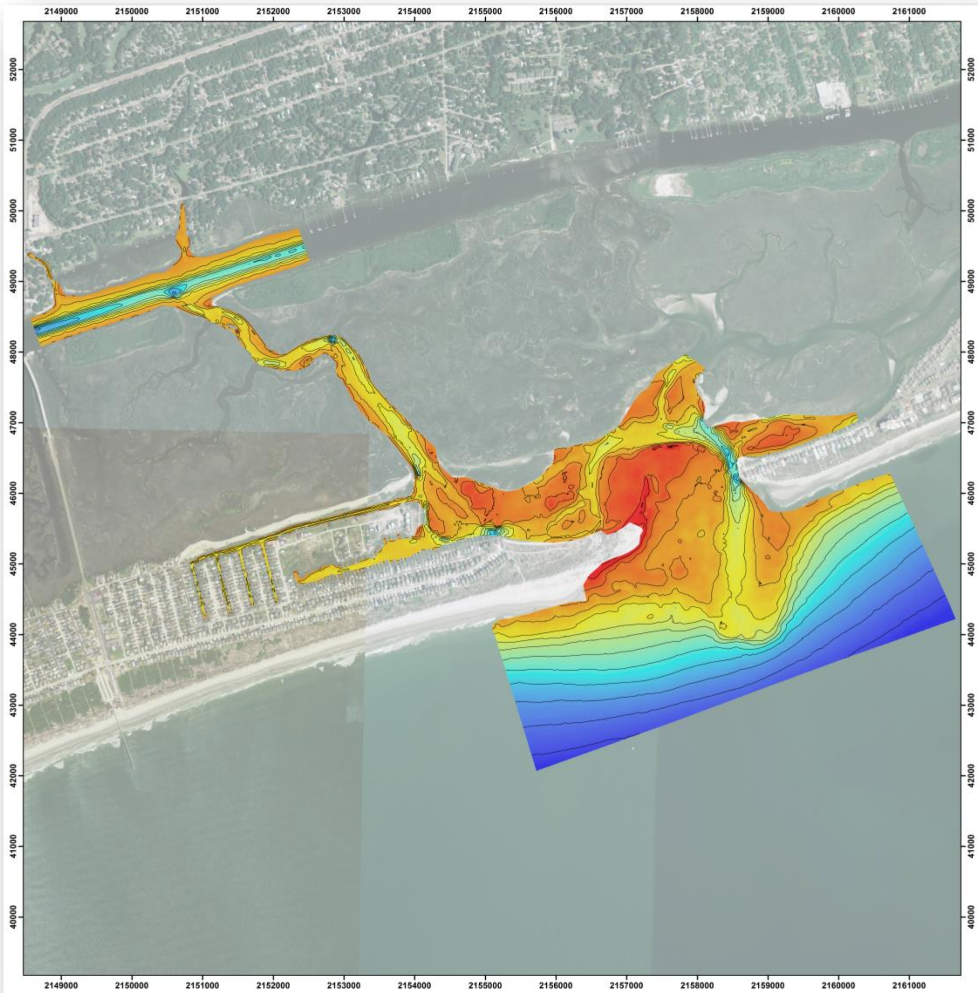
Sunset Beach Hydrographic Survey & DEM Development – Sunset Beach, NC
August 2016



DESCRIPTIVE REPORT

Submitted by:

moffatt & nichol

With Sub-consultant:

geodynamics
COMPLEX COASTAL CHANGE MADE CLEAR

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A. INTRODUCTION

A1. Project Description

The project area is located in Sunset Beach, North Carolina. Survey efforts were focused at Tubbs Inlet and a portion of the Intra-coastal Waterway (AIWW). The purpose of the project is to acquire shallow singlebeam and topographic survey data at a density sufficient to create an accurate Digital Elevation Model (DEM). More specifically, these datasets represent the remaining portions of data required to generate a composite DEM. Previous datasets collected in February 2016 include inside the flood shoal of Tubbs Inlet to the finger piers in the community to the west, through Jinks Channel, the AIWW, and two tributary channels on the north side of the AIWW. This survey meets the criteria for Navigation and Dredging Support Hydrographic Surveys as outlined in the U.S. Army Corps of Engineers Hydrographic Surveying Manual, EM 1110-2-1003 (EM 1110-2-1003 January 2002).

Survey data were collected using hydrographic survey methods. Singlebeam sonar soundings were collected from a 21 ft catamaran, the RV Echo, with a digital Odom CV100, 200 kHz ultra-shallow water sonar system. Real-time horizontal and vertical control for singlebeam data acquisition was provided by the NCGS RTK-VRS network. Topographic data was collected using a backpack and a Trimble R7 GNSS receiver. All singlebeam and topographic data was processed using HYPACK software and developed into a DEM using Surfer and ArcGIS software. All data was cross-checked and verified using Hypack and ArcGIS 10.3 software.

A2. Data Acquisition Timeline and Survey Conditions

Data acquisition activities occurred on 8/23-24/2016. Due to the tidal regime, data collection on the inside of the inlet and nearshore perimeter was collected during higher tides. All attempts were made to collect bathymetric data as near to the shoreline as possible given the conditions. Shown below are graphical illustrations of data acquisition activities with respect to tidal conditions near the survey area (Figure 1).

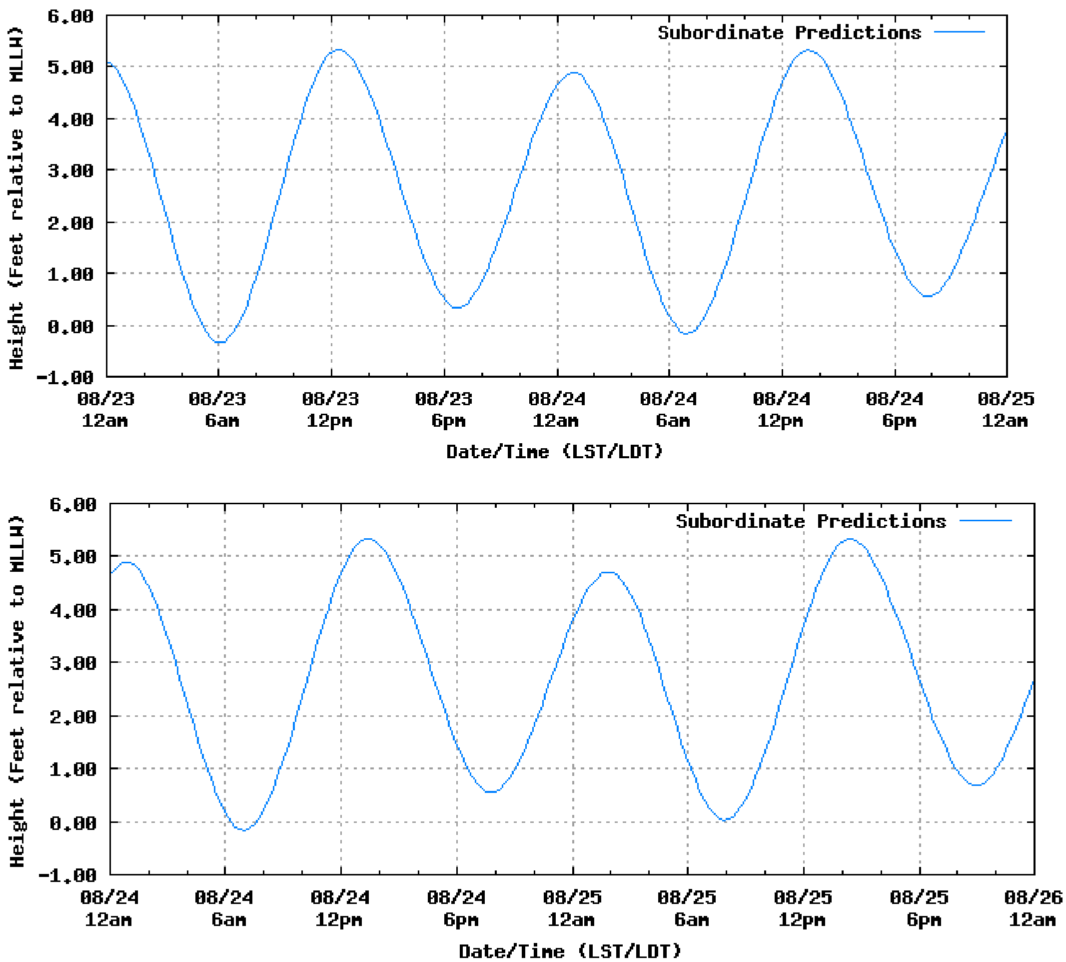


Figure 1: Graph showing predicted and observed tide throughout the survey period.

A3. Survey Area

The survey was conducted across a ~5 mi^2 area in Sunset Beach, NC, ranging in elevations from 4 to -23 ft depths (NAVD88) at Tubbs Inlet, to -1 to -20 ft in the AIWW. The survey bounds are approximately 33°53’05.9564”N, 078°30’41.0895”W (Upper Left Corner), and 33°51’44.222”N, 078°27’55.4827”W (Lower Right Corner) (Figure 2).

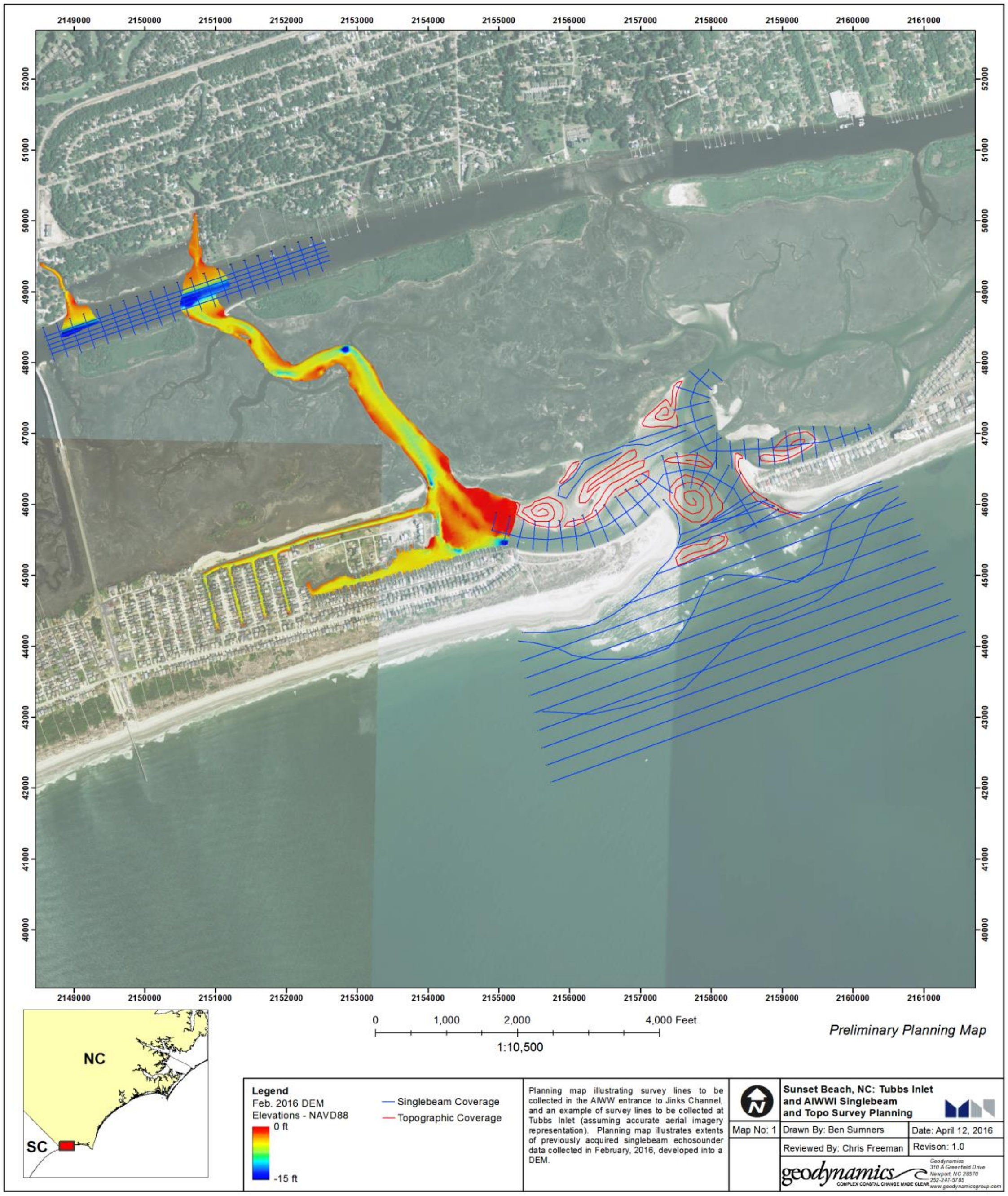
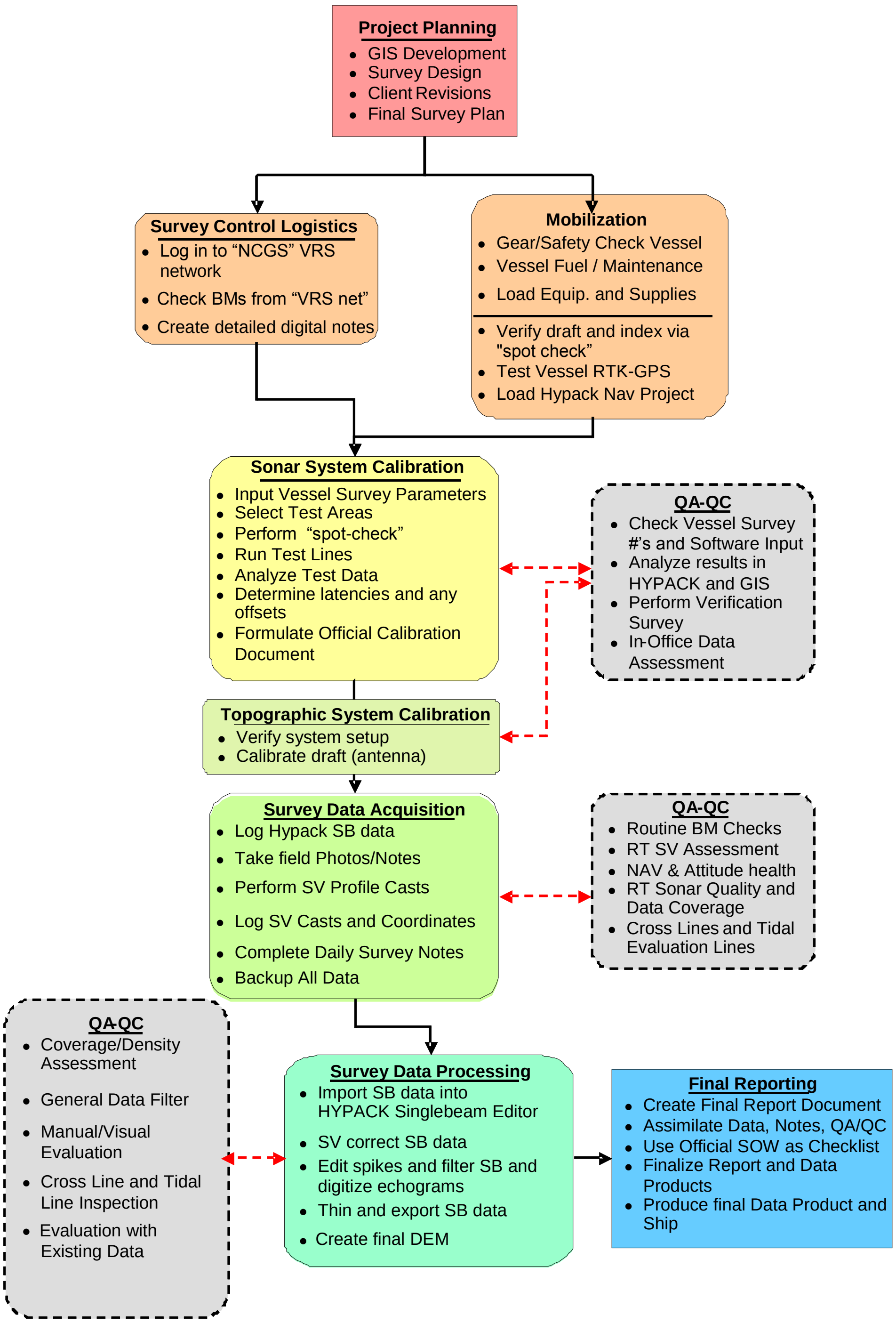


Figure 2: Generalized overview of the survey area and proposed lines in Tubbs Inlet and the AIWW.

A4. Project Workflow – Singlebeam Data



B. SINGLEBEAM DATA ACQUISITION AND PROCESSING

B1. Equipment

A 21 ft catamaran served as the survey platform for singlebeam data acquisition (Figure 3). The RV Echo has a hull mounted singlebeam transducer accompanied by tightly coupled navigation and attitude sensors (Table 1). Sound velocity sensors and customized computer systems allow seamless logging of bathymetric data in extremely shallow conditions (~0.8 ft of water).

Figure 3: The RV Echo.

2.0 Hardware

Table 1: R/V Echo Hardware Systems Inventory

	Hardware Equipment	**Manufacturer**	**Model**
H&V Control	GPS Antenna	Trimble	Zephyr II Geodetic
	Cellular Internet	Verizon	JetPack 4G
	POS MV	Applanix	Wavemaster
Echo Sounding	StructureScan	Simrad	1.7.0
	ODOM CV100	ODOM	CV100
	Operator Station	CCS-inc	FPC-04649
Attitude Positioning	Inertial Motion Unit (IMU)	Applanix	Wavemaster
	Position Compute System (PCS)	Applanix	Wavemaster
	Primary GPS Antenna (port)	Trimble	Zephyr
	Secondary GPS Antenna	Trimble	Zephyr
Sound Velocity	Sound Profile Velocimeter	AML Oceanographic	BaseX SVP w/ GPS enabled Data Xchange

2.1 Horizontal & Vertical Control Equipment

The vertical control for singlebeam data acquisition was provided by the NCGS CORS network to the vessels' POS MV Wavemaster to calculate and record real-time attitude and navigation.

2.2 Sound Velocity Equipment

The AML Oceanographic Minos SVP Exchange sound velocimeter was used during the survey in order to obtain accurate sound velocity profiles throughout the survey area (Figure 4).

Unlike traditional Conductivity, Temperature, and Depth (CTD) sensors, velocimeters measure sound speed directly using "time of flight" technology, automatically compensating for pressure, salinity, and temperature. The system comprises a sound velocity probe attached to the data collector where the survey technician logs the sound velocity profile data as the probe is deployed.

Figure 4: AML Oceanographic Smart SV&P Velocimeter.

2.3 Echo Sounding Equipment

An Odom CV100 singlebeam sonar system was used to acquire singlebeam bathymetry data during the survey (Table 2, Figure 5). The CV100 system operates at frequencies in the 200 kHz band; ideal for shallow depths. The transducer forms a 4 degree conical beam. With an operational depth range from <30 cm to 600 m and a ping rate up to 20 Hz, the CV100 is ideal for shallow water surveys.

Table 2: CV100 specification

Frequencies.	200 kHz / 33 kHz
Maximum ping rate.	up to 20 Hz
Heave compensation	Yes
Depth resolution	1 cm
Transducer	Airmar SMSW200-4a

Figure 5: Odom CV100 digital echosounder used for the Sunset Beach Survey.

3.0 Software

3.1 Software Systems Inventory

Table 3: Software Systems Inventory

	Software	**Version**
Data Acquisition	HYPACK 2015	2015
	Lefebure NTRIP Client	2011.03.14
Data Processing	HYPACK 2015	2015
	Sea Cast	4.0.6
	ArcGIS	10.1-10.3
	Surfer	9.0

3.2 Data Acquisition Software

The initial survey design was developed in HYPACK. Survey lines were drawn based on the expected bathymetry, desired cross sections, and the need to model a DEM. Using a matrix file within HYPACK Survey, surveyors were able to constantly monitor data coverage and collect additional data in areas that were scarce or had complex features. Constantly monitoring HYPACK device windows allowed surveyors to monitor data quality as well.

3.3 Data Processing Software

HYPACK was used to review, manipulate and process singlebeam bathymetric data. The Singlebeam Editor in HYPACK was used to import, investigate GPS quality, remove flyers, digitize (when necessary), and thin the data. Upon cleaning, the *Export* module was used to export the data into a specific format.

Digital Elevation Modeling was performed in Surfer 9.0 using a kriging technique. The ".grd" file generated in Surfer was converted to a raster using ArcGIS 10.3; a complete Geographic Information Systems (GIS) software package. All survey area maps, coverage extents, and final chart products were created using ArcGIS.

B2. Quality Control

1.0 Procedures

1.1 Singlebeam Calibration Checks

In addition to benchmark checks to verify the NCGS CORS status, overlap between topographic and singlebeam data was compared to verify proper setup and collection of field data.

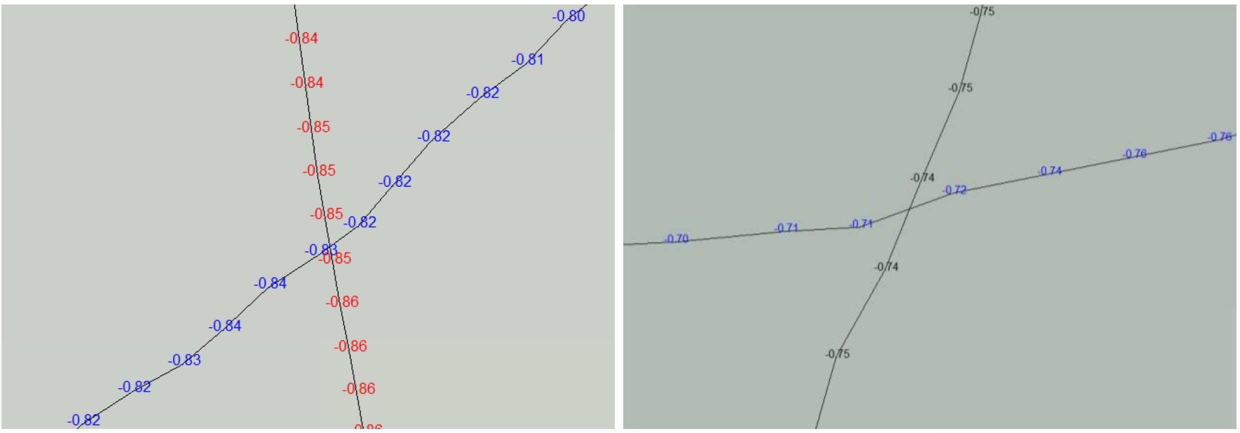


Figure 6: Topo collected by two different surveyors (black and red) vs. singlebeam data points (blue)

1.2 Singlebeam Data Acquisition and Monitoring

At the start of each survey day, a series of pre-survey protocols were run to aid in quality control and to determine any possible errors/issues prior to surveying. For hydro, the offsets, equipment, and hardware settings were verified prior to commencing survey. For positioning, to ensure the quality of the RTK-GPS corrections from the NCGS CORS network, a known benchmark was checked with topo equipment each morning prior to conducting the survey.

All singlebeam data acquisition was completed using HYPACK *Survey* software. Data acquisition was performed at vessel speeds of approximately 2 - 8 knots. The HYPACK data acquisition software produced a constantly-updated on-the-fly data matrix, which allowed for real-time monitoring of the data coverage. Data displays in HYPACK *Survey* were used to monitor all survey parameters and the quality of data being recorded.

Sound velocity profiles were acquired routinely and when the survey vessel moved to a different location within the survey area. Each successive sound velocity cast was assessed and used to determine the need for additional casts.

B3. Corrections to Echo Soundings

1.0 Sensor Offsets

The vessel offsets are measured with respect to the vessel's reference point, located at the top center of the Inertial Motion Unit (IMU). The vessel offsets are entered into POSView to ensure an accurate merging of the IMU data with the singlebeam soundings.

2.0 POS/WM Correctors

The Applanix POSMV WM unit was setup to receive phase-differential RTK position offsets from the CORS network. This configuration allowed the POSMV WM to integrate decimeter positional solutions with highly-accurate vessel attitude positions obtained from the IMU. When the GPS Azimuth Measurement Subsystem (GAMS) is online, positional solutions were being received from 5 or more satellite fixes with a Positional Dilution of Precision (PDOP) equal to or less than 3. When these conditions were not satisfied, the GAMS solution becomes dormant. The GAMS program continues to track satellites while in this state, but does not process the phase-differential corrections real-time.

3.0 Dynamic Draft Correctors

Dynamic draft is the summation of the static draft and settlement and squat corrections, and is a required corrector for the echo soundings. Dynamic draft was accounted for in the echo soundings by using RTK-GPS. The ellipsoid-based vertical RTK corrections provided the survey vessel with an accurate real-time elevation based on the vessels position in the water. The combined correctors work to factor out the static draft, settlement, and squat of the survey vessel.

4.0 Sound Speed Correctors

Sound speed profiles were taken at the start of each survey day, and again throughout the day as warranted by the survey area and water properties. Sound velocity profiles were acquired routinely and when the survey vessel moved to a different location in the survey area or different water properties were observed. Each sound velocity cast was assessed in processing to determine water properties in a specific zone of the survey area.

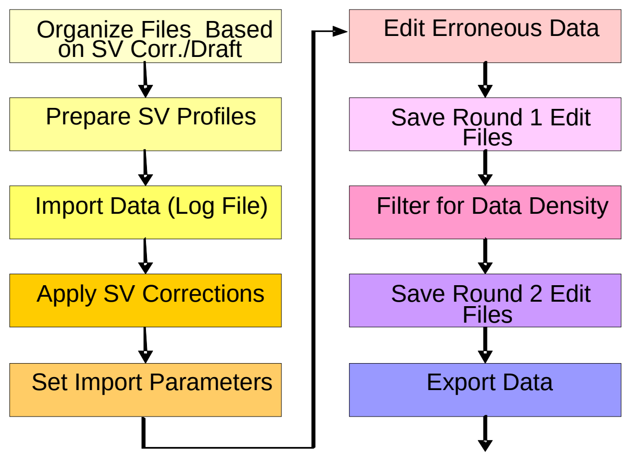
5.0 Water Level Correctors

RTK-GPS based tidal measurements were continuously recorded throughout the survey by HYPACK Survey. The GPS height determined by the POSMV WM was integrated into the raw singlebeam sonar data in the HYPACK data acquisition software real time. After importing the raw singlebeam data in HYPACK, the GPS tide was merged with the heave such to provide accurate tidal corrections and remove vessel heave.

B4. Data Processing

1.0 Singlebeam Data Processing

1.1 Processing Workflow



1.2 Correctors Applied in Post-Processing

Sound velocity corrections are applied to the singlebeam soundings at the initial import during post-processing in HYPACK, as well as attitude and navigation corrections. Due to inherent and common problems associated with RTK-GPS, such as cycle slips, high DOP periods, and data gaps, data was reviewed in all areas with degraded GPS quality and edited appropriately. For this survey, RTK-GPS quality was excellent during the hydrographic data collected and little data had to be removed from the dataset. After importing the soundings and applying the RTK-GPS tide and position, files were reviewed for logical consistency, flyers, and echogram corrected in areas that lost bottom tracking. Soundings were compared to existing USACE navigation data from a recent survey in January 2016. For the comparison, the USACE data was converted from MLLW to NAVD88 using a single value from NOAA's Vdatum software for the conversion. Results are presented in Figure 7. Soundings were thinned to ~5 ft spacing for manageability before being exported to generate ESRI GIS shapefiles (Figure 8) and generate the DEM.

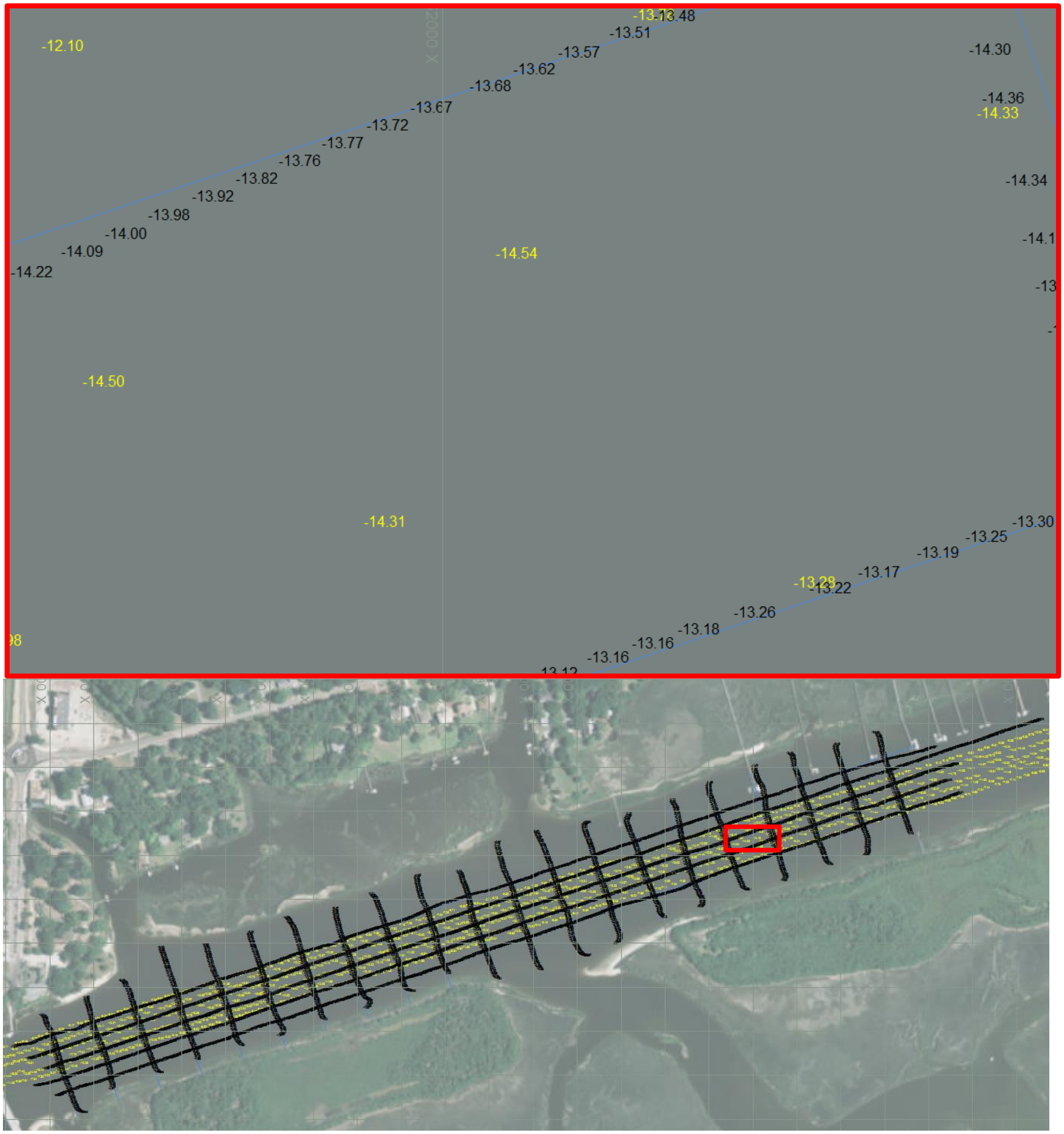


Figure 7: Cross-check comparison (red box) of USACE Navigation survey data (yellow) from January 2016 and Geodynamics survey data from August 2016 (black). USACE elevations were converted from MLLW to NAVD88 prior to comparisons.

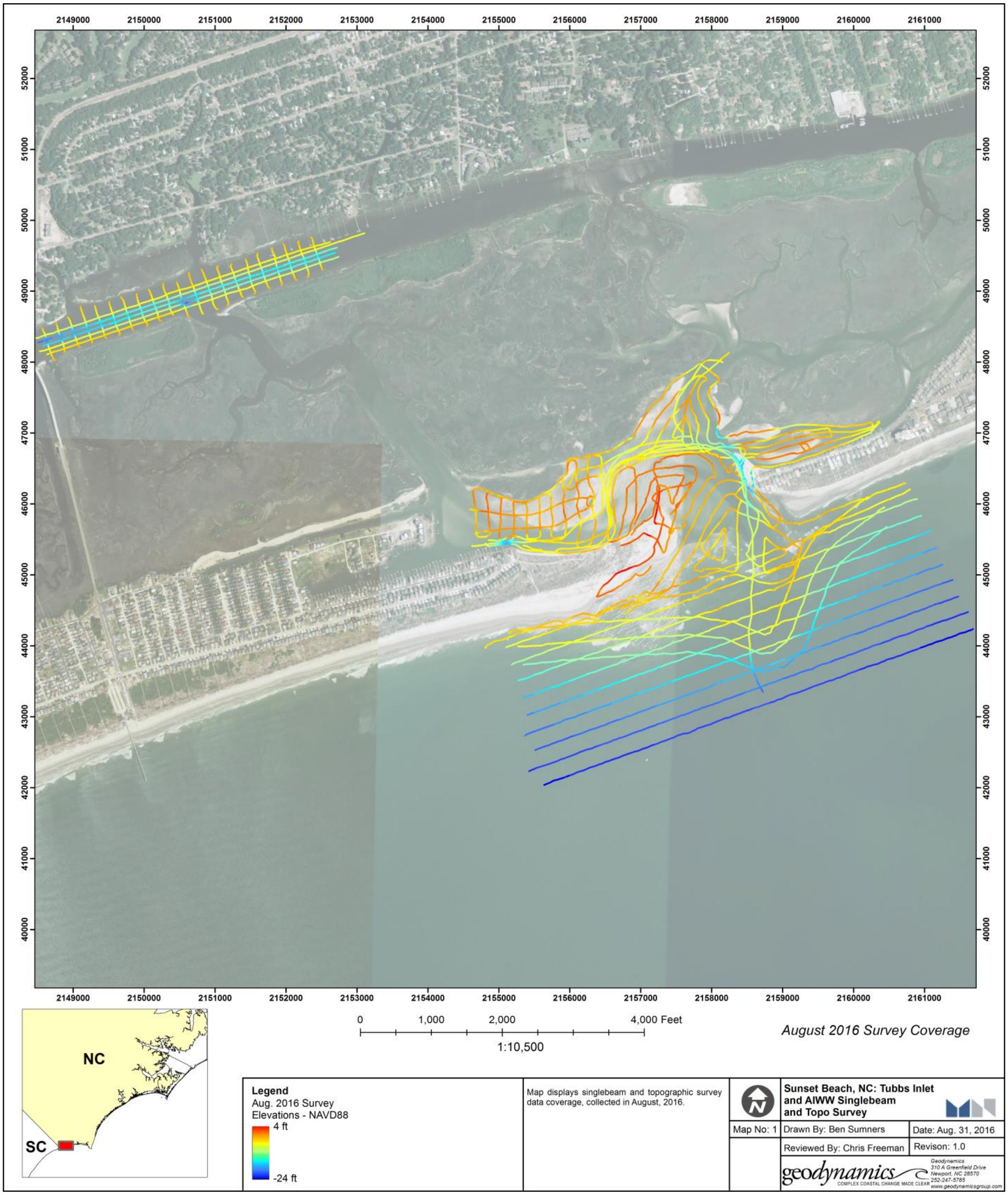


Figure 8: XYZ points of singlebeam-topo elevations.

C. TOPOGRAPHIC DATA ACQUISITION AND PROCESSING

C1. Equipment

1.0 Survey Equipment

A Trimble R7 RTK-GPS rover backpack system was used to acquire topographic data at breaks in elevation and areas unobtainable by the singlebeam vessel. The Trimble R7 RTK-GPS receiver integrates GPS observables with real-time RTK network corrections to provide centimeter-level position and elevation. The RTK-GPS data is output from the R7 receiver at 10 Hz to the Panasonic Toughpad FZ-M1 data acquisition tablet PC. (Figure 9)

Figure 9: The backpack with rover and GPS antenna as worn by surveyor.

2.0 Hardware

2.1 Hardware Systems Inventory

Table 4: Hardware Systems Inventory

Hardware Equipment	Manufacturer	Model
Acquisition PC	Panasonic	Toughpad FZ-M1
GPS Receiver	Trimble	R7/R8
GPS Antenna	Trimble	Zephyr 2
Internet Connection	Verizon	Jetpack 4G

2.2 Vertical and Horizontal Control Equipment

The vertical control for all data acquisition was provided by the NCGS RTK-CORS network. The topographic rover received and integrated the differential corrections from the RTK network for centimeter-level positioning.

3.0 Software

3.1 Software Systems Inventory

Table 5: Software Systems Inventory

	Software	Version
Data Acquisition	HYPACK	2015
	GNSS Internet Radio (for VRS-GPS corrections only)	1.4.11
Data Processing	ArcView	3.4
	ArcGIS	10.3
	Surfer	9

3.2 Data Acquisition Software

The HYPACK software suite was used during survey preparation in order to create profile lines plans as well as to collect topographic data.

3.3 Data Processing Software

HYPACK Singlebeam Editor was used to import, clean, and thin the data the topographic data.

ArcGIS was used to produce survey area maps, coverage extents, and final chart products.

C2. Quality Control

1.0 Procedures

1.1 Survey Planning

All survey line planning was completed in HYPACK. Initial line planning was performed in the office prior to data collection. However, once on site, much of the coverage was obtainable by the singlebeam vessel. Remaining data coverage needed was assessed and captured on the fly, acquiring elevations at breaks in elevation and areas too shallow for singlebeam coverage.

1.2 Topographic Data Acquisition and Monitoring

At the start of each survey day, a series of pre-survey protocols were run to aide in quality control and to determine any possible errors/issues prior to surveying. Each surveyor’s rod and backpack antenna draft were checked and input in the HYPACK survey software.

All topographic data acquisition was completed using the HYPACK Survey software. Data acquisition was performed by walking as upright as possible while following the planned survey line. The surveyor constantly monitored the GPS status, off-line value, distance from baseline, and overall morphology along the profile. The HYPACK data acquisition software produced a constantly updated OTF data matrix, which allowed for real-time monitoring of the data coverage as well. To ensure ample topographic data overlap with the hydrographic data, the surveyor would plot the existing coverage for background. Upon completion of a survey day, all data was thoroughly reviewed and various profiles overlaid on all previous profile data for a quick in-field QA-QC check.

C3. Data Processing

1.0 Topographic Data Processing

1.1 Processing Workflow

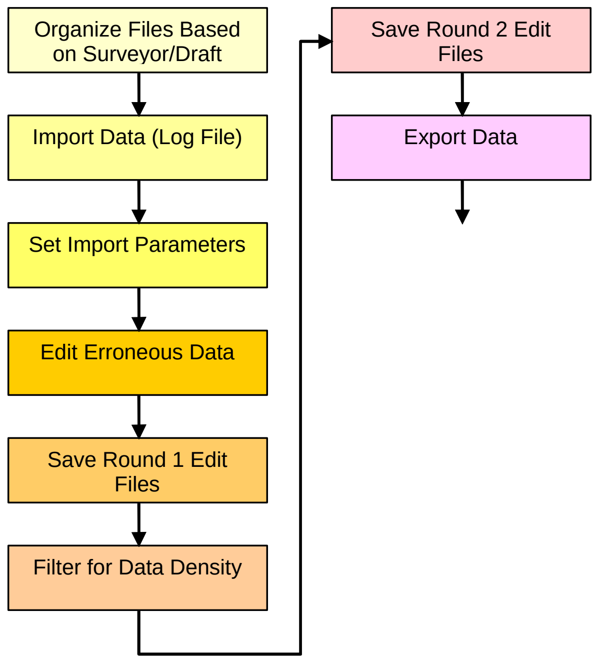


Figure 10: HYPACK topographic data processing workflow

C3. BATHYMETRIC DIGITAL ELEVATION MODEL

The comprehensive bathymetric dataset was imported into SURFER and then plotted geographically to further assess data that could create interpolation artifacts; no outliers were identified in the final model. The data was analyzed for overall point spacing, line-to-line spacing, and data trends. Tubbs Inlet and the AIWW were gridded using unique Kriging parameters, refined over several iterations (Figure 11, 12).

Rasters were reviewed to ensure no crossing contours and consistency with the source data. To merge all existing raster datasets, including Tubbs Inlet and the AIWW section surveyed in August, and Jan-Feb datasets, Jinks Channel, Mary Creek, Turtle Creek, and the “finger piers”, ArcGIS was used. Rasters were compiled into a Mosaic Dataset, merged, and exported as a single 5 ft DEM (Figure 13).

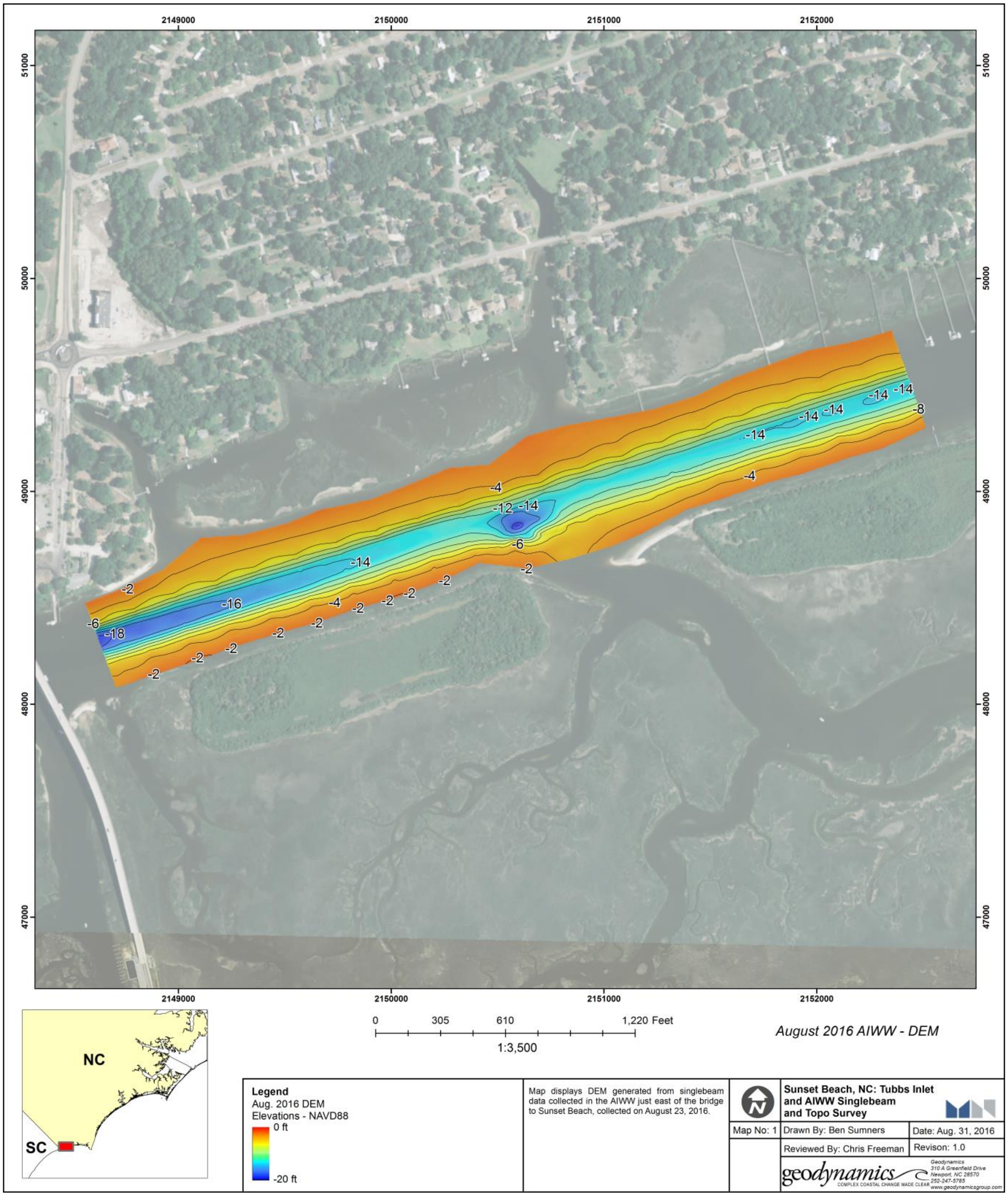


Figure 11: Digital Elevation Model of the AIWW section developed from the singlebeam, August 2016 survey at a 5 ft resolution.

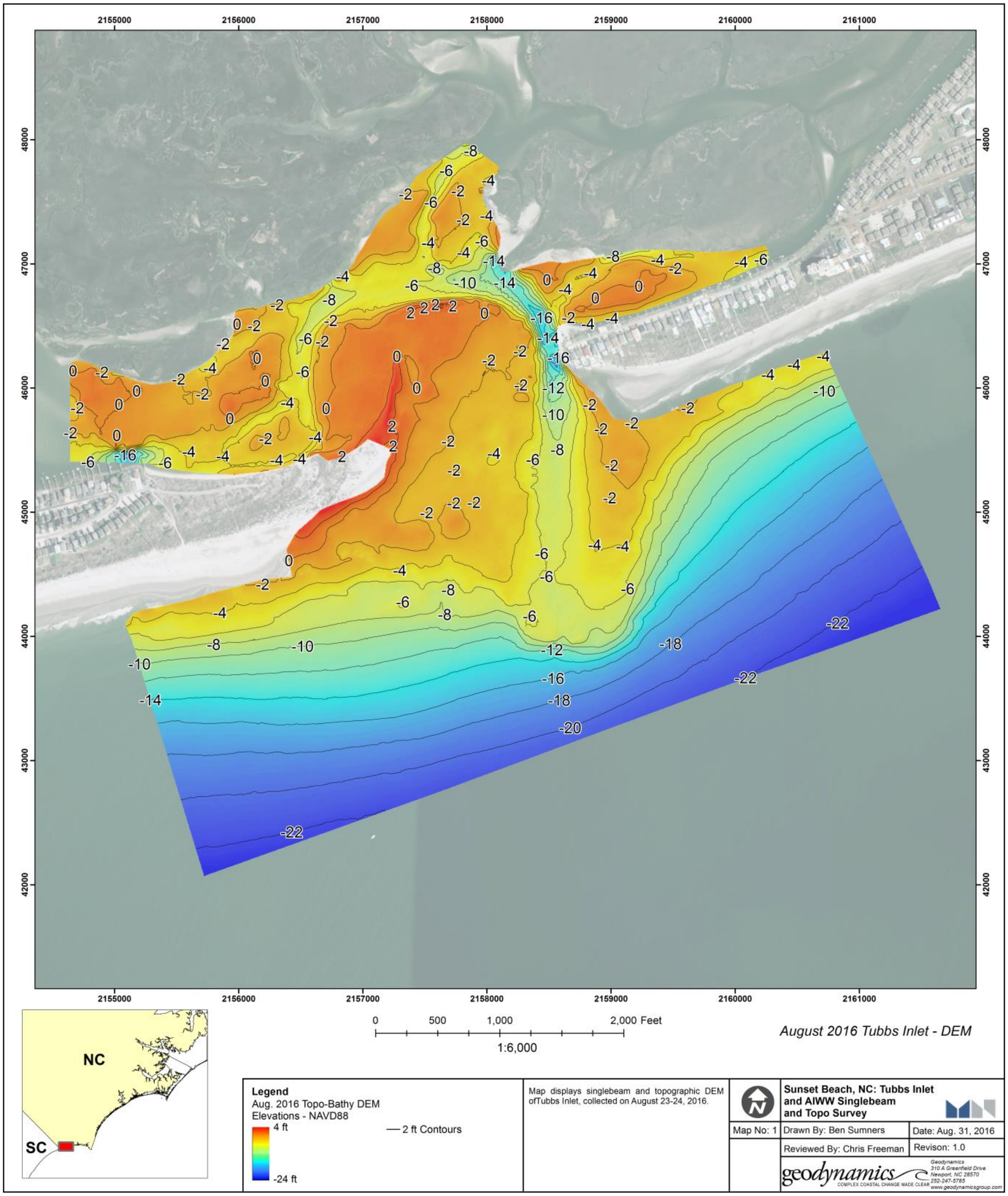


Figure 12: Digital Elevation Model of Tubbs Inlet, developed from the singlebeam and topographic data, collected August 2016 survey at a 5 ft resolution.

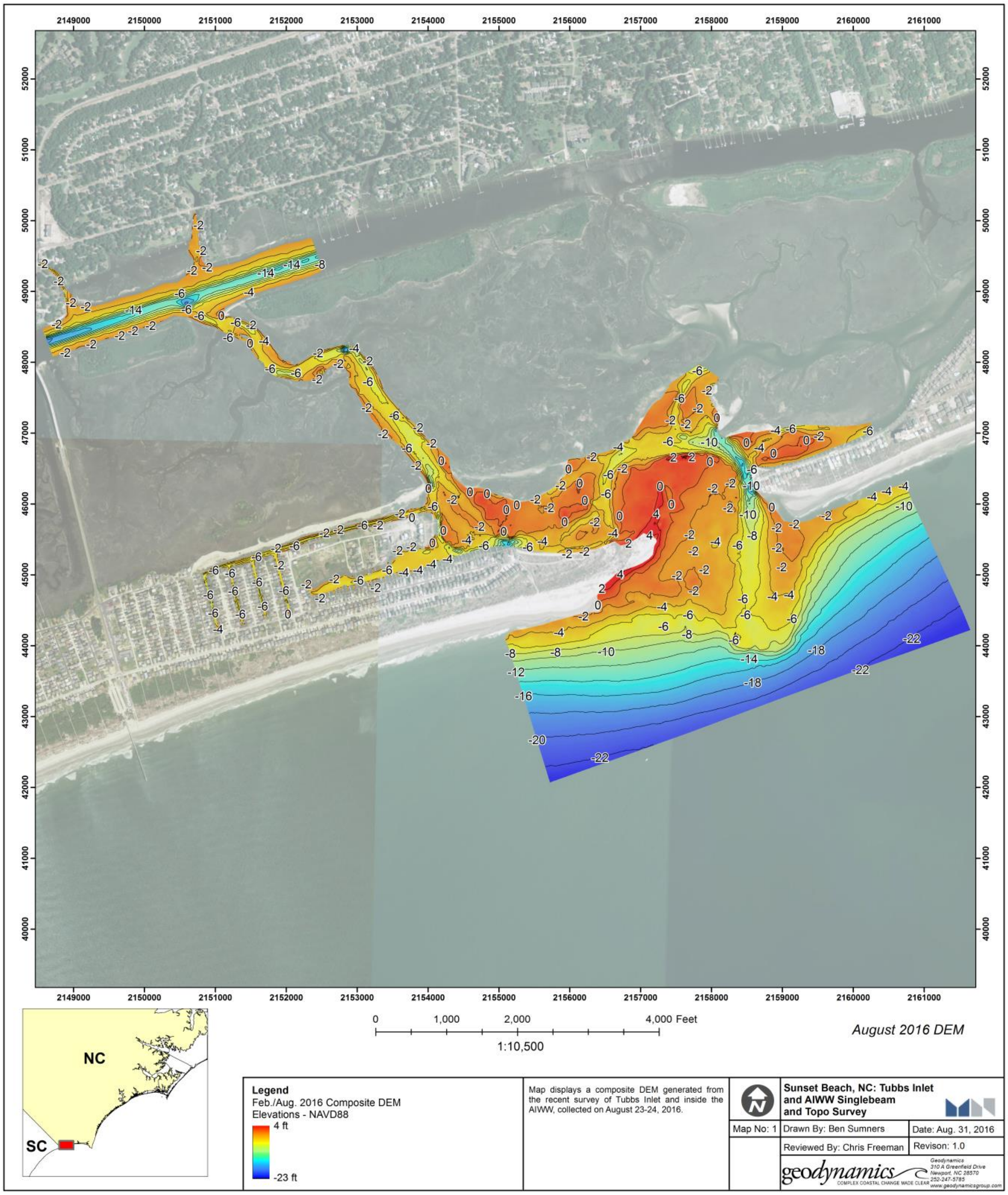


Figure 13. Composite DEM, combining the February and August 2016 survey data at a 5 ft resolution.

E. RESULTS AND DISCUSSION

E1. Results

All bathymetric and topographic data was checked for consistency and accuracy. Data is delivered in ASCII format of the soundings and DEM raster values, BMAP compatible format of DEM values, and ArcGIS 10.x Shapefiles with the following attributes; X (Easting), Y (Northing) and Z in NAVD88 elevation (positive up). DEM coverage was clipped to the extents of the data collected and represents an accurate model of the topography.

Subtle changes in the bathymetry since February have resulted in slight artifact where the grids intersect. Where Tubbs Inlet and Jinks Channel grids intersect, there is a ~0 to 0.5 ft step. Where Jinks Channel and the current AIWW grids intersect, a ~0 to 2.5 ft step is observed. This is an effect of natural change between surveys, but should be recognized for future use of these data.

Additionally, it was observed that the terminal point of Ocean Isle was severely eroded, leaving sandbags and deck pilings essentially at the water line. The following photos illustrate the state of the beach at the point as of August 23, 2016 (Figure 14).

Figure 14. Photos taken of the point at Ocean Isle during high tide.

APPENDIX 1

1.1 Survey Synopsis – General Field Notes

Daily Survey Field Notes

Date:	8/23/2016	**Day of Year:**	236
Time SOS (local):	07:00	**Time EOS (local):**	18:30
Project:	M&N Sunset Beach Singlebeam		
Survey Location:	Sunset Beach NC		
Survey Crew:	Ben Sumners	Brandon Barnette	

Atmospheric Conditions

Sky:	Clear
Wind Speed:	10-15 KT
Wind Direction:	ENE
Temp:	80-90 F

Water Conditions

Swell:	1-2 ft
Chop:	1-2 ft
Temp:	70-80 F

Survey Activities

Control

Arrived at Sunset Beach and checked SEASIDE RESET and setup static data collection. Check was good.

Topo

Following hydro collection, Ben collected topo data around the perimeter of the point at Sunset Beach. Reviewed data in the evening to determine additional coverage needed based on morphology observed.

Hydro

Left Morehead around 7:30 am, arriving to Sunset Beach around 10:45 am. Following control work, launched boat at ramp by bridge, and went out towards Tubbs Inlet to work the high tide. Surveyed the inside of the inlet as seas were too choppy outside. Took SV cast in deepest section mapped, values around 1547 m/s. Following as much coverage in the given tide window and an attempt to survey outside the inlet, transitted to the AIWW, completing the channel lines then the cross sections. Transitted back out to the inside of the inlet and proceeded to collect topographic data on the shoal. Reviewed data in the evening to determine additional coverage needed based on morphology observed.

Daily Survey Field Notes

Date:	7/24/2016	**Day of Year:**	206		
Time SOS (local):	07:00	**Time EOS (local):**	17:30		
Project:	M&N Sunset Beach Singlebeam				
Survey Location:	Sunset Beach NC				
Survey Crew:	Ben Sumners	Brandon Barnette			

Atmospheric Conditions

Sky:	Clear
Wind Speed:	10-15 KT
Wind Direction:	NE
Temp:	80-90 F

Water Conditions

Swell:	1-2 ft
Chop:	0.5 - 1.0 ft
Temp:	70-80 F

Survey Activities

Control

Checked SEASIDE RESET in morning with consistent results.

Topo

Collected topo data at the point of Sunset Beach during low tide in the morning. Data was collected outside of the previously designed survey extents to enhance the final DEM product.

Hydro

Once tide was high enough to travel through Jinks Channel, and started an SV cast and the outer lines, working in. Once nearshore, data was collected as close to the shore as possible near high tide. Data was collected based on the general morphology. Data was reviewed for apparent features, and three more lines were collected to better define the ebb shoal. Additional lines were collected on the inside of the inlet to better define channels flood channels.

APPENDIX 1

2.1 RTK / VRS-GPS Site Calibration

Survey Control

Project Timeframe: 8/23 - 24/2016

Project: Sunset Beach Hydrographic Survey - Tubbs Inlet and AIWW Section

Survey Location: Sunset Beach, NC

Survey Crew: Ben Sumners; Brandon Barnette

Coordinate System/Units: NAD83 NC State Plane — *Units:* M — *Repeater Use:*

Vertical: NAVD88 — **Geoid:** 2012a

Basestation Equipment:

Receiver	GPS Antenna	Radio	Radio Broadcasting
NCGS CORS	Zephyr II Geodetic (55971)	Internet	Internet

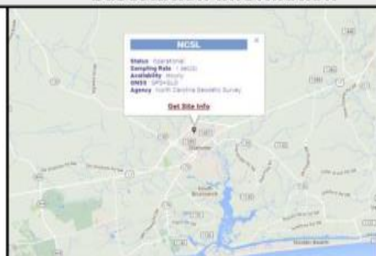
Notes: NC RTK-VRS was used throughout the survey.

Basestation Information

Designation: SHALLOTTE CORS ARP
PID: NCSL
H Order: N/A
V order: N/A
Geoid: 2012a

State Plane Coordinates
Easting (X): 2184922.620
Northing (Y): 85211.260
Z: 84.600

WGS-84 Coordinates
Longitude: 078 23 24.30664
Latitude: 33 58 57.20129
Elevation (m): -10.002



Notes:

The following tables display coordinate and site information on any benchmarks checked for this project

Benchmark Station Reference

Designation: SEASIDE RESET
PID: DD2596
H Order: N/A
V order: Third, Class I
Geoid: 2012a

State Plane Coordinates
Easting (X): 657069.842
Northing (Y): 16281.101
Z: 12.820

Notes:

Notes:

Benchmark Report

Date	Time	Weather	Benchmark	N	E	Z	ΔN	ΔE	ΔZ
8/23/2016	11:10:00	Clear	SEASIDE RESET	16281.083	657069.862	12.773	0.018	-0.020	0.047
	Basestation Used:SHALLOTTE CORS ARP								
8/24/2016	07:15:00	Clear	SEASIDE RESET	16281.081	657069.863	12.774	0.020	-0.021	0.046
	Basestation Used:SHALLOTTE CORS ARP								
					Statistics	Average	0.019	-0.021	0.047
						St. Dev.	0.001	0.001	0.001

APPENDIX 2

3.1. System Calibration Documentation

AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	Geodynamics LLC
Asset Serial Number:	200936
Asset Product Type:	SV•Xchange™ Calibrated Sensor
Calibration Type:	Sound Velocity
Calibration Range:	1375 to 1625 m/s
Calibration RMS Error:	.0058
Calibration ID:	200936 888888 200936 190515 090131
Installed On:	

Coefficient A:	0.000000E+0	Coefficient H:	1.945445E-7
Coefficient B:	0.000000E+0	Coefficient I:	0.000000E+0
Coefficient C:	1.179695E-6	Coefficient J:	0.000000E+0
Coefficient D:	1.945983E-7	Coefficient K:	0.000000E+0
Coefficient E:	-1.825497E-5	Coefficient L:	0.000000E+0
Coefficient F:	1.954585E-7	Coefficient M:	0.000000E+0
Coefficient G:	1.405890E-6	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 19/5/2015

Certified By:

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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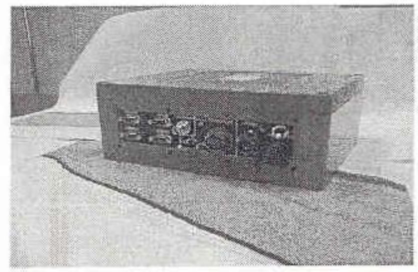
Odom Hydrographic Systems

~~HT100~~

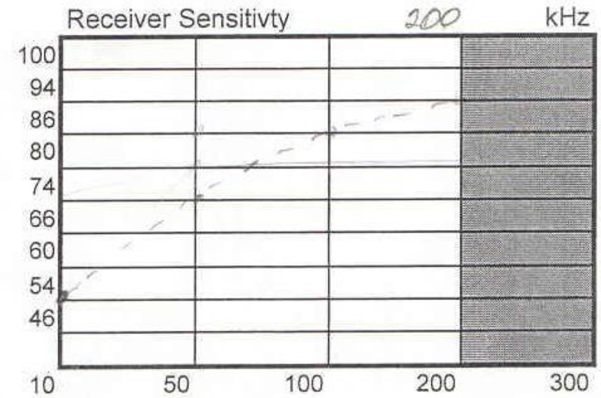
Date: ____________

Serial No: 26010



Software Version Communications Bd Ver 3.28

DSP	1.28
PIC	1.21

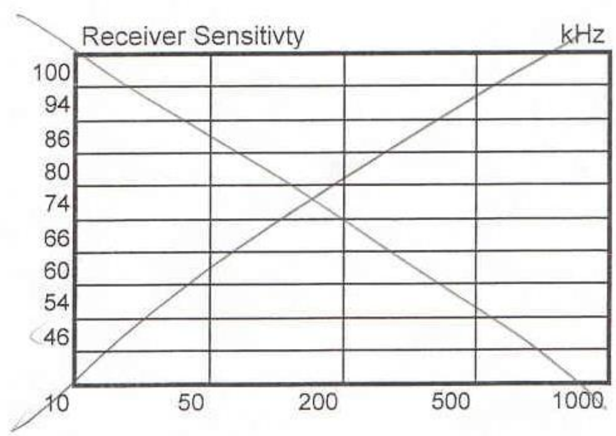


Power Supply

Input Voltage	12-24VDC
~~+48V~~ 24	✓
+15V ~~+~~ 24	✓
-15V -12	✓

Transceiver

~~+48V~~ (TP19) 24	✓
+12V (TP1) 24	✓
+5V (TP2)	✓
-5V (TP4)	✓
-12V (TP5)	✓
Local Oscillator (TP7 = Selected Freq)	✓



Digitizer

~~+15V~~ (TP3) 24V	24.5
+5V (TP2)	5.1
+3.3V (TP1)	3.3

Communications

Control	
Data Out	
GPS In	
GPS Out	

Transmit Power (50ohm)

Settings	Low (1)	Med (4)	High (8)
Voltage	16	113	310

Reverse Polarity Alarm	
Total Burn In Time	

Network Bd ok
Serial I/O ok

APPENDIX 3

4.1. Official Scope of Work

M&N Sunset Beach Singlebeam Phase 2: Basic SOW Synthesized from Email / Phone Conversations w/ PM (4/7 to 4/12/16)

Survey Design & Field Work

4/7 email from Robert:

Chris – Attached are 2 KMZ files showing the survey areas w/n the AIWW and Tubbs Inlet. The 'boxes' somewhat show my thoughts but below I've listed some more considerations. Feel free to recommend a better path!

Tubbs Inlet:

- Tie into the previous survey and capture the approximately 1,500 ft on either side inside Tubbs Inlet, including the 2 waterways heading north and east behind Ocean Isle.
- On the inside I like the contour method you were discussing and that might help with spacing. Otherwise we can stay with the same spacing as the previous work in Jinks.
- On the outside, I'd like shore parallel lines to capture the shoal complex ranging 2,000 ft on either side of the inlet. Total line length could be 6,000 ft. (This will require a very calm day).
- Spacing on the outside can be 250 ft out to an offshore distance of 2,000 ft.

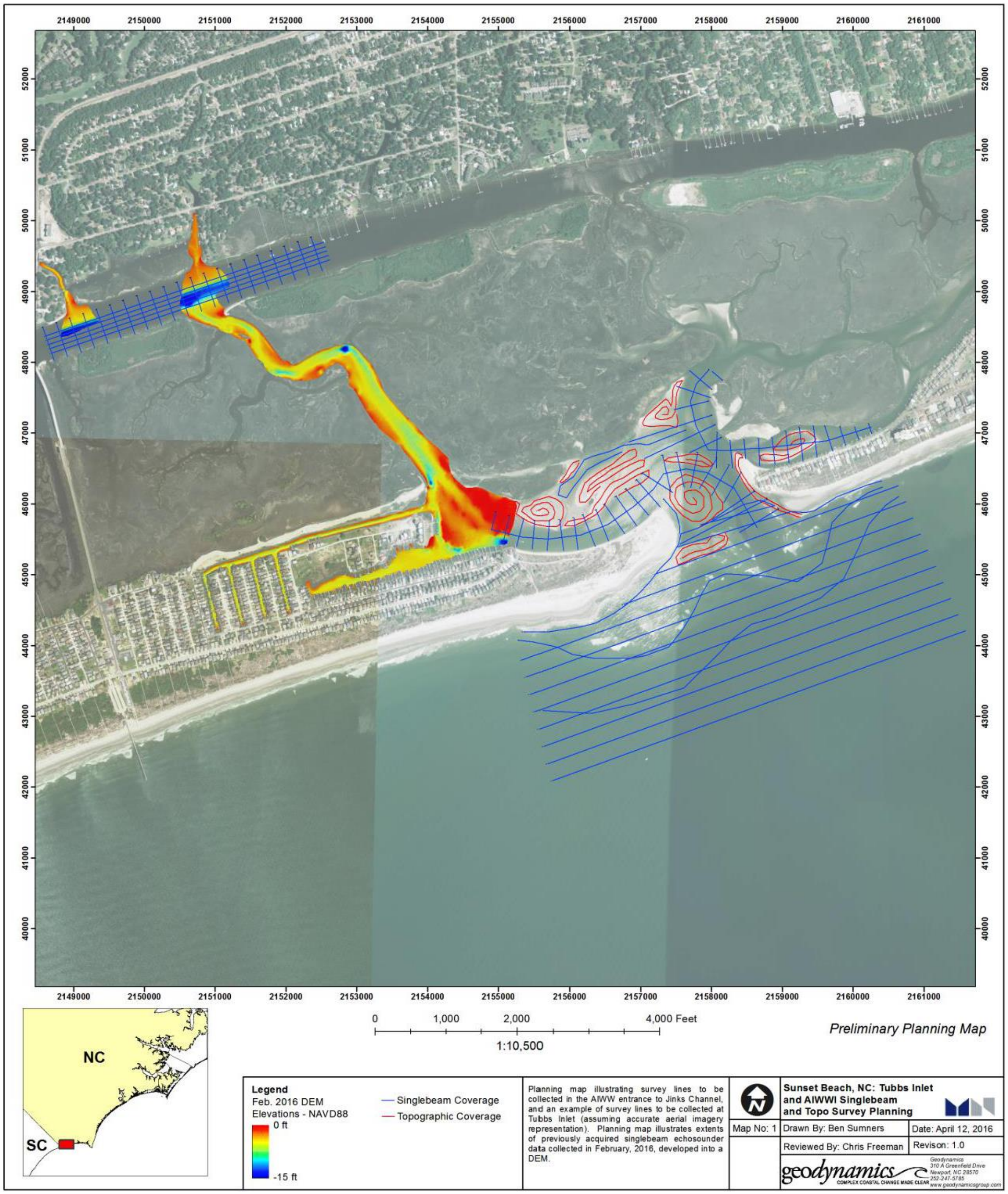
AIWW :

- Profiles on 200 ft centers out to 2,000 ft from the Jinks Channel CL crossing the AIWW (4,000 ft coverage in the AIWW).
- Prob. should add a 2 longitudinal lines for a DTM

NOTE: Provided PM with the attached survey design map and it was approved 4/12/16

Deliverables ("same as previous work" 4/7/16)

- Very basic QA-QC type Final report to include:
  - Example templates. Mason creek, AMA?
  - Control used
- Maps of data with base layers of:
  - Latest or best aerials that show shoaling extents
- Maps of data to include:
  - Probably do each area separately as describe above
  - 2 maps each area. One showing coverage (maybe even color coded) and then one with the DEM.
- Data Deliverables to include:
  - ASCII text files that are BMAP compatible
  - DEM (likely for each site separately) in GIS format
  - Singlebeam lines as .shp files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41000
40000
NC
SC
0
1,000
2,000
4,000 Feet
1:10,500
Preliminary Planning Map
Legend
Feb. 2016 DEM
Elevations - NAVD88
0 ft
-15 ft
Singlebeam Coverage
Topographic Coverage
Planning map illustrating survey lines to be collected in the AIWW entrance to Jinks Channel, and an example of survey lines to be collected at Tubbs Inlet (assuming accurate aerial imagery representation). Planning map illustrates extents of previously acquired singlebeam echosounder data collected in February, 2016, developed into a DEM.
Sunset Beach, NC: Tubbs Inlet and AIWWI Singlebeam and Topo Survey Planning
Map No: 1
Drawn By: Ben Sumners
Date: April 12, 2016
Reviewed By: Chris Freeman
Revison: 1.0
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