PORTSMOUTH HARBOR AND PISCATAQUA RIVER
NEW HAMPSHIRE AND MAINE
NAVIGATION IMPROVEMENT STUDY
FEASIBILITY REPORT

APPENDIX G

TURNING BASIN TIDAL HYDRODYNAMIC ANALYSIS
HYDROLOGIC & HYDRAULIC APPENDIX

PORTSMOUTH HARBOR – PISCATAQUA RIVER
TURNING BASIN TIDAL HYDRODYNAMIC ANALYSIS
HYDROLOGIC & HYDRAULIC APPENDIX

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ATTACHMENT

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FINAL REPORT FOR ADCP AND TIDE DATA COLLECTION
PORTSMOUTH HARBOR AND PISCATAQUA RIVER
PORTSMOUTH, NEW HAMPSHIRE
October 2009

PORTSMOUTH HARBOR – PISCATAQUA RIVER
TURNING BASIN TIDAL HYDRODYNAMIC ANALYSIS
HYDROLOGIC & HYDRAULIC APPENDIX

1.0 EXECUTIVE SUMMARY

This H&H analysis analyzed the tidal hydrodynamics of the study area at the existing turning basin at the upstream end of the federal navigation channel along the Piscataqua River in accordance with turning basin design standards contained in EM 1110-2-1613 (31 May 2006).

Woods Hole Group, under contract to USACE NAE, collected 2 months of tide data, and collected Accoustic Doppler Current Profiler (ADCP) data along four transects over two 12.5 hour tide cycles in June 2009 across the navigation channel to be used in the development and calibration of the two-dimensional mathematical model of the harbor.

The modeling effort evaluated both the existing and alternative improvement conditions and determined that the current magnitude (speed) did not measurably increase or decrease for any of the alternatives. The difference in current between the existing conditions and the different turning basin alternatives are within the error of the field data and model capabilities, which indicate that increasing the width of the turning basin would not increase or decrease the current magnitude within the turning basin area.

Further analysis of the recorded ADCP data reveals that the average current magnitude recorded in 3-minute intervals over the tide cycle does not exceed the maximum allowable current of 1.5 knot per the turning basin regulation (EM 1110-2-1613) within 60-minutes of the low slack tide or high slack tide.

2.0 INTRODUCTION

This document includes the hydrologic and hydraulic (H&H) analysis for the Portsmouth Harbor and Piscataqua River New Hampshire and Maine Navigation Improvement Study, in accordance with Corps Regulations (ER 5-1-11 and ER 1105-2-100, Planning Guidance).

This study was initiated at the request of the State of New Hampshire, Pease Development Authority, Division of Ports and Harbors, the study sponsor, and authorized by Section 436 of the Water Resources Development Act of 2000 (P.L. 105-541):

"The Secretary shall conduct a study to determine the feasibility of modifying the project for navigation, Portsmouth Harbor and Piscataqua River, Maine and New Hampshire, authorized by section 101 of the River and Harbor Act of 1962 (76 Stat. 1173) and modified by section 202(a) of the Water Resources Development Act of 1986 (100 Stat. 4095) to increase the authorized width of turning basins in the Piscataqua River to 1,000."

This H&H analysis will investigate the tidal hydrodynamics of the study area with the authorized turning basin width located at the upstream end of the federal navigation channel in the Piscataqua River. The basis for this investigation will include developing a numerical model to evaluate the altered geometry at the turning basin and the impacts to tidal hydrodynamics at several points within the harbor. These hydrodynamics include the river current magnitude (speed) and tide elevation.

3.0 STUDY AREA

The Portsmouth Harbor is a deep draft harbor located 45 miles northeast of Boston, Massachusetts and 37 miles southwest of Portland, Maine. The Piscataqua River runs through the harbor and includes a federally maintained navigation channel of 35 feet at mean low water and a minimum width of 400 feet. The channel extends from deep water in Portsmouth Harbor (river mile 2.6) upstream to just north of the Sprague terminal in Newington, New Hampshire (river mile 8.8).

The harbor has one of the fastest flowing currents of commercial harbors in northeastern United States with tidal currents reaching speeds of up to 5 knots (5.75 miles per hour). The size of the ships that can navigate within the harbor is restricted by several features of the river, including the current, the width of the Sarah Long Bridge, and the turning basin diameter. In 2011, 3.1 million tons of cargo worth $1.7 billion was transferred in and out of the harbor to southern Hampshire, eastern Vermont and southern Maine.

The Piscataqua River flows southeast through the towns of Eliot and Kittery, Maine, and Dover, Newington, Portsmouth, and New Castle, New Hampshire forming the boundary between New Hampshire and Maine. The river is tidally influenced and spans 13-miles long between its headwater at the confluence of the Salmon Falls and Cocheco Rivers in Dover, New Hampshire

and its mouth at the Gulf of Maine. The drainage basin is approximately 1,495 square miles encompassing five rivers that flow into the Great Bay, a 6,000 acre estuary that discharges into the Piscataqua River headwater in Dover, New Hampshire.

The Portsmouth, New Hampshire area has a temperate climate in the summer months and often severe climate in the winter months. In the winter, coastal storms frequently bring snow mixed with rain with high winds prevailing northwesterly

4.0 EXISTING TURNING BASIN

a. Existing Turning Basin Features and Operation. The existing turning basin is located at the northern end of the federal navigation channel near the Sprague terminal in Newington, New Hampshire.

Existing Operations: Currently, all turns take approximately 10 minutes and take place during slack conditions. Slack conditions occur when the current is at its lowest speed coinciding with both peak and low tide. Turns that take place near low slack tide begin 30 minutes before low tide with 30 minutes of ebb remaining. Currents during these conditions are approximately 1.0 knots. High slack turns begin 50 minutes before high slack with 50 minutes of flood remaining. Currents during this condition are approximately 1.0-1.5 knots. The ability to turn ships may be affected by severe weather conditions, such as noreasters and hurricanes, as they change the physical characteristics of the river.

b. Turning Basin Regulations per EM 1110-2-1613 (31 May 2006). The basin enables the ships to reverse direction and allow an outbound sailing transit. During normal conditions, pilots use tugs to bring the ship about as well as prevailing currents and wind conditions to help maneuver the ship. The pilot strategy may be different on flood or ebb tide and may change with wind direction or the presence of shoals, rocks, docks, etc. The turning basin will be designed to provide sufficient area to allow the design ship to turn around using ship bow and stern thrusters (if available).

i. Turning Basin Size. The size of the turning basin should provide a minimum turning diameter of at least 1.2 times the length of the design ship where prevailing currents are 0.5-1.5 knots or less. The basin should be elongated along the prevailing current direction when currents are greater than 1.5 knots and designed according to tests conducted on a ship simulator.

ii. Features. Where traffic conditions permit, the turning basin should use the navigation channel as part of the basin area. The shape of the basin is usually trapezoidal or elongated trapezoidal with the long side coincident with the prevailing current direction and the channel edge. The short side will be at least equal to the design multiple (1.2 or 1.5, depending on

current) times the ship length. The ends will make angles of 45 degrees or less with the adjacent edge of the channel, depending on local shoaling tendencies.

iii. Depth. Normally, the depth of the turning basin should be equal to the channel depth leading or adjacent to the basin proper. This is done to prevent any possibility of confusion by the channel project users that could cause grounding accidents. The normal dredging tolerance and advance maintenance are included in the depth of the basin..

iv. Shoaling. A turning basin will tend to increase shoaling rates above normal channel rates because of the increase of the channel cross-sectional area, which modifies current patterns. Increased shoaling in the basin could cause modifications in shoaling patterns farther downstream or upstream.

c. Design Vessel for Proposed Turning Basin. Based on the limitations of the existing navigation channel (width, bridges, turns and river currents), the Pilots have determined that the largest vessel that could access the upper turning basin is a maximum length of 800-ft. Vessels of this size typically have a beam of approximately 118-ft. Therefore, this has been selected as the design vessel at the time of this study.

5.0 PROPOSED TURNING BASIN ALTERNATIVES.

The proposed basin alternatives are presented in Figure 1. These alternatives include various basin diameters and drift, which will be evaluated based on the recorded and modeled currents of the river during optimum turning conditions and federal regulation EM 1110-2-1613 (31 May 2006).

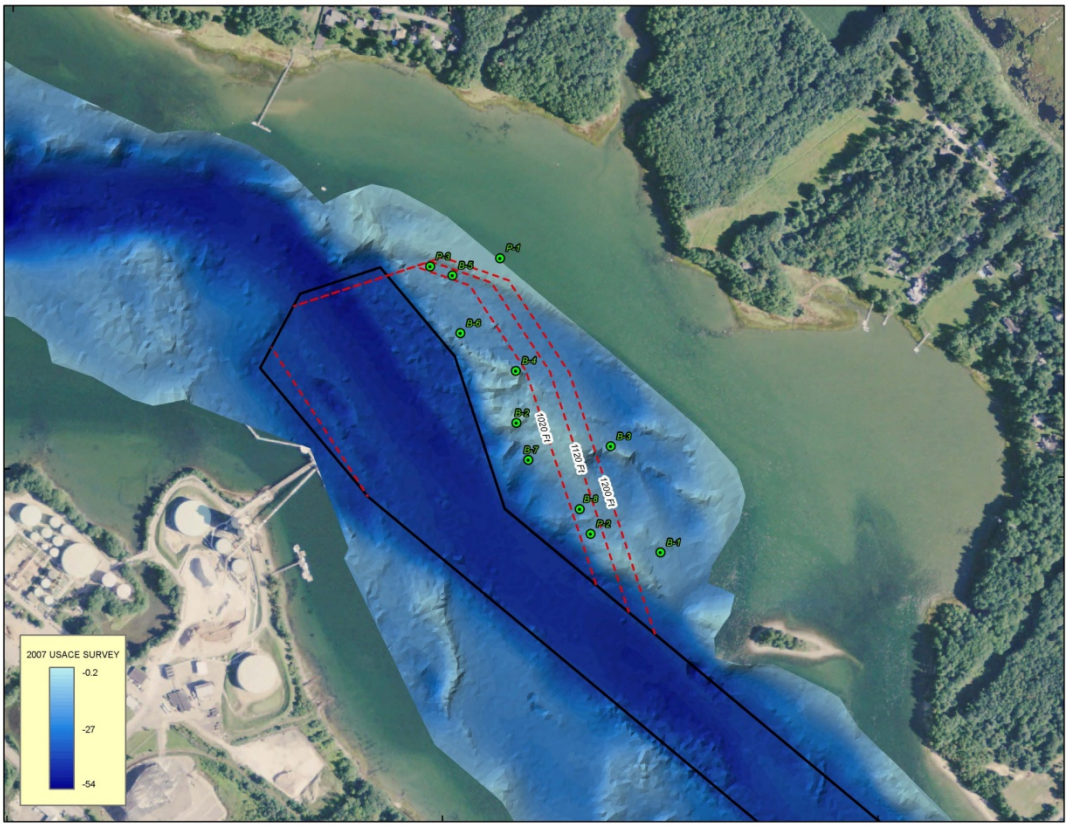

Figure 1. Turning Basin Alternatives

6.0 METHODOLOGY

a. Data Collection / Field Activities. Woods Hole Group under contract to USACE NAE, collected 2 months of tide data and collected Accoustic Doppler Current Profiler (ADCP) data along four transects across the navigation channel to be used in the development and calibration of the two-dimensional model of the harbor. The tide data was collected over the spring tide during 2009.

First, time-series of water surface elevations (WSE) were obtained from two (2) locations over approximately one month at the Piscataqua River site (Figure 1). Measurements were collected directly at the turning basin (Station P2 near the Sprague Energy Terminal at River Road in Newington, NH), and approximately 3.3 miles downstream of the turning basin (Station P1 near the State of New Hampshire, Division of Ports and Harbors , DPH, Market Street Terminal in Portsmouth, NH). Data recorded from these two tide gauges was subsequently compared to data from the National Oceanic and Atmospheric Administration (NOAA) NOS station in Portland, Maine to identify the tidal attenuation in the system, as well as ground truth the observed data. (WHG, 2009).

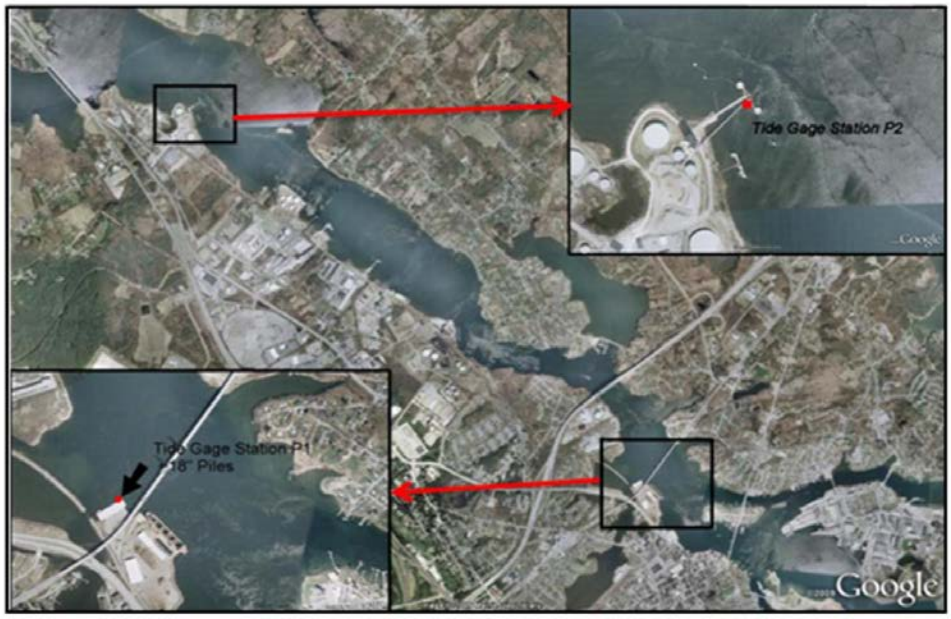

Figure 2. Tide Gauge Locations (WHG, 2009)

Figure 2 presents the results of the atmospherically corrected and vertical referenced tidal observations obtained from the Piscataqua River gauges. The blue line presents the time series of the WSE (ft, NAVD88) at the DPH Market Street Terminal (station P1), while the red line presents the time series of the WSE (ft, NAVD88) at the Sprague Energy Terminal (station P2). The two stations are plotted together for comparison of the upstream and downstream locations. The observations show that there is some tidal attenuation that occurs between these two stations, as the tidal wave propagates in the River. During the spring tide, approximately 1.0-1.5 feet of tidal attenuation occurs between the two stations, while during the neap tide, approximately 0.2-0.5 feet of tidal attenuation occurs. The tide lags approximately 30-45 minutes between the two stations during high tide. This can also be explained that the high tide occurs at the Sprague Energy P2 location approximately 30-45 minutes after high tide occurs at the DPH Market Street Terminal.

A portion of the collected tide signal is provided in the following figure. A slight phase and amplitude difference is discernible between the two gauges.

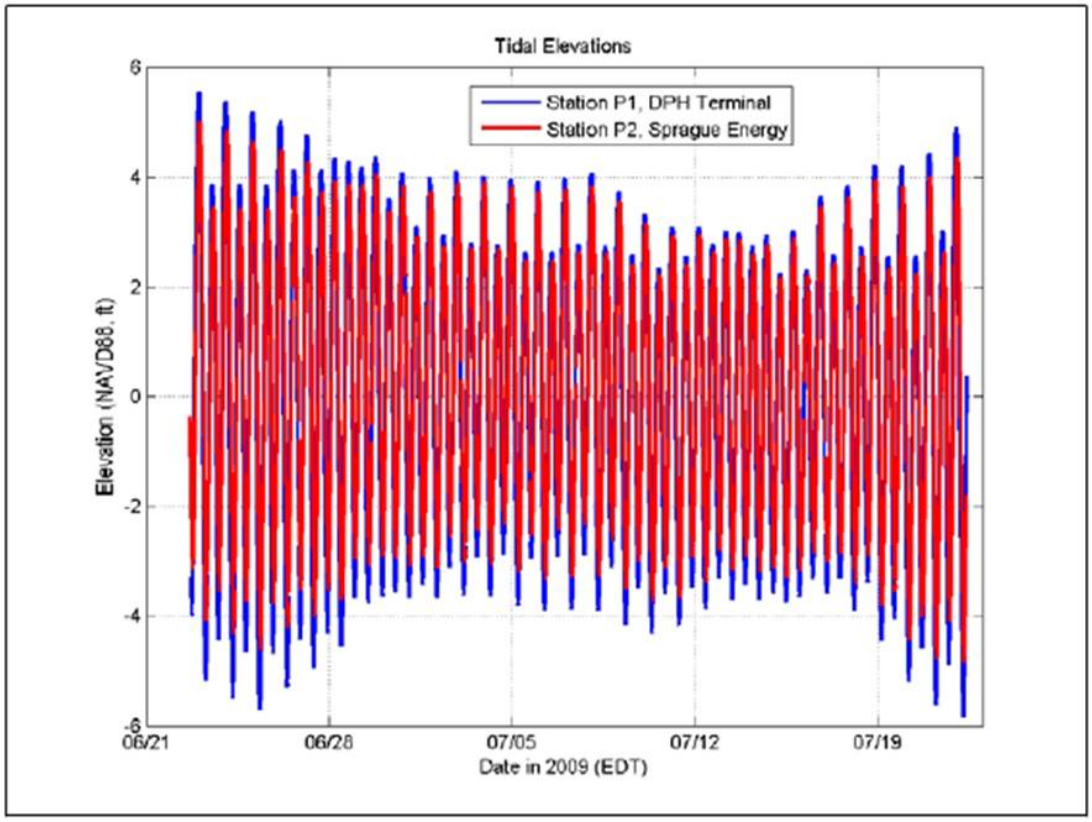

Figure 3. Measured Tide Elevations (WHG, 2009)

b. ADCP Data Collection. Currents were collected by performing boat transects over a 12 hour tide cycle. The location of these transects is shown below in Figure 4 and Figure 5. A plot of the average recorded current during low slack tide and high slack tide conditions is shown in Figure 10, following a discussion of the modeling effort and analysis of current magnitude (speed) during the turning basin alternatives.

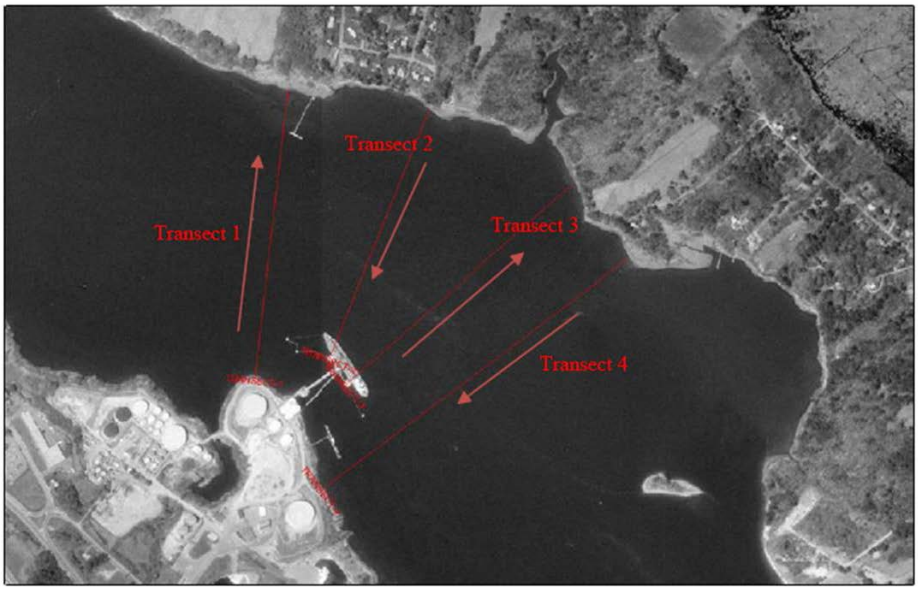

Figure 4. Boat Based ADCP Transects (WHG, 2009)

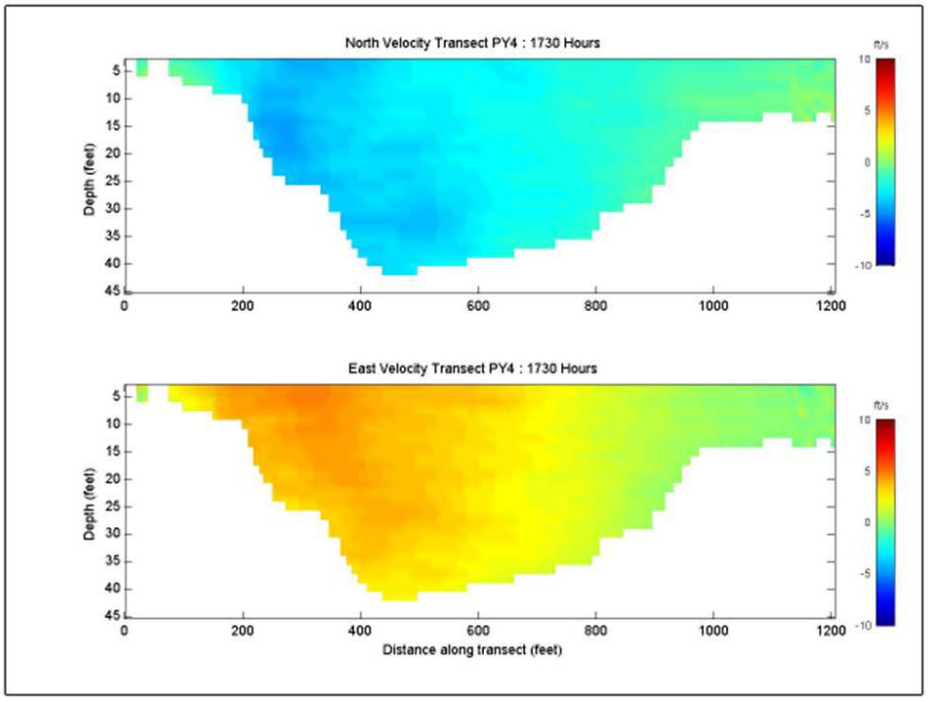

Figure 5. Measured Currents (WHG, 2009).

c. Data Limitations. The analysis is limited by the sparse bathymetry data available outside the navigation channel. Significant effort was made to incorporate other bathymetry data including prior NOAA survey data but a large portion of the river was interpolated from navigation charts.

d. Numerical Modeling.

i. Model Selection. Several two-dimensional numerical models developed and supported by the USACE and ERDC were considered for this analysis. Preliminary efforts made using the RMA-2 and ADH models; however, both of these models had difficulty calibrating and remaining stable throughout the model runs and were ultimately abandoned.

ii. Coastal Modeling System (CMS) Development & Calibration. CMS, developed by USACE and ERDC Coastal & Hydraulics Laboratory (CHL) was selected to evaluate the study area. The CMS software package consists of several individual numerical models and their supporting software in one system. It is a finite-element numerical model that computes both hydrodynamics (water levels and current flow values under any combination of tide, wind, surge, waves and river flow).

A non-uniform grid was constructed to cover the entirety of the river, 42 km in the alongshore and 18 km cross shore. The flow model was driven from temporarily offset tides derived from the Portsmouth Gauge (Station #8418150) and waves from the offshore CDIP Buoy (160). Stream gauge forcing was also provided by prior field observations by NAE.

The CMS model ran stable, showed proper model calibration and was able to effectively perform the alternative runs.

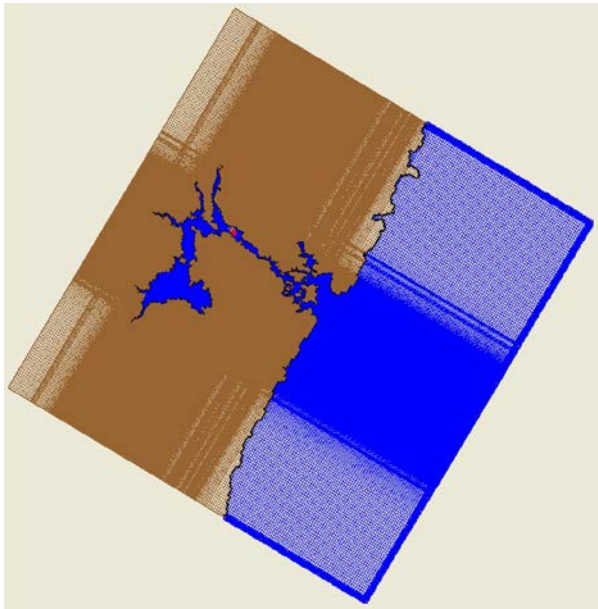

Figure 6. CMS Grid Domain

Model calibration was checked using water levels collected from the 2009 field effort. As shown in the following figure, the phase of the measured and modeled water elevation shows good correlation however the model is slightly over predicting the amplitude of the tide.

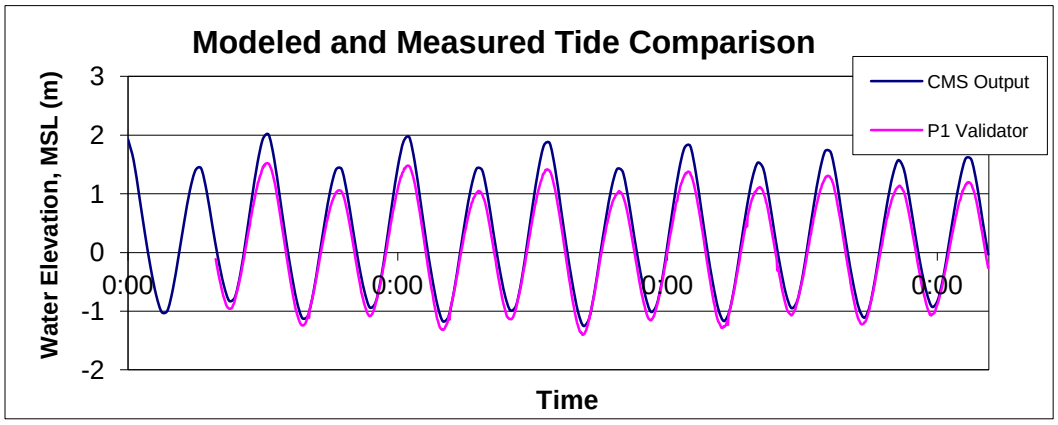

Figure 7. Modeled and Measured Tide Comparison at Station P1

The measured current magnitude (speed) was compared with the simulated currents over each transect. Figure 8 shows Transect 1 current comparison with units of meters/second (m/s) as computed by the CMS model. The model is in phase with the measured currents; however, slightly under predicts the current amplitude. Therefore, additional evaluation of the measured currents, converted from units of m/s to knots, was conducted confirming that the average current magnitude at low slack tide and high slack tide are less than the 1.5 knot allowable per regulation EM 1110-2-1613 (31 May 2006) as discussed in Section 7.0 and presented in Figure 10.

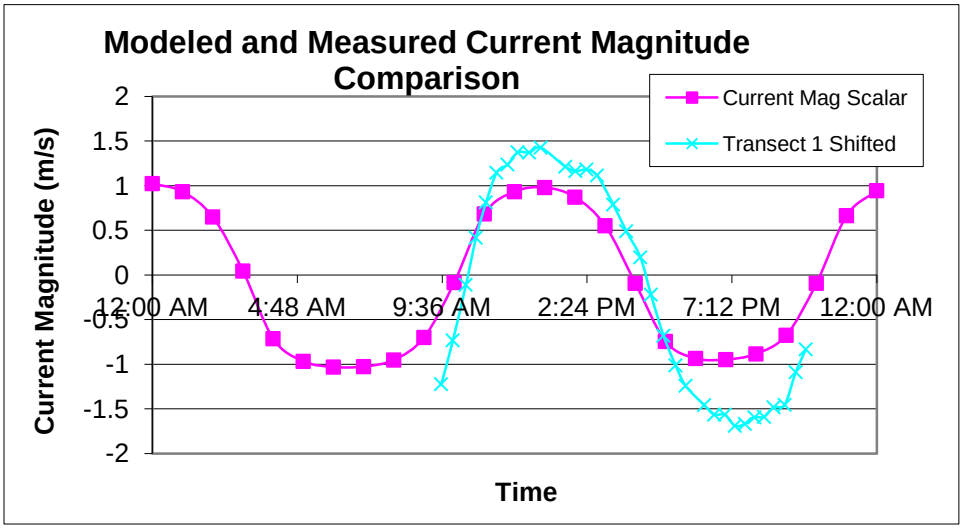

Figure 8. Modeled and Measured Current Magnitude at Transect 1

e. Model Alternative Results. In order to compare and assess alternative performance, four observation points (nodes) were placed in the approximate center of the channel and turning basin and were also the approximate midpoint of the boat based ADCP survey transects. The maximum and average current speeds were extracted at each point for each alternative and compared. These observation points are shown in the following figure as points overlain on the model grid.

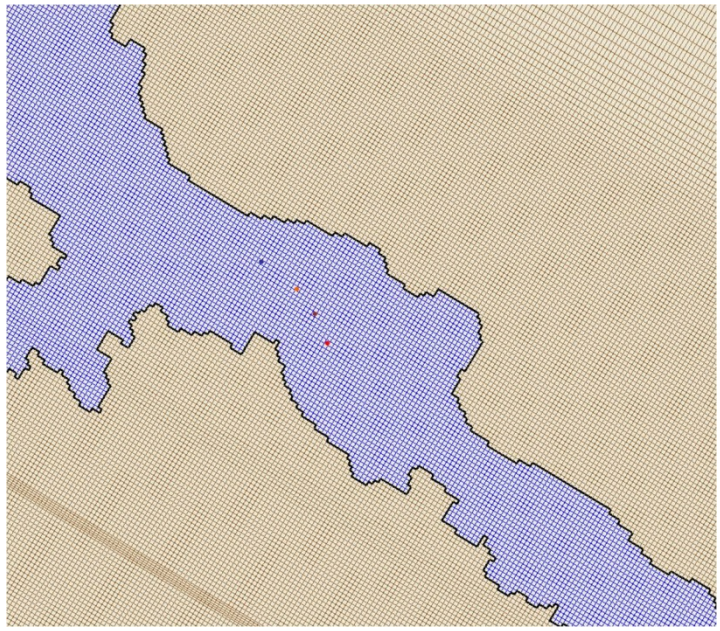

Figure 9. Location of Observation Points

The analysis of the existing and the alternative conditions determined that the current magnitude (speed) did not vary significantly, for all three alternatives. The difference in current between the existing conditions and the different turning basin alternatives are within the error of the field data and model capabilities which indicates that the change in the turning basin would not significantly impact the current during low slack tide or high slack tide. See Table 1.

Table 1. Modeled Current Speeds

Maximum Current Speed, m/s (knots)				
Alternative	**Node 1**	**Node 2**	**Node 3**	**Node 4**
Existing Conditions	1.15 (2.24)	1.16 (2.25)	1.10 (2.13)	1.09 (2.11)
1020	1.15 (2.24)	1.18 (2.29)	1.08 (2.10)	1.07 (2.08)
1120	1.16 (2.25)	1.19 (2.31)	1.09 (2.11)	1.06 (2.06)
1200	1.16 (2.25)	1.19 (2.31)	1.07 (2.08)	1.06 (2.06)

Average Current Speed, m/s (knots)				
Alternative	**Node 1**	**Node 2**	**Node 3**	**Node 4**
Existing Conditions	0.61 (1.19)	0.60 (1.17)	0.60 (1.17)	0.59 (1.15)
1020	0.61 (1.19)	0.61 (1.19)	0.59 (1.15)	0.56 (1.09)
1120	0.61 (1.19)	0.61 (1.19)	0.59 (1.15)	0.55 (1.07)
1200	0.62 (1.21)	0.61(1.19)	0.58 (1.13)	0.54 (1.05)

7.0 CONCLUSION.

Upon determination by the modeling analysis that increasing the basin diameter does not increase or decrease the current magnitude (speed), it can be concluded that the turning schedule allowable at low slack tide and high slack tide will be unchanged. Further analysis of the recorded ADCP tide data is presented in Figure 10. Approximately 45 data points (measuring current) were collected along each transect within a 3-minute time period during an entire 12.5 hour tide cycle. This data was averaged for each 3-minute period as the tide approached both low and high slack tide and confirms the current does not exceed the minimum 1.5 knot regulation EM 1110-2-1613 (31 May 2006) within the turning basin as described in section 4.1.a and 4.1.b.

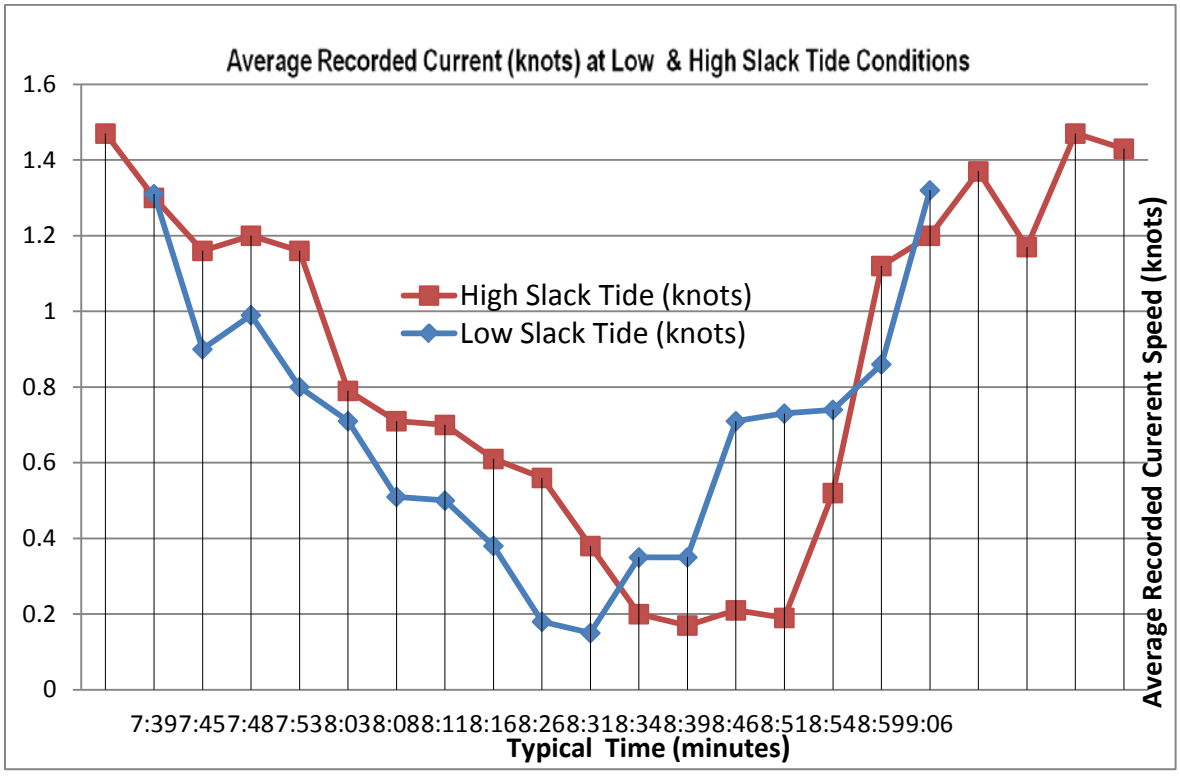

Figure 10. Average Recorded Currents at Low Slack Tide and High Slack Tide (knots)

8.0 REFERENCES.

Woods Hole Group (2009). “Final Report for ADCP and Tide Data Collection Portsmouth Harbor and Piscataqua River, Portsmouth, New Hampshire”.

FINAL REPORT
FOR
ADCP AND TIDE DATA COLLECTION
PORTSMOUTH HARBOR AND PISCATAQUA RIVER
PORTSMOUTH, NEW HAMPSHIRE

Contract No. W912WJ-09-D-0001-0009

Prepared For:
United States Army Corp of Engineers
New England District
696 Virginia Road
Concord, MA 01742

Prepared By:
Woods Hole Group, Inc.
81 Technology Park Drive
East Falmouth, MA 02536

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FOR
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PORSTMOUTH HARBOR AND PISCATAQUA RIVER
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81 Technology Park Drive
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1.0 INTRODUCTION

This brief report presents the boat-based Acoustic Doppler Current Profiler (ADCP) data and associated tide data observed in the Piscataqua River region near Portsmouth, New Hampshire. The data were collected within the Piscataqua River as part of the Piscataqua River Turning Basin deepening/widening study. The overall scope of study by the United States Corps of Engineers (USACE) includes the development of a two-dimensional hydrodynamic model of the region. The data presented herein are intended to be used to assist in the calibration and validation of the model.

Woods Hole Group (WHG) was responsible for collecting these measurements for the U.S. Army Corps of Engineers under task order contract number W912WJ-09-D-0001-0009.

2.0 TIDE DATA COLLECTION

Time-series of water surface elevation were obtained from two (2) locations over approximately one month at the Piscataqua River site (Figure 1). This report and the associated files on the companion CD, present the tide data and the data collection procedures and instrumentation. These observations can be used to analyze and define the tidal fluctuations in the region(s), as well as define boundary conditions and calibration points in the development of a hydrodynamic model.

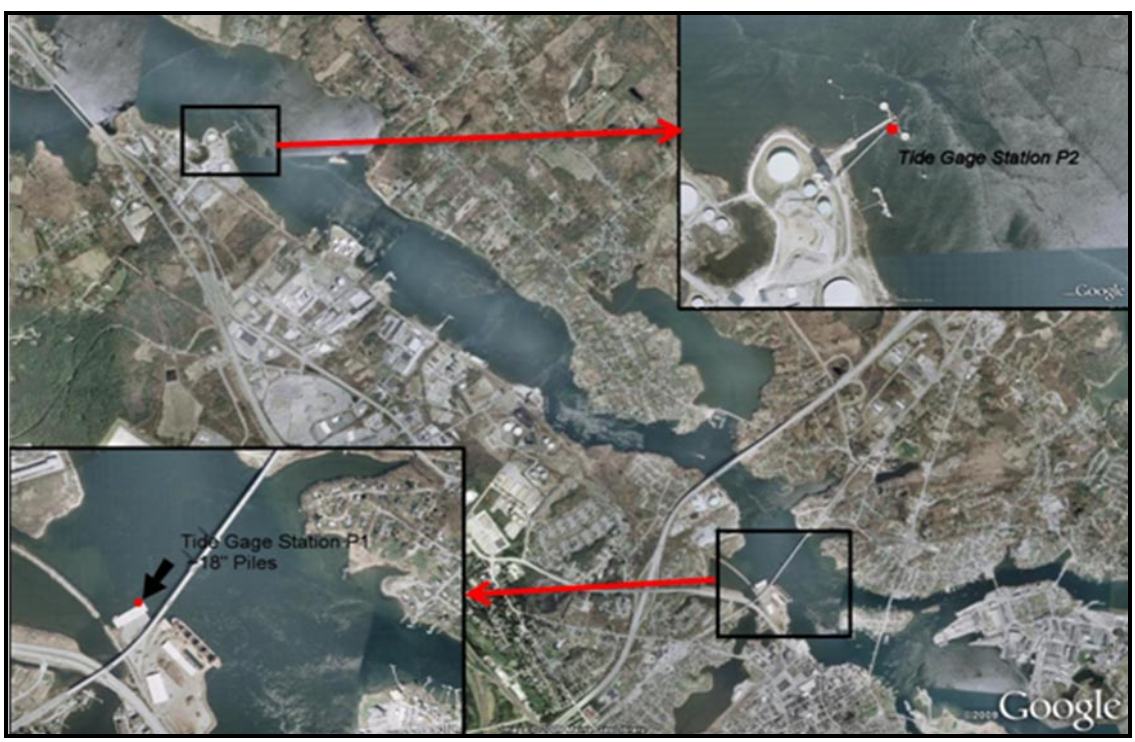


Figure 1. Tide gauge locations within the study area of Piscataqua River.

Deployment locations on the Piscataqua River were chosen to measure the surface water fluctuations directly at the turning basin location (Station P2 near the Sprague Energy Terminal at River Road in Newington), and approximately 3.3 miles downstream of the turning basin location (Station P1 near the State of New Hampshire, Division of Ports and Harbors (DPH) Market Street Terminal in Portsmouth). These locations were selected by the United States Army Corps of Engineers to characterize the local tidal changes that occur through the lower portion of the system, and to provide boundary condition and calibration information for a hydrodynamic modeling effort. Figure 2 shows the tide gage located at the Sprague Energy Terminal (Station P2) at a spring low tide. The photograph illustrates the deployment methodology used to secure the tide gage to the dock piling to ensure the gage remained submerged under the full tidal range. Copies of the field notes from the deployment and recovery of the tide gages is included in Appendix A.

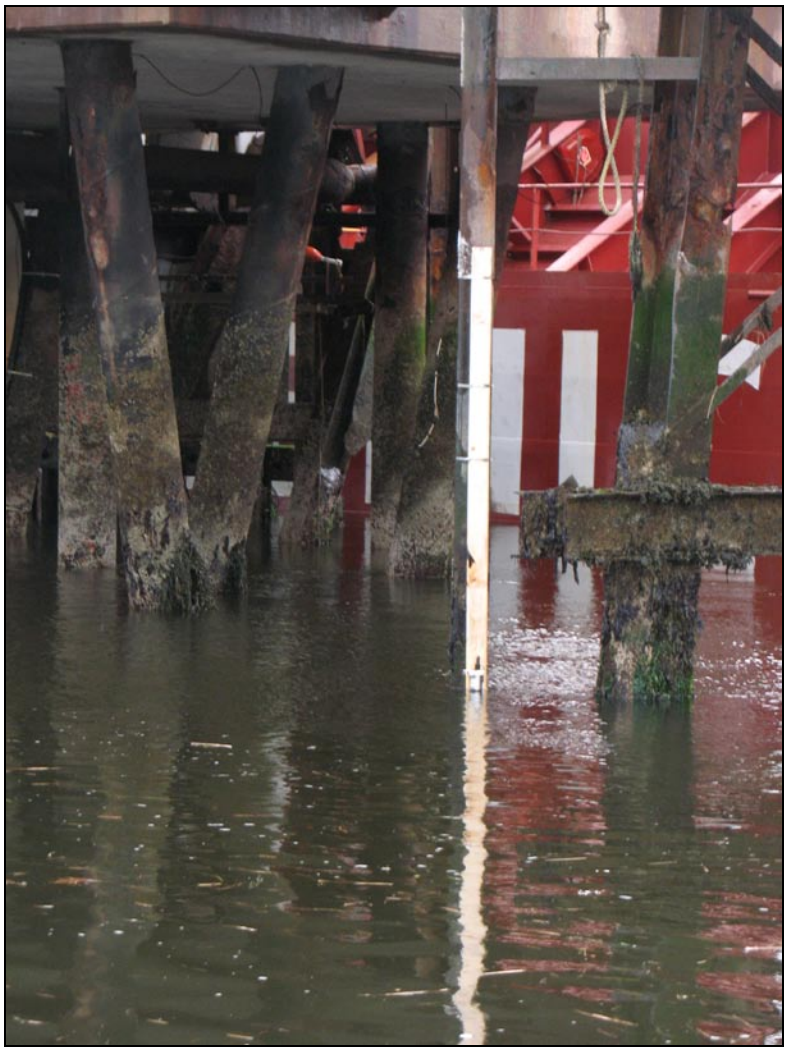


Figure 2. Photograph of tide gage located at station P2, Sprague Energy Terminal in Newington, NH, during a spring low tide.

The data from these two tide gauges was subsequently compared to data from the National Oceanic and Atmospheric Administration (NOAA) NOS station in Portland, Maine to identify the relative tidal attenuation in the system, as well as ground truth the observed data. Table 1 presents the recording interval and frequency of the deployed tide gauges, as well as their exact positions recorded via GPS.

Table 1. Instrument deployment summary.

Tide Station Location (description)	GPS Location (State Plane feet, NAD83)	Log Interval (minutes)	Began Recording	Ended Recording
Piscataqua: DPH Market Street Terminal	northing: 214357.144	6	6/22/2009	7/22/2009
	easting: 1225514.780			
Piscataqua: Sprague Energy Terminal	northing: 225912.377	6	6/22/2009	7/22/2009
	easting: 1212786.076			

Tidal pressures were measured using Sea-Bird SBE37-SM MicroCAT conductivity, temperature and pressure gauges. Each of these instruments measured conductivity, temperature and pressure at set intervals, in this case, every six minutes. Pressure data were downloaded using a personal computer and associated software packages.

Each tide gauge measured the pressure above the instrument, which is a combination of the weight of the water and weight of the atmosphere. In order to analyze the tide data (gauge pressure), the atmospheric pressure needs to be removed from the measured signal. The data collected was pressure corrected using regional atmospheric pressure data from the National Oceanic and Atmospheric Administration (NOAA) station in Wells, Maine. This raw barometric pressure data used for this correction is presented in Figure 3. Gaps in the NOAA barometric pressure record were filled by interpolating between the temporal adjacent observations. Subsequently, this tide pressure data were converted to water surface elevation using the hydrostatic relationship based on the density of water. In order to reference the tide gauges to a common vertical datum, tide data from each gauge was referenced to the NAVD 1988 vertical datum. The tide gauges were surveyed in directly to the instruments pressure port via an RTK-GPS survey and verified with local benchmark information. Appendix B presents the results of the survey and adjustment of the tide gage to the NAVD 1988 vertical datum.

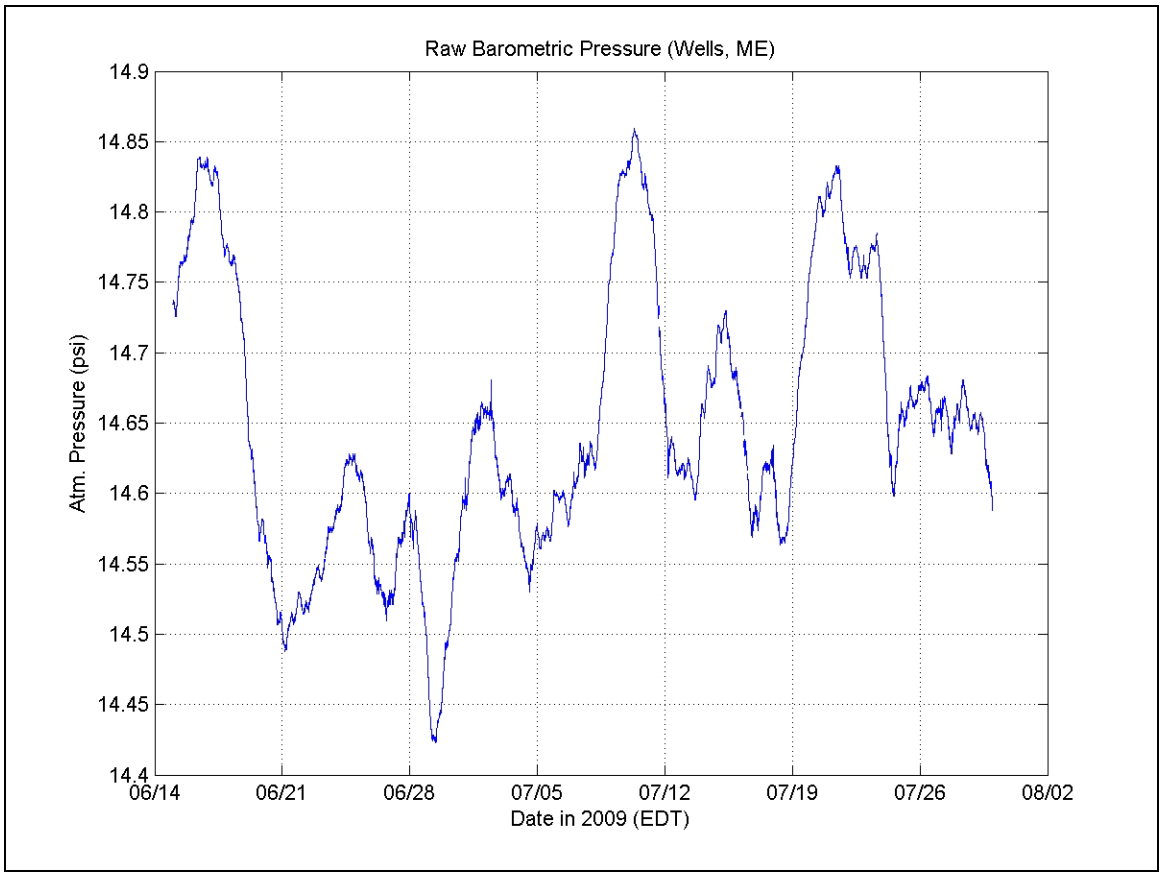


Figure 3. Atmospheric pressure data obtained from National Oceanic and Atmospheric Administration (NOAA) station # 8419317 (Wells, ME).

Figure 4 presents the results of the atmospherically corrected and vertical referenced tidal observations obtained from the Piscataqua River gages. The blue line presents the time series of water surface elevation (feet, NAVD88) at the DPH Market Street Terminal (station P1), while the red line presents the time series of water surface elevation (feet, NAVD88) at the Sprague Energy Terminal (station P2). The two stations at Piscataqua River are plotted together for comparison of the tides at the upstream and downstream locations. The observations show there is some tidal attenuation that occurs between the two stations, as the tidal wave propagates in the River. During the spring tide, approximately 1.0-1.5 feet of tidal attenuation occurs between the two stations, while during the neap tide, approximately 0.2-0.5 feet of tidal attenuation occurs. The phase shift (lag) between high tide at the two stations ranges from approximately 30-45 minutes. In other words, high tide occurs at the Sprague Energy location approximately 30-45 minutes after high tide occurs at the DPH Market Street Terminal.

Figure 5 presents the observed data from Piscataqua River stations, along with the National Oceanic and Atmospheric Administration stations at Portland, ME. The NOAA data are provided as a regional reference to the collected data at local stations on the Piscataqua River. All tide data, including the NOAA station data, is provided on the companion CD to this report in the Tide Data directory.

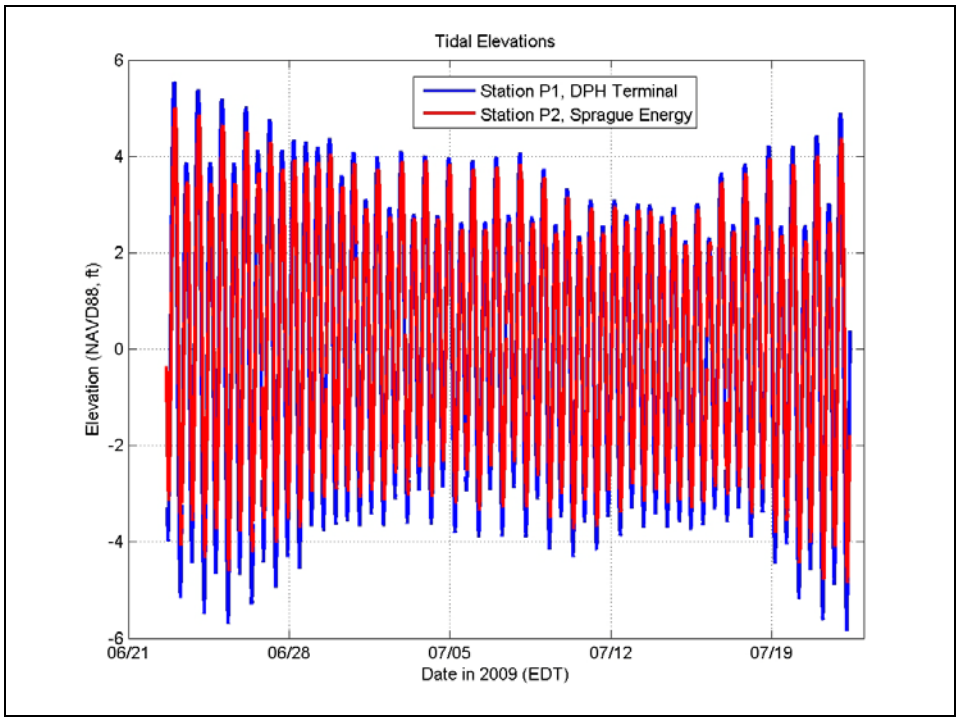


Figure 4. Measured water surface elevation in the Piscataqua River, New Hampshire from June 22 to July 22, 2009.

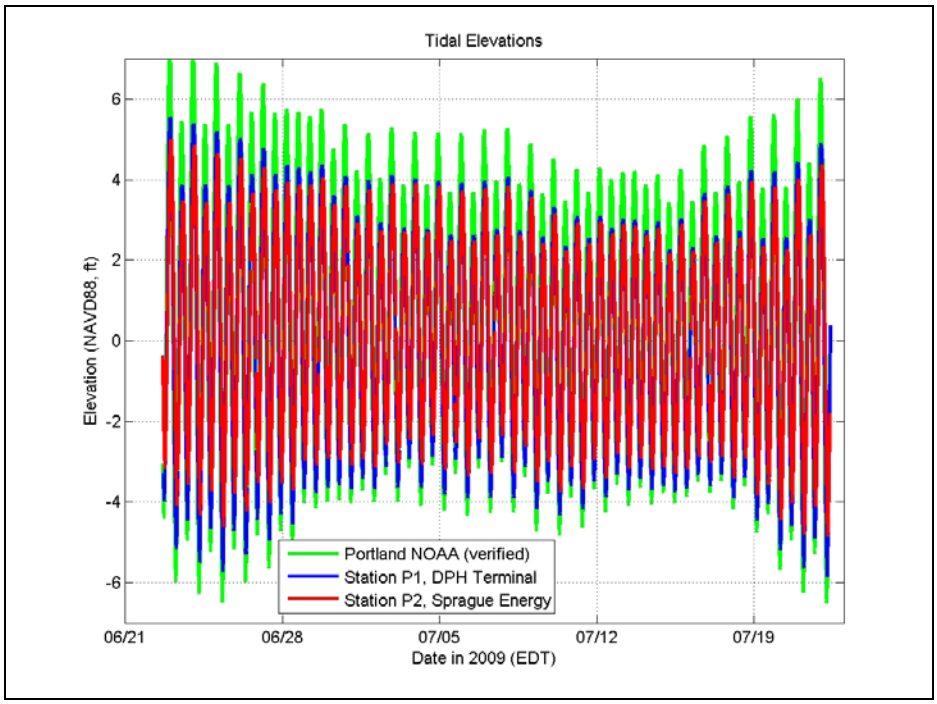


Figure 5. Measured water surface elevation from the Piscataqua River and NOAA's verified water surface elevation from Portland, ME.

3.0 ADCP DATA COLLECTION

In support of the development of the hydrodynamic model and design criteria for the Piscataqua River Turning Basin deepening/widening study, Woods Hole Group, Inc. measured the tidal currents at selected locations in the River during two spring tide conditions. The observations were obtained using an Acoustic Doppler Current Profiler (ADCP) mounted to a small survey vessel. Data were collected through complete lunar semi-diurnal tidal cycles (12.4 hours), once in June and once in July. Each transect was traversed from shoreline to shoreline in a direction perpendicular to the channel. The resulting data sets offer an unparalleled view of the temporal variation in spatial structure of tidal currents through the waterway.

This chapter details the survey instrumentation and methods used to perform the measurements. Data representing high-resolution measurements of tidal current structure at these sample locations are also presented. The results are presented in both time series format (spatially averaged results), as well as full color contours of current velocity components for selected stages of the tide. The complete data set and associated figures are also provided in the companion CD to this report in the ADCP Survey Data directory.

3.1 SURVEY REGION AND DATES

The surveys for the Piscataqua River location were performed on June 23 and July 21, 2009. Four (4) transects were surveyed near the turning basin in the Piscataqua River offshore of the Sprague Energy Terminal, as shown in Figure 6. These four transects formed a reasonable depiction of the currents across the cross-section of the Piscataqua River at this location and adequately represent the current regime in this area. The transects were surveyed continuously throughout the day, travelling in the direction of the arrows indicated on Figure 6. A majority of the transect lines were navigable throughout the tidal cycle; however, the far north/northeast ends of the transect lines were too shallow to survey, and were non-navigable even for the small survey vessel. Table 2 presents the survey dates, locations, transect repetition period and temporal coverage for each transect line.

Table 2. Survey dates, locations, frequency, and temporal coverage of the ADCP transects.

Transect ID	Easting, Northing Transect Start (State Plane NAD83, feet)	Easting, Northing Transect End (State Plane NAD83, feet)	June 23, 2009 Survey		July 21, 2009 Survey	
			Frequency (minutes)	# of Transects	Frequency (minutes)	# of Transects
1	1212157, 225908	1212400, 228014	~4	32	~4	29
2	1213443, 227862	1212714, 226060	~2.5	32	~2.5	29
3	1212845, 225858	1214516, 227326	~3	32	~3	29
4	1214910, 226769	1212673, 225078	~3	32	~3	29

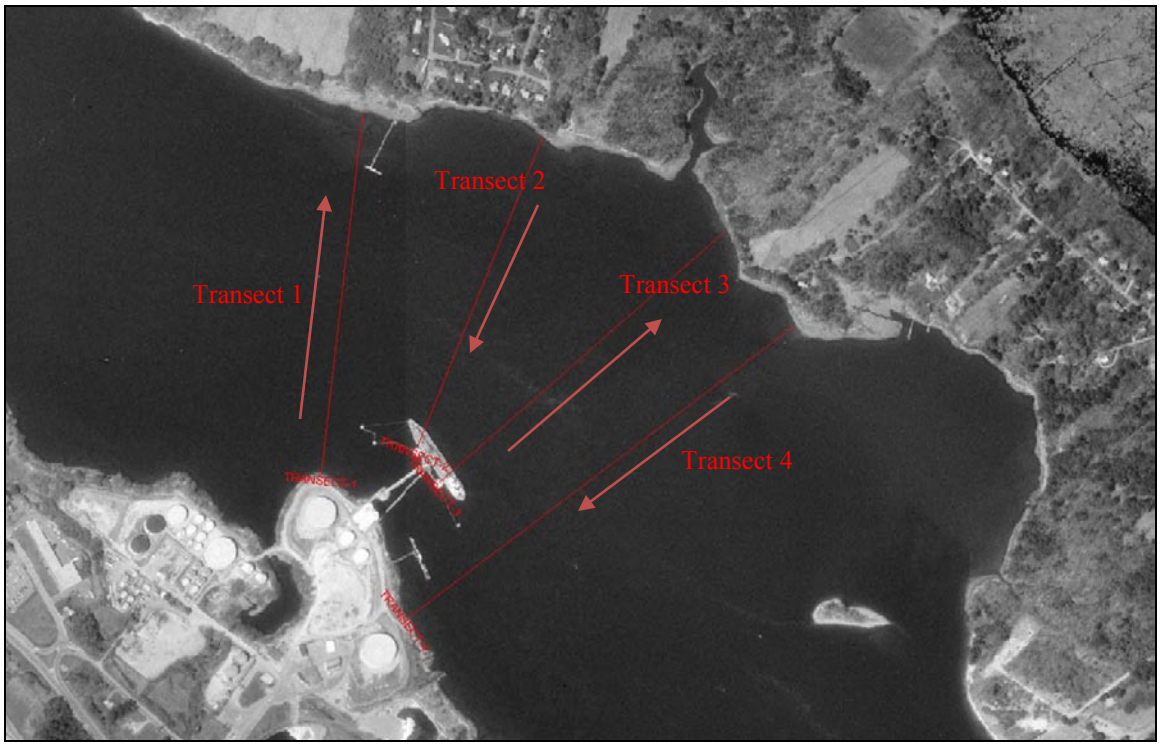


Figure 6. Location of ADCP transects in the Piscataqua River.

3.2 EQUIPMENT DESCRIPTION

Measurements were obtained with a broadband 1200 Khz Acoustic Doppler Current Profiler (ADCP) manufactured by Teledyne/RDInstruments of San Diego, CA. The ADCP was mounted rigidly to the starboard rail of the survey vessel, the 24-foot *Privateer*. Position information was provided by a Trimble 4000-series differential GPS.

The ADCP is capable of high-resolution measurements of the spatial structure of current flow beneath the instrument transducer. When mounted to a moving platform, such as a small vessel, a detailed picture of the current characteristics can be obtained. Repeating the transects at regular time intervals throughout a complete tidal cycle offers an unparalleled determination of the temporal variation in tidal current structure in the study area.

The ADCP measures currents using acoustic pulses emitted individually from four angled (at 20° from the vertical) transducers in the instrument. The instrument listens to the backscattered echoes from discrete depth layers in the water column. The returned echoes, reflected from ambient sound scatters (plankton, debris, sediment, etc.), are compared in the frequency domain to the original emitted pulse. The change in frequency (doppler shift) between the emitted versus the reflected pulse is directly proportional to the speed of the water parallel to the individual beam. For example, an echo of lower frequency indicates water moving away from the transducer while an echo of higher frequency indicates water moving toward the transducer. By combining the doppler velocity components for at least three of the four directional beams, the current

velocities can be transformed to an orthogonal earth coordinate system in terms of east, north, and vertical components of current velocity.

Vertical resolution is gained using a technique called 'range-gating'. Returning pulses are divided into discrete 'bins' based on discrete time intervals following the emission of the original pulse. With knowledge of the speed of sound, the discrete time intervals reflect the range (or depth) of each discrete bin from the transducer face.

The collection of accurate current data with an ADCP requires the removal of the speed of the transducer (mounted to the vessel) from the estimates of current velocity. This is performed by 'bottom tracking' or, using the doppler shift to measure simultaneously the velocity of the transducer relative to the bottom. Bottom tracking allows the ADCP to record absolute versus relative velocities beneath the transducer. In addition, the accuracy of the current measurements can be compromised by random errors (or noise) inherent to this technique. Improvements in the accuracy of each measurement are achieved typically by averaging several individual pulses together. These averaged results are termed 'ensembles'; the more pings used in the average, the lower the standard deviation of the random error.

For these studies each ensemble took approximately 1.8 seconds to collect. The vertical resolution was set to 50 centimeters (approximately 19.7 inches), or one velocity observation per every 50 centimeters (approximately 19.7 inches) of water depth. The first measurement bin was centered approximately 2.7 feet from the surface, allowing for the transducer draft as well as an appropriate blanking distance between the transducer and the first measurement. The transducer was set 1.2 feet below the surface to prevent the transducer from coming out of the water due to potential waves and boat wakes.

Position information was collected by Hypack, an integrated navigation software package running on a PC computer, linked to a Trimble 4000-series differential GPS. Position updates were available every 1 second, and raw position data was also sent to the ADCP laptop to assist in verifying the clock synchronization between the GPS and ADCP.

3.3 SURVEY TECHNIQUE

The transect lines presented in Figure 6 were surveyed throughout the 12.4 hour tidal cycle and the completion of each set of transects represented a loop. These loops were repeated throughout the survey period to depict the changing effects of the current regime throughout the tidal cycle. Each repetition of the loop was performed in the same direction to assure consistent results.

Position data for each transect were recorded using Hypack, with the GPS signals distributed to both the Hypack computer and the ADCP recording computer for later comparison. ADCP data were recorded in binary format on the computer hard disk. Data recording was begun as the vessel neared the start of each line and was terminated at the end of each line. Copies of the field notes recorded throughout each of the ADCP surveys are presented in Appendix A. A summary of transects and loops is also

presented in Appendix C, which includes the start and stop time of each transect, the associated recorded file names, and any comments during the survey.

3.4 DATA PROCESSING TECHNIQUES

The survey resulted in two types of data: current velocity and vessel position. The ADCP data for a single transect consisted of velocity components at every depth bin for every ensemble. In addition, the raw ADCP (binary) files also include ancillary data such as correlation magnitudes, echo amplitudes, percent good pings, and error velocities (among others). These data can be used to recalculate velocities, as well as assure quality of the results. Each ensemble also includes header information such as the ensemble number, time of the ensemble, and water temperature.

Position data were recorded as time-northing-easting. The northing-easting pairs were referenced to State Plane Coordinates, NAD 1983 (feet). The raw ADCP data were converted to ASCII files using Teledyne/RDI's proprietary software to a user-defined data format.

Subsequently, the ensemble profiles must be merged with the position data to assign a unique x-y pair to every ensemble. This merging operation is done using time and GPS position as the common link between the GPS and ADCP data files. By searching for the unique position at a specific time for each of the data sets, an accurate x-y location was assigned to each ensemble. Further numerical processing was performed to calculate the depth-averaged cross-sectional plots.

3.5 SURVEY RESULTS

3.5.1 Data Files

Detailed ASCIII data files, which provide every ensemble of data collected along each transect, are provided on the companion CD in the ADCP survey directory and as indicated in Appendix C. A sample ensemble data set is presented as Table 3.

Table 3. Example data file format for data files provided on the companion CD to this report.

Date and Time (EST)	Easting (NAD83, feet)	Northing (NAD83, feet)	Depth (feet)	Ve (ft/s)	Vn (ft/s)	Magnitude (ft/s)	Direction (radians)
23-Jun-2009 17:31:28	1213568.604	225901.548	2.723	3.88	-3.24	4.36	2.21
23-Jun-2009 17:31:28	1213568.604	225901.548	4.364	3.74	-3.19	4.89	2.19
23-Jun-2009 17:31:28	1213568.604	225901.548	6.004	3.75	-3.05	4.36	2.34
23-Jun-2009 17:31:28	1213568.604	225901.548	7.644	3.91	-2.97	4.62	2.03
23-Jun-2009 17:31:28	1213568.604	225901.548	9.285	3.66	-2.99	4.83	2.20
23-Jun-2009 17:31:28	1213568.604	225901.548	10.925	3.65	-3.06	4.34	2.22
23-Jun-2009 17:31:28	1213568.604	225901.548	12.566	3.62	-2.92	4.69	2.12
23-Jun-2009 17:31:28	1213568.604	225901.548	14.206	3.58	-3.05	4.47	2.13

23-Jun-2009 17:31:28	1213568.604	225901.548	15.846	3.66	-2.97	4.73	2.19
23-Jun-2009 17:31:28	1213568.604	225901.548	17.487	3.84	-3.13	4.92	2.16
23-Jun-2009 17:31:28	1213568.604	225901.548	19.127	3.68	-3.55	4.81	2.38
23-Jun-2009 17:31:28	1213568.604	225901.548	20.768	3.88	-3.38	5.55	2.29
23-Jun-2009 17:31:28	1213568.604	225901.548	22.408	3.68	-3.26	4.65	2.25
23-Jun-2009 17:31:28	1213568.604	225901.548	24.049	3.78	-3.43	4.90	2.37
23-Jun-2009 17:31:28	1213568.604	225901.548	25.689	3.83	-3.45	5.55	2.17
23-Jun-2009 17:31:28	1213568.604	225901.548	27.329	3.89	-3.26	4.72	2.11
23-Jun-2009 17:31:28	1213568.604	225901.548	28.970	3.52	-3.39	4.48	2.21
23-Jun-2009 17:31:28	1213568.604	225901.548	30.610	3.51	-3.56	6.45	2.42
23-Jun-2009 17:31:28	1213568.604	225901.548	32.251	3.47	-3.86	5.76	2.30
23-Jun-2009 17:31:28	1213568.604	225901.548	33.891	3.26	-3.65	4.92	2.28
23-Jun-2009 17:31:28	1213568.604	225901.548	35.531	3.03	-3.29	4.13	2.18
23-Jun-2009 17:31:28	1213568.604	225901.548	37.172	2.84	-3.49	5.35	2.36
23-Jun-2009 17:31:28	1213568.604	225901.548	38.812	2.72	-3.32	3.95	2.32
23-Jun-2009 17:31:28	1213568.604	225901.548	40.453	2.73	-3.47	4.79	2.37
23-Jun-2009 17:31:28	1213568.604	225901.548	42.093	2.27	-3.23	4.41	2.57
23-Jun-2009 17:31:28	1213568.604	225901.548	43.734	NaN	NaN	4.80	2.81
23-Jun-2009 17:31:28	1213568.604	225901.548	NaN	NaN	NaN	NaN	NaN
23-Jun-2009 17:31:28	1213568.604	225901.548	NaN	NaN	NaN	NaN	NaN
23-Jun-2009 17:31:28	1213568.604	225901.548	NaN	NaN	NaN	NaN	NaN

The data files contain information along each transect line throughout depth. The first column is the date and time of the observation, the second and third columns are the easting and northing coordinate of the observation (in NAD 1983, feet), the fourth column is the center of each depth bin (in feet), the fifth column is the east component of velocity (in feet/second), the sixth column is the north component of velocity, the seventh column is the magnitude of the current, and the eighth column is the current direction (in radians with 0 being north). The NaN's in the last rows indicate 'bad' results for depth bins below the bottom; these data are ignored. Some of the deepest bins have NaN's in the easting and northing velocity components as well. The bottom bins can become contaminated by the higher amplitude echoes reflected near the bottom and should be discounted.

3.5.2 Color Contour Plots of Current Structure

Color contour plots for every transect observed during each survey for both sites are presented in the companion CD to this report. The color contour plots represent measured conditions at the time of the survey. Each pair of plots present the spatial structure of flow through the transect at a discrete time period. Viewing a series of these plots for sequential stops through a complete tidal cycle can offer a unique understanding of how the spatial structure of flow varies with time. Figure 7 presents and example color contour plot for the June 23 Survey (transect Y4) during an ebb tide.

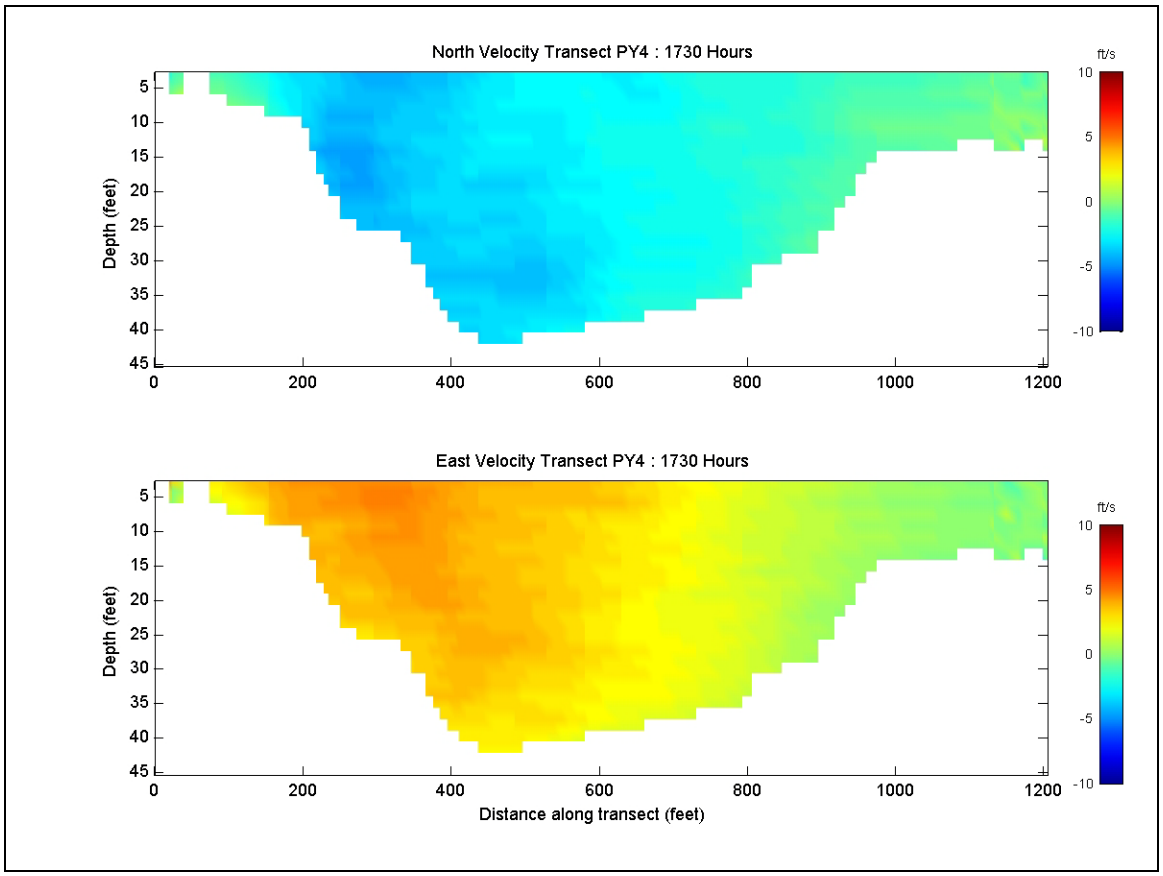


Figure 7. The current velocities, presented in color contour plots, observed during the deployment survey (June 23, 2009) for Transect Y4. The upper panel presents the north/south velocity component, while the lower panel presents the east/west velocity component.

Each figure consists of two panels: the top panel presents the north/south component of velocity through the transect, the bottom panel presents the east/west component of velocity through the transect. The directions are referenced to magnetic north. For example, positive north velocities represent water flowing in a northerly direction. Negative velocities represent water flowing to the south. Positive east velocities represent water flowing to the east; negative east velocities represent flow to the west.

The vertical axis for each plot is depth (in feet), representing the depth of the water column. The horizontal axis represents distance across the transect line. A distance of zero (0) indicates the start of the line, while the end of the transect is indicated by the maximum distance.

The color bar to the right of each plot indicates the magnitude of the north and east current velocities (in feet/second). Strong northerly and easterly flow is indicated by deep red; strong southerly and westerly flow is indicated by deep blue. White areas of

each plot indicate regions below the bottom; therefore, this provides a crude indication of the channel bathymetry outlined by the white areas below the color-filled spaces.

For example, Figure 7 shows a strong south/southeast flow occurring at approximately 1730 on June 23, 2009 along transect 4 occurring during the ebb tide. The strongest flow occurs in the southwest portion of the transect, with maximum current magnitudes of approximately 7-8 feet/second (comprised of a maximum easterly component of approximately 5 to 6 feet/second and a maximum southerly component of approximately 5-6 feet/second). Figure 7 is provided as an example. The complete data set is presented on the companion CD in the ADCP survey directory.

Overall, the differences between the deployment and recovery ADCP surveys are minimal, as the data collected during each survey occurred during similar spring tide conditions. The tidal flow is relatively consistent and the current is concentrated in the River's main channel in the area of the ADCP survey. The current is also relatively uniform in depth and consists of strong flood and ebb currents that are clearly defined from times of slack low and slack high water. At this particular location, maximum current magnitudes during a flood tide are approximately 6-7 feet/second, while during an ebb tide, maximum currents are approximately 7-8 feet/second. The direction of the current aligns with the direction of the main channel in the River and forms a predictable pattern.

3.5.3 Depth Averaged Velocities

The velocities at selected nodes across each transect were determined for each time step. Each transect was divided into eight (8) equal-length subsections; the center of each subsection was labeled individually as node 1 through node 8. For each node, vertically- and horizontally-averaged (east and north) velocity components were calculated for each time step. The vertical average of each ensemble consisted of the mean velocity for all valid bins. The validity of the bottom bin measurements was determined by comparing the standard deviation of bottom values to the standard deviation of mid-column measurements. If the standard deviation at the bottom was more than twice the standard deviation of mid-column measurements, the bottom bin was discarded from the calculation. If the bottom value was within the limits defined by adjacent measurements, the value was included in the calculation. The horizontal average included all vertically-averaged ensemble velocities within each nodal subsection.

The result of this averaging procedure was a series of values showing the average velocity magnitude and direction for each loop of transects. In addition, the nodal averages included the average time of all ensembles in the subsection, average water depth of all ensembles in the subsection, and x-y position of each node. The values for each contiguous loop were plotted as arrows on separate georeferenced maps to show the current characteristics during each time step. Figure 8 shows an example from the June 23, 2009 ADCP survey for loop Y, observed from 1718 to 1733 hours during an ebb tide. Each yellow vector presents the magnitude and direction of the horizontally and depth-averaged currents along a transect line. The length of the vector corresponds to the magnitude of the current, relative to the scale arrow shown at the top of the plot. The plot

shows an overall characterization of the flow patterns in the vicinity of the turning basin. The series of loop figures (presented on the companion CD in the ADCP survey directory) provide a time series of the depth-averaged current patterns for the Piscataqua River survey location.

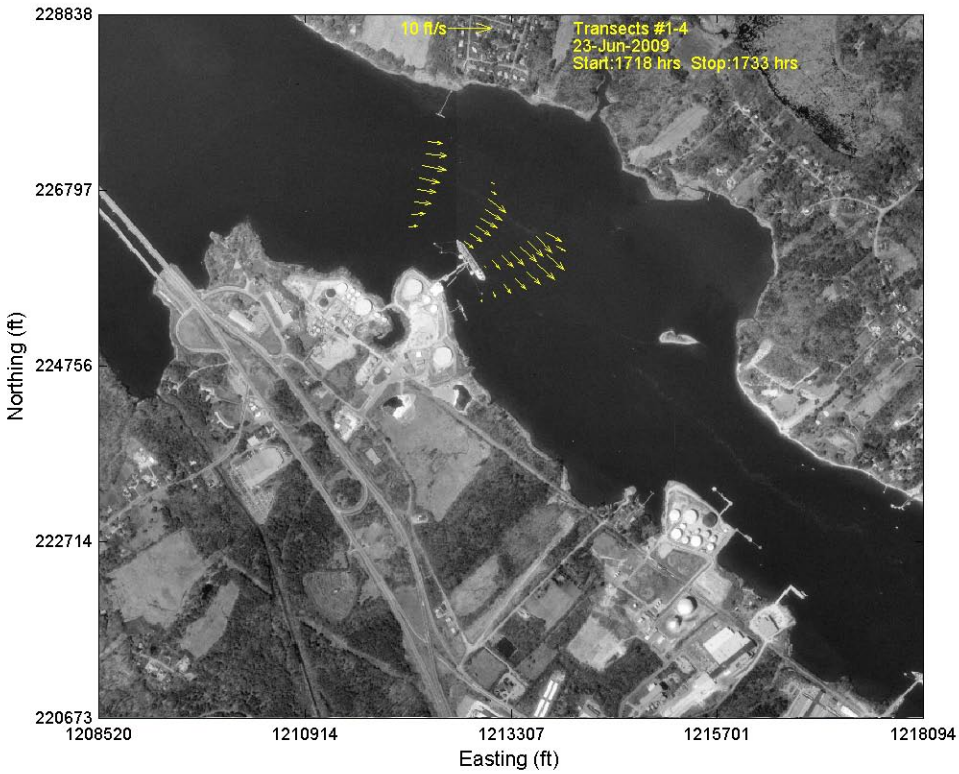


Figure 8. Depth-averaged current results for the transects of Loop Y during the June 23, 2009 survey.

Additionally, a similar method was used to output a depth-averaged velocity (magnitude and direction) at every 25 feet along a transect line, as requested in the RFP. These data files are provided on the companion CD in the ADCP Survey directory, and the file name nomenclature is presented in Appendix C.

APPENDIX A FIELD NOTES

6/22 Piscataqua

1532 - TIDE GAUGE DEPLOYED
OFF OF Sprague Energy.
- SBE 37SM S/N 1826
- POSITION: N 43° 07.000'
W 070° 48.645'
waypoint: "Pis cat TG1"
- TIDE GAUGE MOUNTED ON
A WOODEN 2x4, 8' LENGTH.
Top of 8' 2x4 is 5.3'
below TOP OF STEEL I-BEAM
ON SPRAUGE ENERGY DOCK.

1615 - TIDE GAUGE DEPLOYED
@ City of Portsmouth Dock.
- SBE 37SM S/N 1825
- POSITION: N 43° 05.076'
W 070° 45.813'
waypoint: "PISCAT TG2"
- TIDE GAUGE MOUNTED ON
A WOODEN 2x4, 8' (feet) in Length.
Top of 8' 2x4 is 10.08' below
top of Concrete pier/dock surface.
- TIDE GAUGE ATTACHED TO

6/22 Piscataqua

cont.
wood piling adjacent to Harbor-
master's boat ramp.

6/23/2009

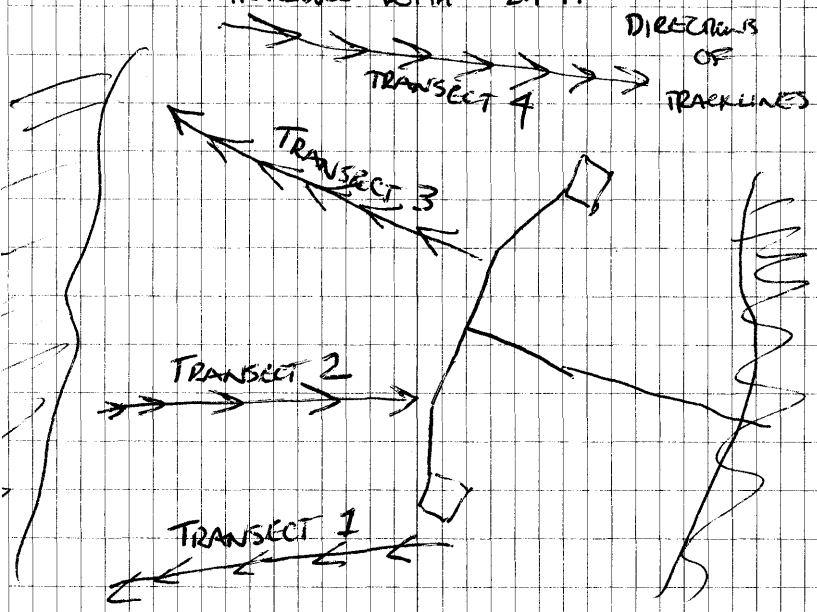
- ADCP SURVEY PRE- PISCATAQUA RIVER
  6/23/2009

- LOG FILE STARTS ON NEXT PAGE

- START TIME : 0500 IN FIELD
  PREPPING ADCP

- 5:30 CHECK ADCP
  TILT AND ROLL CALIBRATION = 2.3°

- 7:20 - TRANSDUCER DEPTH = 2.1 FT



LOOP - TRANSECT #	START TIME	STOP TIME	FILES	COMMENTS
A - 1	0734	0739	PISCATAQUA -001.*	- END OF OUTGOING TIDE
A - 2	0742	0745	PISCATAQUA -002.*	- END OF OUTGOING TIDE
A - 3	0746	0748	PISCATAQUA -003.*	- END OF OUTGOING TIDE
A - 4	0750	0753	PISCATAQUA -004.*	- END OF OUTGOING TIDE
B - 1	0759	0803	PISCATAQUA -005.*	SLACK LOW
B - 2	0805	0808	PISCATAQUA -006.*	SLACK LOW *HIT ROCK
B - 3	0809	0811	PISCATAQUA -007.*	SLACK LOW
B - 4	0812	0816	PISCATAQUA -008.*	SLACK LOW
C - 1	0823	0826	PISCATAQUA -009.*	[redacted]
C - 2	0828	0831	PISCATAQUA -010.*	SLACK
C - 3	0832	0834	PISCATAQUA -011.*	
C - 4	0836	0839	PISCATAQUA -012.*	
D - 1	0843	0846	PISCATAQUA -013.*	SLACK/START OF
D - 2	0849	0851	PISCATAQUA -014.*	[redacted] FLOOD
D - 3	0852	0854	PISCATAQUA -015.*	
D - 4	0856	0859	PISCATAQUA -016.*	
E - 1	0903	0906	PISCATAQUA -017.*	FLOOD
E - 2	0908	0910	PISCATAQUA -018.*	
E - 3	0912	0913	PISCATAQUA -019.*	
E - 4	0915	0918	PISCATAQUA -020.*	
F - 1	0924	0927	Piscataqua -021.*	
F - 2	0931	0934	Piscataqua -022.*	
F - 3	0936	0938	Piscataqua -023.*	
F - 4	0939	0943	Piscataqua -024.*	

COULDN'T GET DOWN CLOSE TO EAST SHORE

LOOP - TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
G-1	0946	0948	PISCATAQUA -025. *	STRONG FLOW
G-2	0951	0954	PISCATAQUA -026. *	
G-3	0955	0958	PISCATAQUA -027. *	
G-4	0959	1002	PISCATAQUA -028. *	
H-1	1006	1009	PISCATAQUA -029. *	
H-2	1012	1015	PISCATAQUA -030. *	FLOOD
H-3	1017	1019	PISCATAQUA -031. *	
H-4	1022	1025	PISCATAQUA -032. *	
I-1	1029	1032	PISCATAQUA -033. *	
I-2	1035	1038	PISCATAQUA -034. *	
I-3	1041	1043	PISCATAQUA -035. *	
I-4	1045	1048	PISCATAQUA -036. *	
J-1	1052	1055	PISCATAQUA -037. *	
J-2	1058	1101	PISCATAQUA -038. *	
J-3	1104	1107	PISCATAQUA -039. *	
J-4	1108	1112	PISCATAQUA -040. *	
K-1	11~~41~~ 1	11~~20~~ 44	PISCATAQUA -043. *	- ADCP power lost 1119-1120 line repeated.
K-2	1146	1149	PISCATAQUA -044. *	
K-3	1151	1153	PISCATAQUA -045. *	
K-4	1154	1157	PISCATAQUA -046. *	
L-1	1201	1204	PISCATAQUA -047. *	STILL STRONG FLOOD
L-2	1206	1209	PISCATAQUA -048. *	
L-3	1211	1214	PISCATAQUA -049. *	
L-4	1215	1219	PISCATAQUA -050. *	

LOOP TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
M-1	1223	1226	PISCATAQUA _051.*	
M-2	1228	1231	PISCATAQUA _052.*	STILL
M-3	1232	1235	PISCATAQUA _053.*	FLOODING 13 OUT TO BASCO -POTENTIAL CURRENTS AT
M-4	1236	1240	PISCATAQUA _054.*	START OF LINE -START OF SLACK
N-1	1244	1247	PISCATAQUA _055.*	~~SLACK~~ START OF
N-2	1249	1252	PISCATAQUA _056.*	SLACK.
N-3	1253	1256	PISCATAQUA _057.*	INTERESTING CURRENT PATTERNS
N-4	1257	1300	PISCATAQUA _058.*	
O-1	1316	1319	PISCATAQUA _059.*	WAIT FOR OCEAN FREIGHTER
O-2	1321	1324	PISCATAQUA _060.*	TO LEAVE SEA-3 TERMINAL
O-3	1326	1330	PISCATAQUA _061.*	CHANGING TIDES
O-4	1332	1337	PISCATAQUA _062.*	ADCP SETUP CHANGED TO 36
P-1	1342	1347	PISCATAQUA _063.*	BINS, 18m DEPTH
P-2	1350	1354	PISCATAQUA _064.*	DUE TO HIGH WATER
P-3	1355	1358	PISCATAQUA _065.*	SLACK, ~~START~~
P-4	1400	1405	PISCATAQUA _066.*	
Q-1	1410	1414	PISCATAQUA _067.*	SLACK
Q-2	1416	1419	PISCATAQUA _068.*	HIGH
Q-3	1419	1422	PISCATAQUA _069.*	
Q-4	1423	1427	PISCATAQUA _070.*	
R-1	1431	1436	PISCATAQUA _071.*	START OF EBB
R-2	1438	1441	PISCATAQUA _072.*	
R-3	1441	1444	PISCATAQUA _073.*	
R-4	1445	1450	PISCATAQUA _074.*	

LOOP TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
S-1	1456	1500	PISCATAQUA -075.*	
S-2	1502	1505	PISCATAQUA -076.*	
S-3	1506	1508	PISCATAQUA -077.*	
S-4	1509	1514	PISCATAQUA -078.*	EBB
T-1	1520	1524	PISCATAQUA -079.*	
T-2	1526	1529	PISCATAQUA -080.*	
T-3	1529	1531	PISCATAQUA -081.*	
T-4	1532	1535	PISCATAQUA -082.*	
U-1	1540	1544	PISCATAQUA -083.*	
U-2	1546	1548	PISCATAQUA -084.*	
U-3	1548	1551	PISCATAQUA -085.*	
U-4	1552	1556	PISCATAQUA -086.*	LOST NAV BATTERIES DEAD IN GPS REPLACED AND CONTINUED
V-1	1617	1621	PISCATAQUA -089.*	
V-2	1622	1625	PISCATAQUA -090.*	
V-3	1625	1627	PISCATAQUA -091.*	
V-4	1628	1632	PISCATAQUA -092.*	EBB
W-1	1637	1642	PISCATAQUA -093.*	
W-2	1643	1645	PISCATAQUA -094.*	
W-3	1646	1648	PISCATAQUA -095.*	
W-4	1648	1652	PISCATAQUA -096.*	
X-1	1658	1702	PISCATAQUA -097.*	
X-2	1704	1706	PISCATAQUA -098.*	
X-3	1706	1708	PISCATAQUA -099.*	
X-4	1709	1712	PISCATAQUA -100.*	

LOOP-TRANSECTS	START TIME	STOP TIME	FILES	COMMENTS
Y - 1	1718	1722	PISCATAQUA -101.*	
Y - 2	1724	1726	PISCATAQUA -102.*	
Y - 3	1727	1729	PISCATAQUA -103.*	
Y - 4	1730	1733	PISCATAQUA -104.*	
Z - 1	1738	1741	PISCATAQUA -105.*	
Z - 2	1742	1744	PISCATAQUA -106.*	
Z - 3	1745	1747	PISCATAQUA -107.*	
Z - 4	1748	1751	PISCATAQUA -108.*	
AA - 1	1757	1801	PISCATAQUA -109.*	
AA - 2	1802	1804	PISCATAQUA -110.*	
AA - 3	1804	1807	PISCATAQUA -111.*	
AA - 4	1808	1811	PISCATAQUA -112.*	
BB - 1	1816	1820	PISCATAQUA -113.*	
BB - 2	1821	1823	PISCATAQUA -114.*	
BB - 3	1823	1826	PISCATAQUA -115.*	
BB - 4	1827	1830	PISCATAQUA -116.*	
CC - 1	1835	1839	PISCATAQUA -117.*	
CC - 2	1841	1843	PISCATAQUA -118.*	
CC - 3	1843	1845	PISCATAQUA -119.*	
CC - 4	1846	1849	PISCATAQUA -120.*	CHECKED TIDE GAUGE TO ENSURE SUBMERGED
DD - 1	1857	1902	PISCATAQUA -121.*	WENT * BEYOND END POINT ON TRANSECT LINE
DD - 2	1903	1905	-122.*	
DD - 3	1906	1909	-123.*	
DD - 4	1910	1913	-124.*	

LOOP - TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
EE-1	1919	1922	PISCATAQUA_0125.*	
EE-2	1924	1925	PISCATAQUA_0126.*	END OF
EE-3	1926	1928	PISCATAQUA_0127.*	EBB
EE-4	1929	1931	PISCATAQUA_0128.*	
FF-1	1939	1942	PISCATAQUA_0129.*	
FF-2	1944	1947	PISCATAQUA_0130.*	
FF-3	1947	1950	PISCATAQUA_0131.*	
FF-4	1951	1954	PISCATAQUA_0132.*	

— END OF SURVEY —

SEARSPORT 6/24/2009

11:42 - SET UP PPK UNIT AT SPRAGUE TERMINAL

11:55 - UP AND RUNNING

CALLED BASE STATION - PPKBASE-TERMINAL

12:25 - PPK ~~[illegible]~~ CORPS BENCH MARK ON SEARSPORT PUBLIC BOAT RAMP TWICE

SEARSPORT - BM1 & SEARSPORT - BM2

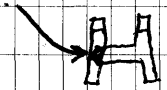
- PPK BENCHMARK ON ISLESBORO ISLAND

ISLESBORO-T1 & ISLESBORO T2

(1827)

ISLESBORO TIDE GAGE DEPLOYED AT 4:04 PM

8.7' FEET FROM PRESSURE PORT TO TOP OF 2X4, THEN 6.95' FROM TOP OF 2X4 TO PPK ~~[illegible]~~ MEASURED POINT ON IBEAM.



SO FROM PRESSURE PORT TO TOP OF IBEAM

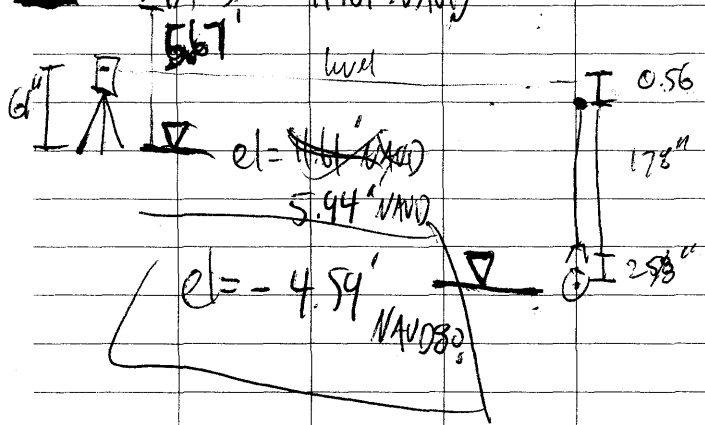
= 15.65'

GAGE 1827

SBE
1826
elevation using
FEMA BM elev
stadia / col-east

11.61' NAVD88
From Photogrammetric
ground Control survey

FEMA BM = 11.61 NAVD



7/21/09 Piscataqua
ADCP Survey

~ 6am arrive Hilton Park

Dave Walsh, Nate Dill
Lenny TGB

VMDAS ADCP software
rr - recorder Record
re - ErASE - Recordin Erase
(clear Internal memory)

730 In Water

ADCP offset 1.9 ft transducer → surfa
0.58 meter

VMDAS
File
Collect Data
Options
Edit data..
Communic tab
ADCP input 9600 bps
NEMA input 4800 bps

ADCP setup 36 Bins
0.5 m

7/21/09 Piscataqua River ADCP Survey

TRANSECT		START TIME	FILE NAME	END TIME
1A	1	0809	Piscataqua2_001.*	0813
2A	2	0818	Piscataqua2_002.*	0822
3A	3	0824	Piscataqua2_003.*	0828
4A	4	0831	_004.*	
5B	1	0842	_005.*	0845
6B	2	0849	_006.*	0854
7B	3	0855	_007.*	0859
8B	4	0901	_008.*	0905
9C	1	0909	_009.*	0913
10C	2	0916	_010.*	0919
11C	3	0921	_011.*	0924
12C	4	0926	_012.*	0931
13D	1	0935	_013.*	0939
14D	2	0942	_014.*	0946
15D	3	0947	_015.*	0950
16D	4	0952	_016.*	0957
17E	1	1000	_017.*	1003
18E	2	1006	_018.*	1010
19E	3	1011	_019.*	1015
20E	4	1019	_020.*	1023
21F	1	1026	_021	1029
22F	2	1032	_022.*	1035
23F	3	1037	_023.*	1041
24F	4	1042	_024.*	1047

(Work Horse Sentinel 1200 kHz)

Install
VmDas v1.44

PROGRAM OPTIONS

ADCP Setup

Bins = 36
Bin size = 0.5
Blank dist. = 0.5
Transducer depth = measure 0.58m

Heading Sensor - Internal
tilt sensor - Internal

Max range = 18

Set Bot track on

Ping as fast as possible

NAV

Enable ship position NEMA1
Enable ship speed NEMA1

Transform

Heading Source ADCP Compass
Tilt source ADCP tilt sensor
Rest Default / Blank

Piscataqua ADCP cont.

Transect	Start Time	Filename	END	
25 G1	1051	Piscataqua2_025.*	1054	
26 G2	1057	_026.*	1101	
27 G3	1101	_027.*	1105	
28 G4	1107	_028.*	1111	
29 H1	1115	_029.*	1119	
30 H2	1122	_030.*	1125	
31 H3	1126	_031.*	1129	
32 H4	1131	_032.*	1136	
33 I1	1139	_033.*	1143	
34 I2	1146	_034.*	1150	
35 I3	1152	_035.*	1156	
36 I4	1158	_036.*	1202	
37 J1	1205	_037.*	1209	
38 J2	1212	_038.*	1216	
39 J3	1216	_039.*	1220	
40 J4	1221	_040.*	1226	
41 K1	1229	_041.*	1233	
42 K2	1236	_042.*	1239	
43 K3	1239	_043.*	1243	
44 K4	1244	_044.*	1249	
45 L1	1254	_045.*	1258	
46 L2	1300	_046.*	1303	
47 L3	1304	_047.*	1308	
48 L4	1308	_048.*	1313	Direction Change
49 M1	1318	049.*	1322	

VmDas setup Cont.

Prog. opt., cont.

Averaging

- Temporal
  - First STA 5 sec
  - LTA 30
- enable Profile Ping Ref. Layer
  - 2 → 10

Data screening

✓ Mark Data bad below Bottom

Right leave

User exits

✓ Launch Wi-xDA

STA

5

Sim Inputs

Leave as is

Piscataqua cont.

transect	start	Filename	End
50 M2	1324	Piscataqua2_050.*	1327
51 M3	1327	_051.*	1331
52 M4	1333	_052.*	1337
53 N1	1342	_053.*	1346
54 N2	1349	_054.*	1351
55 N3	1352	_055.*	1356
56 N4	1358	_056.*	
57 O1	1409	_057.*	1413
58 O2	1415	_058.*	1418
59 O3	1419	_059.*	1423
60 O4	1425	_060.*	1430
61 P1	1435	_061.*	1440
62 P2	1442	_062.*	1444
63 P3	1445	_063.*	1448
64 P4	1451	_064.*	1456
65 Q1	1500	_065.*	1507
66 Q2	1510	_066.*	1512
67 Q3	1513	_067.*	1517
68 Q4	1519	_068.*	1525
69 R1	1530	_069.*	1535
70 R2	1538	_070.*	1540
71 R3	1541	_071.*	1544
72 R4	1545	_072.*	1549
73 S1	1554	_073.*	1559
74 S2	1600	_074.*	1603

7/22/09 Piscataqua

Nate Dill Mitch Burk

PPK survey

Arrive Hilton Park 0715 Tide is Low

Base Antenna @ 1.5m
set on grass (relatively firm soil)
SE corner of Park South of
Boat Ramp, East of Hwy Bridge

PPK Base Recording @ 0744

Boat in Water @ 0850

Recover MicroCAT sn(1826) @ terminal (ppk)

Rover pole 2m on top of Beam

63" Top of 2x4 → top of Beam

113 1/2" Water Surface → top of Beam 0927 Time

96 1/3" top of 2x4 → pressure port

Piscataqua cont.

Transect	Start	Filename	END	
75 S3	1604	Piscataqua2_075.*	1606	
76 S4	1608	_076.*	1611	
77 T1	1616	_077.*	1620	
78 T2	1621	_078.*	1623	
79 T3	1624	_079.*	1628	
80 T4	~~80~~ off track	_080.*		skip
80 T4	1631	_081.*	1634	
81 U1	1638	_082.*	1642	Wake of Boat
82 U2	1643	_083.*	1645	
83 U3	1645	_084.*	1649	
84 U4	1650	_085.*	1653	
85 V1	1657	_086.*	1701	
86 V2	1703	_087.*	1705	
87 V3	1706	_088.*	1709	
88 V4	1712	_089.*	1716	
89 W1	1721	_090.*	1725	
90 W2	1728	_091.*	1731	
91 W3	1731	_092.*	1734	
92 W4	1735	_093	1738	
93 X1	1742	_094.*	1746	ADCP
94 X2	1748	_095.*	1749	Hit shoal
95 X3	1750	_096.*	1753	←
96 X4		_097.*		skip
97 Y1	1844	_097.*	1847	
98 Y2	1849	_098.*	1851	

7/22/09 cont.

MicroCat Recovery Sn 1826 at transect

PA - predeployment test
PC1 - Beam continuity - Rubdown
PC2 - Sensor test
CZ - put to sleep

1753 ADCP struck gravel/rocky bottom of shoal, water obviously very shallow - shallower than indicated on chart. ADCP removed from water & inspected. Inspection shows Transducers all OK, only some scratches/gouges in plastic. Communication w/ADCP OK as well!

Piscataqua Cont.

transect	Start	filename	END
99 Y 3	1851	Piscataqua099.*	1854
100 Y 4	1856	100.*	1858
101 Z 1	1901	101.*	1904
102 Z 2	1905	102.*	1908
103 Z 3	1909	103.*	1911
104 Z 4	1913	104.*	
105 AA 1	1920	105.*	1922
106 AA 2	1925	106.*	1928
107 AA 3	1929	107.*	1931
108 AA 4	1934	108.*	1937
109 BB 1	1940	109.*	1944
110 BB 2	1947	110.*	1950
111 BB 3	1951	111.*	1954
112 BB 4	1957	112.*	1959
113 CC 1	2002	113.*	2005
114 CC 2	2007	114.*	2009
115 CC 3	2010	115.*	2012
116 CC 4	2014	116.*	2016

7/22/09

Recovery of tide gage at Portsmouth fire Boat — Time 0946

10.04 ft top of Pier to top of 2x4 concrete

Tide Looking pretty high

9.7 ft water surface → concrete

0.53 ft high point on piling → concrete

Sn 1825 usually in good condition

96¼" top of 2x4 → pressure port

get data off Microcats

Sn 1826

stop 1120

ds Max sample # 7164

DD

seabird 37sm

Sh 1825

max sample # 7174

stop 1221
dd 0, 7174

Total Stat Survey

Shot 1 : Tripod → BM

X	57.46	57.44	57.42
Z	1.82	1.84	1.80
Z			

Rod 73 1/8"
Total 65 1/8"

Shot 2 : Tripod → P160

X	72.84	72.88
Z	0.20	0.20

Rod = 73 1/8"
Tot = 65 1/8"

Shot 3: Tripod → P200

X	100.40	100.38	100.32
Z	1.42	1.42	1.42

Rod = 73 1/8"
Tot = 65 1/8"

Shot 4: Tripod → S412

X	262.42	262.44	262.30
Z	0.56	0.52	0.52

Rod = 73
Tot = 65 1/8

(Through metal fence)

Shot 5: Tripod → Base

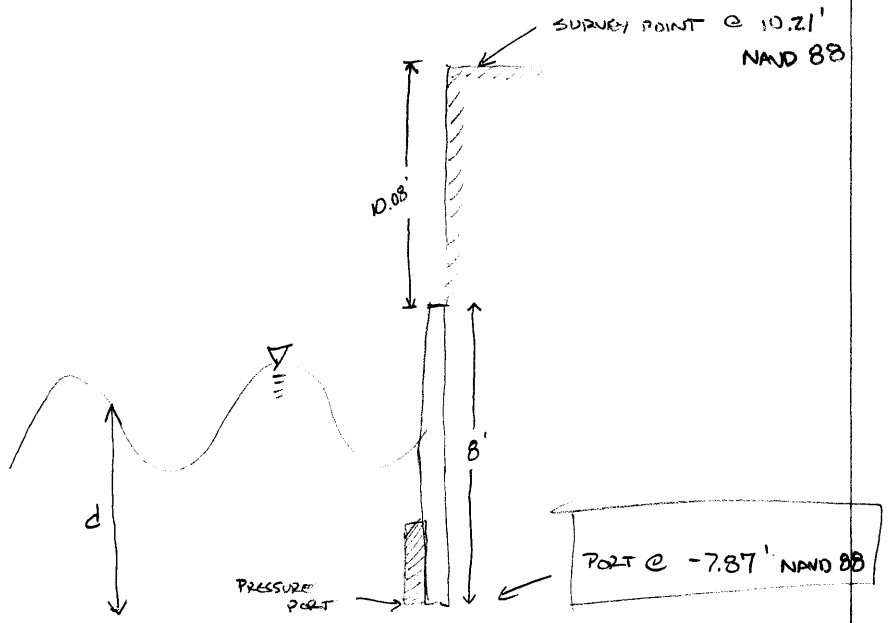
X	520.28	520.24	520.18	520.26
Z	-2.40	-2.02	-2.04	-2.62

X	520.18	520.12	520.02
Z	-2.36	-2.16	2.80

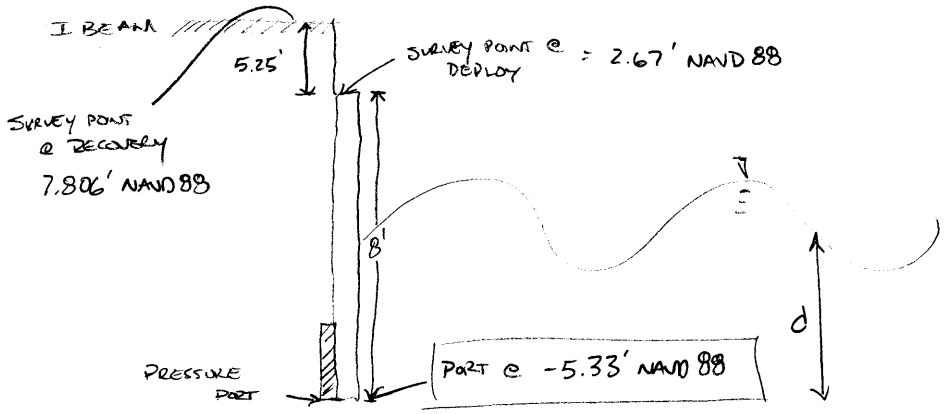
APPENDIX B TIDE DATA BENCHMARKING

PISCATAQUA RIVER TIDAL SURVEY ADJUSTMENT TO DATUM

STATION P1 AT CITY OF PORTSMOUTH DOCK, GAUGE S/N 1825



STATION P2 AT SPRAGUE ENERGY TERMINAL, GAUGE S/N 1826



22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

APPENDIX C ADCP TRANSECT AND LOOP SUMMARY

PISCATAQUA RIVER DEPLOYMENT SURVEY, June 25, 2009						
				Entire	Depth-Averaged	
Loop	Transect	Start Time	Stop Time	Data File	Data File	Comments
A	1	734	739	PA1_0734.dat	DA_PA1_0734.dat	End of Ebb Tide
A	2	742	745	PA2_0742.dat	DA_PA2_0742.dat	
A	3	746	748	PA3_0746.dat	DA_PA3_0746.dat	
A	4	750	753	PA4_0750.dat	DA_PA4_0750.dat	
B	1	759	803	PB1_0759.dat	DA_PB1_0759.dat	Slack Low
B	2	805	808	PB2_0805.dat	DA_PB2_0805.dat	
B	3	809	811	PB3_0809.dat	DA_PB3_0809.dat	
B	4	812	816	PB4_0812.dat	DA_PB4_0812.dat	
C	1	823	826	PC1_0823.dat	DA_PC1_0823.dat	Slack Low
C	2	828	831	PC2_0828.dat	DA_PC2_0828.dat	
C	3	832	834	PC3_0832.dat	DA_PC3_0832.dat	
C	4	836	839	PC4_0836.dat	DA_PC4_0836.dat	
D	1	843	846	PD1_0843.dat	DA_PD1_0843.dat	Start of Flood
D	2	849	851	PD2_0849.dat	DA_PD2_0849.dat	
D	3	852	854	PD3_0852.dat	DA_PD3_0852.dat	
D	4	856	859	PD4_0856.dat	DA_PD4_0856.dat	
E	1	903	906	PE1_0903.dat	DA_PE1_0903.dat	
E	2	908	910	PE2_0908.dat	DA_PE2_0908.dat	
E	3	912	913	PE3_0912.dat	DA_PE3_0912.dat	
E	4	915	918	PE4_0915.dat	DA_PE4_0915.dat	
F	1	924	927	PF1_0924.dat	DA_PF1_0924.dat	
F	2	931	934	PF2_0931.dat	DA_PF2_0931.dat	
F	3	936	938	PF3_0936.dat	DA_PF3_0936.dat	
F	4	939	943	PF4_0939.dat	DA_PF4_0939.dat	
G	1	946	948	PG1_0946.dat	DA_PG1_0946.dat	
G	2	951	954	PG2_0951.dat	DA_PG2_0951.dat	
G	3	955	958	PG3_0955.dat	DA_PG3_0955.dat	
G	4	959	1002	PG4_0959.dat	DA_PG4_0959.dat	
H	1	1006	1009	PH1_1006.dat	DA_PH1_1006.dat	
H	2	1012	1015	PH2_1012.dat	DA_PH2_1012.dat	
H	3	1017	1019	PH3_1017.dat	DA_PH3_1017.dat	
H	4	1022	1025	PH4_1022.dat	DA_PH4_1022.dat	
I	1	1029	1032	PI1_1029.dat	DA_PI1_1029.dat	Flood
I	2	1035	1038	PI2_1035.dat	DA_PI2_1035.dat	
I	3	1041	1043	PI3_1041.dat	DA_PI3_1041.dat	
I	4	1045	1048	PI4_1045.dat	DA_PI4_1045.dat	
J	1	1052	1055	PJ1_1052.dat	DA_PJ1_1052.dat	
J	2	1058	1101	PJ2_1058.dat	DA_PJ2_1058.dat	
J	3	1104	1107	PJ3_1104.dat	DA_PJ3_1104.dat	
J	4	1108	1112	PJ4_1108.dat	DA_PJ4_1108.dat	
K	1	1141	1144	PK1_1141.dat	DA_PK1_1141.dat	ADCP Power lost on Line K1, reinitialized and repeated line
K	2	1146	1149	PK2_1146.dat	DA_PK2_1146.dat	
K	3	1151	1153	PK3_1151.dat	DA_PK3_1151.dat	
K	4	1154	1157	PK4_1154.dat	DA_PK4_1154.dat	
L	1	1201	1204	PL1_1201.dat	DA_PL1_1201.dat	
L	2	1206	1209	PL2_1206.dat	DA_PL2_1206.dat	
L	3	1211	1214	PL3_1211.dat	DA_PL3_1211.dat	
L	4	1215	1219	PL4_1215.dat	DA_PL4_1215.dat	
M	1	1223	1226	PM1_1223.dat	DA_PM1_1223.dat	Vessel traffic, possible induced currents on Line M3
M	2	1228	1231	PM2_1228.dat	DA_PM2_1228.dat	
M	3	1232	1235	PM3_1232.dat	DA_PM3_1232.dat	
M	4	1236	1240	PM4_1236.dat	DA_PM4_1236.dat	
N	1	1244	1247	PN1_1244.dat	DA_PN1_1244.dat	Possible boat induced currents, Ocean Freighter leaving SEA-3 Terminal
N	2	1249	1252	PN2_1249.dat	DA_PN2_1249.dat	
N	3	1253	1256	PN3_1253.dat	DA_PN3_1253.dat	
N	4	1257	1300	PN4_1257.dat	DA_PN4_1257.dat	

O	1	1316	1319	PO1_1316.dat	DA_PO1_1316.dat	
O	2	1321	1324	PO2_1321.dat	DA_PO2_1321.dat	
O	3	1326	1330	PO3_1326.dat	DA_PO3_1326.dat	
O	4	1332	1337	PO4_1332.dat	DA_PO4_1332.dat	
P	1	1342	1347	PP1_1342.dat	DA_PP1_1342.dat	Approaching Slack High
P	2	1350	1354	PP2_1350.dat	DA_PP2_1350.dat	
P	3	1355	1358	PP3_1355.dat	DA_PP3_1355.dat	
P	4	1400	1405	PP4_1400.dat	DA_PP4_1400.dat	
Q	1	1410	1414	PQ1_1410.dat	DA_PQ1_1410.dat	Slack High
Q	2	1416	1419	PQ2_1416.dat	DA_PQ2_1416.dat	
Q	3	1419	1422	PQ3_1419.dat	DA_PQ3_1419.dat	
Q	4	1423	1427	PQ4_1423.dat	DA_PQ4_1423.dat	
R	1	1431	1436	PR1_1431.dat	DA_PR1_1431.dat	Start of Ebb
R	2	1438	1441	PR2_1438.dat	DA_PR2_1438.dat	
R	3	1441	1444	PR3_1441.dat	DA_PR3_1441.dat	
R	4	1445	1450	PR4_1445.dat	DA_PR4_1445.dat	
S	1	1456	1500	PS1_1456.dat	DA_PS1_1456.dat	
S	2	1502	1505	PS2_1502.dat	DA_PS2_1502.dat	
S	3	1506	1508	PS3_1506.dat	DA_PS3_1506.dat	
S	4	1509	1514	PS4_1509.dat	DA_PS4_1509.dat	
T	1	1520	1524	PT1_1520.dat	DA_PT1_1520.dat	Ebb
T	2	1526	1529	PT2_1526.dat	DA_PT2_1526.dat	
T	3	1529	1531	PT3_1529.dat	DA_PT3_1529.dat	
T	4	1532	1535	PT4_1532.dat	DA_PT4_1532.dat	
U	1	1540	1544	PU1_1540.dat	DA_PU1_1540.dat	
U	2	1546	1548	PU2_1546.dat	DA_PU2_1546.dat	
U	3	1548	1551	PU3_1548.dat	DA_PU3_1548.dat	
U	4	1552	1556	PU4_1552.dat	DA_PU4_1552.dat	
V	1	1617	1621	PV1_1617.dat	DA_PV1_1617.dat	Lost GPS signal after Line U4, batteries dead, replaced batteries and
V	2	1622	1625	PV2_1622.dat	DA_PV2_1622.dat	
V	3	1625	1627	PV3_1625.dat	DA_PV3_1625.dat	
V	4	1628	1632	PV4_1628.dat	DA_PV4_1628.dat	
W	1	1637	1642	PW1_1637.dat	DA_PW1_1637.dat	
W	2	1643	1645	PW2_1643.dat	DA_PW2_1643.dat	
W	3	1646	1648	PW3_1646.dat	DA_PW3_1646.dat	
W	4	1648	1652	PW4_1648.dat	DA_PW4_1648.dat	
X	1	1658	1702	PX1_1658.dat	DA_PX1_1658.dat	
X	2	1704	1706	PX2_1704.dat	DA_PX2_1704.dat	
X	3	1706	1708	PX3_1706.dat	DA_PX3_1706.dat	
X	4	1709	1712	PX4_1709.dat	DA_PX4_1709.dat	
Y	1	1718	1722	PY1_1718.dat	DA_PY1_1718.dat	Strong Ebb
Y	2	1724	1726	PY2_1724.dat	DA_PY2_1724.dat	
Y	3	1727	1729	PY3_1727.dat	DA_PY3_1727.dat	
Y	4	1730	1733	PY4_1730.dat	DA_PY4_1730.dat	
Z	1	1738	1741	PZ1_1738.dat	DA_PZ1_1738.dat	
Z	2	1742	1744	PZ2_1742.dat	DA_PZ2_1742.dat	
Z	3	1745	1747	PZ3_1745.dat	DA_PZ3_1745.dat	
Z	4	1748	1751	PZ4_1748.dat	DA_PZ4_1748.dat	
AA	1	1757	1801	PAA1_1757.dat	DA_PAA1_1757.dat	
AA	2	1802	1804	PAA2_1802.dat	DA_PAA2_1802.dat	
AA	3	1804	1807	PAA3_1804.dat	DA_PAA3_1804.dat	
AA	4	1808	1811	PAA4_1808.dat	DA_PAA4_1808.dat	
BB	1	1816	1820	PBB1_1816.dat	DA_PBB1_1816.dat	
BB	2	1821	1823	PBB2_1821.dat	DA_PBB2_1821.dat	
BB	3	1823	1826	PBB3_1823.dat	DA_PBB3_1823.dat	
BB	4	1827	1830	PBB4_1827.dat	DA_PBB4_1827.dat	
CC	1	1835	1839	PCC1_1835.dat	DA_PCC1_1835.dat	Checked tide gage after Line CC4
CC	2	1841	1843	PCC2_1841.dat	DA_PCC2_1841.dat	
CC	3	1843	1845	PCC3_1843.dat	DA_PCC3_1843.dat	

CC	4	1846	1849	PCC4_1846.dat	DA_PCC4_1846.dat	
DD	1	1857	1902	PDD1_1857.dat	DA_PDD1_1857.dat	
DD	2	1903	1905	PDD2_1903.dat	DA_PDD2_1903.dat	
DD	3	1906	1909	PDD3_1906.dat	DA_PDD3_1906.dat	
DD	4	1910	1913	PDD4_1910.dat	DA_PDD4_1910.dat	
EE	1	1919	1922	PEE1_1919.dat	DA_PEE1_1919.dat	End of Ebb Tide
EE	2	1924	1925	PEE2_1924.dat	DA_PEE2_1924.dat	
EE	3	1926	1928	PEE3_1926.dat	DA_PEE3_1926.dat	
EE	4	1929	1931	PEE4_1929.dat	DA_PEE4_1929.dat	
FF	1	1939	1942	PFF1_1939.dat	DA_PFF1_1939.dat	
FF	2	1944	1947	PFF2_1944.dat	DA_PFF2_1944.dat	
FF	3	1947	1950	PFF3_1947.dat	DA_PFF3_1947.dat	
FF	4	1951	1954	PFF4_1951.dat	DA_PFF4_1951.dat	

PISCATAQUA RIVER RECOVERY SURVEY, July 21, 2009						
				Entire	Depth-Averaged	
Loop	Transect	Start Time	Stop Time	Data File	Data File	Comments
A	1	809	813	PA1_0809.dat	DA_PA1_0809.dat	
A	2	818	822	PA2_0818.dat	DA_PA2_0818.dat	
A	3	824	828	PA3_0824.dat	DA_PA3_0824.dat	
A	4	831	835	PA4_0831.dat	DA_PA4_0831.dat	
B	1	842	845	PB1_0842.dat	DA_PB1_0842.dat	
B	2	849	854	PB2_0849.dat	DA_PB2_0849.dat	
B	3	855	859	PB3_0855.dat	DA_PB3_0855.dat	
B	4	901	905	PB4_0901.dat	DA_PB4_0901.dat	
C	1	909	913	PC1_0909.dat	DA_PC1_0909.dat	
C	2	916	919	PC2_0916.dat	DA_PC2_0916.dat	
C	3	921	924	PC3_0921.dat	DA_PC3_0921.dat	
C	4	926	931	PC4_0926.dat	DA_PC4_0926.dat	
D	1	936	939	PD1_0936.dat	DA_PD1_0936.dat	
D	2	942	946	PD2_0942.dat	DA_PD2_0942.dat	
D	3	947	950	PD3_0947.dat	DA_PD3_0947.dat	
D	4	952	957	PD4_0952.dat	DA_PD4_0952.dat	
E	1	1000	1003	PE1_01000.dat	DA_PE1_01000.dat	
E	2	1006	1010	PE2_01006.dat	DA_PE2_01006.dat	
E	3	1011	1015	PE3_01011.dat	DA_PE3_01011.dat	
E	4	1018	1023	PE4_01018.dat	DA_PE4_01018.dat	
F	1	1026	1029	PF1_01026.dat	DA_PF1_01026.dat	
F	2	1032	1035	PF2_01032.dat	DA_PF2_01032.dat	
F	3	1037	1041	PF3_01037.dat	DA_PF3_01037.dat	
F	4	1042	1047	PF4_01042.dat	DA_PF4_01042.dat	
G	1	1051	1054	PG1_01051.dat	DA_PG1_01051.dat	
G	2	1057	1101	PG2_01057.dat	DA_PG2_01057.dat	
G	3	1101	1105	PG3_01101.dat	DA_PG3_01101.dat	
G	4	1107	1111	PG4_01107.dat	DA_PG4_01107.dat	
H	1	1115	1119	PH1_1115.dat	DA_PH1_1115.dat	
H	2	1122	1125	PH2_1122.dat	DA_PH2_1122.dat	
H	3	1126	1129	PH3_1126.dat	DA_PH3_1126.dat	
H	4	1131	1136	PH4_1131.dat	DA_PH4_1131.dat	
I	1	1139	1143	PI1_1139.dat	DA_PI1_1139.dat	
I	2	1146	1150	PI2_1146.dat	DA_PI2_1146.dat	
I	3	1152	1156	PI3_1152.dat	DA_PI3_1152.dat	
I	4	1158	1202	PI4_1158.dat	DA_PI4_1158.dat	
J	1	1205	1209	PJ1_1205.dat	DA_PJ1_1205.dat	
J	2	1212	1216	PJ2_1212.dat	DA_PJ2_1212.dat	
J	3	1216	1220	PJ3_1216.dat	DA_PJ3_1216.dat	
J	4	1222	1226	PJ4_1222.dat	DA_PJ4_1222.dat	
K	1	1229	1233	PK1_1229.dat	DA_PK1_1229.dat	
K	2	1236	1239	PK2_1236.dat	DA_PK2_1236.dat	
K	3	1239	1243	PK3_1239.dat	DA_PK3_1239.dat	
K	4	1244	1249	PK4_1244.dat	DA_PK4_1244.dat	
L	1	1254	1258	PL1_1254.dat	DA_PL1_1254.dat	
L	2	1300	1303	PL2_1300.dat	DA_PL2_1300.dat	
L	3	1304	1308	PL3_1304.dat	DA_PL3_1304.dat	
L	4	1308	1313	PL4_1308.dat	DA_PL4_1308.dat	
M	1	1318	1322	PM1_1318.dat	DA_PM1_1318.dat	
M	2	1324	1327	PM2_1324.dat	DA_PM2_1324.dat	
M	3	1327	1330	PM3_1327.dat	DA_PM3_1327.dat	
M	4	1333	1337	PM4_1333.dat	DA_PM4_1333.dat	
N	1	1342	1346	PN1_1342.dat	DA_PN1_1342.dat	
N	2	1349	1351	PN2_1349.dat	DA_PN2_1349.dat	
N	3	1352	1356	PN3_1352.dat	DA_PN3_1352.dat	
N	4	1358	1403	PN4_1358.dat	DA_PN4_1358.dat	

O	1	1408	1413	PO1_1408.dat	DA_PO1_1408.dat	
O	2	1416	1418	PO2_1416.dat	DA_PO2_1416.dat	
O	3	1419	1423	PO3_1419.dat	DA_PO3_1419.dat	
O	4	1425	1430	PO4_1425.dat	DA_PO4_1425.dat	
P	1	1435	1440	PP1_1435.dat	DA_PP1_1435.dat	
P	2	1442	1444	PP2_1442.dat	DA_PP2_1442.dat	
P	3	1445	1448	PP3_1445.dat	DA_PP3_1445.dat	
P	4	1450	1456	PP4_1450.dat	DA_PP4_1450.dat	
Q	1	1500	1507	PQ1_1500.dat	DA_PQ1_1500.dat	
Q	2	1509	1512	PQ2_1509.dat	DA_PQ2_1509.dat	
Q	3	1513	1517	PQ3_1513.dat	DA_PQ3_1513.dat	
Q	4	1519	1525	PQ4_1519.dat	DA_PQ4_1519.dat	
R	1	1530	1535	PR1_1530.dat	DA_PR1_1530.dat	
R	2	1537	1540	PR2_1537.dat	DA_PR2_1537.dat	
R	3	1541	1544	PR3_1541.dat	DA_PR3_1541.dat	
R	4	1545	1549	PR4_1545.dat	DA_PR4_1545.dat	
S	1	1554	1559	PS1_1554.dat	DA_PS1_1554.dat	
S	2	1601	1603	PS2_1601.dat	DA_PS2_1601.dat	
S	3	1603	1606	PS3_1603.dat	DA_PS3_1603.dat	
S	4	1608	1611	PS4_1608.dat	DA_PS4_1608.dat	
T	1	1616	1620	PT1_1616.dat	DA_PT1_1616.dat	
T	2	1621	1623	PT2_1621.dat	DA_PT2_1621.dat	
T	3	1624	1628	PT3_1624.dat	DA_PT3_1624.dat	
T	4	1631	1634	PT4_1631.dat	DA_PT4_1631.dat	
U	1	1638	1642	PU1_1638.dat	DA_PU1_1638.dat	
U	2	1643	1645	PU2_1643.dat	DA_PU2_1643.dat	
U	3	1646	1649	PU3_1646.dat	DA_PU3_1646.dat	
U	4	1650	1653	PU4_1650.dat	DA_PU4_1650.dat	
V	1	1657	1701	PV1_1657.dat	DA_PV1_1657.dat	
V	2	1703	1705	PV2_1703.dat	DA_PV2_1703.dat	
V	3	1705	1709	PV3_1705.dat	DA_PV3_1705.dat	
V	4	1712	1716	PV4_1712.dat	DA_PV4_1712.dat	
W	1	1720	1725	PW1_1720.dat	DA_PW1_1720.dat	
W	2	1728	1731	PW2_1728.dat	DA_PW2_1728.dat	
W	3	1731	1734	PW3_1731.dat	DA_PW3_1731.dat	
W	4	1734	1738	PW4_1734.dat	DA_PW4_1734.dat	
X	1	1742	1746	PX1_1742.dat	DA_PX1_1742.dat	
X	2	1748	1749	PX2_1748.dat	DA_PX2_1748.dat	Shallow water, ADCP hit bottom, removed and inspected and tested prior to restarting survey
X	3	1750	1753	PX3_1750.dat	DA_PX3_1750.dat	
X	4	NaN	NaN	NaN	NaN	
Y	1	1844	1847	PY1_1844.dat	DA_PY1_1844.dat	
Y	2	1849	1851	PY2_1849.dat	DA_PY2_1849.dat	
Y	3	1851	1854	PY3_1851.dat	DA_PY3_1851.dat	
Y	4	1856	1858	PY4_1856.dat	DA_PY4_1856.dat	
Z	1	1901	1904	PZ1_1901.dat	DA_PZ1_1901.dat	
Z	2	1906	1908	PZ2_1906.dat	DA_PZ2_1906.dat	
Z	3	1909	1911	PZ3_1909.dat	DA_PZ3_1909.dat	
Z	4	1913	1918	PZ4_1913.dat	DA_PZ4_1913.dat	
AA	1	1920	1922	PAA1_1920.dat	DA_PAA1_1920.dat	
AA	2	1925	1928	PAA2_1925.dat	DA_PAA2_1925.dat	
AA	3	1929	1931	PAA3_1929.dat	DA_PAA3_1929.dat	
AA	4	1934	1937	PAA4_1934.dat	DA_PAA4_1934.dat	
BB	1	1940	1944	PBB1_1940.dat	DA_PBB1_1940.dat	
BB	2	1947	1950	PBB2_1947.dat	DA_PBB2_1947.dat	
BB	3	1951	1954	PBB3_1951.dat	DA_PBB3_1951.dat	
BB	4	1957	1959	PBB4_1957.dat	DA_PBB4_1957.dat	
CC	1	2002	2005	PCC1_2002.dat	DA_PCC1_2002.dat	
CC	2	2007	2009	PCC2_2007.dat	DA_PCC2_2007.dat	

CC	3	2010	2012	PCC3_2010.dat	DA_PCC3_2010.dat	
CC	4	2014	2016	PCC4_2014.dat	DA_PCC4_2014.dat	