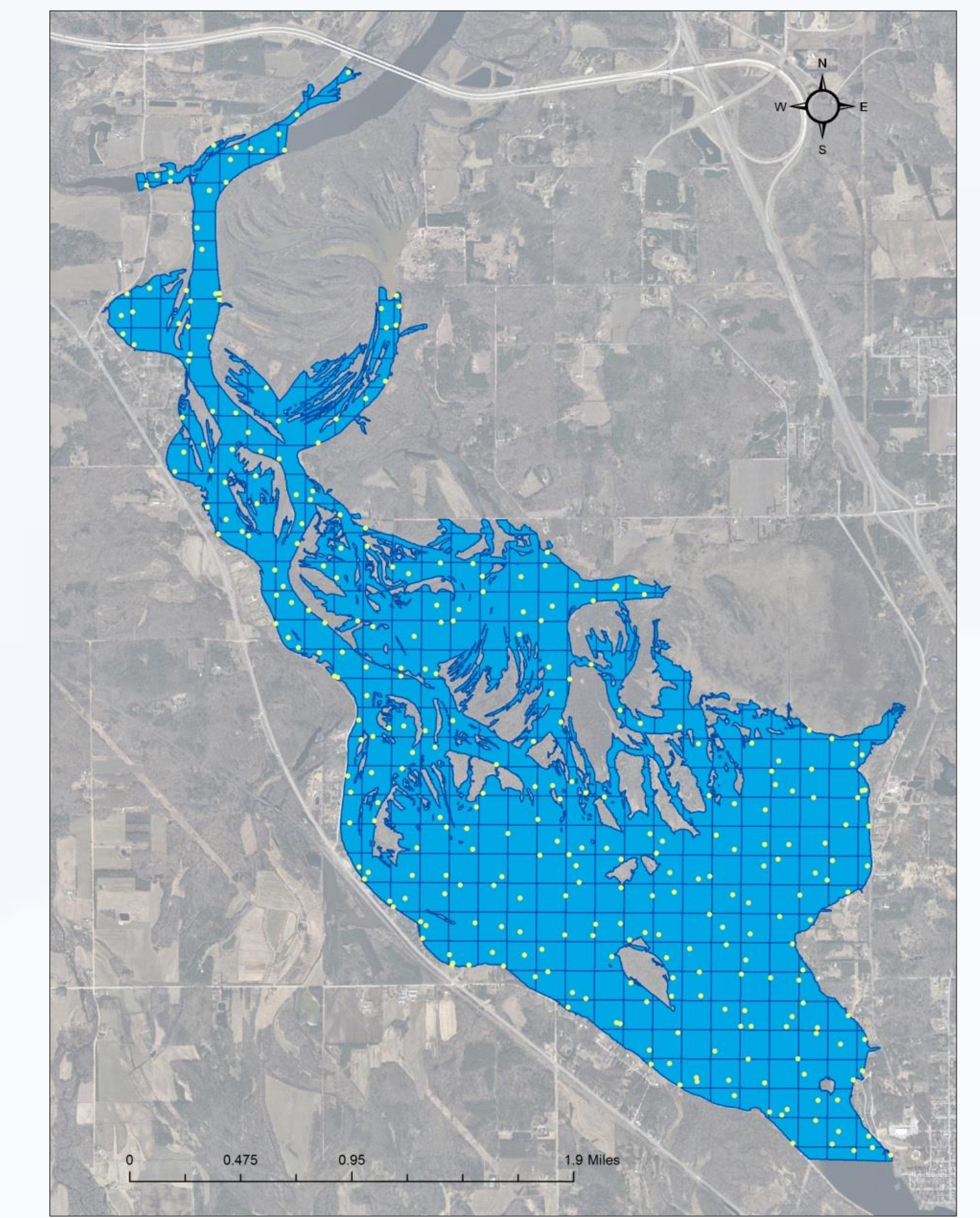Figure 9: Trimble 1m raster grid with 16x exaggerated heights.

Figure 10: Random points generated within each 10-acre grid.

DISCUSSION

High cost, survey-grade equipment (Trimble), produces accurate GPS locations to the sub-centimeter level. Low-cost survey equipment (Lowrance) failed to produce an accurate representation of the Stevens Point Flowage when compared to Trimble. Error associated with Lowrance survey equipment resides in the inability to receive instantaneous coordinate corrections (Figure 9). Modeling lakes require a higher level of accuracy to represent them, depending on the objective.

Transects spaced 300 feet apart result in more accurate lake volume estimations. Increasing transect spacing will likely reduce accurate lake volume estimations. This poses a problem when developing best management practices. Lake managers controlling aquatic invasive species often use water level drawdown techniques to eliminate these species. Drawing-down lakes to an extreme level can result in native plant's being unable to establish. Knowing lake volume reduces this risk.

References:

Aquatic Plant Management - Water Level Drawdown. Available at http://www.ecy.wa.gov/programs/wq/plants/management/drawdown.html (verified30 March 2014).

Beyer, H.L. (2012). Geospatial Modelling Environment (Version 0.7.2.0). (software). URL: http://www.spatialecology.com/gme.

Fridl, J., Kolega, N., & Žerjal, A. (2009). Applications of Seafloor Mapping Using Precise Sonars. Cartography & Geoinformation, 8(11), 14-24.

Hell, B., Broman, B., Jakobsson, L., Jakobsson, M., Magnusson, Å., & Wiberg, P. (2012). The use of bathymetric data in society and science: A review from the baltic sea. Ambio, 41(2), 138-50. doi:http://dx.doi.org/10.1007/s13280-011-0192-y.

GIS Center
College of Letters and Science
University of Wisconsin-Stevens Point