

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Horizontal and Vertical Control Report

Type of Survey _____ Hydrographic Survey _____

Field No. _____ H11837, H11838, H11839, H11840, H11841, H11842 _____

Registry No. _____ OPR-P385-TE-08 _____

LOCALITY

State _____ Alaska _____

General Locality _____ Northern Cook Inlet _____

2008

CHIEF OF PARTY

Kathleen Mildon

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DATE _____ November 2009 _____

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HYDROGRAPHIC TITLE SHEET

**Horizontal & Vertical
Control Report
OPR-P385-TE-08**

INSTRUCTIONS - The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

FIELD No. **H11837, H11838, H11839,
H11840, H11841, H11842**

State Alaska

General Locality Northern Cook Inlet

Sub-Locality Various

Scale N/A Date of Survey June 22 - August 17, 2008

Instructions dated March 3, 2008 Project No. OPR-P385-TE-08

Vessel R/V Mt. Mitchell & R/V Mt. Augustine

Chief of party Katie Mildon

Surveyed by TerraSond Ltd.

Soundings by echo sounder, lead line, pole Multibeam Echosounder, Side Scan Sonar

Graphic record scaled by N/A

Graphic record checked by N/A Automated Plot N/A

Verification by N/A

Soundings in fathoms feet at MLW MLLW Meters at MLLW

REMARKS: Contract No.: DG133C-05-CQ-1079

Contractor: TerraSond Ltd. All times recorded in UTC

1617 South Industrial Way, Suite 3

Palmer, AK 99645

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OPR-P385-TE-08
2008
Northern Cook Inlet



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|--------|
| H11837 |
| H11838 |
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| H11842 |

R/V Mt. Mitchell and Mt. Augustine

State: Alaska

Locality: Northern Cook Inlet

Year: 2008

Lead Hydrographer: Kathleen Mildon

A. Vertical Control

The time meridian for this project was 000° longitude. All measurements were made in Universal Time, Coordinated (UTC). No measurements were made using local time. The local time meridian for the project was 135° west longitude and local time Alaska was offset from UTC by nine hours (Alaska Daylight Time = UTC - 9 hours).

Two subordinate gauges were installed to provide preliminary tide processing for the project area. TerraSond, Ltd. installed a bubbler-style tide gauge at Point Possession, AK (945-5866) and contracted with John Oswald and Associates (JOA) to install a radar-type gauge at North Foreland, AK (945-5869). JOA was also contracted to process the subordinate tide data and also to deliver final verified tides and zones along with an ellipsoid to mean lower low water model. The Pt. Possession Station Gauge 1, during quality control checks, was found to be reading inaccurately. A visit to the site followed and the orifice was found to be flipped over. This affected data from July 26 2008 thru July 31 2008. Two separate final deliverable tide products were created from this one previous to July 26th and one following July 31st. Refer to Appendix I for tide station information.

The large tidal range of up to 32 feet and strong currents of Cook Inlet led TerraSond to process the final soundings on the NAD83 ellipsoid and then apply an offset to the data to Mean Lower Low Water (MLLW). Therefore, all final sounding data were adjusted for tidal influence using Post Processed Kinematic (PPK) GPS data reduced to MLLW using an ellipsoid to MLLW model. This led to a much better match-up between adjacent lines and much higher percentage of soundings meeting IHO Order 1 during crossline analysis then conventional verified, zoned tides.

To derive an ellipsoid to MLLW model, a large network static survey was performed by TerraSond and JOA. The network static survey comprised of nine sites that were geographically distributed across Cook Inlet that each had bench marks referencing MLLW. See Figure 1 below.

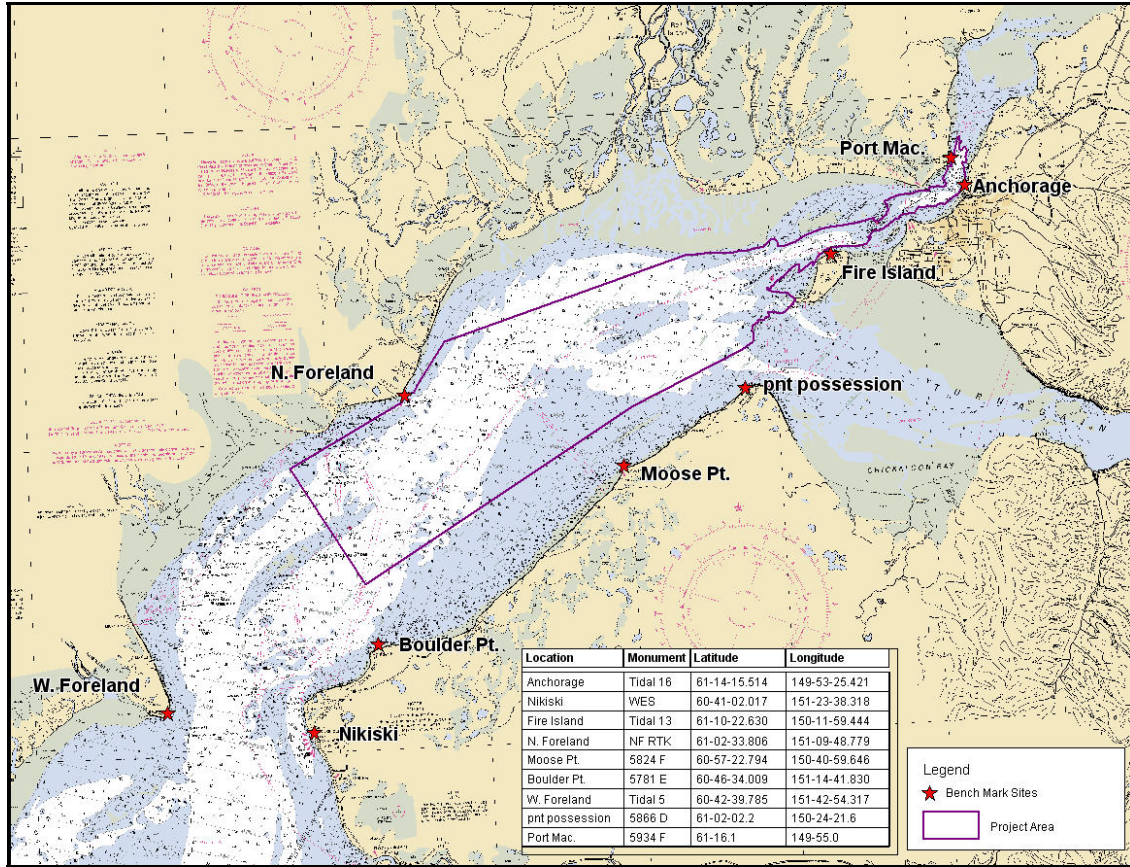


Figure 1 – Location of bench marks used during the network survey

For this survey, receivers we set up on established benchmarks. The decision of which benchmark to use at each site was arrived at by looking at a number of factors, including GPS masking angle, stability and height above MHW for that day’s tides.

| Tide Gauge Location | Survey Monument | NAD 1983 | |
|---------------------|-----------------|--------------|---------------|
| | | Latitude | Longitude |
| Anchorage | Tidal 16 | 61-14-15.514 | 149-53-25.421 |
| Nikiski | WES | 60-41-02.017 | 151-23-38.318 |
| Fire Island | Tidal 13 | 61-10-22.630 | 150-11-59.444 |
| N. Foreland | NF RTK | 61-02-33.806 | 151-09-48.779 |
| Moose Pt. | 5824 F | 60-57-22.794 | 150-40-59.646 |
| Boulder Pt. | 5781 E | 60-46-34.009 | 151-14-41.830 |
| W. Foreland | Tidal 5 | 60-42-39.785 | 151-42-54.317 |
| Pt. Possession | 5866 D | 61-02-02.2 | 150-24-21.6 |
| Port Mac. | 5934 F | 61-16.1 | 149-55.0 |

Table 1: Bench Mark monuments chosen at each site.

After deciding on a monument to occupy, levels were run to surrounding benchmarks in an effort to justify relative elevations with historical data. After running levels and checking the computations a GPS receiver was set up.

An ellipsoid to MLLW model that covered the entire project area was compiled by JOA using the results of the network static survey data. This model specified offsets for the ellipsoid to MLLW separation across the survey area with a resolution of 100 meters. See Figure 2 for a representation of the shift model.

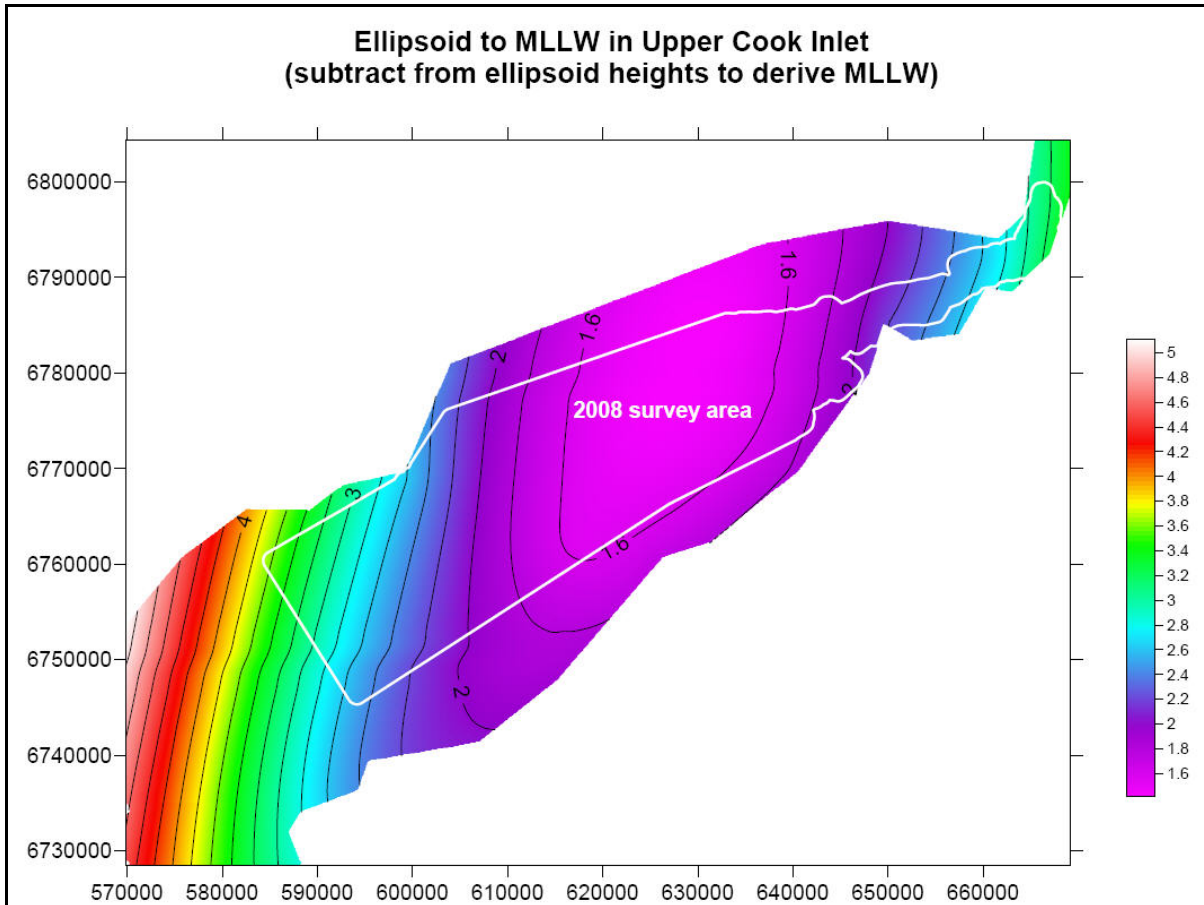


Figure 2 – Representation of the shift from the Ellipsoid to MLLW.

To provide dual-frequency GPS base station data for PPK processing, TerraSond installed a GPS unit in Tyonek, Alaska as one of the four base stations used in post processing. A Trimble NetRS receiver was set up in a conex container and connected to the internet. A Trimble Zephyr GPS antenna was connected to the system and installed on the roof of the conex. The system logged dual-frequency GPS data at a rate of 1 string every 5 seconds which was then downloaded once every two weeks through the internet. See Figure 3 and 4 below.



Figure 3: Trimble NetRS, Tyonek AK



Figure 4: Trimble Zephyr antenna, Tyonek AK

A final coordinate was computed using NGS's OPUS service for the Tyonek base station. Six files over the project time that were each four hours long were sent to OPUS and the six coordinates were then averaged for the final Tyonek base station coordinate used in post processing. Refer to Appendix II for the OPUS solution results. The base station data was then used to post-process the rover POS data logged from the *R/V Mt. Mitchell* and the *R/V Mt. Augustine* vessels' Applanix POSMV V4s. Post-processing was done using Applanix POSPAC MMS v5.1. See Appendix III for a summary of processing results. Refer to the Data Acquisition and Processing Report for further details on the production

of the Smoothed Best Estimate Trajectory (SBET) files and the application of the ellipsoid model to the sounding data.

Three Continuously Operating Reference Stations (CORS) were also used in the final post processing along with the Tyonek Base station: ANC1, TBON, and TSEA. These were used to supplement the Tyonek station as the project area was longer than the recommended base line length. Between the CORS in Anchorage and the Tyonek station all of the rover data collected in the project area could be post-processed. Please Appendix II for the base station data sheets.

| Station | Latitude | Longitude | Ellipsoid Height (meters) |
|---------|-------------------|--------------------|---------------------------|
| Tyonek | 61°04'15.975297"N | 151°08'14.988268"W | 35.518 |
| TSEA | 61°11'14.37488"N | 149°53'41.81988"W | 42.517 |
| TBON | 61°10'46.98000"N | 149°47'06.41489"W | 92.721 |
| ANC1 | 61°10'56.56684"N | 149°59'48.28806"W | 46.1 |

Table 2: Base Stations used for PPK processing.

The application of the PPK-GPSTide technique for tidal reduction was chosen over conventional verified tides and zones, as a definite improvement in data quality was observed with the PPK-GPSTide method. Cook Inlet has an extremely high tidal range that is difficult to correct for using conventional tide zoning techniques. Data corrected using the conventional tide zoning technique demonstrated many temporal mismatches that reduced or disappeared with application of PPK-GPSTide corrections. Crossline comparison results also had a much lower incidence of failures at IHO Order 1 for PPK-GPSTide.

Note that as a QC check the version of the survey corrected with PPK-GPSTide was compared to a version of the survey corrected using conventional tides. Other than mismatches in the conventional tides version that were not as apparent in the PPK-GPSTide version, agreement was very good.

Ellipsoid Height Survey

Ellipsoid Height survey at Point Possession, Station 9455866, was completed on benchmark D. Observations were made using a Trimble 5700 GPS receiver. The ellipsoid height survey at North Foreland, Station 9455869, was completed on bench mark H. Observations were made using a Novatel DL4+ GPS receiver. At both stations a level loop was run through 5 bench marks to carry the elevation down to the water for staff shots. See Appendix I for more details.

B. Horizontal Control

The horizontal control datum used for this survey was the North American Datum of 1983 (NAD 83). The projection used was Universal Transverse Mercator (UTM) Zone 5 North.

Sounding position control was determined using a Global Positioning System (GPS). The primary source of navigation correctors was the United States Coast Guard differential

GPS (DGPS) station at Kenai, AK, CORS ID KEN6 PID DJ3031. The NGS data sheet information, acquired from the NGS website, is also included in this report in Appendix II.

DGPS confidence checks were performed for the *R/V Mt. Mitchell* and *R/V Mt. Augustine* by comparing the positions calculated by the POS M/V to a common node calculated by the DSM. The differences in the northing and easting values were calculated and graphed. A circle based on the allowable error was placed on the graph. The circle in the graph represents where the 10 meter positional accuracy was met in accordance with the Specifications and Deliverables April 2007. A summary of weekly DGPS confidence checks is provided in Separates I: Acquisition and Processing Logs for each survey sheet.

**Project Wide
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All information contained in this Vertical and Horizontal Report for OPR-P385-TE-08
Has been reviewed and approved by me and is hereby respectfully submitted.

Kathleen Mildon, Lead Hydrographer
TerraSond Ltd.

Date November 23, 2009