NOS HYDROGRAPHIC SURVEYS SPECIFICATIONS and DELIVERABLES

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TABLE OF CONTENTS

Page

Page

APPENDICES

LIST OF FIGURES

Page

SPECIFICATIONS AND DELIVERABLES

1. Introduction

These technical specifications detail the requirements for hydrographic surveys to be undertaken either by National Oceanic and Atmospheric Administration(NOAA) field units or by organizations under contract to the Director, Office of Coast Survey (OCS), National Ocean Service (NOS), NOAA, U.S. Department of Commerce.

The specifications described herein are based in part on the International Hydrographic Organization's Standards for Hydrographic Surveys, Special Publication 44, Fourth Edition, April 1998, specifically for Order 1 surveys. Hydrographic surveys classified as Order 1 is intended for harbors, harbor approach channels, recommended tracks, inland navigation channels, coastal areas of high commercial traffic density, and are usually in shallower areas lower than 100 meters water depth. Additional details for the specific project areas, including any modifications to the specifications in this manual, will be provided in Hydrographic Survey Letter Instructions for NOAA field units or the Statement of Work for contractors.

1.1. Definition

The term "hydrographer" as used through this document, refers to: (a) the chief of party or officer in charge, when the survey is being conducted by NOAA field units, or (b) the contractor where the work is being performed for NOAA under contract.

2. Datums

2.1. Horizontal Datum

All positions will be referenced to the North American Datum of 1983 (NAD 83). This datum must be used throughout a survey project for everything that has a geographic position or for which a position is to be determined. Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or adjusted to NAD 83. In addition, all software used on a survey must contain the correct datum parameters.

2.2. Sounding Datum

All sounding data will be reduced to Mean Lower Low Water (MLLW). Heights of bridges and overhead cables will be referenced to Mean High Water (MHW).

2.3. Time

Coordinated Universal Time (UTC) will be used for all time records.

3. Hydrographic Position Control

3.1. Horizontal Position Accuracy

The NOS specification for hydrographic positioning is that the total error in position of soundings, dangers, and all other significant features, at the 95 percent confidence level, will not exceed 5 meters + 5 percent of the depth. This accuracy requirement is independent of survey scale.

For hydrographic surveys using single-beam echosounders, the accuracy of the vessel position can be considered the accuracy of the sounding obtained by that vessel, taking into account transducer offsets. However, for multibeam surveys, due to the oblique sounding pattern, the position of a sounding may be at some distance from the vessel position. The accuracy requirement for the vessel position will depend upon how accurately the sounding is positioned relative to the vessel. That, in turn, will depend upon the characteristics of the multibeam system, depth of water, the accuracy with which heave, roll, pitch, heading, and latency are accounted for and applied, and the reliability with which the speed of sound profile is known.

3.2. Differential Global Positioning System (DGPS)

DGPS is the primary positioning system currently used for hydrographic surveys. DGPS correctors can be obtained either through the U.S. Coast Guard (USCG) Maritime DGPS Service or other differential services provided they meet the accuracy requirement in Section 3.1.

3.2.1. DGPS Specifications

Unless specified otherwise in the Hydrographic Survey Letter Instructions or Statement of Work, the following specifications will be followed when DGPS is used as the primary positioning system:

- GPS receiver(s) aboard the vessel will be configured such that satellites below 8 degrees above the horizon will not be used in position computations.

- The age of pseudo-range correctors used in position computation will not exceed 20 seconds; however, any horizontal positioning interpolation must not exceed the accuracy requirement in Section 3.1.

- Horizontal Dilution of Precision (HDOP) will be monitored and recorded, and should not exceed 2.5 nominally. Satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. Other variables, including satellite pseudorange residuals, are used in conjunction with HDOP to estimate DGPS horizontal accuracy.

- A minimum of four satellites will be used to compute all positions.

- Horizontal and vertical offsets between the GPS antenna and transducer(s) will be observed and applied in no coarser than 0.1 m increments.

3.2.2. DGPS Site Confirmation

The hydrographer will conduct a 24-hour certification of all non-USCG differential reference stations prior to use for positioning control. The purpose of this certification is to ensure that no multipath or other site specific problems exist. Once the differential station is set up at the site and configured for survey operations, differential corrections will be broadcast and received at a remote site. This remote site may be within 2 meters of the differential reference station control point or over an existing control point (third order or better). The remote site will receive correctors, compute a final position at a rate of not less than once per second, and compare that position to the control point position. A position plot will be constructed comparing the known position and the differentially computed position. An analysis of the data must prove that the position accuracy requirement of Section 3.1 are met. Certification for any non-USCG differential station is valid for one year only. All related position accuracy plots will be included in the Vertical and Horizontal Control Report for each project.

4. Tides and Water Levels Requirements

4.1. General Project Requirements and Scope

4.1.1. Scope

The requirements and specifications contained in this section cover the water level and vertical datum requirements for operational support of hydrographic surveys conducted as part of the NOAA Nautical Charting Program. The scope of this support comprises the following functional areas:

1. Tide and water level requirement planning
2. Preliminary tidal zoning development
3a. Control water level station operation;
3b. Supplemental water level station installation, operation and removal
4. Data quality control, processing, and tabulation
5. Tidal datum computation and tidal datum recovery
6. Generation of water level reducers and final tidal zoning

For in-house surveys, personnel from the National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) are responsible for functional areas 1, 2, 4, 5, and 6. NOS hydrographers and CO-OPS Field Operations Division will be responsible for functional area 3 above.

For contract surveys, CO-OPS personnel are responsible for functional areas 1, 2 and 3a. NOS contract hydrographers will be responsible for functional areas 3b through 6 above. NOS continues to be responsible for operating, maintaining, and processing data from the control stations (e.g., the NWLON).

4.1.2. Objectives

The work performed under the requirements and specifications of this section is required for NOS major program areas of navigational products and services. The first objective for the support detailed in this section is to provide time series of water level reducers that can be applied to hydrographic soundings so that they can be corrected to chart datum. A second objective is to establish and/or recover tidal datums relative to local benchmarks at each station that can be used for continuing and future hydrographic surveys in the area. A third objective is to provide new or updated information that can be used to update NOAA tide prediction products and tidal zoning for promoting safe navigation applications.

4.1.3. Planning and Preliminary Tidal Zoning

CO-OPS is responsible for all planning of tide requirements for NOS hydrographic surveys. CO-OPS will analyze historical data and tidal characteristics for each project area, specify operational NOS control stations, specify subordinate tide station locations to be installed, and provide the preliminary tidal zoning to be used during survey operations. CO-OPS will provide 6-minute interval tide predictions relative to chart datum for appropriate NOS control stations prior to each survey and will also provide historical published bench mark information available for all historical tide stations specified for reoccupation. If CO-OPS provides a new preliminary tidal zoning scheme, the contractor must use that zoning scheme first for each project, and then, may generate a new scheme if the one provided is not adequate. At the conclusion of the survey, the contractor shall suspend the use of preliminary zoning scheme and develop final zoning scheme using correctors derived from the subordinate stations installed during the survey. Refer to Section 4.5.2 for further details.

4.1.4. NOS Control Stations and Data Quality Monitoring

National Water Level Observation Network

CO-OPS manages the National Water Level Observation Network (NWLON) of approximately 175 continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite radios, near real-time (within about 3 hours of collection) raw data are made available to all users through the interface to the CO-OPS Home Page on the Web. Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to MLLW datum, station datum, or special water level datum (such as Columbia River datum) as a user option in the interface.

Data Quality Monitoring

CO-OPS has an in-place Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hour/day, 7 days/week, all year around basis. CORMS will monitor the status and performance of all hydro gauges equipped with satellite radios using the NOS satellite message format installed by the hydrographer, and once listed on the hydro hot list by CO-OPS, as it does for all other NOS water level systems, including all NWLON stations. The CORMS system description can be found in System Development Plan, CORMS. CORMS is a NOS provided support function to the operational field parties and does not relieve the hydrographer of responsibility for performing QC and ensuring proper gauge operation.

4.1.5. General Data and Reference Datum Requirements

The present NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001 as defined in the Tide and Current Glossary. All tidal datum computations and water level reductions shall be referenced to this datum. In non-tidal areas, including the Great Lakes, special low water datums have been defined for specific areas and are used as chart datum in these locations.

In some cases where historical sites are re-occupied, site datum shall be zeroed to a pre-established MLLW datum held on a bench mark. In that case, data can be acquired relative to MLLW for immediate application during the survey. At present, in Great Lakes areas, a special Low Water Datum relative to IGLD 85 is the reference datum.

4.1.6. Error Budget Considerations

The water level reducers can be a significant corrector to soundings to reduce them relative to chart datum especially in shallow water areas with relatively high ranges of tide. The errors associated with water level reducers are generally not depth dependent, however. The portion of the error of the water level reducers must be balanced against all other sounding errors to ensure that the total sounding error budget is not exceeded. The allowable contribution of the error for tides and water levels to the total survey error budget falls between 0.20 m and 0.45 m (at the 95% confidence level) depending on the complexity of the tides.

The total error of the tides and water levels can be considered to have component errors of:

1) the measurement error of the gauge/sensor and processing error to refer the measurements to station datum. Gauges/sensors need to be calibrated, and sensor design and data sampling need to include

strategies to reduce measurement errors due to waves, currents, temperature and density effects. The measurements need to be properly referenced to the bench marks and tide staffs, as appropriate and monitored for vertical stability. The measurement error, including the dynamic effects, should not exceed 0.10 m at the 95% confidence level. The processing error also includes interpolation error of the water level at the exact time of the soundings. A estimate for a typical processing error is 0.10 m at the 95% confidence level.

2) the error in computation of tidal datums for the adjustment to an equivalent 19-year National Tidal Datum Epoch (NTDE) periods for short term stations. The shorter the time series, the less accurate the datum, i.e. bigger the error. An inappropriate control station also decreases accuracy. The NTDE does not apply in the Great Lakes, however the accuracy of datum based on shorter time series is analogous. The estimated error of an adjusted tidal datum based on one month of data is 0.08 m for the east and west coasts and 0.11 m for the Gulf coast (at the 95% confidence level).

3) the error in application of tidal zoning. Tidal zoning is the extrapolation and/or interpolation of tidal characteristics from a known shore point(s) to a desired survey area using time differences and range ratios. The greater the extrapolation/interpolation, the greater the uncertainty and error. Estimates for typical errors associated with tidal zoning are 0.20 m at the 95% confidence level. However, errors for this component can easily exceed 0.20 m if tidal characteristics are very complex, or not well-defined, and if there are pronounced differential effects of meteorology on the water levels across the survey area.

Project planning by NOS attempts to minimize and balance these potential sources of errors through the use and specification of accurate reliable water level gauges, and optimization of the mix of zoning required, the number of station locations required, and the length of observations required within practical limits of the survey area and survey duration. The practical limits depend upon the tidal characteristics of the area and suitability of the coastline for the installation and operation of appropriate water level stations.

4.2. Data Collection and Field Work

The hydrographer shall collect continuous and valid data series. Accurate datums cannot be computed for a month of data with a break in the water level measurement series in excess of three days. Even breaks of significantly less than three days duration will not allow for interpolation during times when strong meteorological conditions are present and in areas with little periodic tidal influence. Any break in the water level measurement series affects the accuracy of datum computations. Breaks in data also result in increased error in the tide reducers when interpolation is required to provide data at the time of soundings. At a critical measurement site where the water level measurement data cannot be transmitted or monitored during hydrographic operations, an independent backup sensor or a complete redundant water level collection system shall be installed and operated during the project.

4.2.1. Water Level Station Requirements

Data from NOS National Water Level Observation Network (NWLON) stations will be provided to support hydrographic survey operations where appropriate. Data provided are relative to Chart Datum which is Mean Lower Low Water for the 19-year National Tidal Datum Epoch (NTDE).

The acquisition of water level data from subordinate locations may be required for hydrographic surveys and if so shall be specified by NOS in each individual set of Project Instructions or Statement of Work. These stations shall be used to provide 6-minute time series data, tidal datum references and tidal zoning which all factor into the production of final tide reducers for specific survey areas. Station locations and requirements may be modified after station reconnaissance or as survey operations progress. Any changes shall be made

only after consultation between the CO-OPS and the hydrographer (and COTR if contract survey) as moving required stations to new locations may require new seven-digit station identifier numbers and new/historical station and bench mark information.

The duration of continuous data acquisition shall be a 30-day minimum except for zoning stations. Data acquisition shall be from at least 4 hours before the beginning of the hydrographic survey operations to 4 hours after the ending of hydrographic survey operations, and/or shoreline verification in the applicable areas. Stations identified as "30-day" stations are the "main" subordinate stations for datum establishment, providing tide reducers for a given project and for harmonic analysis from which harmonic constants for tide prediction can be derived. At these stations, data must be collected throughout the entire survey period in specified areas for which they are required, and not less than 30 continuous days are required for accurate datum determination. Additionally, supplemental and/or back-up gauges may also be necessary based upon the complexity of the hydrodynamics and/or the severity of environmental conditions of the project area.

In non-tidal areas the correctors for hydrographic soundings are simply water level measurements relative to a specified local low water level datum established for navigational purposes. Laguna Madre and parts of Pamlico Sound are examples of such areas classified as non-tidal which have special low water datums. Some river areas also have special datums due to the effects of seasonal changes on the river, e.g., Columbia River Datum, Hudson River datum, and Mississippi River Low Water are examples of this case. Great Lakes NWLON permanent stations will provide water level data referenced to an established Low Water Datum relative to International Great Lakes Datum of 1985 (IGLD '85) (see Standing Project Instructions: Great Lakes Water Levels, June 1978).

4.2.2. Water Level Measurement Systems and Data Transmissions

Water Level Sensor and Data Collection Platform

The water level sensor shall be a self-calibrating air acoustic, pressure (vented), or other suitable type. The sensor measurement range shall be greater than the expected range of water level. Gauge/sensor systems shall be calibrated prior to deployment, and the calibration shall be checked after removal from operations. The calibration standard's accuracy must be traceable to National Institute of Standards and technology (NIST). The required water level sensor resolution is a function of the tidal range of the area in which hydrographic surveys are planned. For tidal range less than or equal to 5 m, the required water level sensor resolution shall be 1 mm or better; for tidal range between 5 m and 10 m, the required water level sensor resolution shall be 3 mm or better; and for tidal range greater than 10 m, the required water level sensor resolution shall be 5 mm or better.

The Data Collection Platform (DCP) shall acquire and store water level measurements at every 6- minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite radio system shall be within 5 seconds per month so that channel "stepping" does not occur. Non-satellite radio systems shall have a clock accuracy of within one minute per month. Known error sources for each sensor shall be handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types.

The NOS is currently using the Aquatrak® self-calibrating air acoustic sensors at the majority of the NWLON stations. (For further information refer to Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991 and User's Guide for 8200 Acoustic Gauges, NOAA/NOS, Updated August 1998). At stations where the acoustic sensor can not be used due to freezing or the lack of a suitable structure, either a ParoScientific intelligent pressure (vented) sensor incorporated into a gas purge system, or a well/float with absolute shaft angle encoder (Great Lakes Stations) are used for water level measurements. (For further information refer to User's Guide for 8200 Bubbler Gauges, NOAA/NOS, Updated February 1998).

In each and any case, the water leveling sampling/averaging scheme shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor is preferred over pressure sensor whenever possible. Where the air acoustic sensor can not be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998). When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (at least two times per week or minimum eight times per month) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations shall be at least three hours long at the beginning and end of deployment and the periodic observations during deployment shall be 1 hour long. Along with the averaging procedure described above which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in figure 4.1.

Data Transmissions

The ability to monitor water level measurement system performance for near real-time quality assurance is essential to properly support hydrographic survey operations. Therefore, it is required that, where access to the satellite is available, the measurement system shall be equipped with a GOES transmitter to telemeter the data to NOS every three hours. The data transmissions must use a message format identical to the format as currently implemented in NOS' Next Generation Water Level Measurement Systems (NGWLMS). This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document "NGWLMS GOES MESSAGE FORMATTING" (refer to Section 4.7 for References). Once station and gauge information is configured in DMS and station listed on the Hydro Hot List (HHL), the NOS Continuous Operational Real-Time System (CORMS) will monitor all water level measurement system GOES transmissions to assure they are operating properly, provided that the GOES data transmitted is compatible with NOS format. Data that is not transmitted by GOES, or data transmitted but not in NOS compatible GOES format, or is submitted to CO-OPS via diskette, CD-ROM, or such other digital media, must also conform to the format specified in the above document so that data can be loaded properly into DMS software. Refer to Section 4.6.3 for further details about the water level data format specifications.

Close coordination is required between hydrographer and Requirements and Development Division (RDD) of CO-OPS for all hydrographic water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc. At least three business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform-ID, transmit time, channel, and serial numbers of sensors, and DCP shall be faxed, phoned, or sent to RDD. Test transmissions conducted on site are outside this requirement. This station and DCP information must be configured in DMS before data transmissions begin so that the data will be accepted in DMS. The documentation required prior to transmission in field is defined in the NGWLMS Site

Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 4.6 Data Submission Requirements).

4.2.3. Station Installation, Operation and Removal

Hydrographers shall obtain all required permits and permissions for installation of the water level sensor(s), Data Collection Platforms (DCP), bench marks, and utilities, as required. The hydrographer shall be responsible for security and/or protective measures, as required. The hydrographer shall install all components in the manner prescribed by manufacturer, or installation manuals. The hydrographer or contractor shall provide CO-OPS of the position of all tide gauges installed before hydrography begins, including those that were not specified in the Statement of Work or Project Instructions, as appropriate. The positions of bench marks and stations installed or recovered shall be obtained as latitudes and longitudes (degrees, minutes, and hundredths of seconds).

The following paragraphs provide general information regarding requirements for station installation, operations and maintenance, and station removal.

Station Installation

A complete water level measurement gauge installation shall consist of the following:

(A) The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter) and its supporting structure and a tide staff if required.

(B) The recovery and/or installation of a minimum number of bench marks and a level connection between the bench marks and the water level sensor(s), and tide staff as appropriate.

(C) The preparation of all documentation and forms.

Operation and Maintenance

When GOES telemetry and NOS satellite message format is used, the hydrographer shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. This monitoring can be performed by accessing the CO-OPS web page (http://www.CO-OPS.NOS.NOAA.GOV) The data over this system are typically available for review within three to four hours after collection.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate maintenance forms (see section on water level station documentation below) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset, or time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed; etc.

Removal

A complete removal of the water level measurement gauge shall consist of the following:

(A) Closing levels - a level connection between the minimum number bench marks and the water level sensor(s) and tide staff as appropriate.

(B) Removal of the water level measurement system and restoration of the premises, reasonable wear and tear excepted.

(C) The preparation of all documentation, forms, data, and reports.

4.2.4. Tide Staffs

Staff

The hydrographer shall install a tide staff at a station if the reference measurement point of a sensor (zero of a gauge) cannot be directly leveled to the local bench marks, e.g. orifice is laid over sea floor in case of pressure based bubbler gauges. Even if a pressure gauge can be leveled directly, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column over time. The tide staff shall be mounted independent of the water level sensor so that stability of the staff or sensor is maintained. Staff shall not be mounted to the same pile on which the water level sensor is located. The staff shall be plumb. When two or more staff scales are joined to form a long staff, the hydrographer shall take extra care to ensure the accuracy of the staff throughout its length. The distance between staff zero and the rod stop shall be measured before the staff is installed and after it is removed and the rod stop above staff zero height shall be reported on the documentation forms.

In areas of large tidal range and long sloping beaches (i.e. Cook Inlet and the Gulf of Maine), the installation and maintenance of tide staffs can be extremely difficult and costly. In these cases, the physical installation of a tide staff(s) may be substituted by systematic leveling to the water's edge from the closest bench mark. The bench mark becomes the "staff stop" and the elevation difference to the water's edge becomes the "staff reading".

Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (at least three times per week or minimum eight times per month) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations at the start and end of deployment shall be at least each three hours long and the periodic observations during the deployment shall be 1 hour long.

If a gauge requiring independent staff readings is installed, the installation report must be accompanied by a 3-hour set of staff-to-gauge observations documenting the proper operation of the gauge. During the first or second day of gauge operations, the gauge and staff must be read simultaneously and recorded every 6 minutes for a 3-hour period. The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. Gauge time should be set to Coordinated Universal Time (UTC). The gauge and staff shall be read simultaneously and recorded once a day (minimum of three days in each seven day period) for the duration of the water level measurements. The average staff-to-gauge difference shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decreases the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Figure 4.2 for an example pressure tide gauge record.

If the old staff is found destroyed by elements during the deployment, then a new staff shall be installed for the remainder period of the deployment and a new staff to gauge constant needs to be derived by new sets of staff to gauge observations. Also when a staff or an orifice is replaced or re-established, check levels shall be run to minimum of three bench marks including the PBM. Refer to Section 4.2.5 for leveling frequency and other leveling requirements. Bubbler Orifice and Parallel Plate Assembly

This bottom assembly is made of red brass, its chemical properties prevent the growth of marine life by the slowly releasing copper oxide on its metal surface. A Swagelok® hose fitting is screwed into the top end cap and is used to discharge the Nitrogen gas. The Nitrogen gas flows through the bottom of the orifice at a rate sufficient to overcome the rate of tidal change and wave height. This opening establishes the reference point for tidal measurements. The parallel plates produce a laminar flow across the orifice to prevent venturi effect. A two inch by eight inch pipe provides the correct volume gas for widest range of surf conditions encountered by most coastal surveys.

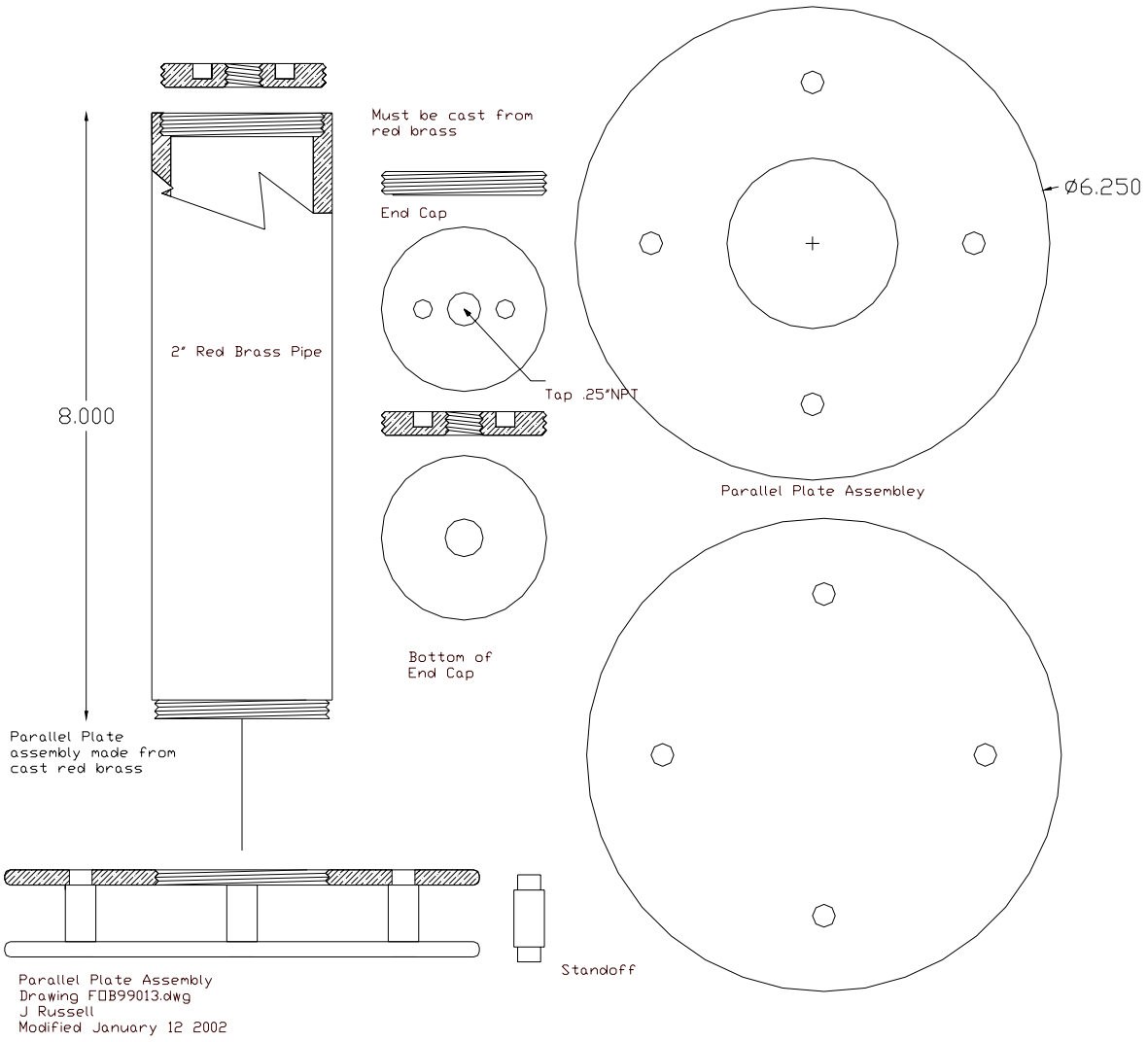


Figure 4.1 : Bubbler orifice bottom assembly

Figure 4.2 Example - Pressure Tide Gauge Record

4.2.5. Bench Marks and Leveling

PRESSURE TIDE GAUGE RECORD

Station Name: _____ **Station No. (7 digit #)** _____

Date	Time		Staff Reading		Gage/Staff	Gas Pressure		Wind	Air	
(M,D,Y)	Gage	Correct	High	Low	Diference	Cyln	Feed	(Dir/Spd)	Temp.	Remarks

Bench Marks

A bench mark is a fixed physical object or marker (monumentation) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level measurement station are used as the reference for the local tidal datums derived from the water level data. The relationship between the bench marks and the water level sensor or tide staff shall be established by differential leveling.

Number and Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, dated October 1987, specifies the installation and documentation requirements for the bench marks. Each station will have one bench mark designated as the primary bench mark (PBM), which shall be leveled to on every run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The contractor shall select a PBM at sites where the PBM has not already been designated. For historic NOS station reoccupations, CO-OPS will furnish the name of the PBM and PBM elevation above station datum, as appropriate and if available.

The most desirable bench mark for GPS observations will have 360 degrees of horizontal clearance around the mark at 10 degrees and greater above the horizon and stability code of A or B. Refer to Section 4.2.8 GPS Observations, and User's Guide for GPS Observations, Updated January 2003, for further information.

If the PBM is determined to be unstable, another mark shall be designated as PBM. The date of change and the elevation difference between the old and new PBM shall be documented. NOAA will furnish the individual NOS standard bench mark disks to be installed. Bench mark descriptions shall be written according to User's Guide for Writing Bench Mark Descriptions, updated January 2003.

Leveling

At least third-order levels shall be run at short-term subordinate stations operated for less than one-year. Requirements for higher order levels will be specified in individual project instructions, as appropriate. Standards and specifications for leveling are found in Standards and Specifications for Geodetic Control Networks and Geodetic Leveling (NOAA Manual NOS NGS 3). Additional field requirements and procedures used by NOS for leveling at tide stations can be found in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations. Electronic digital/barcode level systems are acceptable. Specifications and standards for digital levels can be found in Standards and Specifications for Geodetic Control Networks and additional field requirements and procedures used by NOS for electronic leveling at water level stations can be found in the User's Guide for Electronic Levels, updated January 2003.

Leveling Frequency

Levels shall be run between the water level sensor(s) or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. In any case, levels are required at a maximum interval of six (6) months during the station's operation, and are recommended after severe storms, hurricanes, earthquakes to document stability (see stability discussed below).

Bracketing levels to appropriate number of marks (five for 30-day minimum stations) are required (a) if smooth tides are required 30 days or more prior to the planned removal of a applicable gauge(s), or (b) after 6 months for stations collecting data for long term hydrographic projects.

Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next of greater than 0.010 m, the hydrographer shall verify the apparent movement by rerunning the levels between the sensor zero or tide staff to the PBM. This threshold of 0.010 m should not be confused with the closure tolerances used for the order and class of leveling.

4.2.6. Water Level Station Documentation

The field team shall maintain a documentation package for each water level measurement station installed for hydrographic projects. The documentation package shall be forwarded to CO-OPS within 10 business days of a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station.

Generally, all documentation submitted (see Section 4.6 for Data Submission Requirements) shall be forwarded to CO-OPS when a station is installed. For other situations, only information that has changed shall be submitted (e.g., levels and abstract for bracketing or removal levels, NGWLMS Site Report for maintenance and repair or station removal, etc.)

4.2.7. Additional Field Requirements

(A) Generally upon completion of the data acquisition for each gauge installed, the data must be sent all together for 30-day minimum stations unless the data are transmitted via satellite. For long term stations running more than three months, the data shall be sent periodically (monthly) unless the data are transmitted via satellite.

(B) All water level data from a gauge shall be downloaded and backed up at least weekly on diskettes whether the gauge data are sent via satellite or not.

(C) For new stations that do not have station numbers assigned, once the location of the gauge has been finalized then contact CO-OPS and provide latitude and longitude of the gauge site at least three business days prior to actual installation of the gauge in field. CO-OPS will assign a new station number within three business days and inform the hydrographer.

(D) The progress sketch shall show the field sheet, layout, area of hydrography, gauge locations, and other information as appropriate. Verify the location of the gauge as shown on the progress sketch, bench mark and tide station location sketch, field tide note, NGWLMS Site Report (or Tide Station Report or Great Lakes Water Level Station Report, as appropriate).

4.2.8. GPS Observations

GPS observations are required to obtain elevation ties between the tidal datums and GPS derived datums.

(A) High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites.

A choke ring antenna is preferred, however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas should be used during the entire observing sessions. If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied. This is extremely critical for obtaining precise vertical

results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

(B) A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing an Height of Instrument (HI) "blunder" during the post-processing of the data.

(C) The manufacturer, model, and complete serial numbers of all receivers and antennas must be included for each occupation on each station/bench mark observation log sheet as shown in Figure 4.18

(D) The station bench mark selected for GPS observations shall have stability code either an A or B. GPS observations on the PBM are preferred if the PBM has the stability code of A or B and also if it is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. It may be necessary to select new GPS marks, or set new marks, at some stations to ensure stability over time as the case may be.

(E) Additional GPS suitable marks shall also be connected during the static survey using rapid static GPS procedures to verify bench mark stability, if time and personnel resources are available. Priority shall be given to connecting to the NSRS, particularly to the North American Vertical Datum of 1988 (NAVD 88) bench marks.

(F) All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. A note shall be made, either in the APP field of the electronic leveling HA file, if electronic levels are used, or on the bench mark descriptions sheet, stating the suitability of GPS observations for each mark. GPS visibility obstruction diagram shall also be completed for each mark observed as shown in Figure 4.20.

(G) The most desirable bench mark for GPS observations will have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have the required clearances, if at all possible. Public property is usually a good location choice. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new 3-D rod mark or a mark installed in rock outcrop with stability A shall be established according to NOS standard procedure. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

(H) Static GPS surveys shall be conducted on a minimum of one bench mark, preferably two marks if time and resources permit, at each subordinate water level station installed/occupied for hydrography.

(I) Static GPS surveys shall be conducted at water level stations concurrently with the occupation of NAVD 88 marks, if possible, to accomplish water level datum transfers using GPS-derived orthometric heights.

(J) A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 4.22. If digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 4.21. A digital photo of the stamping is preferred over rubbing of the mark.

(K) Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation

mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites

(L) The length of GPS observation sessions depends upon the length of the time field crew has available for GPS observations, number of satellites available at a site, number of bench marks available for GPS observations, etc. The basic requirement for GPS observations on a bench mark is minimum two sessions of 6 hours each and both sessions should begin with proper antenna setup. The two GPS observation sessions on the same bench mark shall be done on the same day or on two different days. When two sessions are done (whether on the same day or on two different days), then close down the antenna at the end of the first session and re-setup the antenna at the beginning of the second session. If two sessions are done on the same day, then start the second session at least after ½ hour after the completion of the first session. If two GPS observation sessions are selected on two different days, then ideally the second session should start 28 hours after the beginning of the first session so that a different set of GPS satellites are available for the second session. When two sessions are done on the same day, the gap between the end of the first session and the beginning of the second session can be, or need to be increased if PDOP is not suitable for observations, this is applicable only if PDOP information is available to the field crew.

For contract and NOAA hydrographic surveys and special projects three GPS observation sessions of 6 hours each on two or three different days are recommended, if time and resources permit. If three GPS sessions are done then they should be spread over minimum two different days. Two GPS sessions can be done the same day, or on two different days.

If only one GPS observation session is possible for the available time, then record minimum of 24 hours of GPS observations on a bench mark. Minimum two GPS observation sessions of 6 hours each are preferred over one long 24 hour GPS session.

Always collect a little bit of extra data if time and schedule permit, so that blunders or invalid data, if any, can be removed during processing still leaving minimum of 24 hours of valid data for one GPS session, or 6 hours of valid data for each session for two (or three as the case may be) GPS sessions.

(M) It is recommended that after the session is complete, two independent downloads be done from the GPS receiver to the laptop computer, so that if one downloaded file gets corrupted, the other file may have good data. Since two downloads of the GPS observation file is a requirement, do not make copy of the downloaded file twice to the laptop instead, as both the files will have the same problem, if there exists a problem. Send both copies of digital GPS data so that one copy of the data can be forwarded to NGS and other copy will be kept for record in CO-OPS.

(N) Meteorological data (air temperature, barometric pressure, and relative humidity) need to be collected, if available, during the GPS observations. Collect appropriate meteorological data at the beginning, middle, and at the end of each GPS session, if a sensor is available and GPS session length is greater than 2 hours. If a sensor is available, then air temperature must be observed and recorded to the nearest 1° Celsius, and barometer must be observed and recorded to at least nearest 1 millibar. Meteorological data should be collected at or near the antenna phase center. All equipment should be checked for proper calibration periodically.

If none of the meteorological sensors (air temperature, barometric pressure, and relative humidity) are available for recording observations, then note any change in the atmospheric conditions on the GPS station/bench mark observation log form under Remarks section.

(O) GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the HA files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each subordinate water level station occupied for hydrography.

(P) Refer to Section 4.6.2. for GPS Project Documentation requirements later in this document.

4.3. Data Processing and Reduction

4.3.1. Data Quality Control

The required output product used in generation of tide reducers and for tidal datum determination is a continuous time series of 6-minute interval water level data for the desired time period of hydrography and for a specified minimum time period from which to derive tidal datums. CO-OPS will monitor the installed system operation information for all gauges equipped with GOES satellite radios. The 6-minute interval water level data from the water level gauges shall be quality controlled to NOS standards by the contractor for invalid and suspect data as a final review prior to product generation and application. This includes checking for data gaps, data discontinuities, datum shifts, anomalous data points, data points outside of expected tolerances such as expected maximum and minimum values and for anomalous trends in the elevations due to sensor drift or vertical movement of the tide station components and bench marks.

Quality control shall include comparisons with simultaneous data from backup gauges, predicted tides or data from nearby stations, as appropriate. Data editing and gap filling shall use documented mathematically sound algorithms and procedures and an audit trail shall be used to track all changes and edits to observed data. All inferred data shall be appropriately flagged. Water level measurements from each station shall be related to a single, common datum, referred to as Station Datum. Station Datum is an arbitrary datum and should not be confused with a tidal datum such as MLLW. All discontinuities, jumps, or other changes in the gauge record (refer to the specific gauge user's guide) that may be due to vertical movement of any the gauge, staff, or bench marks shall be fully documented. All data shall be recorded on UTC and the units of measurement shall be properly denoted on all hard-copy output and digital files. Refer to Section 4.6 Data Submission Requirements for details.

4.3.2. Data Processing and Tabulation of the Tide

The continuous 6-minute interval water level data are used to generate the standard tabulation output products. These products include the times and heights of the high and low waters, hourly heights, maximum and minimum monthly water levels, and monthly mean values for the desired parameters. Examples of these tabulation products are found in Figures 4.3 and 4.4 for tide stations and 4.5 for Great Lakes stations. The times and heights of the high and low waters shall be derived from appropriate curve-fitting of the 6-minute interval data. For purposes of tabulation of the high and low tides and not non-tidal high frequency noise, successive high and low tides shall not be tabulated unless they are greater than 2.0 hours apart in time and 0.030 meters different in elevation. Hourly heights shall be derived from every 6-minute value observed on the hour. Monthly mean sea level and monthly mean water level shall be computed from the average of the hourly heights over each calendar month of data. Data shall be tabulated relative to a documented consistent station datum such as tide staff zero, arbitrary station datum, MLLW, etc.. over the duration of the data observations. Descriptions of general procedures used in tabulation are also found in the *Tide and Current Glossary, Manual of Tide Observations,* and *Tidal Datum Planes.*

4.3.3. Computation of Monthly Means

Monthly means are derived on a calendar month basis in accordance with the definitions for the monthly mean parameters as found in the Tide and Current Glossary. Examples of the desired monthly means are found in figures 4.4 and 4.6. For purposes of monthly mean computation, monthly means shall not be computed if gaps in data are greater than three consecutive days.

4.3.4. Data Editing and Gap Filling Specifications

When backup sensor data are not available, data gaps in 6-minute data shall not be filled if the gaps are greater than three consecutive days in length. Data gap filling shall use documented mathematically and scientifically sound algorithms and procedures and an audit trail shall be used to track all gap-fills in observed data. Data gaps of less than 3-hours can be inferred using interpolation and curve-fitting techniques. Data gaps of longer than three hours shall use external data sources such as data from a nearby station. All data derived through gap-filling procedures shall be marked as inferred. Individual hourly heights, high and low waters, and daily means derived from inferred data shall also be designated as inferred.

Figure 4.3

TIDES, HIGH AND LOW WATERS July 1998
National Ocean Service (NOAA)
Water Level Heights in meters on Station Datum

Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY , CA
Time Meridian: 0 W Tide Type: Mixed

DAY	HIGH TIME	HIGH HEIGHT	LOW TIME	LOW HEIGHT	DAY	HIGH TIME	HIGH HEIGHT	LOW TIME	LOW HEIGHT
1	> 1.4	3.337	6.8	2.521	16	> 0.6	3.550	6.2	2.343
	12.6	2.996	> 18.5	2.253		12.6	3.187	> 18.1	2.195
2	> 2.0	3.393	7.8	2.434	17	> 1.4	3.654	7.4	2.205
	13.9	2.950	> 19.4	2.406		14.1	3.096	19.0	2.335
3	> 2.6	3.458	> 9.1	2.367	18	> 2.2	3.725	> 8.6	2.054
	15.2	2.941	20.1	2.498		15.6	3.132	20.2	2.504
4	> 3.2	3.524	> 9.7	2.210	19	> 3.1	3.819	> 9.7	1.891
	16.5	2.988	21.1	2.612		16.9	3.188	21.5	2.586
5	> 4.0	3.584	> 10.3	2.018	20	> 4.1	3.899	>10.7	1.763
	17.6	3.054	22.0	2.644		18.0	3.267	22.5	2.597
6	> 4.6	3.656	> 11.1	1.913	21	> 4.9	3.903	>11.6	1.654
	18.3	3.124	22.7	2.682		18.8	3.309	23.4	2.583
7	> 5.1	3.711	> 11.8	1.812	22	> 6.0	3.884		
	19.1	3.194	23.4	2.697		19.6	3.347	>12.4	1.587
8	> 5.8	3.754			23	> 6.4	3.880	0.2	2.587
	19.7	3.223	> 12.4	1.730		20.3	3.390	>13.1	1.611
9	> 6.3	3.789	0.1	2.703	24	> 7.4	3.833	1.1	2.586
	20.4	3.285	> 13.1	1.669		20.9	3.409	> 13.9	1.659
10	> 7.3	3.795	0.9	2.709	25	> 8.1	3.780	1.7	2.562
	21.1	3.306	> 13.7	1.627		21.6	3.445	> 14.5	1.719
11	> 8.0	3.712	1.6	2.614	26	> 8.7	3.668	2.6	2.564
	21.7	3.302	> 14.4	1.579		22.2	3.437	> 14.9	1.826
12	> 8.8	3.639	2.5	2.584	27	> 9.3	3.510	3.2	2.549
	22.3	3.356	> 15.1	1.609		>22.8	3.416	> 15.6	1.932
13	> 9.3	3.547	3.1	2.530	28	10.1	3.356	4.1	2.538
	23.1	3.419	> 15.6	1.692		>23.5	3.430	> 16.1	2.042
14	10.1	3.443	4.1	2.522	29	10.9	3.202	5.0	2.495
	> 23.9	3.484	> 16.5	1.800				> 16.6	2.199
15	11.3	3.282	5.1	2.422	30	> 0.1	3.432	5.9	2.492
			> 17.0	1.967		12.0	3.099	> 17.3	2.402
					31	> 0.8	3.472	> 6.9	2.431
						13.1	3.018	18.5	2.513

HIGHEST TIDE: 3.903 4.9 HRS Jul 21 1998
LOWEST TIDE: 1.579 14.4 HRS Jul 11 1998

MONTHLY MEANS FOR July 1998

HWL	3.903		
MHHW	3.641	DHQ	0.208
MHW	3.433	GT	1.720
MTL	2.832	MN	1.203
DTL	2.781		
MSL	2.816		
MLW	2.230	DLQ	0.309
MLLW	1.921		
LWL	1.579		
HWI	7.570 HRS		
LWI	0.760 HRS		

> higher high/lower low waters [ ] denotes inferred water level values Data Status: Verified

Figure 4.4

HOURLY WATER LEVELS

National Ocean Service (NOAA) July 1998

Water Level Heights in meters on Station Datum

Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY , CA Time Meridian 0 W Tide Type: Mixed

HOUR	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Jul 7	Jul 8	Jul 9	Jul 10	Jul 11	Jul 12	Jul 13	Jul 14	Jul 15	Jul 16
00	3.247	3.183	3.119	3.052	2.936	2.837	2.770	2.724	2.717	2.763	2.814	2.960	3.152	3.354	3.481	3.529
01	3.329	3.333	3.319	3.274	3.157	3.066	2.972	2.851	2.762	2.694	2.637	2.723	2.901	3.162	3.365	3.517
02	3.311	3.391	3.449	3.437	3.378	3.293	3.173	3.060	2.913	2.799	2.627	2.602	2.653	2.868	3.123	3.395
03	3.164	3.312	3.463	3.526	3.526	3.504	3.423	3.298	3.171	2.988	2.750	2.618	2.529	2.621	2.792	3.103
04	2.948	3.158	3.338	3.469	3.595	3.629	3.617	3.555	3.420	3.261	2.985	2.755	2.606	2.523	2.523	2.741
05	2.725	2.914	3.091	3.304	3.474	3.628	3.714	3.707	3.652	3.519	3.247	3.012	2.757	2.576	2.423	2.459
06	2.558	2.651	2.811	3.012	3.209	3.430	3.640	3.740	3.782	3.711	3.508	3.252	2.986	2.745	2.472	2.302
07	2.528	2.451	2.531	2.651	2.833	3.112	3.342	3.580	3.746	3.785	3.668	3.485	3.217	2.954	2.619	2.399
08	2.581	2.453	2.387	2.366	2.448	2.653	2.915	3.225	3.496	3.677	3.715	3.628	3.433	3.155	2.804	2.480
09	2.648	2.510	2.375	2.228	2.133	2.243	2.435	2.701	3.060	3.348	3.540	3.626	3.535	3.354	2.997	2.651
10	2.778	2.568	2.400	2.229	2.017	1.994	2.057	2.236	2.477	2.819	3.159	3.410	3.510	3.444	3.185	2.870
11	2.890	2.696	2.494	2.280	2.057	1.909	1.859	1.919	2.081	2.327	2.576	2.970	3.257	3.389	3.283	3.040
12	2.976	2.813	2.643	2.431	2.159	1.972	1.826	1.719	1.774	1.922	2.101	2.422	2.818	3.165	3.248	3.162
13	2.995	2.917	2.750	2.581	2.327	2.124	1.913	1.756	1.674	1.667	1.781	2.000	2.350	2.735	3.051	3.175
14	2.904	2.945	2.897	2.760	2.559	2.338	2.117	1.908	1.744	1.633	1.588	1.706	1.946	2.305	2.737	3.069
15	2.742	2.903	2.922	2.898	2.778	2.611	2.387	2.154	1.944	1.759	1.625	1.612	1.732	1.965	2.365	2.831
16	2.505	2.783	2.909	2.986	2.937	2.862	2.683	2.455	2.260	2.014	1.791	1.690	1.697	1.794	2.053	2.492
17	2.359	2.594	2.814	2.976	3.040	3.034	2.954	2.786	2.585	2.366	2.084	1.911	1.852	1.854	1.971	2.258
18	2.250	2.473	2.649	2.915	3.028	3.137	3.124	3.015	2.936	2.739	2.449	2.242	2.074	1.986	2.020	2.177
19	2.272	2.401	2.550	2.773	2.960	3.099	3.190	3.187	3.141	3.021	2.814	2.618	2.419	2.256	2.193	2.269
20	2.336	2.413	2.484	2.647	2.812	2.990	3.149	3.215	3.271	3.239	3.094	2.975	2.797	2.595	2.462	2.415
21	2.508	2.514	2.527	2.637	2.690	2.843	2.999	3.128	3.251	3.310	3.275	3.220	3.131	2.954	2.781	2.677
22	2.736	2.685	2.631	2.636	2.634	2.709	2.835	2.982	3.130	3.233	3.280	3.369	3.339	3.242	3.104	2.961
23	2.965	2.912	2.814	2.752	2.703	2.700	2.688	2.779	2.916	3.063	3.177	3.322	3.422	3.417	3.336	3.284
Mean	2.761	2.791	2.807	2.826	2.808	2.822	2.824	2.820	2.829	2.819	2.762	2.755	2.755	2.767	2.766	2.802

HOUR	Jul 17	Jul 18	Jul 19	Jul 20	Jul 21	Jul 22	Jul 23	Jul 24	Jul 25	Jul 26	Jul 27	Jul 28	Jul 29	Jul 30	Jul 31	
00	3.514	3.373	3.180	2.993	2.778	2.625	2.586	2.678	2.821	3.048	3.228	3.317	3.411	3.444	3.438	
01	3.654	3.617	3.485	3.264	3.035	2.810	2.649	2.586	2.613	2.749	2.951	3.122	3.270	3.357	3.466	
02	3.620	3.720	3.720	3.573	3.322	3.071	2.848	2.682	2.573	2.590	2.680	2.834	3.030	3.195	3.394	Monthly
03	3.427	3.686	3.818	3.785	3.641	3.379	3.133	2.884	2.694	2.576	2.550	2.625	2.735	2.937	3.148	Max HWL
04	3.111	3.433	3.737	3.907	3.840	3.659	3.444	3.201	2.926	2.761	2.591	2.538	2.547	2.704	2.888	04:54/21
05	2.704	3.048	3.487	3.775	3.898	3.849	3.697	3.460	3.206	2.978	2.759	2.586	2.487	2.523	2.660	3.903
06	2.398	2.607	3.017	3.452	3.745	3.887	3.866	3.717	3.505	3.247	2.976	2.757	2.553	2.486	2.467	
07	2.215	2.254	2.539	2.948	3.376	3.678	3.851	3.828	3.704	3.501	3.210	2.928	2.697	2.545	2.448	
08	2.255	2.073	2.167	2.436	2.810	3.269	3.593	3.770	3.778	3.652	3.390	3.150	2.860	2.659	2.477	Monthly
09	2.319	2.064	1.953	2.018	2.299	2.662	3.083	3.430	3.637	3.659	3.504	3.302	3.031	2.809	2.571	Min LWL
10	2.483	2.155	1.884	1.806	1.896	2.146	2.526	2.942	3.284	3.486	3.479	3.358	3.144	2.948	2.725	14:24/11
11	2.691	2.304	1.993	1.757	1.696	1.794	2.071	2.397	2.758	3.107	3.252	3.294	3.203	3.055	2.856	1.579
12	2.876	2.544	2.195	1.877	1.664	1.603	1.743	1.981	2.282	2.618	2.907	3.090	3.119	3.107	2.975	
13	3.037	2.784	2.453	2.094	1.808	1.637	1.621	1.723	1.924	2.215	2.471	2.741	2.953	3.037	3.031	
14	3.088	2.995	2.738	2.387	2.076	1.816	1.662	1.644	1.740	1.919	2.149	2.402	2.658	2.905	2.975	Monthly
15	3.038	3.104	2.978	2.738	2.434	2.122	1.918	1.797	1.762	1.827	1.956	2.144	2.396	2.676	2.908	Mean
16	2.880	3.119	3.134	3.028	2.790	2.510	2.249	2.056	1.942	1.882	1.950	2.016	2.231	2.493	2.725	MSL
17	2.621	3.011	3.191	3.220	3.078	2.887	2.646	2.422	2.219	2.117	2.061	2.118	2.218	2.398	2.595	2.816
18	2.400	2.812	3.107	3.284	3.266	3.162	3.018	2.791	2.604	2.412	2.302	2.244	2.299	2.432	2.508	
19	2.323	2.600	2.938	3.179	3.300	3.316	3.273	3.162	2.978	2.775	2.615	2.496	2.465	2.490	2.527	
20	2.402	2.513	2.731	3.013	3.210	3.336	3.394	3.345	3.271	3.109	2.939	2.795	2.688	2.663	2.620	
21	2.554	2.550	2.605	2.755	3.012	3.214	3.345	3.401	3.415	3.335	3.215	3.075	2.963	2.884	2.766	
22	2.789	2.698	2.619	2.612	2.735	2.975	3.189	3.316	3.427	3.428	3.369	3.310	3.184	3.109	2.984	
23	3.073	2.920	2.760	2.631	2.613	2.707	2.912	3.118	3.300	3.400	3.407	3.429	3.373	3.308	3.178	
Mean	2.811	2.833	2.851	2.855	2.847	2.838	2.847	2.847	2.848	2.850	2.830	2.820	2.813	2.840	2.847	

[ ] denotes inferred water level values Data Status: Verified

Figure 4.5

HOURLY WATER LEVELS

National Ocean Service (NOAA) July 1998

Water Level Heights in meters IGLD (1985)

Station: 9052030 Oswego, Lake Ontario , NY Time Meridian: 75 W Data Type: Great Lakes

HOUR	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Jul 7	Jul 8	Jul 9	Jul 10	Jul 11	Jul 12	Jul 13	Jul 14	Jul 15	Jul 16	
01	75.21	75.21	75.19	75.18	75.19	75.17	75.15	75.17	75.17	75.20	75.21	75.21	75.20	75.17	75.17	75.17	
02	75.25	75.21	75.19	75.19	75.22	75.14	75.17	75.16	75.19	75.19	75.20	75.22	75.18	75.17	75.18	75.16	
03	75.26	75.21	75.19	75.17	75.19	75.18	75.18	75.16	75.16	75.19	75.21	75.19	75.18	75.18	75.15	75.17	
04	75.25	75.20	75.19	75.20	75.21	75.18	75.17	75.16	75.17	75.20	75.21	75.18	75.17	75.18	75.16	75.16	
05	75.25	75.21	75.20	75.19	75.21	75.18	75.17	75.20	75.20	75.18	75.21	75.20	75.19	75.17	75.19	75.16	
06	75.25	75.21	75.19	75.20	75.20	75.19	75.17	75.16	75.19	75.20	75.20	75.20	75.17	75.17	75.14	75.15	
07	75.25	75.20	75.19	75.19	75.19	75.17	75.18	75.20	75.20	75.19	75.21	75.20	75.18	75.17	75.14	75.17	
08	75.24	75.21	75.19	75.21	75.20	75.17	75.17	75.14	75.19	75.20	75.22	75.20	75.19	75.15	75.18	75.15	
09	75.24	75.21	75.19	75.20	75.19	75.19	75.16	75.17	75.18	75.18	75.22	75.20	75.19	75.18	75.16	75.14	
10	75.24	75.20	75.19	75.18	75.19	75.18	75.16	75.20	75.17	75.20	75.22	75.22	75.18	75.18	75.17	75.16	
11	75.23	75.19	75.17	75.18	75.20	75.18	75.15	75.15	75.19	75.20	75.22	75.20	75.19	75.18	75.16	75.15	
12	75.22	75.21	75.18	75.18	75.17	75.17	75.17	75.16	75.17	75.19	75.22	75.20	75.18	75.18	75.17	75.16	
13	75.22	75.20	75.18	75.19	75.18	75.16	75.16	75.15	75.17	75.18	75.21	75.19	75.19	75.17	75.16	75.16	
14	75.23	75.20	75.19	75.21	75.18	75.19	75.14	75.15	75.16	75.18	75.20	75.22	75.17	75.17	75.18	75.17	
15	75.22	75.21	75.17	75.19	75.17	75.15	75.14	75.18	75.17	75.19	75.20	75.18	75.18	75.17	75.17	75.17	
16	75.21	75.20	75.19	75.18	75.19	75.16	75.18	75.18	75.17	75.19	75.19	75.19	75.17	75.16	75.16	75.16	
17	75.21	75.20	75.20	75.21	75.20	75.17	75.17	75.18	75.17	75.19	75.20	75.18	75.17	75.17	75.17	75.15	
18	75.22	75.20	75.20	75.21	75.21	75.20	75.18	75.18	75.15	75.17	75.20	75.18	75.16	75.15	75.16	75.16	
19	75.21	75.20	75.19	75.21	75.19	75.19	75.18	75.20	75.18	75.22	75.19	75.19	75.17	75.16	75.16	75.17	
20	75.20	75.22	75.19	75.25	75.19	75.17	75.18	75.18	75.20	75.22	75.20	75.20	75.16	75.16	75.16	75.13	
21	75.20	75.18	75.18	75.15	75.19	75.19	75.15	75.19	75.22	75.18	75.21	75.19	75.18	75.16	75.15	75.17	
22	75.21	75.20	75.17	75.17	75.19	75.18	75.19	75.17	75.23	75.20	75.21	75.19	75.18	75.18	75.15	75.13	
23	75.20	75.19	75.17	75.24	75.19	75.16	75.18	75.19	75.22	75.22	75.21	75.17	75.18	75.16	75.17	75.13	
24	75.21	75.20	75.17	75.20	75.18	75.17	75.17	75.19	75.18	75.21	75.21	75.18	75.18	75.15	75.16	75.15	
Mean	75.23	75.20	75.19	75.19	75.19	75.18	75.17	75.17	75.18	75.20	75.21	75.19	75.18	75.17	75.16	75.16	

HOUR	Jul 17	Jul 18	Jul 19	Jul 20	Jul 21	Jul 22	Jul 23	Jul 24	Jul 25	Jul 26	Jul 27	Jul 28	Jul 29	Jul 30	Jul 31	
01	75.17	75.17	75.14	75.12	75.13	75.14	75.11	75.16	75.14	75.11	75.09	75.07	75.07	75.10	75.09	
02	75.17	75.18	75.14	75.16	75.12	75.16	75.12	75.16	75.14	75.10	75.08	75.09	75.06	75.11	75.08	
03	75.16	75.19	75.15	75.15	75.11	75.16	75.12	75.15	75.13	75.10	75.08	75.06	75.06	75.10	75.08	Monthly
04	75.17	75.18	75.14	75.14	75.13	75.15	75.10	75.14	75.14	75.10	75.07	75.09	75.02	75.09	75.08	Max HWL
05	75.16	75.18	75.16	75.13	75.14	75.13	75.14	75.16	75.13	75.10	75.06	75.11	75.07	75.08	75.08	03:00/01
06	75.17	75.16	75.15	75.16	75.10	75.17	75.12	75.16	75.12	75.10	75.06	75.07	75.16	75.07	75.08	75.259
07	75.16	75.16	75.17	75.14	75.12	75.13	75.14	75.14	75.13	75.10	75.07	75.06	75.14	75.07	75.07	
08	75.16	75.16	75.14	75.15	75.15	75.12	75.14	75.16	75.13	75.10	75.06	75.08	75.11	75.05	75.07	
09	75.15	75.15	75.11	75.14	75.12	75.20	75.15	75.17	75.13	75.11	75.06	75.06	75.10	75.08	75.07	Monthly
10	75.16	75.15	75.11	75.14	75.11	75.18	75.10	75.15	75.13	75.12	75.08	75.07	75.11	75.07	75.06	Min LWL
11	75.16	75.16	75.13	75.14	75.11	75.16	75.11	75.16	75.12	75.11	75.08	75.06	75.11	75.06	75.07	04:00/29
12	75.16	75.17	75.16	75.14	75.12	75.12	75.13	75.14	75.11	75.11	75.09	75.07	75.12	75.10	75.07	75.021
13	75.16	75.15	75.14	75.14	75.12	75.14	75.13	75.14	75.11	75.10	75.07	75.05	75.08	75.08	75.07	
14	75.16	75.17	75.13	75.15	75.10	75.11	75.14	75.14	75.10	75.11	75.06	75.08	75.08	75.08	75.06	
15	75.17	75.16	75.13	75.13	75.12	75.12	75.12	75.13	75.11	75.09	75.07	75.06	75.07	75.08	75.05	Monthly
16	75.16	75.16	75.13	75.13	75.13	75.14	75.14	75.13	75.12	75.09	75.08	75.05	75.09	75.05	75.06	Mean
17	75.18	75.16	75.13	75.13	75.08	75.11	75.16	75.13	75.10	75.07	75.08	75.07	75.08	75.09	75.06	MSL
18	75.17	75.15	75.14	75.16	75.12	75.13	75.13	75.13	75.10	75.07	75.08	75.06	75.08	75.09	75.06	75.152
19	75.16	75.16	75.13	75.14	75.11	75.11	75.10	75.14	75.10	75.08	75.06	75.05	75.07	75.09	75.06	
20	75.17	75.16	75.16	75.15	75.12	75.13	75.16	75.14	75.11	75.09	75.06	75.07	75.09	75.07	75.06	
21	75.18	75.14	75.11	75.13	75.16	75.12	75.17	75.14	75.11	75.08	75.07	75.05	75.09	75.07	75.04	
22	75.18	75.15	75.14	75.13	75.10	75.15	75.17	75.14	75.11	75.08	75.07	75.06	75.09	75.08	75.06	
23	75.18	75.14	75.14	75.12	75.09	75.14	75.18	75.14	75.11	75.08	75.09	75.05	75.10	75.08	75.05	
24	75.19	75.14	75.11	75.11	75.09	75.12	75.17	75.15	75.11	75.09	75.10	75.08	75.09	75.09	75.06	
Mean	75.17	75.16	75.14	75.14	75.12	75.14	75.14	75.15	75.12	75.10	75.07	75.07	75.09	75.08	75.07	

[ ] denotes inferred water level values Data Status: Verified

4.4. Computation of Tidal Datums and Water Level Datums

4.4.1. National Tidal Datum Epoch

Tidal datums must be computed relative to a specific 19 year tidal cycle adopted by the National Ocean Service (NOS) called the National Tidal Datum Epoch (NTDE). The present NTDE is the period 1983 through 2001. A primary datum determination is based directly on the average of tide observations over the 19 year Epoch period at NOS permanent long term primary control stations in the National Water Level Observation Network (NWLON). The data from NOS primary stations are used to compute datums at short term subordinate stations by reducing the data from those subordinate stations to equivalent 19 year mean values through the method of comparison of simultaneous observation.

4.4.2. Computational Procedures

The equivalent 19 year tidal datums for subordinate stations are computed for certain phases of the tide using tide-by-tide comparisons or monthly mean comparisons with an appropriate NOS long term control station. Accepted 19 year mean values of mean tide level (MTL), mean range (Mn), diurnal high water inequality (DHQ), diurnal low water inequality (DLQ), diurnal tide level (DTL), and great diurnal range (Gt) are required in the reduction process in which a "short series" of tide observations at any location are compared with simultaneous observations from an NOS control station. Datums are computed by the "standard" method of range ratio comparison generally on the West coast and Pacific Islands where there exists a large diurnal inequality in the low and high waters. The "modified" method of range ratio comparison is generally used on the East coast and Caribbean where small differences exist in the low and high water diurnal inequalities. For stations requiring a datum determination, at least 30 continuous days of tide observations are required for stations where adequate primary datum control exists. For error budget purposes, one month of data results in a datum accuracy of 0.11 m (95% confidence level) for Stations in the Gulf of Mexico and 0.08 m (95% confidence level) for east and West Coast stations. Examples of a tide by tide and a monthly mean simultaneous comparison for datum determination are found in Figures 4.6 and 4.7. Descriptions of the tidal datum computational procedures are found in the *Tide and Current Glossary, Tidal Datum Planes, Manual of Tide Observations, NOAA Special Publication NOS CO-OPS 1Tidal Datums and Their Applications and Computational Techniques for Tidal Datums.*

4.4.3. Tidal Datum Recovery

Whenever tide stations are installed at historical sites, measures shall be taken to "recover" the established tidal datums through leveling which shall be accomplished by referencing the gauge or tide staff zero "0" to more than one existing bench mark (three bench marks are preferred) with a published tidal elevation. Through this process, the published MLLW elevation is transferred by level differences to the "new" gauge or tide staff and compared to the MLLW elevation computed from the new data on the same zero "0". Factors affecting the datum recovery (i.e. differences between old and newly computed datums) include the length of each data series used to compute the datums, the geographical location, the tidal characteristics in the region, the length of time between reoccupations, the sea level trends in the region, and the control station used. Based on all of these factors, the datum recovery can be expected to vary from +/- 0.03 m to +/- 0.08 m. Hence, this process also serves as a very useful quality control procedure. After a successful datum recovery is performed and benchmark stability is established, the historical value of Mean Lower Low Water (MLLW) shall be used as the operational datum reference for data from the gauge during hydrographic survey operations. An example of a published tidal datum sheet for a station for which a datum recovery could be made is found in Figure 4.8.

Figure 4.6

COMPARISON OF SIMULTANEOUS OBSERVATIONS FOR 98 6 15 TO 98 7 14 9/11/1998
1960-1978 TIDAL EPOCH (EXPECTED DIFFERENCE (STATION A - STATION B) = .0 HOURS)

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER ACCEPTED TM (0W) TIDE TYPE (M)
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY ACCEPTED TM (0W) TIDE TYPE (M)

	(A) STATION TIM E OF			(B) STATION TIM E OF		(A) - (B) TIME DIFFERENCE		(A) STATION HEIGHT OF		(B) STATION HEIGHT OF		(A) - (B) HEIGHT DIFFERENCE	
	H W	L W		H W	L W	H W	L W	H W	L W	H W	L W	H W	L W
DATE	HOURS	HOURS	DATE	HOURS	HOURS	HOURS	HOURS	METERS	METERS	METERS	METERS	METERS	METERS
JUN 15	10.6	15 5.2	JUN 15	10.4		.2		5.248	4.455	3.459		1.789	
		17.5			16.7		.8		3.553		1.858		1.695
	16 1.0	16 6.4		16 .6	5.5	.4	. 9	5.225	4.469	3.420	2.750	1.805	1.719
	11.9	18.4		11.5	17.7	.4	. 7	5.169	3.694	3.391	2.019	1.778	1.675
	17 1.6	17 7.6		17 1.4	6.6	.2	1.0	5.304	4.304	3.509	2.638	1.795	1.666
	13.1	19.3		12.6	18.7	.5	.6	5.057	3.841	3.285	2.185	1.772	1.656
	18 2.5	18 8.6		18 2.1	7.6	.4	1.0	5.378	4.112	3.585	2.411	1.793	1.701
	14.3	20.2		14.0	19.3	.3	.9	4.948	3.887	3.162	2.229	1.786	1.658
	19 3.3	19 9.6		19 2.8	8.7	.5	.9	5.450	3.911	3.653	2.197	1.797	1.714
	15.9	21.2		15.6	20.6	.3	.6	4.972	4.041	3.173	2.326	1.799	1.715
	20 4.0	20 10.6		20 3.6	9.9	.4	.7	5.581	3.698	3.786	1.955	1.795	1.743
	17.2	22.2		16.7	21.5	.5	.7	5.009	4.157	3.208	2.423	1.801	1.734
	21 4.7	21 11.6		21 4.4	10.9	.3	.7	5.677	3.495	3.870	1.762	1.807	1.733
	18.2	23.1		17.8	22.6	.4	.5	5.072	4.195	3.261	2.450	1.811	1.745
	22 5.5	22 12.6		22 5.2	11.8	.3	.8	5.725	3.362	3.935	1.635	1.790	1.727
	19.2	23 .1		18.8	23.5	.4	.6	5.102	4.258	3.290	2.505	1.812	1.753
	23 6.2	13.6		23 6.0	12.5	.2	1.1	5.748	3.257	3.943	1.550	1.805	1.707
	20.3			19.8		.5		5.144		3.329		1.815	
	24 7.2	24 1.0		24 6.8	.3	.4	.7	5.759	4.339	3.951	2.587	1.808	1.752
	21.1	14.3		20.6	13.3	.5	1.0	5.198	3.249	3.371	1.514	1.827	1.735
	25 7.7	25 1.8		25 7.5	1.1	.2	.7	5.708	4.355	3.892	2.625	1.816	1.730
	22.0	15.0		21.5	14.1	.5	.9	5.198	3.246	3.366	1.540	1.832	1.706
	26 8.7	26 2.6		26 8.4	2.1	.3	.5	5.559	4.363	3.763	2.625	1.796	1.738
	22.6	15.6		22.4	14.6	.2	1.0	5.158	3.236	3.343	1.536	1.815	1.700
	27 9.3	27 3.6		27 9.0	2.9	.3	.7	5.432	4.360	3.625	2.629	1.807	1.731
	23.5	16.2		23.1	15.4	.4	.8	5.195	3.350	3.382	1.625	1.813	1.725
	28 10.1	28 4.4		28 9.7	3.7	.4	.7	5.293	4.389	3.494	2.661	1.799	1.728
	29 .2	16.7		23.8	16.1	.4	.6	5.190	3.487	3.376	1.762	1.814	1.725
	10.9	29 5.6		29 10.6	4.7	.3	.9	5.105	4.360	3.315	2.649	1.790	1.711
		17.6			16.8		.8		3.605		1.907		1.698
	30 1.0	30 6.6		30 .6	5.7	.4	.9	5.150	4.288	3.354	2.589	1.796	1.699
	12.0	18.5		11.6	17.9	.4	.6	4.897	3.738	3.120	2.077	1.777	1.661
JUL 1	1.6	1 7.8	JUL 1	1.4	6.8	.2	1.0	5.123	4.195	3.337	2.520	1.786	1.675
	13.1	19.2		12.6	18.5	.5	.7	4.764	3.899	2.995	2.253	1.769	1.646
	2 2.4	2 8.8		2 2.0	7.8	.4	1.0	5.161	4.112	3.392	2.434	1.769	1.678
	14.3	20.0		13.9	19.4	.4	.6	4.713	4.078	2.950	2.406	1.763	1.672
	3 3.1	3 9.9		3 2.6	9.1	.5	.8	5.232	4.036	3.458	2.366	1.774	1.670
	15.6	20.8		15.2	20.1	.4	.7	4.697	4.200	2.940	2.498	1.757	1.702
	4 3.7	4 10.4		4 3.2	9.7	.5	.7	5.301	3.895	3.524	2.209	1.777	1.686
	16.7	21.8		16.5	21.1	.2	.7	4.751	4.326	2.987	2.612	1.764	1.714
	5 4.2	5 11.1		5 4.0	10.3	.2	.8	5.365	3.737	3.584	2.017	1.781	1.720
	17.9	22.7		17.6	22.0	.3	.7	4.833	4.384	3.053	2.644	1.780	1.740
	6 4.8	6 11.8		6 4.6	11.1	.2	.7	5.442	3.620	3.656	1.913	1.786	1.707
	18.7	23.5		18.3	22.7	.4	.8	4.905	4.418	3.124	2.681	1.781	1.737
	7 5.6	7 12.6		7 5.1	11.8	.5	.8	5.506	3.532	3.710	1.812	1.796	1.720
	19.5	8 .2		19.1	23.4	.4	.8	4.991	4.434	3.193	2.697	1.798	1.737

Figure 4.6 (cont.)

COMPARISON OF SIMULTANEOUS OBSERVATIONS FOR 98 6 15 TO 98 7 14 9/11/1998
1960-1978 TIDAL EPOCH (EXPECTED DIFFERENCE (STATION A - STATION B) = .0 HOURS)

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER ACCEPTED TM (0W) TIDE TYPE (M)
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY ACCEPTED TM (0W) TIDE TYPE (M)

	(A) STATION TIM E OF				(B) STATION TIM E OF		(A) - (B) TIME DIFFERENCE		(A) STATION HEIGHT OF		(B) STATION HEIGHT OF		(A) - (B) HEIGHT DIFFERENCE	
	H W		L W		H W	L W	H W	L W	H W	L W	H W	L W	H W	L W
DATE	HOURS		HOURS	DATE	HOURS	HOURS	HOURS	HOURS	METERS	METERS	METERS	METERS	METERS	METERS
JUL 8	6.0	8	13.2	JUL 8	5.8	12.4	.2	.8	5.568	3.463	3.754	1.729	1.814	1.734
	20.2				19.7		.5		5.024		3.222		1.802	
9	6.7	9	.7	9	6.3	.1	.4	.6	5.589	4.445	3.789	2.702	1.800	1.743
	20.8		13.9		20.4	13.1	.4	.8	5.092	3.402	3.285	1.669	1.807	1.733
10	7.6	10	1.6	10	7.3	.9	.3	.7	5.605	4.442	3.794	2.709	1.811	1.733
	21.5		14.5		21.1	13.7	.4	.8	5.120	3.349	3.306	1.627	1.814	1.722
11	8.4	11	2.2	11	8.0	1.6	.4	.6	5.527	4.342	3.712	2.613	1.815	1.729
	22.1		15.2		21.7	14.4	.4	.8	5.112	3.294	3.302	1.578	1.810	1.716
12	8.8	12	3.2	12	8.8	2.5	.0	.7	5.445	4.309	3.638	2.584	1.807	1.725
	22.7		15.8		22.3	15.1	.4	.7	5.163	3.334	3.355	1.608	1.808	1.726
13	9.6	13	3.8	13	9.3	3.1	.3	.7	5.354	4.264	3.547	2.529	1.807	1.735
	23.5		16.6		23.1	15.6	.4	1.0	5.243	3.438	3.419	1.691	1.824	1.747
14	10.6	14	4.7	14	10.1	4.1	.5	.6	5.235	4.262	3.443	2.521	1.792	1.741
			17.1		23.9	16.5		.6		3.521	3.483	1.800		1.721

	HHW	HLW	HHW	HLW	HHW	HLW
SUMS	152.420	120.010	102.090	71.841	50.330	48.169
ITEMS	28	28	28	28	28	28
MEANS	5.444	4.286	3.646	2.566	1.797	1.720

	IHW	LLW	LHW	LLW	LHW	LLW
SUMS	20.6 43.5	146.092	103.320	93.990	53.800	52.102	49.520
ITEMS	57 57	29	29	29	29	29	29
MEANS	.36 .76	5.038	3.563	3.241	1.855	1.797	1.708

COMPARISON OF SIMULTANEOUS OBSERVATIONS FOR 98 6 15 TO 98 7 14 9/11/1998
1960-1978 TIDAL EPOCH (EXPECTED DIFFERENCE (STATION A - STATION B) = .0 HOURS)

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER ACCEPTED TM (0W) TIDE TYPE (M)
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY ACCEPTED TM (0W) TIDE TYPE (M)

ERROR SCAN FOR TIME DIFFERENCE OF HW
STANDARD DEVIATION= .111
ERROR IN 98 7 12 88 (SUBORDINATE STATION) .0
ERROR SCAN FOR TIME DIFFERENCE OF LW
STANDARD DEVIATION= .141
ERROR IN 98 6 23 136 (SUBORDINATE STATION) 1.1
ERROR SCAN FOR HEIGHT DIFFERENCE OF HHW
STANDARD DEVIATION= .013
ERROR IN 98 7 2 24 (SUBORDINATE STATION) 1.769
ERROR SCAN FOR HEIGHT DIFFERENCE OF LHW
STANDARD DEVIATION= .020
ERROR SCAN FOR HEIGHT DIFFERENCE OF HLW
STANDARD DEVIATION= .026
ERROR IN 98 6 17 76 (SUBORDINATE STATION) 1.666
ERROR IN 98 6 18 202 (SUBORDINATE STATION) 1.658
ERROR SCAN FOR HEIGHT DIFFERENCE OF LLW
STANDARD DEVIATION= .027
ERROR IN 98 7 1 192 (SUBORDINATE STATION) 1.646

Figure 4.6 (cont.)

COMPARISON OF SIMULTANEOUS OBSERVATIONS FOR 98 6 15 TO 98 7 14 9/11/1998
1960-1978 TIDAL EPOCH (EXPECTED DIFFERENCE (STATION A - STATION B) = .0 HOURS)

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER ACCEPTED TM (0W) TIDE TYPE (M)
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY ACCEPTED TM (0W) TIDE TYPE (M)

MEAN DIFFERENCE IN HIGH (.36) AND LOW (.76) WATER INTERVALS

MEAN HHW HEIGHT AT (A) = 5.444	MEAN HLW HEIGHT AT (A) = 4.286
MEAN LHW HEIGHT AT (A) = 5.038	MEAN LLW HEIGHT AT (A) = 3.563
DHQ AT (A) = .207	DLQ AT (A) = .355
MEAN HW HEIGHT AT (A) = 5.237	MEAN LW HEIGHT AT (A) = 3.918
MN AT (A) = 1.319	MTL AT (A) = 4.578
GT AT (A) = 1.881	DTL AT (A) = 4.503
MEAN HHW DIFFERENCE = 1.797	MEAN HLW DIFFERENCE = 1.720
MEAN LHW DIFFERENCE = 1.797	MEAN LLW DIFFERENCE = 1.708
DHQ DIFFERENCE = .000	DLQ DIFFERENCE = .006
MEAN HW DIFFERENCE = 1.797	MEAN LW DIFFERENCE = 1.714
MN DIFFERENCE = .083	MTL DIFFERENCE = 1.755
GT DIFFERENCE = .090	DTL DIFFERENCE = 1.753
MN RATIO = 1.067	DHQ RATIO = 1.002
GT RATIO = 1.050	DLQ RATIO = 1.018
MSL AT (A) = 4.570	
MSL AT (B) = 2.804	
MSL DIFFERENCE = 1.766	

	HWI HOURS	LWI HOURS	MTL METERS	MN METERS	DHQ METERS	DLQ METERS
ACCEPTED FOR B	7.56	.83	2.728	1.250	.183	.344
DIFFERENCES AND RATIOS	.36	.76	1.755	1.067	1.002	1.018
CORRECTED FOR A	7.92	1.59	4.483	1.334	.183	.351

	MSL METERS	DTL METERS	GT METERS
ACCEPTED FOR B	2.713	2.646	1.777
DIFFERENCES AND RATIOS	1.766	1.753	1.050
CORRECTED FOR A	4.479	4.398	1.866

MRR METHOD
MHHW= 5.331 MLLW= 3.465
DHQ = .181 DLQ = .351

SRANDARD METHOD
MHHW= 5.334 MLW = 3.816
MHW = 5.150 MLLW= 3.466

DIRECT METHOD

	MHHW METERS	MHW METERS	MLW METERS	MLLW METERS
ACCEPTED FOR B	3.536	3.353	2.103	1.759
DIFFERENCES AND RATIOS	1.797	1.797	1.714	1.708
CORRECTED FOR A	5.333	5.150	3.817	3.466

MN = 1.333
GT = 1.867

Figure 4.7 - Monthly Mean Simultaneous Comparison Example

COMPARISON OF MONTHLY MEANS (JAN-98 - JUN-98) 1960-78 TIDAL EPOCH
(A) SUBORDINATE: 9414863 RICHMOND, CA TM (000W) TIDE TYPE:MIXED
(B) CONTROL: 9414290 SAN FRANCISCO, CA TM (000W) TIDE TYPE:MIXED

month/year		MTL			MSL			HWI	
	A	B	A - B	A	B	A - B	A	B	A - B
	meters	meters	meters	meters	meters	meters	hours	hours	hours
Jan-98	4.736	3.001	1.735	4.726	2.981	1.745	7.900	7.510	0.390
Feb-98	4.841	3.103	1.738	4.839	3.082	1.757	7.900	7.580	0.320
Mar-98	4.624	2.883	1.741	4.615	2.859	1.756	7.840	7.520	0.320
Apr-98	4.542	2.798	1.744	4.532	2.776	1.756	7.880	7.530	0.350
May-98	4.562	2.811	1.751	4.547	2.787	1.760	7.890	7.540	0.350
Jun-98	4.600	2.849	1.751	4.588	2.826	1.762	7.930	7.570	0.360
month/year		LWI			MN			DHQ	
	A	B	A - B	A	B	A/B	A	B	A/B
	hours	hours	hours	meters	meters	ratio	meters	meters	ratio
Jan-98	1.460	0.790	0.670	1.367	1.287	1.062	0.207	0.213	0.972
Feb-98	1.570	0.820	0.750	1.208	1.101	1.097	0.161	0.183	0.880
Mar-98	1.430	0.660	0.770	1.321	1.215	1.087	0.118	0.125	0.944
Apr-98	1.450	0.660	0.790	1.309	1.210	1.082	0.111	0.117	0.949
May-98	1.460	0.690	0.770	1.306	1.217	1.073	0.155	0.158	0.981
Jun-98	1.490	0.720	0.770	1.292	1.205	1.072	0.194	0.196	0.990
month/year		DLQ			MHW			MLW	
	A	B	A/B	A	B	A - B	A	B	A - B
	meters	meters	meters	ratio	meters	meters	meters	meters	meters
Jan-98	0.331	0.337	0.982	5.420	3.644	1.776	4.053	2.357	1.696
Feb-98	0.251	0.261	0.962	5.445	3.653	1.792	4.237	2.552	1.685
Mar-98	0.210	0.207	1.014	5.284	3.490	1.794	3.983	2.275	1.708
Apr-98	0.279	0.268	1.041	5.196	3.403	1.793	3.887	2.193	1.694
May-98	0.336	0.328	1.024	5.215	3.420	1.795	3.909	2.203	1.706
Jun-98	0.360	0.352	1.023	5.246	3.452	1.794	3.954	2.247	1.707
month/year		DRL(TL)			GT			MHHW	
	A	B	A - B	A	B	A/B	A	B	A - B
	meters	meters	meters	meters	meters	ratio	meters	meters	meters
Jan-98	4.675	2.939	1.736	1.905	1.837	1.037	5.627	3.857	1.770
Feb-98	4.806	3.063	1.743	1.640	1.545	1.061	5.626	3.836	1.790
Mar-98	4.578	2.841	1.737	1.649	1.547	1.066	5.402	3.615	1.787
Apr-98	4.458	2.723	1.735	1.699	1.595	1.065	5.307	3.520	1.787
May-98	4.471	2.726	1.745	1.797	1.703	1.055	5.370	3.578	1.792
Jun-98	4.517	2.772	1.745	1.846	1.753	1.053	5.440	3.648	1.792
month/year		MLLW							
	A	B	A - B						
	meters	meters	meters						
Jan-98	3.722	2.020	1.702						
Feb-98	3.986	2.291	1.695						
Mar-98	3.753	2.068	1.685						
Apr-98	3.608	1.925	1.683						
May-98	3.573	1.875	1.698						
Jun-98	3.594	1.895	1.699						

Figure 4.7 - Monthly Mean Simultaneous Comparison Example (cont.)

COMPARISON OF MONTHLY MEANS (JAN-98 - JUN-98) 1960-78 TIDAL EPOCH
(A) SUBORDINATE: 9414863 RICHMOND, CA TM (000W) TIDE TYPE:MIXED
(B) CONTROL: 9414290 SAN FRANCISCO, CA TM (000W) TIDE TYPE:MIXED

	MTL A - B meters	MSL A - B meters	HWI A - B hours	LWI A - B hours	MN A/B ratio	DHQ A/B ratio	DLQ A/B ratio
months	6.000	6.000	6.000	6.000	6.000	6.000	6.000
sums	10.460	10.536	2.090	4.520	6.473	5.825	6.046
means	1.743	1.756	0.348	0.753	1.079	0.971	1.008
accepted B	2.728	2.713	7.560	0.830	1.250	0.183	0.344
corrected A	4.471	4.469	7.908	1.583	1.349	0.178	0.347

	MHW A - B meters	MLW A - B meters	DRL(TL) A - B meters	GT A/B ratio	MHHW A - B meters	MLLW A - B meters
months	6.000	6.000	6.000	6.000	6.000	6.000
sums	10.744	10.176	10.441	6.337	10.718	10.162
means	1.791	1.696	1.740	1.056	1.786	1.694
accepted B	3.353	2.103	2.646	1.777	3.536	1.759
corrected A	5.144	3.799	4.386	1.877	5.322	3.453

METHOD	DATUM	VALUE meters
MRR	MHHW	5.325
MRR	MLLW	3.448
MRR	DHQ	0.179
MRR	DLQ	0.349
STANDARD	MHW	5.146
STANDARD	MLW	3.797
STANDARD	MHHW	5.323
STANDARD	MLLW	3.450
DIRECT	MN	1.345
DIRECT	GT	1.870
DIRECT	DHQ	0.179
DIRECT	DLQ	0.346

FINAL/PRELIMINARY DATUMS
METHOD : STANDARD 1960-78 EPOCH

DATUM	VALUE meters
MHHW	5.323
MHW	5.146
MTL	4.471
MSL	4.469
DRL(TL)	4.386
MLW	3.797
MLLW	3.450
MN	1.349
GT	1.873
DHQ	0.178
DLQ	0.347

Figure 4.7 - Monthly Mean Simultaneous Comparison Example (cont.)

COMPARISON OF MONTHLY MEANS (JAN-98 - JUN-98) 1960-78 TIDAL EPOCH
(A) SUBORDINATE: 9414863 RICHMOND, CA TM (000W) TIDE TYPE:MIXED
(B) CONTROL: 9414290 SAN FRANCISCO, CA TM (000W) TIDE TYPE:MIXED

OUTLIER REPORT: MAXIMUMS AND MINIMUMS WHEN INDIVIDUAL MONTHLY MEAN DIFFERENCE EXCEEDS TWO STANDARD DEVIATIONS FROM OVERALL MEAN

	MTL	MSL	HWI	LWI	MN	DHQ	DLQ
STD.DEV.	0.004	0.003	0.018	0.019	0.008	0.012	0.017
MAXIMUM	1.752	1.762	0.384	0.791	1.095	0.994	1.041
MINIMUM	1.734	1.750	0.313	0.715	1.062	0.948	0.974
month/year							
Jan-98		1.745	0.390	0.670	1.062		
Feb-98					1.097		0.962
Mar-98						0.944	
Apr-98							1.041
May-98							
Jun-98							

	MHW	MLW	DTL	GT	MHHW	MLLW
STD.DEV.	0.003	0.006	0.003	0.006	0.004	0.004
MAXIMUM	1.796	1.708	1.746	1.068	1.794	1.703
MINIMUM	1.785	1.684	1.734	1.045	1.779	1.685
month/year						
Jan-98	1.776			1.037	1.770	
Feb-98						
Mar-98						
Apr-98						1.683
May-98						
Jun-98						

Figure 4.8: Published Bench Mark Sheet

PUBLICATION DATE: 06/06/1996 Page 1 of 5

CALIFORNIA 941 4290
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
TIDAL BENCH MARKS
THE PRESIDIO, SAN FRANCISCO
LATITUDE: 37° 48.4' N LONGITUDE: 122° 27.9' W
NOAA CHART: 18649 USGS QUAD: SAN FRANCISCO NORTH

TO REACH TIDE STATION: To reach the tide station from the intersection of U.S. Highway 101 (north) and Lincoln Boulevard (last exit before the Golden Gate toll plaza), proceed NE on Lincoln Boulevard approximately 1.6 km (1.0 mile) to Cowles Street, turn left onto Cowles Street and proceed 0.8 km (0.5 mile) to McDowell Avenue, turn left onto McDowell Avenue and proceed 0.5 km (0.3 mile) to Crissey Field Avenue, turn left onto Crissey Field Avenue and proceed 0.3 km (0.2 mile) to a stop sign, turn right and then immediately left onto Mason street, proceed along the National Parks Service parking lot fence where Mason Street turns into Hamilton Street, and proceed 0.5 km (0.3 mile) to a parking lot at the end of the street. The tide station is located in the 2nd building on the L-shaped wooden pier formerly owned by the U.S.Coast Guard, now owned by the National Park Service.

.....

BENCH MARK STAMPING: 180 1936
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Tidal Bench Mark
SETTING CLASSIFICATION: Concrete Seawall
The primary bench mark is set in the top of a 0.9-m (3') high concrete seawall at the NW end of Crissy Field on the Coast Guard property, 15 m (49') east of the NE corner of the crews quarters building, 6 m (20') south of the south side of the garage building, and 1.1 m (3.5') north of an angle in the seawall.

BENCH MARK STAMPING: 181 1945
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Tidal Bench Mark
SETTING CLASSIFICATION: Concrete Seawall
The bench mark is set in the top of the NW corner of a seawall at the Fort Point Coast Guard Station, 62 m (204') west of the inshore end of the Coast Guard wharf, 46 m (151') NW of a flagpole, 22 m (71') NE of the north corner of Building S.F. 19.4 (paint shop and storage building), and 1.2 m (4.0') above grade.

Figure 4.8 (cont.)
PUBLICATION DATE: 06/06/1996 Page 2 of 5

CALIFORNIA 941 4290
THE PRESIDIO, SAN FRANCISCO

BENCH MARK STAMPING: 4290 J 1976
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: NOS Tidal Bench Mark
SETTING CLASSIFICATION: Copper Clad Steel Rod
The bench mark is in an elevated beach area midway between the Fort Point Coast Guard pier and the engineer's dock, 133 m (435') WNW of the west end of the seawall surrounding the Coast Guard crews quarters, 27 m (89') SW of the shoreward end of the old seaplane ramp, 18.3 m (60.0') SE of the shoreward end of the concrete discharge pipe, and 0.8 m (2.5') north of a chain link fence surrounding U.S. Army Field Maintenance Building #937. The mark is crimped to a copper-clad steel rod driven 15 m (48'), encased in a 4-inch diameter PVC pipe, and marked by a witness post.

BENCH MARK STAMPING: 4290 K 1976
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: NOS Tidal Bench Mark
SETTING CLASSIFICATION: Bedrock
The bench mark is set vertically in bedrock on the south side of Marine Drive, 24 m (79') SSW of the SE corner of National Park Service building #T989, 14.7 m (48.2') SW of Bench Mark 174 1925, and 2.4 m (8.0') south of the south curb of Marine Drive.

BENCH MARK STAMPING: BM 174 1925
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Tidal Bench Mark
SETTING CLASSIFICATION: Concrete Monument
The bench mark is set in a concrete monument level with the ground inside a brick circle in the pavement at the center of the Y-junction between Marine Drive and the road leading SE to Fort Winfield Scott, 38 m (125') west of the extension of the west edge of the engineer's dock where it crosses Marine Drive, 13.0 m (42.5') SW of a fire hydrant, and 8.7 m (28.5') south of the south edge of an iron manhole cover.

BENCH MARK STAMPING: BM 175 1925
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Tidal Bench Mark
SETTING CLASSIFICATION: Concrete Seawall
The bench mark is set in the seawall near the National Park Service building, 62.2 m (214') NE of Bench Mark 4290 L 1976, 59 m (193') west of the NW corner of the park service building, 28.9 m (94.8') WNW of the northernmost post of a pedestrian gate, 6.9 m (22.5') north of the centerline of Marine Drive, and 0.7 m (2.4') south of the north edge of the seawall. (Note: The seawall was repaired in April 1981 and the elevation of the bench mark was changed after the repair, but the elevation seems stable since then.)

Figure 4.8 (cont.)

PUBLICATION DATE: 06/06/1996 Page 3 of 5

CALIFORNIA 941 4290
THE PRESIDIO, SAN FRANCISCO

BENCH MARK STAMPING: BM 176 1925
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Tidal Bench Mark
SETTING CLASSIFICATION: Concrete Step
The bench mark is set in the west end of the lowest concrete step at the main entrance to the porch of the U.S. Army Logistic Control office at #651 Mason Avenue, 30 m (98') SE of the intersection of Crissy Field and Mason Avenues, 15 m (50') south of the centerline of Mason Avenue, and about 0.2 m (0.7') above the sidewalk.

BENCH MARK STAMPING: CLARK 1948
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Triangulation Mark
SETTING CLASSIFICATION: Concrete Seawall
The bench mark is set in the top of a concrete seawall, about 549 m (1800') NW of the Fort Point Coast Guard station, 24.2 m (79.5') west of the west edge of the engineer's dock, 6.9 m (22.5') NE of the NW corner of corrugated iron building #985, 3.0 m (10') west of the NW corner of a stucco paint locker building, and about 1.1 m (3.6') above ground.

BENCH MARK STAMPING: NO 2 1948
MONUMENTATION: Survey Disk
AGENCY/DISK TYPE: USC&GS Reference Mark
SETTING CLASSIFICATION: Concrete Seawall
The bench mark is set flush in the top of a concrete seawall, 11.4 m (37.5') west of the west edge of the engineer's dock, 8.1 m (26.5') NE of the NE corner of corrugated iron building #985, and about 0.9 m (3.0') above ground.

Figure 4.8 (cont.)

PUBLICATION DATE: 06/06/1996 Page 4 of 5

CALIFORNIA 941 4290
THE PRESIDIO, SAN FRANCISCO

Tidal datums at THE PRESIDIO, SAN FRANCISCO are based on the following:
LENGTH OF SERIES = 19 YEARS
TIME PERIOD = 1960-1978
TIDAL EPOCH = 1960-1978
CONTROL TIDE STATION =

Elevations of tidal datums referred to mean lower low water (MLLW) are as follows:

HIGHEST OBSERVED WATER LEVEL (01/27/1983)	= 8.87 FEET
MEAN HIGHER HIGH WATER (MHHW)	= 5.83 FEET
MEAN HIGH WATER (MHW)	= 5.23 FEET
MEAN TIDE LEVEL (MTL)	= 3.18 FEET
MEAN SEA LEVEL (MSL)	= 3.13 FEET
MEAN LOW WATER (MLW)	= 1.13 FEET
*NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)	= 0.14 FEET
MEAN LOWER LOW WATER (MLLW)	= 0.00 FEET
LOWEST OBSERVED WATER LEVEL (12/17/1933)	= -2.67 FEET

*NAVD is based on elevations published in Quad 371221, 1993, and NOS leveling of 1995.

Bench mark elevation information:

	ELEVATION IN FEET ABOVE:	
BENCH MARK STAMPING	MLLW	MHW
180 1936	13.24	8.01
181 1945	13.29	8.06
4290 J 1976	11.18	5.95
4290 K 1976	19.31	14.08
BM 174 1925	16.65	11.42
BM 175 1925	13.84	8.61
BM 176 1925	15.99	10.76
CLARK 1948	14.08	8.85
NO 2 1948	14.04	8.81

Figure 4.8 (cont.)

PUBLICATION DATE: 06/06/1996 Page 5 of 5

CALIFORNIA 941 4290
THE PRESIDIO, SAN FRANCISCO

MSL is the local mean sea level and should not be confused with the fixed datums of NGVD (sometimes referred to as Sea Level Datum of 1929) or NAVD 88. NGVD is a fixed datum adopted as a standard geodetic reference for heights. It was derived from a general adjustment of the first order leveling nets of the U.S. and Canada. Mean sea level was held fixed as observed at 26 stations in the U.S. and Canada. Numerous adjustments have been made since originally established in 1929.

NAVD 88 involved a simultaneous, least squares, minimum-constraint adjustment of Canadian-Mexican-United States leveling observations. Local mean sea level at Father Point/Rimouski, Canada was held fixed as the single constraint. These fixed datums do not take into account the changing stands of sea level and because they represent a "best" fit over a broad area, their relationship to local mean sea level is not consistent from one location to another.

4.4.4. Quality Control

It is essential for tidal datum quality control to have data processing and leveling procedures carried out to the fullest extent. Caution must also be used in computing tidal datums in riverine systems or in regions of unknown tidal regimes. Tide-by-tide comparisons between subordinate and control station data will often detect anomalous differences which should be investigated for possible gauge malfunction or sensor movement. Datums shall be established from more than one bench mark. Differences in elevations between bench marks based on new leveling must agree with previously established differences from the published bench mark sheets. Any changes in the elevation differences must be reconciled before using in any datum recovery procedure. Datum accuracy at a subordinate station depends on various factors, but availability and choice of an adequate control station of similar tidal characteristics, similar daily mean sea level and seasonal mean sea level variations, and similar sea level trends are the most important. The length of series will also determine accuracy. The longer the series, the more accurate the datum and the greater quality control and confidence gained from analyzing numerous monthly mean differences between the subordinate and control station. At reoccupied historical stations for which datum recoveries are made, updated datums shall be computed from the new time series and compared with the historical datums as the survey progresses.

4.4.5. Geodetic Datum Relationships

Tidal datums are local vertical datums which may change considerably within a geographical area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic reference datum of the National Geodetic Spatial Reference System and is officially supported by the National Geodetic Survey (NGS) through a network of GPS continuously operating reference stations. The relationship of tidal datums to NAVD has many hydrographic, coastal mapping and engineering applications including monitoring sea level change and the deployment of GPS electronic chart display and information systems, etc.

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at http://www.ngs.noaa.gov. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has geodetic bench marks located nearby. NAVD 88 height elevations for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to *NOAA Technical Memorandum NOS NGS-58*). At the present time, GPS ellipsoid heights conforming to the 2 cm accuracy standards are required for contract hydrographic surveying projects. Refer to Section 4.2.8 GPS Observations and *User's Guide for GPS Observations, NOAA/NOS, Updated January 2003.*

An orthometric level connection is preferred over ellipsoidal GPS tie, where applicable, for deriving NAVD 88 heights. An orthometric level connection is required if any geodetic marks (up to five marks) are located within a radius of 0.8 km (0.5 mi) from the subordinate tide station location. If suitable marks are found in the NGS database, and are farther than 0.8 km (0.5 mi) but less than 10 km (6 mi) from a subordinate tide station, then a GPS tie is required to derive the ellipsoid heights. If a minimum of five existing tidal bench marks within 1 km of a subordinate tide station location are not found, or suitable geodetic marks are not found in the NGS database within 10 km (6 mi) of a subordinate tide station, then five new bench marks shall be installed, described, connected by levels, and GPS observations shall be done on at least one of the five marks. (Refer to *User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003*, *User's Guide for GPS Observations, NOAA/NOS, Updated January 2003*, and the Section 4.2.8 GPS Observations.) At least two geodetic bench marks should be used to validate the leveling or GPS ellipsoid height connection for quality control purposes.

4.5. Final Zoning and Tide Reducers

Data relative to MLLW from subordinate stations or from NWLON stations, as appropriate, shall be applied to reduce sounding data to chart datum, either directly or indirectly through a correction technique referred to as tidal zoning. Whether corrected or direct, time series data relative to MLLW or other applicable LWD applied to reference hydrographic soundings to chart datum are referred to as "tide reducers" or "water level reducers".

4.5.1. Water Level Station Summaries

Data are reduced to mean values and subsequently adjusted to National Tidal Datum Epoch (NTDE) values for tidal datums and characteristic tidal attributes as prescribed in Section 4.4. and 4.5. "Summary files" shall be created for each subordinate tide station occupied for the survey. These summary data facilitate the development of corange and cophase lines and final zoning schemes. They also provide input into the NOS tidal datum bench mark publication process which supports navigation, boundary and shoreline determination, coastal engineering and management. NTDE values for Greenwich high and low water intervals, mean and diurnal ranges and high and low water inequalities shall be tabulated in these summary files which also contain the datums, the time and length of the series and NOS control station which was used to compute 19-year equivalent NTDE values. NTDE datums shall be tabulated in the summary file relative to a documented consistent station datum such as tide staff zero or arbitrary station datum. The elevation of the primary bench mark shall be provided in this summary relative to the same zero or station datum. Latitude and longitude positions shall also be provided. An example of a summary file is provided in Figure 4.9.

Summary file data from new station occupations and NOS provided summaries from historical occupations and control stations within the survey area shall be used as input data to the tidal zoning process.

4.5.2. Construction of Final Tidal Zoning Schemes

As tidal characteristics vary spatially, data from deployed water level gauges may not be representative of water levels across a survey area. Tidal zoning shall be implemented to facilitate the provision of time series water level data relative to chart datum for any point within the survey area such that prescribed accuracy requirements are maintained for the water level measurement component of the hydrographic survey. NOS currently utilizes the "discrete tidal zoning" method for operations, where survey areas are broken up into a scheme of zones bounding areas of common tidal characteristics. The minimum requirement is for a new zone for every 0.06 m change in mean range of tide and every 0.3 hour progression in time of tide (Greenwich high and low water intervals). Phase and amplitude corrections for appropriate tide station data shall be assigned to each zone.

As part of the process, tidal characteristics shall be accessed using geographic spacial placement of summary data in a commercial GIS compatible format to assess spatial variations in tidal characteristics. Corange and cophase maps shall be generated to provide the base for development of zoning schemes. Preliminary zoning, which is based on available historical tide station data and estuarine and global tide models, is referenced to an applicable predictions reference station for utilization during field work. For final processing, preliminary zoning shall be superseded by "final zoning" which is a refinement based on new data collected at subordinate stations during the survey. With the final zoning scheme, correctors for each zone shall be derived from a subordinate station specifically installed for the survey rather than the reference station used with preliminary zoning. For contract surveys, the contractor shall develop and utilize a zoning scheme to the specifications mentioned above such that water level reducers are within required accuracy across the entire survey area. Zoning errors shall be minimized such that when combined with errors from actual water level measurement at the gauge and errors in reduction to chart datum, the total error of the tide reducers is within specified tolerances. The final zoning scheme and all data utilized in its development shall be documented and submitted. Examples of zoning files and graphics are provided in Figures 4.10, 4.11, 4.12, 4.13 and 4.15.

4.5.3. Tide Reducer Files and Final Tide Note

Verified time series data collected at appropriate subordinate stations are referenced to the NTDE Mean Lower Low Water (Chart Datum) through datum computation procedures outlined in Section 4.4. Time series data collected in six-minute intervals and reduced to chart datum as specified, both from subordinate gauges operated by the contractor and from NWLON stations where appropriate, shall be used either directly or corrected through use of a zoning scheme as determined appropriate by the contractor such that tide reducers are within specified tolerances. A Final Tide Note shall be submitted for each hydrographic sheet with information as to what final tidal zoning should be applied to which stations to obtain the final tide reducers. An example Final Tide Note and final tidal zoning graphic is found in Figure 4.15.

Figure 4-9 Tide Station Summary

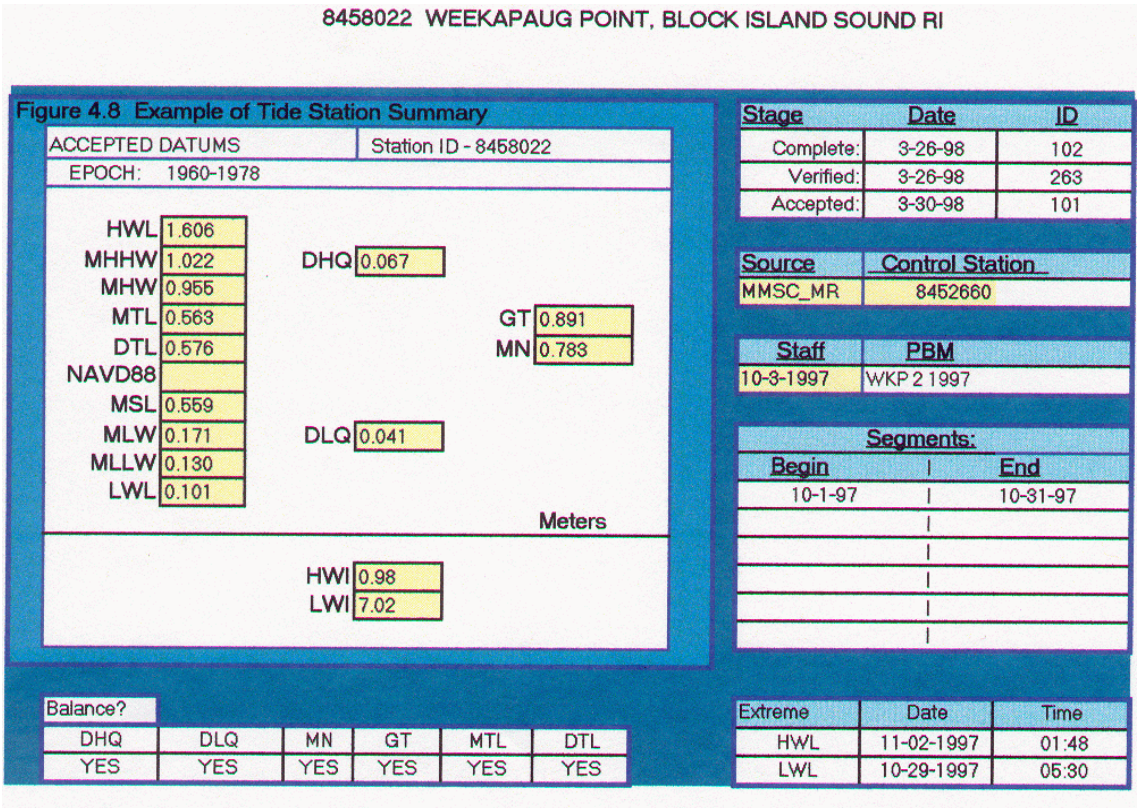


Figure 4-10 GIS Summary Data File

GIS Summary Data File

STATION	NAME	ST	HWI	LWI	TCHHWI	TCLLWI	MN	DHQ	DLQ	GT	EPOCH	SERIES	HA_SERIES	COMP_STAT	COMMENTS	LATITUDE	LONGITUDE
9455176	BURNT ISLAND, JURNALAIN ARM	AK	3.67	10.25	N/A	N/A	28.0	0.8	2.4	31.2		4H/L,1912	N/A	Fire Island		60.950000000	-149.883333333
9455182	CAIRN POINT, KNIK HARBOR	AK	3.69	10.35	N/A	N/A	26.97	0.76	2.38	30.11		224H/L,1918	N/A	Anchorage staff		61.233333333	-149.916666667
9455697	SISTERS ROCK, COOK INLET	AK	0.31	6.85	N/A	N/A	16.31	0.85	2.02	19.18	41-59	34H/32L,Jul-Aug79	N/A	Seldovia		60.301666667	-151.455000000
9455711	CAPE KASILOF, COOK INLET	AK	0.43	6.80	N/A	N/A	17.66	0.60	2.08	20.34	41-59	60H/L,Jun-Aug74	N/A	Seldovia		60.336666667	-151.380000000
9455715	KASILOF, KASILOF RIVER	AK			N/A	N/A						36H,Jul80	N/A		High waters only	60.358333333	-151.276666667
9455722	KALGIN ISLAND (WEST)	AK	0.36	6.71	N/A	N/A	15.63	0.71	1.90	18.24	41-59	128H/127L,Jun-Aug74	N/A	Seldovia	mean of 2 series	60.453333333	-151.956666667
9455728	LIGHT POINT, KALGIN ISLAND	AK	0.70	7.13	N/A	N/A	15.95	0.70	2.00	18.65		58H/L,Jul-Aug75	N/A	Nikiski		60.486666667	-151.835000000
9455735	CHINULNA POINT, COOK INLET	AK	0.68	7.22	N/A	N/A	17.89	0.74	2.02	20.65	60-78	1Mo,Jun95	N/A	Seldovia	3 series	60.503333333	-151.283333333
9455737	KENAI RIVER	AK	0.80		N/A	N/A		0.67			41-59	24Dy,Jul-Aug74	N/A	Nikiski	high waters only	60.521666667	-151.206666667
9455741	DRIFT RIVER	AK	0.69	7.04	N/A	N/A	15.58	0.68	1.93	18.19		64H/L,Jul-Aug74	N/A	Seldovia	superceded	60.555000000	-152.133333333
9455742	KENAI	AK	0.78	7.75	N/A	N/A	14.49	0.73	1.64	19.86	41-59	2Mo,Jun-Jul76	N/A	Seldovia		60.545000000	-151.218333333
9455760	NIKISKI	AK	1.22	7.60	N/A	N/A	17.69	0.70	2.08	20.47	60-78	5Yr,1972-75&77	N/A	Seldovia		60.683333333	-151.396666667
9455768	WEST FORELAND	AK	1.53	7.56	N/A	N/A	13.30	0.68	2.23	18.21	60-78	1Mo,Jul76	N/A	Seldovia		60.713333333	-151.710000000
9455769	NIKISHKA, 1ST EAST FURGUNA	AK	1.43	8.03	N/A	N/A	18.05	0.49	2.11	20.65		9H/L,1909	N/A	Seldovia		60.733333333	-151.333333333
9455771	PLATFORM DILLON,T-39,COOK INLET	AK	1.48	7.70	N/A	N/A	17.28						N/A		CHART 16660	60.736666667	-151.513333333
9455772	NIKISHKA #2, COOK INLET	AK	1.59	8.22	N/A	N/A	17.33	0.65	2.21	20.19	41-59	4Mo,Jul-Oct71	N/A	Seldovia		60.743333333	-151.308333333
9455779	SHELL PLATFORM, GIDDLE GROUND	AK	1.68	8.06	N/A	N/A	16.4					1Mo,1966	N/A		Chart 16660	60.795000000	-151.495000000
9455781	JUMBO ROCK, BOULDER POINT	AK	1.83	8.48	N/A	N/A	18.02	0.68	2.06	20.76	41-59	15H/L,Sep76	N/A	Nikiski		60.797000000	-151.170000000
9455782	DOLLY VARDEN PLATFORM,COOK INLET	AK	1.68	8.14	N/A	N/A	16.22	0.68	2.11	19.01		1Mo,Dec71	N/A	Anchorage		60.808333333	-151.636666667
9455783	TRADING BAY, COOK INLET	AK	1.47	7.88	N/A	N/A	16.5	0.8	2.20	19.50		22H.12L,1910	N/A	Seldovi/1st Red.		60.801666667	-151.776666667
9455787	GRAY CLIFFE	AK	1.95	8.58	N/A	N/A	19.47	0.79	2.06	22.32	41-59	2Mo,Jul-Aug77	N/A	Anchorage		60.833333333	-150.971666667
9455799	MIDDLE RIVER, COOK INLET	AK			N/A	N/A							N/A			60.911666667	-151.616666667
9455809	T-37 PLATFORM (OPR 469)	AK			N/A	N/A	16.82	0.63	2.15	19.60	60-78	24H/L,Jul75	N/A	Nikiski		60.928333333	-151.530000000
9455824	MOOSE POINT	AK	2.73	9.23	N/A	N/A	20.6	0.8	2.3	23.7		4H/L,1910	N/A	Chinulna Pt.		60.953300000	-150.731600000
9455826	MOOSE POINT T33 (OPR 469)	AK			N/A	N/A							N/A			60.975000000	-150.606666667
9455828	T-29 CHICALOON BAY,TURNAGAIN ARM	AK			N/A	N/A							N/A			60.966666667	-149.850000000
9455845	T-36 PLATFORM, OFF GRANITE POINT	AK	2.25	8.68	N/A	N/A	16.73	0.65	2.08	19.46		62h/l,Jul-Aug1975	N/A	Nikiski		61.000000000	-151.330000000
9455846	T-29 RAINBOW (OPR-469)	AK	3.59	11.28	N/A	N/A	27.51	0.59	1.56	29.66		20H/L,Jul1975	N/A	Anchorage		61.000000000	-149.640000000
9455856	TYONEK, COOK INLET	AK	2.32	8.77	N/A	N/A	17.5	0.8	2.3	20.6		4H/L,1910	N/A	Chinulna Pt.		61.020000000	-151.316666667
9455866	T-39 POINT POSSESSION (OPR-469)	AK	3.00	9.68	N/A	N/A	23.19	0.66	2.20	26.05	41-59	1Mo,Jul1975	N/A	Anchorage		61.036666667	-150.413000000
9455869	NORTH FORELAND	AK	2.71	9.03	N/A	N/A	17.88	0.61	2.08	20.57	41-59	107H/L,Jun-Aug1975	N/A	Nikiski	GP changed 5/5/98	61.048300000	-151.158300000
9455885	PHILLIPS PLATFORM	AK	2.79	9.21	N/A	N/A	19.20	0.64	2.19	13.04	60-78	1Mo,Jul1975	N/A	Anchorage	not verified	61.076700000	-150.951666667
9455909	THREE MILE CREEK, COOK INLET	AK	2.68	9.18	N/A	N/A	19.2	0.8	2.3	22.3		7H/8L,1919	N/A	Chinulna Pt.		61.143333333	-151.075000000
9455911	FIRE ISLAND (WEST SIDE)	AK			N/A	N/A	24.6	0.7	2.2	27.5		22H/21L,May1941	N/A			61.156666667	-150.240000000
9455912	FIRE ISLAND	AK	3.27	10.00	N/A	N/A	24.01	0.65	2.08	26.74	60-78	108H/107LMay-Jun1962	N/A	Anchorage		61.173333333	-150.213333333
9455915	PT. WORONZOF	AK	3.41	10.15	N/A	N/A	24.43	0.68	2.12	27.23	60-78	2Mo,Jul-Aug1971	N/A	Anchorage		61.196666667	-150.030000000
9455920	ANCHORAGE, KNIK ARM, COOK INLET	AK	3.72	10.42	N/A	N/A	26.25	0.71	2.28	29.24	60-78	8Yr,1984-91	N/A	Seldovia		61.238333333	-149.888333333
9455921	ANCHORAGE (ADR)	AK			N/A	N/A							N/A			61.238333333	-149.888333333
9456043	HARRIET POINT	AK	0.50	6.72	N/A	N/A	14.19	0.70	1.95	16.84	41-59	100H/99L,Jun-Jul1974	N/A	Seldovia		60.403333333	-152.255000000
9456094	REDOUBT PT	AK	0.33	6.50	N/A	N/A	14.01	0.44	1.95	16.40	41-59	1Mo,Jul75	N/A	Nikiski		60.301666667	-152.385000000

Figure 4-11 CORANGE LINE of GREENWICH, High and Low Water Intervals (In Hours)

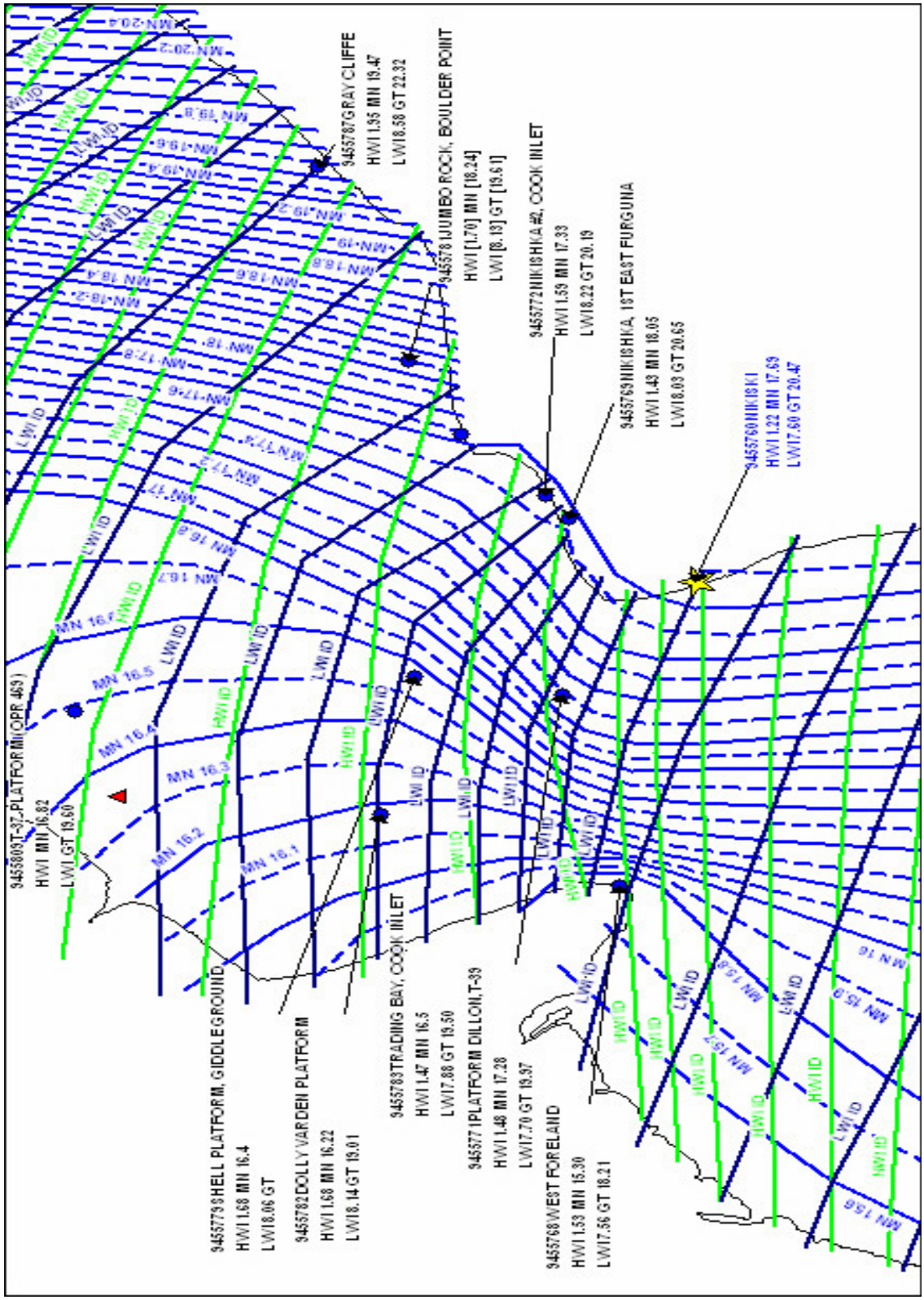


Figure 4-12 TIDAL ZONING for APPROACHES TO NIKISKI, ALASKA

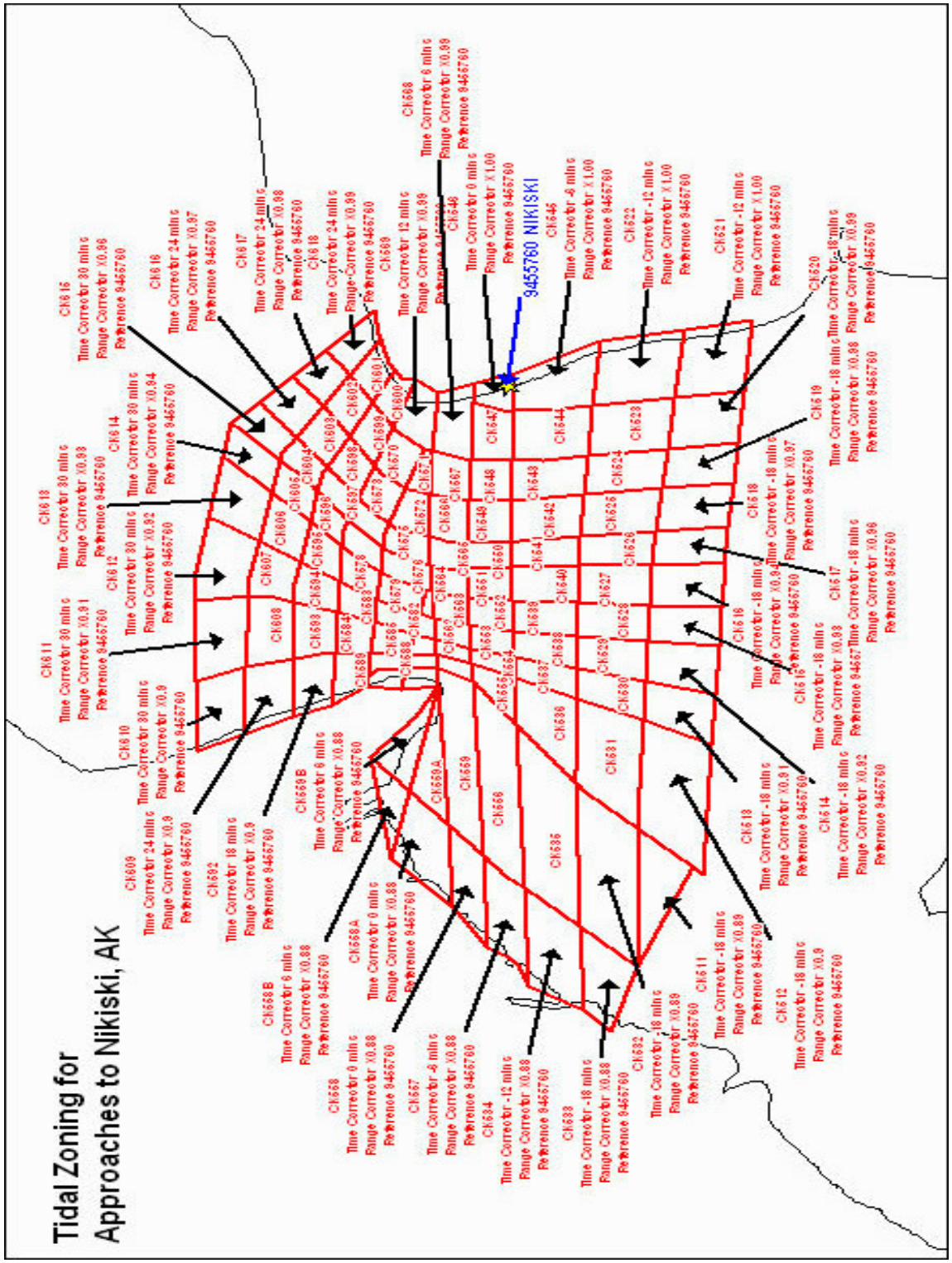


Figure 4.13 Example Tide Reducer File from NOAA acoustic system

STATION	DATE/TIME	WL VALUE on MLLW	WL SIGMA	inferred	quality control flags: flat	rofc	temp
	utc	meters	meters				
9414290	10/1/98 0:00	1.373	0.042	0	0	0	0
9414290	10/1/98 0:06	1.390	0.043	0	0	0	0
9414290	10/1/98 0:12	1.403	0.036	0	0	0	0
9414290	10/1/98 0:18	1.424	0.039	0	0	0	0
9414290	10/1/98 0:24	1.426	0.033	0	0	0	0
9414290	10/1/98 0:30	1.436	0.034	0	0	0	0
9414290	10/1/98 0:36	1.458	0.032	0	0	0	0
9414290	10/1/98 0:42	1.489	0.035	0	0	0	0
9414290	10/1/98 0:48	1.507	0.032	0	0	0	0
9414290	10/1/98 0:54	1.520	0.038	0	0	0	0
9414290	10/1/98 1:00	1.533	0.042	0	0	0	0
9414290	10/1/98 1:06	1.537	0.029	0	0	0	0
9414290	10/1/98 1:12	1.541	0.033	0	0	0	0
9414290	10/1/98 1:18	1.548	0.032	0	0	0	0
9414290	10/1/98 1:24	1.572	0.033	0	0	0	0
9414290	10/1/98 1:30	1.596	0.037	0	0	0	0
9414290	10/1/98 1:36	1.609	0.039	0	0	0	0
9414290	10/1/98 1:42	1.624	0.036	0	0	0	0
9414290	10/1/98 1:48	1.639	0.040	0	0	0	0
9414290	10/1/98 1:54	1.638	0.036	0	0	0	0
9414290	10/1/98 2:00	1.649	0.032	0	0	0	0
9414290	10/1/98 2:06	1.658	0.036	0	0	0	0
9414290	10/1/98 2:12	1.659	0.033	0	0	0	0
9414290	10/1/98 2:18	1.660	0.041	0	0	0	0
9414290	10/1/98 2:24	1.671	0.029	0	0	0	0
9414290	10/1/98 2:30	1.669	0.039	0	0	0	0
.	.	.	.				
.	.	.	.				
.	.	.	.				
.	.	.	.				
9414290	11/30/98 23:00	0.350	0.120	0	0	0	0
9414290	11/30/98 23:06	0.342	0.124	0	0	0	0
9414290	11/30/98 23:12	0.343	0.090	0	0	0	0
9414290	11/30/98 23:18	0.359	0.106	0	0	0	0
9414290	11/30/98 23:24	0.389	0.079	0	0	0	0
9414290	11/30/98 23:30	0.412	0.087	0	0	0	0
9414290	11/30/98 23:36	0.446	0.128	0	0	0	0
9414290	11/30/98 23:42	0.459	0.102	0	0	0	0
9414290	11/30/98 23:48	0.399	0.089	0	0	0	0
9414290	11/30/98 23:54	0.463	0.136	0	0	0	0

4.6. Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for the installation, maintenance, and removal of stations, and the formatted digital water level data collected by the water level measurement system required for NOS quality control and ingestion into the NOS data base management system. In addition, documentation for processing and tabulation of the data, tidal datum computation, and final tidal zoning are required.

Data submission requirements for GPS project consists of project reports, station (bench mark) description or recovery notes, observation log sheets, station visibility diagrams, photographs or rubbings of station marks, raw GPS data, Rinex GPS data, and other info as pertinent.

4.6.1. Station Documentation

The documentation package shall be forwarded to CO-OPS within 10 business days of: a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station. Refer to Section 4.2.6 for general documentation requirements and Figure 4.14, Water Level Station Documentation Checkoff List. The station documentation generally includes, but is not limited to the following:

(a) Field Tide Note

(b) Calibration test documentation from an independent source other than the manufacturer for each sensor used to collect water level or ancillary data.

(c) NGWLMS Site Report (see *Next Generation Water level Measurement System Site Design, Preparation, and Installation Manual*) , and/or Tide Station Report (NOAA Form 77-12), or Great Lakes Water Level Station Report (NOAA Form 77-75) or equivalent. Contractor created Site Reports are acceptable as long as the reports provide same required information.

(d) New or updated Nautical chart section or U.S. Geological Survey quadrangle map indicating the exact location of the station, with chart number or map name and scale shown.

(e) Large-scale sketch of the station site and digital GIS compatible file provided on diskette showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from handheld GPS) of the gauge and all bench marks.

(f) New or updated description of how to reach the station from a major geographical landmark.

(g) Photographs of station components and bench marks. Digital photographs are preferred. As a minimum, photographs shall show a view of the water level measurement system as installed, including sensors and DCP; a front view of the staff (if any); multiple views of the surroundings and other views necessary to document the location; and photographs of each bench mark, including a location view and a close-up showing the bench mark stamping. All photographs shall be annotated and referenced with the station name, number, location, and date of the photograph.

(h) Description/Recovery Notes of Bench Marks (see *User's Guide for Writing Bench Mark Descriptions*, NOAA/NOS, Updated January 2003).

(I) Level records and level abstract, including level equipment information.

(j) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor "zero" is referenced to the bench marks.

4.6.2. GPS Project Documentation

The following information shall be submitted to CO-OPS at the end of the project so that proper information can be forwarded to NGS.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the "Data Submission to NGS Section" of NGS-58 and the "Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base" to become part of the NSRS.

GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - Receiver Independent Exchange Format (RINEX) data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

GPS forms in PDF format can be found at the following NGS Federal Base Network web site:

http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm

Refer to Figures 4.16 through 4.22 for GPS projects submission checklist and sample package contents.

(A) Project report (Refer to Figure 4.16):
One project report per GPS project is required.

(B) Station (bench mark) description or recovery notes (Refer to Figure 4.17)
One per bench mark, for which GPS observations are submitted, is required.

(C) Observation log sheets (Refer to Figure 4.18 and 4.19)
One per each GPS observation session is required.

(D) Station/bench mark visibility diagrams (Refer to Figure 4.20)
One per each bench mark, for which GPS observations are submitted, is required.

(E) Photographs or rubbings of station (bench) marks (Refer to Figure 4.22 and 4.21)
One per each bench mark, for which GPS observations are submitted, is required.

(F) Raw GPS data

(G) Rinex GPS data

Figure 4.14

I. For Each Water Level Station:

PROJECT DOCUMENTATION AND DATA CHECKOFF LIST

Project Number: _____ Locality: _____

Station Number: _____ Station Name: _____

A. Field Tide Note

____ 1.Verify latitude and longitude with handheld GPS.
____ 2.Verify dates.

B. Site Report (required for both installation and removal)

____ 1.All applicable information complete, especially serial numbers of DCP/sensors and dates of installation/removal of DCP/sensors and levels.
____ 2.Verify latitude and longitude (ensure that this is the same as on the field tide note).
____ 3.Denote latitude and longitude as NAD 83. Also note if position was derived from handheld GPS.

C. Chart Section

____ 1.Ensure that station location is clearly depicted with circle and station number.
____ 2.Note chart number, edition, date and scale.

D. Bench Mark/Station Location Sketch

____ 1.Gage/staff and bench marks shown.
____ 2.Title block provided (NOAA Form 76-199).
____ 3.North arrow depicted.
____ 4.Include hard copy sketch and GIS digital format on diskette.

E. Photographs

____ 1.Digital photographs of gage, staff and surrounding area.

F. Bench Mark Descriptions/Recovery Notes

____ 1.Stampings for new and recovered marks verified.
____ 2.Descriptions for new marks provided in NOS format (WordPerfect).
____ 3.Recovery notes provided for all historical marks.

Figure 4.14 (continued)

G. Levels

____ 1.Ensure all information written in ink.
____ 2.Cover information complete; station name, number, instrument and rod type, serial numbers, date, personnel.
____ 3.Note types of levels; installation, bracketing and closing.
____ 4.Staff information complete (if applicable).
____ 5.Collimation check shown.
____ 6.Note that bench mark descriptions are submitted on separate sheets.
____ 7.Headers on all applicable pages complete.

H. Datum Offset Computation Worksheet

____ 1. Submit for stations using Vitel or Sutron 8200 DCP with Aquatrak sensor.

I. Data Submitted on Diskettes

____ 1.Label diskettes with contractor name and list of files on each diskettes.
____ 2.Data files should be named in the following format: xxxxxxx1.dat, where xxxxxxx = seven digit station number and 1 is the DCP designation. For multiple files from the same station, change the extension, i.e., xxxxxxx1.da1, da2, etc.
____ 3.Check the begin and end dates of data submitted with dates of hydrographic operations.
____ 4.Check data continuity.

II For the Project:

A. Files

____ 1. GIS files for final zoning
____ 2. Final Tide Reducer Files for each H-Sheet

B. Final Tide Notes

____ 1.Final Tide Note for each H-Sheet

C. Transmittal Letter

____ 1.Transmittal letter attached with current contractor address, phone number and email.

D. All Documentation Enclosed in Tide Level Envelope (NOAA Form 75-29A)

____ 1.Leave “sheets” box blank, complete other information in title boxes.
____ 2.Verified complete by Contractor and Include date.

Figure 4.15: **FINAL TIDE NOTE and FINAL TIDAL ZONING CHART**

DATE: December 22, 1999

HYDROGRAPHIC BRANCH: Pacific
HYDROGRAPHIC PROJECT: OPR-P342-RA-99
HYDROGRAPHIC SHEET: H-10910

LOCALITY: 6 NM Northwest of Cape Kasilof, AK

TIME PERIOD: July 22 - August 20, 1999

TIDE STATION USED: 945-5711 Cape Kasilof, AK
Lat. 60º 20.2'N Lon. 151º 22.8'W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 5.850 meters

REMARKS: RECOMMENDED ZONING
Use zone(s) identified as: CK394, CK395, CK399, CK400, CK401, CK407, CK408, CK409, CK434, CK435, CK441, CK442, CK443, CK467, CK468, CK469, CK470, CK477, CK480, CK481, CK482, CK483, CK493 & CK494.

Refer to attachments for zoning information.

Note 1: Provided time series data are tabulated in metric units (Meters), relative to MLLW and on Greenwich Mean Time.

Note 2: Nikiski, AK served as datum control for subordinate tide stations and for tidal zoning in this hydrographic survey. Accepted datums for this station have been updated recently and have changed significantly from previous values.

The current National Tidal Datum Epoch (NTDE) used to compute tidal datums at tide stations is the 1960-78 NTDE. Traditionally, NTDEs have been adjusted when significant changes in mean sea level (MSL) trends were found through analyses amongst the National Water Level Observation Network (NWLON) stations. Epochs are updated to ensure that tidal datums are the most accurate and practical for navigation, surveying and engineering applications and reflect the existing local sea level conditions. For instance, analyses of sea level trends show that a new NTDE is necessary and efforts are underway to update the 1960-1978 NTDE to a more recent 19-year time period.

Note: This example of Field Tide Note and Final Tidal Zoning Chart was written in December 1999, at that time NTDE was 1960-1978, now the new NTDE is 1983-2001.

Figure 4.15 (continued)

However, analyses also show that there are several geographic areas whose sea level trends are strongly anomalous from the average trends found across the NWLON and thus, must be treated differently. One of these areas is in Cook Inlet, Alaska. Nikiski has shown a significant relative sea level change due to continued vertical land movement after the 1964 earthquake. NOS has adopted a procedure for computing accepted tidal datums for this anomalous region by using an MSL value calculated from the last several years of data rather than the 19-year NTDE. The accepted range of tide is still based on the 19-year NTDE and, when applied to the updated MSL, will result in updated values for Mean High Water (MHW) and Mean Lower Low Water (MLLW) derived through standard datum calculation procedures. For Nikiski, the MSL value was computed from the period of 1994-1998. This resulted in a lowering of the MLLW datums relative to land by approximately 1.0 ft at Nikiski compared to the previous MLLW elevations used in surveys prior to January 1, 1998. Subordinate tide stations in the area used for hydrographic surveys and controlled by Nikiski will be affected similarly. Accepted datums have been computed and may be accessed on the Internet through the URL specification **http://www.co-ops.nos.noaa.gov**.

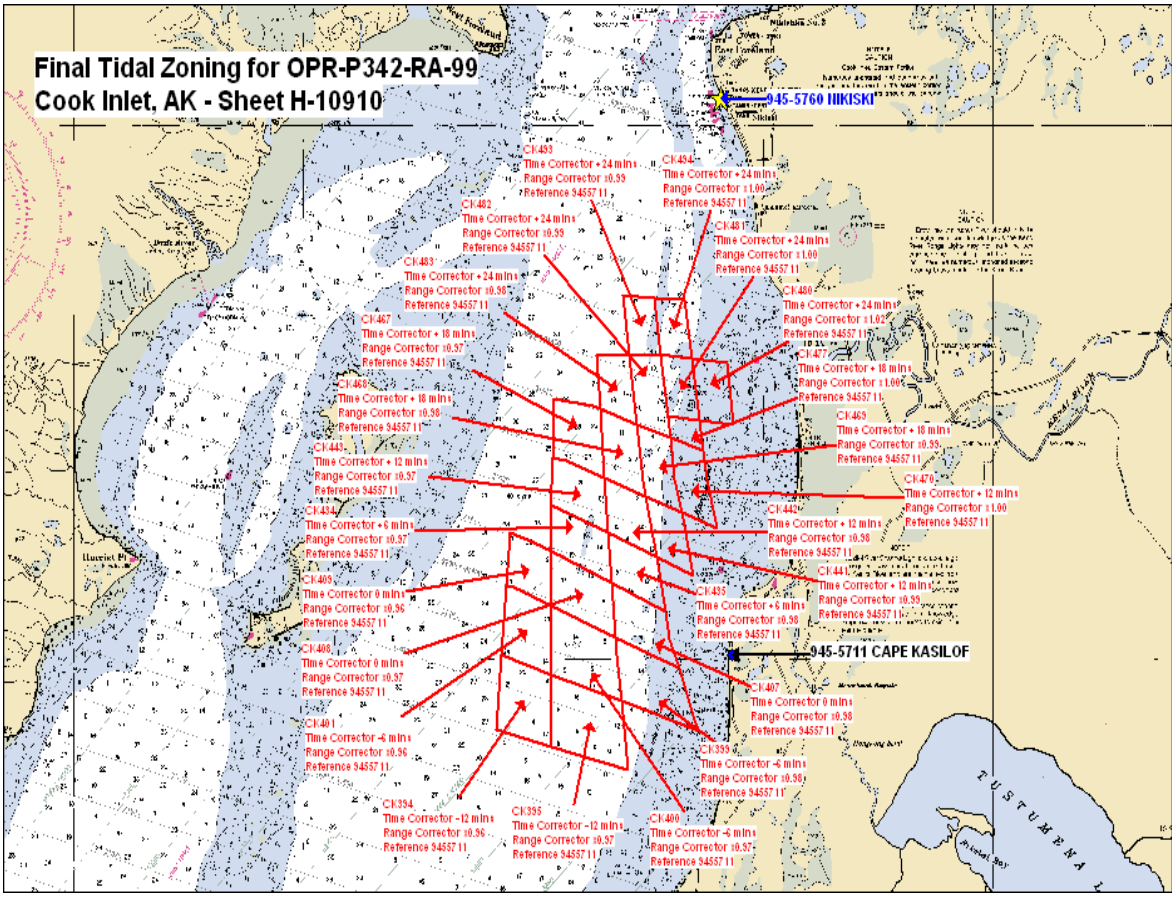


Figure 4.16 **PROJECT SUBMISSION CHECKLIST**
GPS PROJECTS

Project Title : _____

Submitting Agency: _____

Observing Agency: _____

Receiver Type: _____

Antenna Type: _____

PACKAGE CONTENTS

( ) Project Report

( ) Station Description or Recovery notes

( ) Observations Logs Sheets
Data which must be filled out: Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name

( ) Station Visibility Diagrams

( ) Photographs or Rubbings of Station Marks

( ) Raw GPS data

( ) Rinex GPS Data - See below

( ) Other

DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx
Where: aaaa = alphanumeric 4-character station identifier, ddd = day of year, s = session, yy = year of observations, and xxx is the receiver-dependent file extension (e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 Navigation File: aaaaddds.yyn
RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames from station BALD 2 on session A of 12/31/98 are BALD365A.98o and BALD365A.98n Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

Figure 4.17: Station (Bench mark) Description/ Recovery Form

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY
STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET

Country: (USA / USA) State: OR County: LINCOLN

Latitude: N 44 49 49.17802 " Longitude: W 124 03 56.23447 " Elevation: 17.0 (meter / ft)

Original Description (check one):	
☐ P	Preliminary (mark has not been set yet)
☐ D	A newly set mark
☑ R	A recovered mark
Established by: (NGS / CGS / Other:)	Oregon DOT
Date:	Chief of Party (initials): ???

Recovery Description (check one):	
☐ F	Full description of a station *not* in the database
☑ T	Full description of a station *in* the database
☐ M	*Partial* description of a station in the database
Recovered by: (NGS / Other:)	Oregon DOT
Date:	Chief of Party (initials): CFS

Monument Stability (check one):	
☑ A	Of the most reliable nature; expected to hold well
☐ B	Will probably hold position and elevation well
☐ C	May hold well, but subject to ground movement
☐ D	Of questionable or unknown reliability

Recovery Condition (check one):	
☑ G	Recovered in good condition
☐ N	Not recovered or not found
☐ P	Poor, disturbed, or mutilated
☐ X	Surface mark known destroyed

Setting Information:	
Marker Type: (Rod / Disk / Other)	
Setting Type: (Bedrock / Concrete / Other:)	
☑ / N / ?	Monument contains magnetic material?

Stamping:	BALD 2 1991
Agency Inscription: (NGS / CGS / Other:)	Oregon DOT
Rod Depth: (meter/ft), Sleeve Depth:	(meter/ft)
Monument is: (flush / projecting / recessed)	(cm/inch)

Special Type (check all applicable):	
☐ F	Fault monitoring site
☐ T	Tidal Station
☑ --	Control Station: (FBN / CBN / Benchmark)
☐ --	Airport Control Station: (PACS / SACS)
☑ /N	Mark is suitable for GPS use?

Transportation (check one):	
☑ C	Car
☐ P	Light truck (pickup, carry-all, etc.)
☐ X	Four-Wheel Drive Vehicle
☐ __	Other (SnowCat, Plane, Boat; describe)
☑ /N	Pack Time (hike) to mark? (hh:mm): 00:03

See Back of Form to add Text Description

General Station Location: The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Pack northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: John Q. Surveyor Phone: (301) 713-3194 e-mail: jqs@ordot.gov

Figure 4.18: GPS Station Observation Log

--> Click here to clear the sample data <--

GPS STATION OBSERVATION LOG (01-Nov-2000)

Station Designation: (check applicable: FBN / CBN / PAC / SAC / PM) BALD 2 RESET		Station PID, if any: QE2736	Date (UTC): 31-Dec-98
General Location: Boiler Bay Wayside	Airport ID, if any: ---	Station 4-Character ID: BALD	Day of Year: 365
Project Name: Sample GPS, 1998	Project Number: GPS- 1234	Station Serial # (SSN):	Session ID:(A,B,C etc) A

NAD83 Latitude: 44° 49' 49.17802"	NAD83 Longitude: 124° 03' 56.23447"	NAD83 Ellipsoidal Height: -6.44 meters NAVD88 Orthometric Ht.: 17.0 meters GEOID99 Geoid Height: -23.52 meters	Agency Full Name: Oregon DOT Operator Full Name: John Q. Surveyor Phone #: ( ) (301) 713-3194 e-mail address: jqs@ordot.gov
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30 Actual Start 11:55 Stop 17:32	Epoch Interval= 15 Seconds Elevation Mask = 10 Degrees		

GPS Receiver:
Manufacturer & Model: Leica SR530
P/N: p/n 667122
S/N: s/n 0030354
Firmware Version: Version 3.0
✔ CamCorder Battery, ☐ 12V DC, ☐ 110V AC, ☐ Other

GPS Antenna:
Manufacturer & Model: Trimble Choke Ring
P/N: p/n 29659-00
S/N: s/n 02200-63591
Cable Length, meters: 30 meters
Vehicle is Parked 25 meters N (direction) from antenna.

		Circle Yes or No -If no, explain "
Antenna plumb before session?	✔ (Y / N)	
Antenna plumb after session?	✔ (Y / N)	
Antenna oriented to true North?	✔ (Y / N)	
Weather observed at antenna ht	✔ (Y / N)	
Antenna ground plane used?	✔ (Y / N)	
Antenna radome used?	(Y / N) ✔	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N) ✔	
Any obstructions above 10°?	(Y / N) ✔	
Radio interference source nearby	(Y / N) ✔	

Tripod or Ant. Mount: Check one:
✔ Fixed-Height Tripod, ☐ Slip-Leg Tripod, ☐ Fixed Mount
Manufacturer & Model: SECO
P/N: none.
S/N: 97-G
Last Calibration date: 1998-11-01

Tribrach: Check one:
✔ None, ☐ Wild GDF 22, ☐ Topcon, ☐ Other (describe)
Last Calibration date:

**** ANTENNA HEIGHT ****
(see back of form for measurement illustration)

	Before Session Begins: measure and record both Meters	AND Feet	After Session Ends: measure and record both Meters	AND Feet
A= Datum point to Top of Tripod (Tripod Height)	2.000		2.000	
B= Additional offset to ARP if any (Tribrach/Spacer)	-0.003		-0.003	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				

Note: Meters = Feet X (0.3048)
Height Entered Into Receiver = 2.000 meters.
Please note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer:
Manufacturer & Model: pretel altiplus A2
P/N: none.
S/N: J.Q.S.
Last Calibration or check Date: 11-Sep-01

Psychrometer:
Manufacturer & Model: Psychrodyne
S/N: J.Q.S.

Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit	Celsius	WetBulb Temp Fahrenheit	Celsius	Rel. % Humidity	Atm. Pressure inches Hg	millibar	Weather Codes *
Before	12:00	74.0		68.0		74	29.4		00000
Middle	14:45	77.0		72.5		81	29.6		00001
After	17:30	82.5		78.0		82	29.7		00102
Average of Readings				Calculate					* See back of form for codes

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

1. Winds, calm at start, gradually increased to 20 knots by end of session.

2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment.

3. Center pole of tripod projected 3 mm into dimple of disk.
Antenna height was therefore 2 m - 3 mm = 1.997 m

Note: Entries are Required in all Unshaded areas.

Data File Name(s): BALD365A.dat
(Standard NGS Format = aaaadddd.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description:	✔ Attached	☐ Submitted earlier	LOG CHECKED BY: JGE
Visibility Obstruction Form:	✔ Attached	☐ Submitted earlier	
Photographs of Station:	✔ Attached	☐ Submitted earlier	
Pencil Rubbing of Mark:	✔ Attached		

Figure 4.19: GPS Antenna Height Measurements

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length **(A)** and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) **(B)**

$$Antenna.Height = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm= inch x (2.54)		Overall average, cm		

S = _____ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

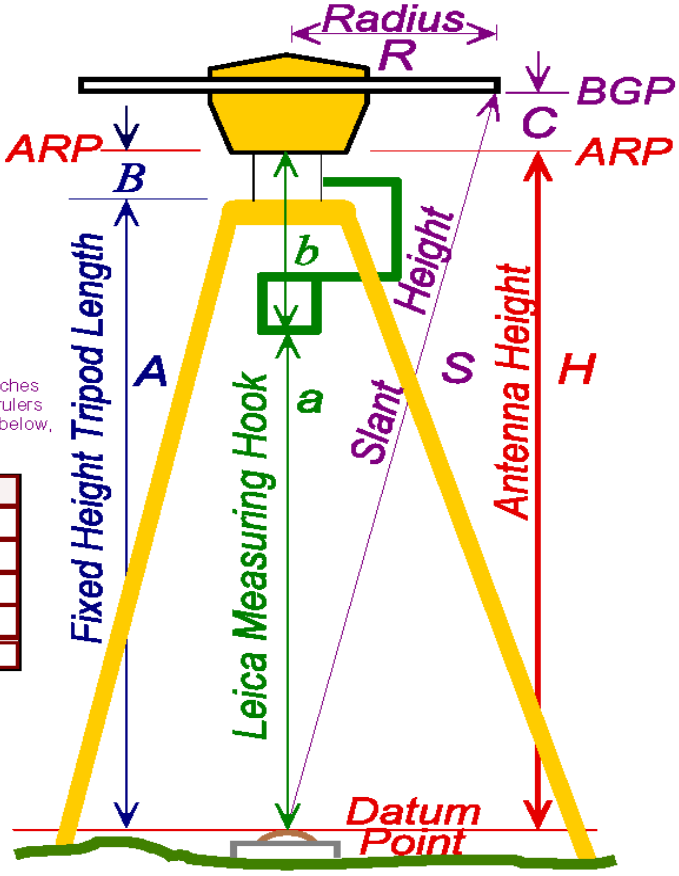
R = 19.05 cm

C = 3.50 cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$Antenna.Height = H = ((\sqrt{S^2 - R^2}) - C)$$



III. Instructions for using the Leica Brand Measuring Hook:

Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

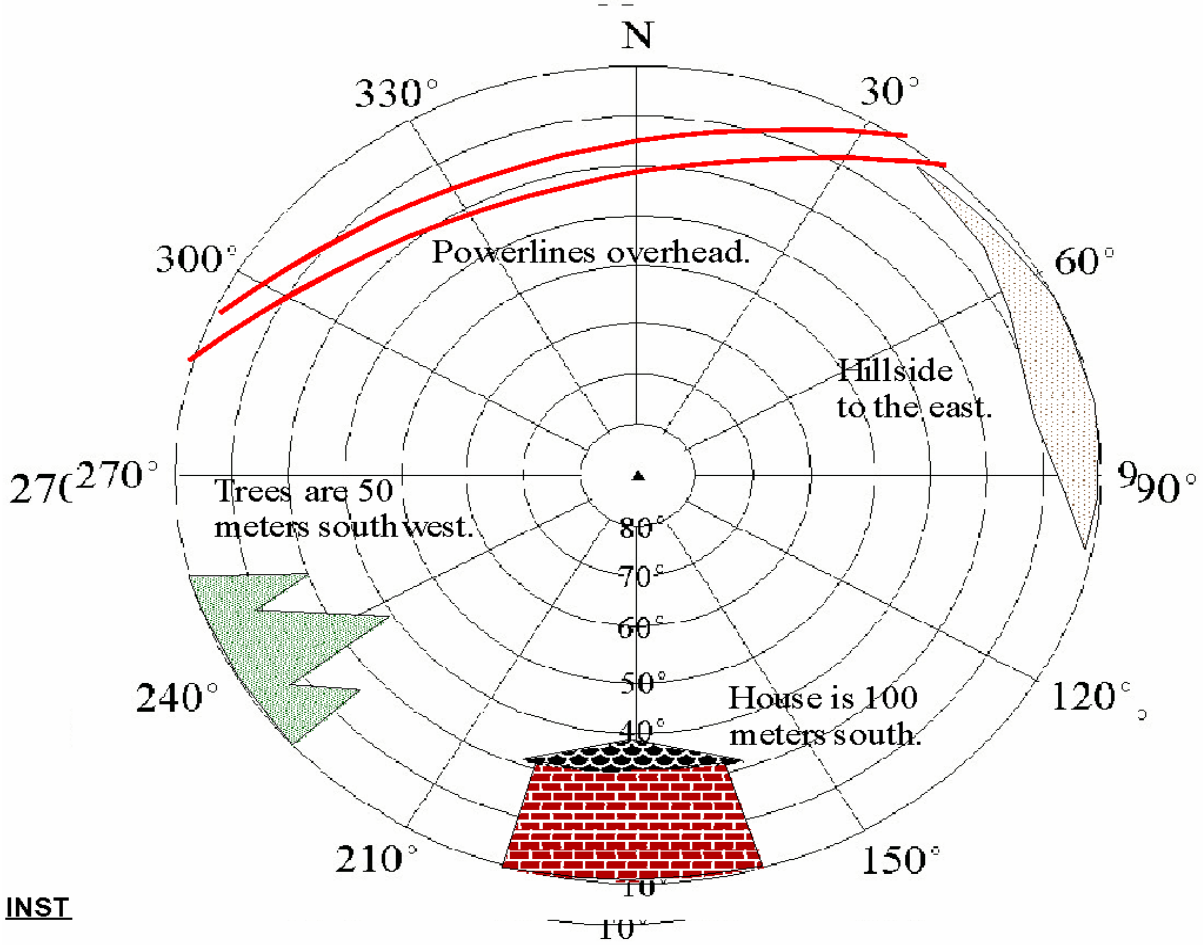
$$Antenna.Height = H = a + b$$

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80°F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80°F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over15mph (24km/h)
Examples: Code 00000 =	0 - No problems,	0 - good visibility,	0 - normal temperature,	0 - clear sky,	0 - calm wind
Code 12121 =	1 - Problems,	2 - poor visibility,	1 - hot temperature,	2 - overcast,	1 - moderate wind

Figure 4.20: Visibility Obstruction Diagram

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY
VISIBILITY OBSTRUCTION DIAGRAM



INST

Identify obstructions by azimuth (magnetic) and elevation angle (above horizon) as seen from station mark.
Indicate distance and direction to nearby structures and reflective surfaces (potential multipath sources).

Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

Reconnaissance By: John Q. Surveyor Height above mark: 2 Meters

Agency/Company: Oregon DOT Phone: ((301))713-3194 Date: 1998-12-31

Figure 4.21: Station Pencil Rubbing Form

Station Pencil Rubbing Form

--> Click here to clear the sample data <--

Location / Airport Name and ID: Boiler Bay Wayside Project: Sample GPS, 1998

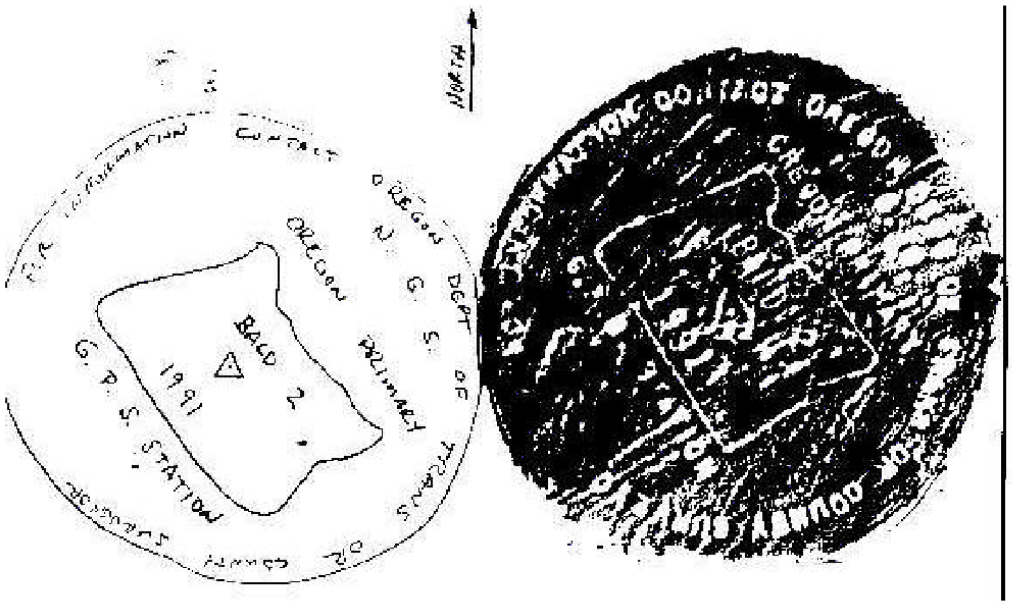
Station Designation: BALD 2 RESET PID: QE2736 Date: 1998-12-31

Circle all applicable: PACS SACS PM FBN CPN OTHER_____

Observer & Organization: John Q. Surveyor, ORDOT

Station Pencil Rubbing

Instructions: Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.



Remarks:
This disk is reset into the same drill hole as the original station BALD 1962.

Monument Type: Brass Disk

Inscribed Agency: Oregon DOT

Stamping: BALD 2 1991

Figure 4-22: Digital Photograph of a Stamping of a Bench Mark

4.6.3. Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum and shall be referenced to UTC. The final tide reducer time series data shall be referenced to MLLW and shall be referenced to UTC. The contractor must provide CO-OPS with the water level data from all tide gauges installed with in 90 days of removal of stations/gauges.

The original raw water level data and also the correctors used to convert the data to chart datum shall be retained until notified in writing or at least two years after the survey is completed. All algorithms and conversions used to provide correctors shall be fully supported by the calibrations, maintenance documentation, leveling records, and sound engineering/oceanographic practices. Sensors for measurements used to convert data (e.g. pressure to heights) shall be calibrated and maintained for the entire water level collection period.

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting, Libraro, 1998). These satellite messages are then decoded by NOS DMS upon receipt from NESDIS before further processing and review by CORMS can be completed. If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS, as shown in the format below, in a digital format, on 3.5 inch floppy disks, CD-ROM, or by email as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances. Data download files shall be named in the following format: xxxxxxxy.DAZ, where xxxxxxx is the seven digit station number, y is the DCP number (usually 1), and DAZ is the extension (where Z = 1,2,3...if more than one file is from the same station and DCP). This is the format needed when the data is loaded into DMS.

The 6-minute interval data (acoustic sensor and pressure sensor examples follow) shall have the following format once decoded:

Acoustic Sensor Data (XXX.ACO format)

Column 1-7	Station ID (assigned in the project instructions)
Column 8	1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19	Date (MMM DD YYYY format, e.g. JAN 01 1998)
Column 20	Blank
Column 21-22	Hours in 24 hour format (i.e. 01, 01, ..., 23)
Column 23	: (place a colon)
Column 24-25	Minutes (00,06,12,etc..)
Column 26-32	Data value in millimeters, right justified, (e.g. 1138)
Column 33-38	Sigma (standard deviation in millimeters in integer format)
Column 39-44	Outlier (integer format)
Column 45-50	Temperature 1 (tenth of degrees C in integer format)
Column 51-56	Temperature 2 (tenth of degrees C in integer format)
Column 57-58	Sensor type (A1 for acoustic type)
Column 59-60	blank
Column 61-61	Data Source (S for Satellite, D for Diskette)

Sample data:

```
85169901AUG 17 1993 05:00   1138   23    0   308   297A1 S
85169901AUG 17 1993 05:06   1126   26    0   308   298A1 S
85169901AUG 17 1993 05:12   1107   26    1   309   298A1 S
```

Pressure Sensor Data (XXX.BWL format)

Column 1-7	Station ID (assigned in the project instructions)
Column 8	1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19	Date (MMM DD YYYY format, e.g. JAN 01 1998)
Column 20	Blank
Column 21-22	Hours in 24 hour format (i.e. 01, 01, ..., 23)
Column 23	: (place a colon)
Column 24-25	Minutes (00-59)
Column 26-32	Data value in millimeters, right justified, (e.g. 1138)
Column 33-38	Sigma (standard deviation in millimeters in integer format)
Column 39-44	Outlier (integer format)
Column 45-50	DCP temperature (tenth of degrees C in integer format)
Column 51-52	Sensor type (B1 for pressure type)
Column 53-53	blank
Column 54-54	Data Source (S for Satellite, D for Diskette)

```
85169901AUG 17 1993 05:00   1138   23    0   308B1 S
85169901AUG 17 1993 05:06   1126   26    0   308B1 S
85169901AUG 17 1993 05:12   1107   26    1   309B1 S
```

Note: pressure data must be accompanied by documented staff observations as listed in Section 4.2.2. and 4.2.4.

4.6.4. Tabulations and Tidal Datums

For contract surveys, the contract hydrographer shall provide digital and hard copies of tabulations of staff/gauge differences, hourly heights, high and low waters, and monthly means for the entire time series of observations from each station. Along with the final contractor computed tidal datums, the contractor shall provide copies of the tide-by-tide and/or monthly mean simultaneous comparison sheets from which the final tidal datums were determined. Audit trails of data edits and gap-filling shall be summarized and provided also.

The digital tabulation files for hourly heights and high and low waters shall have the following formats:

Hourly height data

COLUMN	
1 - 7	Station ID number
8 - 11	Year
12 - 13	Month
14 - 15	Day
16	Line Number (1 = 1st line of day for 0 to 11 hours, 2 = 2nd line of day for 12 to 23 hours).
17 - 20	Time Meridian (Example: 000W)

21 - 26	0/12 Hourly height in meters (to millimeter resolution)
27 - 32	1/13 Hourly height in meters (to millimeter resolution)
33 - 38	2/14 Hourly height in meters (to millimeter resolution)
39 - 44	3/15 Hourly height in meters (to millimeter resolution)
45 - 50	4/16 Hourly height in meters (to millimeter resolution)
51 - 56	5/17 Hourly height in meters (to millimeter resolution)
57 - 62	6/18 Hourly height in meters (to millimeter resolution)
63 - 68	7/19 Hourly height in meters (to millimeter resolution)
69 - 74	8/20 Hourly height in meters (to millimeter resolution)
75 - 80	9/21 Hourly height in meters (to millimeter resolution)
81 - 86	10/22 Hourly height in meters (to millimeter resolution)
87 - 92	11/23 Hourly height in meters (to millimeter resolution)

High and Low Water data

COLUMN

1 - 7	Station ID Number	
8 - 9	Year	
10 - 11	Month	
12 - 13	Day	
14 - 17	Time Meridian (Example: 075W)	
18 - 26	First Tide	
	18	1 = High
		2 = Low
		3 = Higher High
		4 = Lower Low
	19	0 Nothing unusual/Normal
		1 If Inferred Tide
		2 If Flat Tide
		3 If Extra Tide
		4 If Inferred and Flat Tide
		5 If Extra and Flat Tide
	20 - 22	Hour (Tenths of Hours)
	23 - 27	Height (in meters to millimeter resolution)
28 - 37	Second Tide	
38 - 47	Third Tide	
48 - 57	Fourth Tide	
58 - 67	Fifth Tide (If any)	
68 - 77	Sixth Tide (If any)	
78 - 87	Seventh Tide (If any)	

4.6.5. Tide Reducers and Final Zoning and Final Tide Note

The final zoning scheme shall be fully supported by documentation of data and methodology which comprised the final zoning model. The contractor must provide CO-OPS with his/her final tidal zoning scheme digitally and it must be in the MAPINFO or ARCVIEW compatible format. Final tidal zoning scheme in AUTOCAD format is not acceptable.

Final tide reducers shall be submitted in the specified format.

All documentation listed below shall be forwarded to CO-OPS:

(b) Contractor created summary files.
(c) Documentation of NOS summary files utilized for final zoning
(c) GIS compatible zoning development steps including geographical presentation of summary data and cophase/corange maps
(d) GIS compatible digital final zoning files
(e) Final tide reducer data files
(f) Final Tide Note

The final zoning scheme shall be fully supported by documentation of data and methodology which comprised the final zoning model.

4.6.6. Submission

The check list in Figure 4.14 shall be used to check and verify the documentation that is required for submission. All documentation, water level data, GPS info and data, and other reports as required shall be forwarded to the following address:

NOAA, National Ocean Service
Thomas Mero
Chief, Requirements and Development Division
SSMC4 - Station 6531, N/OPS1
1305 East-West Highway
Silver Spring, MD 20910

Voice: 301-713-2897 ext. 145
Fax: 301 - 713-4436

4.7. Guidelines and References

References for the water level measurement and leveling requirements issued by the NOS Center of Operational Oceanographic Products and Services (CO-OPS) and the National Geodetic Survey (NGS) are listed below.

Some of these documents are available on CO-OPS web site at http://www.CO-OPS.nos.noaa.gov.

1 Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991.

2. User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, NOAA/NOS, dated October 1987.

3. User's Guide for Writing Bench Marks Descriptions, NOAA/NOS, Updated January 2003.

4. User's Guide for Electronics Levels, NOAA/NOS, updated January 2003.

5. User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998.

6. User's Guide for 8200 Acoustic Gauges, NOAA/NOS, updated August 1998.

7. User's Guide for 8210 Bubbler Gauges, NOAA/NOS, updated February 2001.

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19. Geodetic Leveling, NOAA Manual NOS NGS 3, U.S. Department of Commerce, NOAA, National Ocean Survey, August, 1981.

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5. Depth Sounding

5.1. Sounding Units

Depths shall be recorded in meters, with a precision of at least tenths of meters. Plotting units for final deliverables will be specified in the Hydrographic Survey Letter Instructions or Statement of Work.

5.2. Accuracy and Resolution Standards

5.2.1 Accuracy Standards

NOS standards for the accuracy of measured depths in hydrographic surveys apply to the systematic measurement of general water depths and to the least depths determined over wrecks and obstructions. By extension, they also apply to the elevations of rocks or other features which uncover at low water and to the measurement of overhead clearances. These standards apply regardless of the method of determination; whether by single beam echosounder, Multibeam echosounder, lead line or diver investigation.

The total sounding error in a measured depth at the 95 percent confidence level, after systematic and system specific errors have been removed, shall not exceed:

$$\pm\sqrt{[a^2 + (b * d)^2]}$$

where in depths less than 100 meters, a = 0.5 meters and represents the sum of all constant errors, (b * d) represents the sum of all depth dependent errors, b = 0.013 and is a factor of depth dependent error, and d is depth (in meters) (IHO S-44, Order 1).

In depths greater than 100 meters, a =1.0, b=0.023, d=depth (IHO S-44, Order 2).

The maximum allowable error in measured depth includes all inaccuracies due to residual systematic and system specific instrument errors; the velocity of sound in water; static vessel draft; dynamic vessel draft; heave, roll, and pitch; and any other sources of error in the actual measurement process, including the errors associated with water level (tide) variations (both tidal measurement and zoning errors).

For Multibeam echosounders, the total sounding error is applicable to swath widths of at least two times the water depth (i.e., 45° to both sides of nadir). However, swath widths greater than two times the water depth may be used if the depth accuracy criteria stated above is met.

5.2.2. Multibeam Resolution Standards

The hydrographer shall maintain and operate the Multibeam sonar system, from data acquisition to processing, such that it detects shoals that measure 2 meters x 2 meters horizontally and 1 meter vertically in depths of 40 meters or less. For depths greater than 40 meters, the minimum size of detectable targets shall be 10 percent of the depth for horizontal dimensions and 5 percent of the depth for vertical dimensions. Depths shall be determined and recorded with a vertical resolution no coarser than 10 centimeters. The hydrographer shall ensure that vessel speed is adjusted so that no less than 3.2 beam footprints, center-to-

center, fall within 3 m, or a distance equal to 10 percent of the depth, whichever is greater, in the along track direction.

Total swath width shall be no less than twice the water depth (i.e., 45° to both sides of nadir). The portions of the swath widths greater than twice the water depth that do not meet these resolution requirements and the accuracy requirements in Section 5.2.1 shall not be depicted on the preliminary smooth sheet or included in the digital file for the preliminary smooth sheet.

Sounding tracklines shall generally be parallel. Sinuous lines and data acquired during turns shall not be included in the final processed data, and shall not be used to meet coverage requirements.

5.3. Coverage

In general, there are two classifications of Multibeam coverage: Full Bottom Coverage and Set Line Spacing. The survey coverage technique will be specified in the Hydrographic Survey Letter Instructions or Statement of Work.

- ***Full Bottom Coverage***

Line spacing shall be such that the portions of the swaths that meet the accuracy and resolution requirements in Section 5.2 overlap to ensure that no gap in coverage exists due to the uncertainty in positioning and vessel motion.

- ***Set Line Spacing***

The hydrographer shall conduct Multibeam operations at the line spacing specified in the Hydrographic Survey Letter Instructions or Statement of Work.

5.3.1. Demonstration of Coverage

Regardless of coverage technique, the hydrographer shall demonstrate bottom coverage using a raster summary image, color coded by depth. The raster image shall be created from fully corrected data that meet accuracy and resolution specifications (see Section 5, Depth Soundings) are cleaned of all anomalous soundings, and serve as the source for all smooth sheet soundings. Each colored cell in the raster image shall be binned, line by line, using shoal biased filtering at a bin size not to exceed 5 meters + 5 percent of the depth.

The submitted digital image file shall be in a standard geo-referenced image format.

5.4. Corrections to Echo Soundings

To meet the accuracy and resolution standards for measured depths specified in Section 5.2, observed echosounder depths must be corrected for all departures from true depths attributable to the method of sounding or to faults in the measuring apparatus.

In recognition of the possibility that some discrepancies in sounding may not be detected until the post-processing phase of the survey, the determination and application of corrections to echo soundings must be accomplished and documented in a systematic manner. In addition, all corrections shall be applied in such

a way that the on-line values may be removed and replaced with a revised set of correctors in post-processing.
Corrections to echo soundings are divided into five categories, and listed below in the sequence in which they are applied:

- *Instrument error corrections* account for sources of error related to the sounding equipment itself.

- *Draft corrections* shall be added to the observed soundings to account for the depth of the echosounder transducer below the water surface.

- *Appropriate corrections for settlement and squat* shall be applied to soundings to correct the vertical displacement of the transducer, relative to its position at rest, when a vessel is underway.

- *Velocity of sound correctors* shall be applied to soundings to compensate for the fact that echosounders may only display depths based on an assumed sound velocity profile while the true velocity may vary in time and space.

- *Heave, roll, pitch, heading, and navigation timing error (latency) corrections* shall be applied to Multibeam soundings to correct the effect of vessel motion caused by waves and swells (heave, roll, pitch), the error in the vessel's heading, and the time delay from the moment the position is measured until the data is received by the data collection system (navigation timing error).

5.4.1. Instrument Error Corrections

In modern digital sounding instruments, instrument errors are generally small and of a fixed magnitude independent of the observed depth. Proper set up and adjustment of digital sounding equipment using internal checks and echo simulators will often eliminate instrument error entirely. However, to ensure the proper operation of echosounders, "confidence checks" shall be conducted periodically.

For single beam echosounders, a comparison should be made at least once per week with depths from bar checks, lead lines, or other single beam echosounders.

For Multibeam echosounders, comparisons should be made daily between the nadir (vertical) beam of the Multibeam and a single beam system or lead line.

Comparisons should be conducted during calm sea conditions, preferably in areas with a relatively flat sandy bottom. Any differences should be investigated, and if, after analysis, a corrector is necessary, it should be applied with an explanation of the cause of the difference.

5.4.2. Draft Corrections

The corrections for draft account for the depth of the transducer face below the surface of the water. Draft corrections comprise a value for the draft of the vessel at rest, sometimes known as static draft, and settlement and squat corrections which compensate for the variation in draft that occurs when the vessel is making way. The sum of the static draft and the settlement and squat correctors is known as the dynamic draft. Draft is transducer-specific. When more than one transducer is fixed to a vessel, the hydrographer must exercise care to apply the proper draft correction for each transducer.

- ***Static Draft***

The static draft, as an echo-sounding correction, refers to the depth of the transducer face below surface of the water when the vessel is not making way through the water. The required frequency of static draft measurements depends upon the range of variation in the vessel draft and the depths of water to be surveyed. For depths of 30 m or less, the static draft shall be observed and recorded to the nearest 0.1 m. Measurements are required with sufficient frequency to meet this criteria. When sounding in waters deeper than 30 m, the static draft shall be observed and recorded to the nearest 0.2 m.

Draft values for small vessels such as survey launches should be determined for the range of loading conditions anticipated during survey operations (maximum and minimum). Draft values for larger vessels must be observed and entered into the record before departing from and upon returning to port. In both cases, the draft should be determined by averaging the max/min or beginning/ending values if the differences do not exceed ±0.2 m. Otherwise, the applicable draft should be determined in 0.1 m increments. If significant changes to a vessel's draft (greater than ±0.1 m) occur, draft values shall be modified and applied accordingly.

- ***Settlement and Squat***

Transducers are generally displaced vertically, relative to their positions at rest, when a vessel is making way. Depth measurements are correspondingly affected by these vertical displacements. The displacements may be of sufficient magnitude to warrant compensation, especially when sounding at moderate to high speeds in shoal water. The factors accountable for this vertical displacement are called settlement and squat.

Settlement is the general difference between the elevation of a vessel when at rest and when making way. For lower speed, non-planing vessels, settlement is caused by a local depression of the water surface. Settlement is not an increase in the vessel displacement and, therefore, cannot be determined by reference to the water surface in the immediate vicinity. Vessels surveying at higher speeds may experience a negative settlement, or lift, when planing.

Squat refers to changes in trim of the vessel when making way and is generally manifested by a lowering of the stern and rise of the bow. Occasionally, the bow lowers on smaller vessels.

Major factors that influence settlement and squat are hull shape, speed, and depth of water beneath the vessel. Squat does not appreciably affect transducer depth on transducers mounted near amidships. Settlement, on the other hand, is almost always significant at normal sounding speeds, regardless of transducer location.

Combined effects of settlement and squat at the full range of sounding speeds must be determined to the nearest 0.05 m by the hydrographer at the beginning of the project for each vessel, including launches and skiffs used for hydrographic surveying in shoal or moderate depths. When the measurements are made, each vessel should carry an average load and have an average trim. Sounding vessel speeds (or RPM) must be entered in the hydrographic records during survey operations to permit accurate corrections for settlement and squat. If a Heave-Roll-Pitch (HRP) sensor is used to determine changes in squat, care must be taken to ensure that squat is not corrected for twice.

5.4.3. Velocity of Sound Corrections

- ***General***

To ensure that the overall depth measurement accuracy criteria specified in Section 5.2 are met, velocity of sound observations should be taken with sufficient frequency, density, and accuracy. The accuracy with which the speed of sound correction can be determined is a complex function of the accuracy with which salinity, temperature, and depth, or alternately, sound speed and depth, can be measured.

The velocity of sound through water shall be determined using instrumentation capable of producing sound velocity profiles with errors no greater than 2 meters per second. The sound velocity profile must reach the deepest depths of the survey but the physical measurement of sound velocity need only extend to:

- 95 percent of the anticipated water depth in 30 m or less of water. For example, if the maximum depth to be surveyed is 25 m, then the velocity profile should continue to a depth of at least 23.8 m.
- 90 percent of the anticipated water depth in depths from 30 m to 100 m.
- 85 percent of the anticipated water depth in greater than 100 m of water.

Sound velocity correctors must be determined accurately and often enough to ensure that the depth accuracy requirements in Section 5.2 are met. If changes in the temperature or salinity in the water column dictate that updated correctors are needed, additional sound velocity profiles shall be acquired. Additionally, the hydrographer should establish a means of monitoring changes in the water column between subsequent velocity casts.

Regardless of the sound velocity determination system employed, an independent sound velocity measurement system must be used to establish a confidence check. Confidence checks shall be conducted at least once per week. Include confidence check results in Separate III, Sound Velocity Profile Data (see Section 8.1.4.).

A geographic distribution of profiles may be necessary to correct for spatial and diurnal variability. Velocity corrections shall be based on the data obtained from the profile, and not based on an averaged sound velocity reading for the water column. Survey specific sound velocity information shall be included in Separate III, Sound Velocity Profile Data (see Section 8.1.4. Descriptive Report Supplemental Records).

The hydrographer shall calibrate sound velocity profiler(s) no earlier than six months prior to the commencement of survey operations. Calibration correctors shall be applied to all profiler data. These instrument(s) shall be re-calibrated at intervals no greater than twelve months until survey completion. In addition, the instrument(s) must be re-calibrated when the survey is complete if the completion date is later than six months from the date of last re-calibration. Copies of calibration data shall be included in Separate III, Sound Velocity Profile Data (see Section 8.1.4. Descriptive Report Supplemental Records**),** separates to be included with the survey data.

- ***Velocity Corrections for Single Beam Surveys***

For each individual area identified, a minimum of at least one cast each week, taken in the waters surveyed that week, is required. The variation of physical conditions throughout a survey area or any portion thereof

may dictate that this minimum may not be sufficient. Where casts taken early in a project indicate that physical characteristics are extremely variable, observations of velocity may be required more frequently.

- ***Velocity Corrections for Multibeam Surveys***

The sound velocity profile must be known accurately in Multibeam swath sounding for two reasons. First, as in all echo-sounding, the depth is computed from the product of the velocity and the elapsed time between transmission of a sound pulse and reception of its echo. Second, since sound pulses travel at oblique angles through the water column, variations in the velocity profile will affect the path of sound through water. The sound path from the transducer to the bottom and back will affect not only the observed depth of water, but the apparent position of the observed sounding.

Even though sampling equipment and computer systems are capable of dividing the water column into intervals so small as to allow close approximation of the integral expression for harmonic mean velocity, practical limitations may require the hydrographer to use a small number of discrete points on the velocity profile for the purpose of correcting echo soundings. If the hydrographer chooses the inflection points of the smooth velocity profile as the discrete points for layer boundaries, the velocity curve between the points can reasonably be approximated by a straight line. Integration of all the segments using the trapezoidal rule to approximate the area under each layer will yield very accurate results.

For multibeam operations, the following specifications apply to sound velocity profile frequency and application:

- One sound velocity profile shall be acquired immediately before the beginning of the data acquisition period. During the course of survey operations, changes in the water column should be monitored at a sufficient frequency such that the general requirements specified earlier in this section are met.

- Sound velocity profiles shall be acquired in the immediate area where subsequent data acquisition will occur.

- When using an undulating velocimeter, the real time sound velocity profiles shall extend to at least 80% of the anticipated water depth. At a minimum, one cast per 24-hour period shall extend to 95% of the anticipated water depth (30 m or less water depth).

5.4.4. Heave, Roll, Pitch, Heading, and Navigation Timing Error Corrections

Heave, roll, pitch, heading, and navigation timing error corrections shall be recorded in the data files and applied to all multibeam soundings and cross- track distances as applicable. For single-beam surveys, only heave shall apply.

- *Heave, roll, and pitch.* Heave shall be observed in no coarser than 0.05 m increments. Roll and pitch shall be observed in no coarser than 0.1 degree increments.

- *Heading* shall be observed in no coarser than 0.5 degree increments.

- *Navigation timing error* shall be observed in no coarser than 0.01 second increments.

5.4.5 Error Budget Analysis for Depths

The hydrographer shall discuss (in Section B2 of the Descriptive Report) the methods used to minimize the errors associated with the determination of depth (corrections to echo soundings). Error estimate ranges for six of these errors (measurement error, transducer draft error, settlement and squat error, sound velocity error, heave error and tide/water level error) are presented below. These errors are inherent to hydrographic surveying and all have practical minimums that are usually achievable only under ideal circumstances or with highly specialized equipment. In addition, some errors may be dependent on depth (e.g. sound velocity). Maximum allowable errors are specified to ensure that all errors sources are properly managed. It should be noted that if the maximum value for each error source is used in an error budget (i.e. root-sum-squared), the result will exceed the prescribed accuracy standard. The minimum and maximum values discussed below are at the 95% confidence level (i.e. 2 sigma).

Measurement error: This includes the instrument error for the sounding system, the effects of imperfectly measured roll/pitch and errors in detection of the sea floor due to varying density of the bottom material. Multibeam systems are particularly susceptible to this error due to the off-nadir nature of outer beams. The minimum achievable value is expected to be 0.20 meter at 10 meters depth. The maximum allowable error is 0.30 meter plus 0.5% of the depth.

Transducer draft error: This error is controlled by variability in vessel loading, and the techniques used to measure/monitor transducer draft. This error is depth independent with an expected minimum of 0.05 meter and an allowable maximum 0.15 meter.

Settlement and squat error: Conventional methods of determining settlement and squat are limited by sea surface roughness and proximity of a suitable location to the survey area. Careful application of modern methods (Real Time Kinematic GPS) will minimize this error. This error is also depth independent although the effect of settlement and squat is greater in shallow water. The practical expected minimum is 0.05 meter and the allowable maximum is 0.20 meter.

Sound velocity error: The factors associated with this error include (1) the ability to accurately measure sound velocity or calculate sound velocity from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound velocity throughout the survey area and (3) how the sound velocity profile is used to convert measured time to depth. In addition, this error encompasses depth errors associated with refraction for Multibeam systems. The expected minimum is 0.20 meter and the allowable maximum is 0.30 meter plus 0.5% of the depth.

Heave error: This error is directly dependent on the sea state and the sensitivity of the heave sensor but is not dependent on depth. The expected minimum is 0.05 meter and the allowable maximum is 0.20 meter.

Tide/water level error: This error has been discussed in detail in Section 4. The practical minimum is 0.20 meter and the allowable maximum is 0.45 meter.

5.5. Quality Control

5.5.1. Multibeam Sonar Calibration

Prior to commencing survey operations, the hydrographer shall conduct a system accuracy test to quantify the accuracy, precision, and alignment of the Multibeam system. Testing shall include determination of residual biases in roll, pitch, heading, and navigation timing error. These values will be used to correct the initial alignment and calibrate the Multibeam system. System accuracy testing should be conducted in an

area similar in bottom profile and composition to the survey area, and during relatively calm seas to limit excessive motions and ensure suitable bottom detection. In addition, system accuracy tests should be conducted in depths equivalent to the deepest depths in the survey area. Static transducer draft, settlement and squat corrections, sound velocity corrections, and tide corrections shall be determined and applied to the data prior to bias determination.

The order in which these biases are determined may affect the accurate calibration of the Multibeam system. The hydrographer should determine the biases in the following order: navigation timing error, pitch, roll, heading. Variations from this order, or simultaneous determination of all values, must be explained and justified.

Pitch and navigation timing error biases should be determined from two or more pairs of reciprocal lines 500–1,000 m long, over a 10°–20° smooth slope, perpendicular to the depth curves. The lines should be run at different speeds, varied by up to 5 knots, for the purpose of delineating the along track profiles when assessing time delay. Navigation timing error bias could also be determined from running lines over a distinct feature (i.e., shoal) on the bottom, as long as the feature is pinged by the vertical (nadir) beam.

Roll bias should be determined from one or more pair of reciprocal lines 500–1000 m in length over a flat bottom. Lines should be run at a speed which will ensure significant forward overlap.

Heading bias should be determined from two or more adjacent pairs of reciprocal survey lines, made on each side of a submerged object or feature (i.e., shoal), in relatively shallow water. Features with sharp edges should be avoided. Adjacent swaths should overlap by 10–20 percent while covering the shoal. Lines should be run at a speed which will ensure significant forward overlap.

Once calibration data have been processed and final system biases determined, the new corrections shall be used in a performance check to ensure that the new system biases are adequate. The hydrographer shall discuss procedures and results in the Data Reduction section of the project Data Acquisition and Processing Report. Copies of all system alignment, accuracy, calibration reports, and performance checks shall be included in the Data Acquisition and Processing Report.

System accuracy testing shall be repeated whenever changes (e.g., sensor failure, replacement, re-installations, re-configurations, or upgrade; software changes which could potentially affect data quality) are made to the system's baseline configuration, or whenever assessment of the data indicates that system accuracies do not meet the requirements in Section 5.2.

5.5.2. Positioning System Confidence Checks

Confidence checks of the primary positioning system shall be conducted and recorded in the survey records at least once every week when USCG differential correctors are used as the primary positioning system, and once daily when non-USCG differential correctors are used. A successful confidence check shall compare positions from the primary system to simultaneously observed check positions from a separate, independent system with a positional accuracy better than 10 meters. The inverse distance shall not exceed 10 meters. If correctors for the primary positioning system are obtained from a non-USCG differential system, then the check system must use correctors from a reference station different from the primary system's. If correctors are obtained from a USCG differential station, the check system may use the same correctors as the primary system. The confidence checks shall be an integral part of the daily survey data record. Copies of positioning system confidence checks shall be included in section I of "Separates to be Included with the Survey Data" (see 8.1.3).

5.5.3. Crosslines

- ***General***

The regular system of sounding lines shall be supplemented by a series of crosslines for verifying and evaluating the accuracy and reliability of surveyed depths and plotted locations. Crosslines shall be run across all planned sounding lines at angles of 45° to 90°. The preferred area in which to run crosslines is in an area of gently sloping bottom.

- ***Single beam***

The lineal nautical miles of crosslines for single-beam surveys shall be at least 8 percent of the lineal nautical miles of all planned sounding lines.

The hydrographer shall make a general evaluation of the single beam crossline to mainscheme agreement, and discuss the results in Section B of the Descriptive Report. If the magnitude of the discrepancy varies widely over the survey, the hydrographer shall make a quantitative evaluation of the disagreements area by area.

- ***Multibeam***

The lineal nautical miles of crosslines for Multibeam surveys shall be at least 5 percent of the lineal nautical miles of all planned sounding lines.

Comparisons shall be made between mainscheme lines and crosslines at 1% of all crossings (or 25 crossings, whichever is greater) distributed throughout the data both spatially and temporally. At these crossings the nadir or near-nadir depths of mainscheme lines shall be compared to each of the nearest unsmoothed soundings obtained from the crosslines. The hydrographer shall perform a separate statistical analysis as a function of beam number for each of the mainscheme/crossline intersections used for comparison. Include a statement about the results in Section B of the Descriptive Report, and include a summary plot of each crossing in Separate V, Crossline Comparisons.

5.5.4 Multibeam Sun-Illuminated Digital Terrain Model (DTM) Images

Regardless of the Multibeam coverage technique used (see Section 5.3. Coverage), the hydrographer shall create two sun-illuminated DTM images. These sun-illuminated DTM images are the preferred method for detection of depth artifacts associated with errors in bottom detection algorithms, vessel motion compensation, navigation timing, water level correctors and false bottom detections.

Each image shall depict data illuminated from orthogonal directions, using a light source with an elevation no greater than 45 degrees. At a minimum, an 8 bit color depth shall be used for compilation of the sun-illuminated images. The two sun-illuminated images shall be created from fully corrected data that meet accuracy and resolution specifications (see Section 5, Depth Soundings) are cleaned of all anomalous soundings, and serve as the source for all smooth sheet soundings. Data shall be binned, line by line, using shoal biased filtering at a bin size not to exceed 5 meters + 5 percent of the depth.

The submitted digital image file shall be in a standard geo-referenced image format.

6. Towed Side Scan Sonar

During hydrographic surveys, the use of side scan sonar may be required for supplementing echo-sounding by searching the region between regular sounding lines for additional indications of dangers and topographic irregularities. Any requirement for side scan sonar coverage in conjunction with a hydrographic survey will be specified in the Hydrographic Survey Letter Instructions or Statement of Work.

6.1. Coverage

Scanning coverage is the concept used to describe the extent to which the bottom has been covered by side scan sonar swaths, that is, the band of sea bottom which is ensonified and recorded along a single vessel track line. For hydrographic purposes, scanning coverage of an area is expressed in multiples of 100 percent, and is cumulative. One hundred percent coverage results in an area ensonified once, and two hundred percent coverage results in an area ensonified twice. Advisory note: Side scan coverage may not be achieved as planned due to varying water conditions, such as thermoclines, limiting such coverage.

The scanning coverage requirements will be stated in the Hydrographic Survey Letter Instructions or Statement of Work. Approved 200-percent coverage techniques are as follows:

- *Technique 1.* Conduct a single survey wherein the vessel track lines are separated by one-half the distance required for 100-percent coverage.

- *Technique 2.* Conduct two separate 100-percent coverages wherein the vessel track lines during the second coverage split the difference between the track lines of the first coverage. Final track spacing is essentially the same as technique 1.

- *Technique 3.* Conduct two separate 100-percent coverages in orthogonal directions. This technique may be advantageous when searching for small man-made objects on the bottom as the bottom is ensonified in different aspects. However, basic line spacing requirements for single-beam echosounders may not be met when using this technique.

6.2. Side Scan Acquisition Parameters and Requirements

6.2.1. Accuracy

The side scan sonar system shall be operated in such a manner that it is capable of detecting an object on the sea floor that measures 1 m x 1 m x 1 m from shadow length measurements.

6.2.2. Speed

The hydrographer shall tow the side scan sonar at a speed such that an object 1 m on a side on the sea floor would be independently ensonified a minimum of three times per pass.

The number of pulses per unit time, or pulse repetition rate, determines the speed at which the transducer (i.e. the vessel) can move along the track and still maintain the required coverage of the bottom.
Longer operating ranges have slower pulse repetition rates, which requires the vessel speed to be slower if the entire bottom is to be ensonified.

The maximum vessel speed for three ensonifications can be calculated if the pulse repetition rate (prr) or the pulse period (pp) is known. The rate is the reciprocal of the period. This rate and/or period is usually published in the operating manual for the side scan sonar system. The calculation is as follows:

Maximum vessel speed (meters/second) = target size (meters) X prr/3 (sec^{-1}).

6.2.3. Towfish Height

The hydrographer shall operate the side scan sonar system with a towfish height above the bottom of 8 percent to 20 percent of the range scale in use. For any towfish height below 8 percent of the range scale in use, the effective scanning range is defined to equal 12.5 times the towfish height, provided adequate echoes have been received.

6.2.4. Horizontal Range

The achievable horizontal range of a side scan sonar is a function of several parameters. Among these are sonar conditions, sea bed composition, the range scale in use, side scan sonar system characteristics, and towfish height. Actual conditions in the survey area will determine the effective range of a particular side scan sonar system. The maximum allowable range scale for any towed side scan sonar is 100 m.

If the effective range scale of the side scan sonar is reduced due to external factors, then the representation of the swath coverage should be reduced accordingly. For example, changes in the water column or inclement weather may distort the outer half of the 100 m range scale. In this case, only 50 m of effective range could be claimed.

6.3. Quality Control

6.3.1. Confidence Checks

Confidence checks of the side scan sonar system shall be conducted at least once daily. These checks should be accomplished at the outer limits of the range scales being used based on a target near or on the bottom. Each sonar channel (i.e., port and starboard channels) shall be checked to verify proper system tuning and operation. Confidence checks can be made on any discrete object, offshore structure, or bottom feature which is convenient or incidental to the survey area. Targets can include wrecks, offshore structures, navigation buoy moorings, distinct trawl scours, or sand ripples.

Confidence checks can be made during the course of survey operations by noting the check feature on the sonargram. If a convenient or incidental target is not available, a known target may be placed on or near the bottom and used for confidence checks. Confidence checks shall be an integral part of the daily side scan sonar operation and shall be annotated in the side scan sonar data records.

6.3.2. Significant Contacts

In depths of water less than or equal to 20 m, contacts with computed target heights (based on side scan sonar shadow lengths) of at least 1 m should be considered “significant.” In depths of water greater than 20 m, contacts with computed target heights rising above the bottom at least 10 percent of the depth should be considered “significant”. Other contacts without shadows may also be considered “significant” if the sonargram signature (e.g., size, shape, or pattern qualities) is notable. In addition, contacts with less than 1 m target heights should be considered “significant” if they are found near the critical navigation depths of the local area. For example, if a 0.5 m contact is discovered in 10 m of water at the seaward approach to a dredged channel with a controlling depth of 10 m, then the contact should be considered significant.

6.3.3. Contact Correlation

The hydrographer shall examine and correlate targets between successive side scan sonar coverages (i.e., compare the first 100 percent with the second 100 percent sonar coverage). If applicable, the hydrographer shall examine the Multibeam data and correlate anomalous features or soundings with the side scan sonar data. Anomalous features or targets which appear consistently and correlate in each type of data record provide increased confidence that acquisition systems are working correctly and help to confirm the existence of these features or targets. The hydrographer shall cross reference and remark on each target correlation in the *Remarks* column (column 7) of the Side Scan Sonar Contact List (see Section 8.4.2.).

6.3.4. Identification of Potential Field Examinations

The hydrographer shall use the sonar contact list, in conjunction with an analysis of echosounder least depths, to identify hydrographic features which may require further examination.

7. Other Data

7.1. Bottom Characteristics

When required in the Hydrographic Survey Letter Instructions or Statement of Work, the hydrographer shall obtain samples of the bottom sediment. The letter instructions or statement of work will specify density of sampling. In general, the distance between bottom samples should not exceed 1200 meters in charted anchorage areas, and the distance between samples in all other areas should not exceed 2000 meters. Bottom samples will not be required in depths greater than 100 meters.

When sampling is required, the hydrographer shall record position and depth data for each sample obtained. In addition, each sample shall be described in accordance with NOS Cartographic Codes and Symbols (see Appendix 2). The location and abbreviated description of each sample shall be depicted on the preliminary smooth sheet or separate overlay.

7.2. Aids to Navigation

The hydrographer shall investigate all U.S. Coast Guard (USCG) and privately maintained fixed and floating aids to navigation located within the survey limits. Upon inspection of the most recent edition of the largest scale chart of the survey area and the latest edition of the USCG Light List, the hydrographer shall confirm the aid's characteristics and determine whether the aid adequately serves the intended purpose for which it was established.

If the hydrographer determines that an aid to navigation is located off station, is damaged to the extent that it does not serve its intended purpose or its characteristics are incorrectly charted, the facts should be reported immediately in the form of a danger to navigation letter (see Section 8.1.2 Danger to Navigation Report).

If an uncharted fixed or floating aid to navigation is discovered within the survey area, the hydrographer shall obtain a differential GPS position on the aid and report the new aid to navigation promptly to the nearest USCG district and submit a Danger to Navigation Report. Include geographic position, characteristics, apparent purpose, and by whom the aid is maintained (if known).

Other fixed and floating aids to navigation and landmarks within the survey area may require specific positioning methods. Positioning specifications and requirements will be provided in the Hydrographic Survey Letter Instructions or Statement of Work.

8. Deliverables

8.1. Field Reports

8.1.1. Progress Sketch

The hydrographer shall submit a Monthly Progress Sketch digitally via email, to the addresses specified in the Hydrographic Survey Letter Instructions or Statement of Work no later than 5 calendar days from the end of the reported month. Progress sketches shall be constructed using a desktop Geographic Information System, capable of exporting the associated data in a format compatible with MapInfo (Version 5.0 or higher) or ArcView (Version 3.0 or higher). Other formats may be allowed, if approved in advance by the COTR.

The Progress Sketch is a page-size graphic that portrays survey accomplishments. All portions of the sketch must be neat and legible for reproduction. Every Progress Sketch shall be overlayed onto the largest scale chart of the survey area (do not include the raster chart file in email attachment, only reference chart used) and depict the following information, if applicable:

- Title block
- Statistics block
- Latitude and longitude tick marks
- Shoreline
- Geographic names of significant features
- Sheet limits
- Survey area limits
- Sheet letters and registry numbers

The title block consists of the title "Progress Sketch", project number, locality, type of survey, inclusive dates of survey, name of vessel(s), chief of party, and approximate scale of the sketch.

The statistics block contains monthly columns showing, in rows, the following items, if applicable:

- Lineal nautical miles of sounding lines (list side scan sonar, Multibeam and/or single beam separately)
- Square nautical miles of each survey sheet completely surveyed.
- Number of sound velocity casts
- Number of bottom samples collected
- Number of items from the Automated Wreck and Obstruction Information System (AWOIS) completed
- Number of tide gauges installed

- Number of position control stations established or surveyed (include bench marks that have been positioned with static GPS).
- Number of days of down time due to weather
- Number of days of down time due to equipment
- Number of days field unit was on site working on project (for instance, the field unit may have departed on the 15th, meaning the monthly progress sketch only reflects 15 days of work)

Labeled latitude and longitude ticks, shoreline, and geographic names for orientation and easy identification are also shown. Distinctive hatching or a percentage complete value should be used to differentiate the sheet areas surveyed each calendar month. Additional symbols may be used on the Progress Sketch as necessary, but should be explained in the legend.

Sheet limits, registry numbers, and letter designators are displayed on the Progress Sketch when survey sheets are begun.

8.1.2. Danger to Navigation Report

As soon as practicable after discovery, the hydrographer shall submit a Danger to Navigation Report. Timeliness is a critical issue in reporting dangers to navigation. The hydrographer should ensure that the discovery of a potential danger to navigation is reported immediately to the appropriate authority. Further, should additional dangers be discovered during the processing of the survey, a danger report shall be immediately forwarded.

A danger to navigation is considered to be any natural feature (e.g., shoal, boulder, reef, rock outcropping) as well as any cultural feature (e.g., wreck , obstruction, pile, wellhead) which, during the course of survey operations was found by the hydrographer to be inadequately charted. Potential dangers shall be evaluated in the context of the largest scale nautical chart of the area. Unless specified otherwise in the Hydrographic Survey Letter Instructions or Statement of Work, all submerged features with depths of 11 fathoms (66 feet) or less in navigable waters should be considered potential dangers to navigation and subject to reporting. During the course of reviewing survey data for potential dangers to navigation, the hydrographer should be aware of the types of vessels transiting the area along with usual and seasonal vessel routes throughout the survey area.

Danger to Navigation Reports are required for:

- Significant uncharted rocks, shoals, wrecks, and obstructions
- Depths from the present survey which are found to be significantly shoaler than charted depths or features, and are navigationally significant (typically depths of 11 fathoms (66 feet) or less)
- Uncharted or inadequately charted clearances for bridges and overhead cables or pipelines
- A fixed or floating aid to navigation found to be off station to an extent that the aid does not serve its purpose adequately

- A fixed or floating aid showing significantly different characteristics than those charted or described in the Light List

- Other submerged or visible features, or conditions considered dangerous to navigation

Once all dangers to navigation (DTON) are identified by using the criteria above, they must be reviewed in context with the largest scale chart covering the survey area. DTONs submitted should not cause undue clutter in relation to other soundings or features on the chart. When multiple distinct features are located within 3mm of each other, as depicted on the largest scale chart of the area, then the most significant DTON located within the 3mm radius shall be submitted as a single danger to navigation.

In cases where dangers are too complex to be adequately identified as discrete features, they should be appropriately depicted on the chartlet which accompanies the danger letter. For example, widespread shoaling would be represented as a series of depths with appropriate depth curves instead of listing individual soundings and geographic positions.

NOAA field units shall use Pydro and submit all Danger to Navigation Reports via e-mail directly to Marine Chart Division's (MCD) Nautical Data Branch at e-mail address 'mcd.dton@noaa.gov', with courtesy copies to Chief, Operations Branch and to the chief of the appropriate Processing Branch.

The Pydro reports will be submitted as follows:
1) Letter in the format shown in Appendix 9,
2) Pydro created .xml file
Please note, that chartlets are no longer required, but may be created if useful to the field unit and/or Processing Branch.

Contractors shall submit all Danger to Navigation Reports via e-mail to the COTR.

The contractor reports will be submitted as follows;
1) Letter in the format shown in Appendix 9,
2) an ascii text file of the format; 'latitude, longitude, depth, feature'.

The COTR will forward the DTON to the appropriate Processing Branch. The Processing Branch will review the DTON, import the ascii file into Pydro, and create the .xml file. A letter and .xml file will then be forwarded to the Nautical Data Branch at 'mcd.dton@noaa.gov'.

MCD will process the Danger to Navigation Reports and send the information to the USCG for inclusion in the Local Notice to Mariners. MCD will notify the submitting party of any changes made to the Dangers to Navigation Report by return e-mail. The Processing Branches will submit any dangers to navigation detected during office processing to MCD as stated above. If the Processing Branch is submitting a DTON that changes an earlier DTON submitted by a field unit, please explain the change in the cover letter.

A copy of the Danger to Navigation Report shall be included in Appendix I of the Descriptive Report.

8.1.2.1. Charted Feature Removal Request

Charted features, particularly "Position Approximate" wrecks and obstructions, that are located in major shipping corridors should be expeditiously removed from the chart if adequately disproved. The Charted Feature Removal Request is similar to a Danger to Navigation Report, except it is used to remove a charted feature that represents a hazard, which does not exist, rather than add a newly found hazard. This process should be used sparingly, usually by responding to a request from local pilots or other authorities that a

charted feature is a hindrance to operations. If removal of a feature is not time critical, utilize the descriptive report to recommend removal from the chart rather than the Charted Feature Removal Request.

The Operations Branch, within the Hydrographic Surveys Division, is responsible for defining the search criteria for all AWOIS items. If local authorities request the hydrographer to investigate a feature that has not been assigned, contact Operations Branch for a determination of the search criteria. Once the hydrographer meets the search criteria and determines the feature does not exist, they should expeditiously prepare the Charted Feature Removal Request and forward it to the appropriate Processing Branch for verification. The format for the request is the same as a Danger to Navigation Report. The Processing Branch will review the request and, if the verifier concurs with the hydrographers recommendation, will forward the request to the Marine Chart Division. See Appendix 9 for an example of a Charted Feature Removal Request.

8.1.3. Descriptive Report

A Descriptive Report is required for each hydrographic survey sheet completed, unless specified otherwise in the Letter Instructions or Statement of Work The Descriptive Report is submitted to the Atlantic or Pacific Hydrographic Branch along with the preliminary smooth sheet (including the Pydro PSS file, if appropriate) and other supplemental reports and survey records, after field data acquisition and processing of the survey has been completed.

The primary purposes of a Descriptive Report are to: 1) help cartographers process and evaluate the survey; 2) assist the compilers producing or revising charts; 3) document various specifications and attributes related to the survey and its by-products (e.g., preliminary smooth sheet); and 4) provides a legal description of the survey standards, methods, and results. The cartographers will have no knowledge of the particulars of a survey, other than what is documented in the Hydrographic Survey Letter Instructions or Statement of Work, digital survey data, Descriptive Report, and supplemental reports referenced in the Descriptive Report. The Descriptive Report is archived as a historical and legal record for the survey.

The Descriptive Report supplements hydrographic sheets and sounding records with information that cannot be depicted or described in the digital data, or shown clearly in graphic form. The Descriptive Report describes the conditions under which the survey was performed, discusses important factors affecting the surveys adequacy and accuracy, and focuses upon the results of the survey. It contains required information on certain standard subjects in concise form, and serves to index all other applicable records and reports.

General statements and detailed tabulations of graphically evident data, such as inshore rocks, shoals, or coral heads already shown on the preliminary smooth sheet, should not be included in the Descriptive Report. Hydrographic characteristics of the survey area such as nearshore features, shoreline, currents, water levels, and changes to the chart that are otherwise not clearly defined by the graphic or digital products should be completely described in the Descriptive Report.

The following information is required in each Descriptive Report in the order listed below:

COVER SHEET (NOAA Form 76-35A, see Appendix 3) Appropriate entries are made to identify the survey. For each survey, the Registry Number, Sublocality, General Locality, and State will be provided in the Hydrographic Survey Letter Instructions or Statement of Work.

TITLE SHEET (NOAA Form 77-28, see Appendix 4). The "Hydrographic Title Sheet" is often referred to for information pertaining to the survey. The "State", "General locality", and "Locality" entries are to be identical to those on the Cover Sheet. The "Date of survey" entries are the inclusive dates of the fieldwork.

For "Vessel", enter the name and hull number of the surveying vessel. The name(s) listed after "Surveyed by" are the personnel who supervised sounding operations and/or data processing.

The "Remarks" section should contain any additional information, including the purpose of the survey and survey area information, that will identify the project or clarify the entries above. Other Descriptive Reports or special reports containing information or data pertinent to the survey that are not listed in Section E of the Descriptive Report text should be referenced here. Note the time zone used during data acquisition (e.g., All times are recorded in UTC). If applicable, list the name and address of the contractor and any subcontractors.

DESCRIPTIVE REPORT TEXT. Print the text on one-sided 8.5 by 11-inch paper with left-hand margins of 1.25 inches to permit binding. Do not use oversized sheets. Text shall be Times New Roman, with a font size of 12. Include all information required for complete understanding of the field records. When referring to a hydrographic feature on the preliminary smooth sheet, give the latitude, longitude and datum of the feature. Discussions and explanations should be written in a clear and concise manner. Avoid verbosity.

A digital copy of the Descriptive Report (DR) shall be provided in Word or WordPerfect format. The main body of the DR (sections A through E) shall be contained in a single file.

Provide the following information in the form of a title on the first page of the text: Descriptive Report to Accompany Hydrographic Survey H _____ (registry number), scale and year of the survey, name of survey vessel(s) or party, and the chief of party (or lead hydrographer). On each subsequent page, include registry number and field unit as a header. Pages shall be numbered consecutively from the first page of text, continuing through the Approval Sheet (page numbers as a footer, centered on page). Include a Table of Contents with page numbers.

Avoid using geographic names in the text of the Descriptive Report that do not appear on the nautical chart.

To provide uniformity of reports for future reference, arrange the text under the following lettered headings in the order appearing here.

A. AREA SURVEYED

Include a coverage graphic (black and white or grey scale) inclusive of the survey area. The information related to the present survey should be clearly shown and highlighted in some way to draw attention to its location within the project area.

B. DATA ACQUISITION AND PROCESSING

B1. Equipment

In this section of the Descriptive Report list by manufacturer and model number only the major systems used to acquire survey data or control survey operations (e.g., single beam sonar, Multibeam sonar, side scan sonar, vessel attitude system, positioning system, sound velocity system). Include a brief description of the vessel (e.g., length overall and draft). A detailed description of the systems used to acquire survey data or control operations shall be included in the project-wide **Data Acquisition and Processing Report**. See Section 8.1.4 for additional information.

Include in a narrative description, with figures when useful, of any deviations from the vessel or equipment configurations described in the **Data Acquisition and Processing Report**.

B2. Quality Control

Discuss the internal consistency and integrity of the survey data. State the percentage of crossline miles as compared to main scheme miles. Evaluate their general agreement, in accordance with the Hydrographic Survey Letter Instructions or Statement of Work. If the magnitude of the discrepancy varies widely over the sheet, make a quantitative evaluation of the disagreements by area. Explain the methods used to reconcile significant differences at crossings, and give possible reasons for crossline discrepancies that could not be reconciled.

Include an imbedded diagram or plot depicting the preliminary smooth sheet histogram along with an analysis of the results (see Section 8.2.2)

Evaluate survey junctions in this section. Junctions are made between adjoining contemporary surveys to ensure completeness and relative agreement of depths. List, by registry number, scale, date, and relative location, each survey with which junctions were made. Include a summary of each junction analysis. Explain methods used to reconcile significant differences at junctions, and give possible reasons for junction discrepancies that could not be reconciled. Include recommendations for adjustments to soundings, features, and depth curves, if applicable.

Discuss Multibeam quality control checks as required by the Hydrographic Survey Letter Instructions or Statement of Work.

Discuss any unusual conditions encountered during the present survey which would downgrade or otherwise affect the equipment operational effectiveness. Discuss any deficiencies that would affect the accuracy or quality of sounding data. Document these conditions, including how and when they were resolved.

Describe any other factors that affected corrections to soundings, such as sea state effects, the effect of sea grass or kelp, and unusual turbidity, salinity, or thermal layering in the water column.

B3. Corrections to Echo Soundings

Discuss any deviations from those described in the **Correction to Echo Soundings** section of the **Data Acquisition and Processing Report.**

Discuss the results of any patch test conducted after the initial patch test, that affect the survey data and were not included in the Data Acquisition and Processing Report. Comment on the reason a new patch test was conducted.

C. VERTICAL AND HORIZONTAL CONTROL

Include in this section of the Descriptive Report a summary of the methods used to determine, evaluate, and apply tide or water level corrections to echo soundings on this survey.

Describe how the preliminary zoning was determined to be accurate and/or describe any changes made to the preliminary zoning scheme.

State the horizontal datum and projection used for this survey. Briefly discuss the control stations used during this specific survey. If USCG DGPS stations are used, only list the station name in this section. Explain in detail any difficulties that may have degraded the expected position accuracy.

See Section 8.1.4 for additional information to be provided in the project **Vertical and Horizontal Control Report.**

D. RESULTS AND RECOMMENDATIONS

D.1 Chart Comparison

Compare the survey with all charts listed in the Hydrographic Survey Letter Instructions or Statement of Work. Identify the chart by number, scale, edition number, and edition date. In addition, Notices to Mariners affecting the survey area which were issued subsequent to the date of the Hydrographic Survey Letter Instructions or Statement of Work and before the end of the survey must be specifically addressed. Identify the last Weekly and Local Notices to Mariners compared to during the survey by notice number and date. Any Notice that prompts a chart comparison item must be identified by its Notice to Mariners number and date.

Comment on the degree of general agreement with charted soundings. Discuss general trends, such as shoaling or deepening occurring in the survey area. List significant charted depths that have been disproved.

Make a comparison between the survey data and all charted shoals and potentially hazardous features. Describe the methods of investigation and include least depths for significant changes. List charted features not found during the present survey.

List and discuss comparisons of survey depths with controlling depths, tabulated depths, and reported depths of all maintained channels. Also discuss soundings in designated anchorages, precautionary areas, safety fairways, traffic separation schemes, pilot boarding areas and along channel lines and range lines.

Briefly describe assigned Automated Wreck and Obstruction Information System (AWOIS) items investigated by singlebeam or Multibeam echosounder, side scan sonar, divers, and/or other methods in this section. Include an analysis of any differences between past and present survey findings and make a specific charting recommendation. Complete the AWOIS database record with field investigation results and include a copy of the record along with a copy of any graphic correlation output in Appendix VI. Also, include any official salvage documentation that would expunge the feature from the chart without having to further investigate with a survey platform.

Any charted features that contain the label PA, ED, PD, or Rep (see Chart No. 1 for definitions.), not specifically assigned as an AWOIS item and investigated in this survey, should be documented and discussed in this section. The source of the charted feature should be listed if known. Also, discuss features such as wrecks and obstructions from miscellaneous sources. Describe the condition and distinguishing characteristics of all items mentioned.

Refer to any Danger to Navigation Reports submitted for this survey. A negative statement is required if no Danger to Navigation Reports were submitted.

D.2 Additional Results

If specified in the Hydrographic Survey Letter Instructions or Statement of Work, describe and discuss the shoreline investigation results.

If applicable, briefly discuss prior survey comparisons conducted by the hydrographer. In general, prior survey comparisons are not required by field personnel, but may be used at the discretion of the hydrographer for quality control purposes. Prior survey comparisons can be very helpful to the hydrographer both in the field and during preparation of the preliminary smooth sheet. Prior surveys may be obtained by contacting the appropriate Processing Branch or by contacting the COTR (if not already provided on the project CD).

Discuss aids to navigation which do not serve their intended purpose, are damaged, or whose characteristics do not match the chart or Light List (see Section 7.2). A statement shall be made in this section of the Descriptive Report if all aids serve their intended purpose.

List all bridges, overhead cables, and overhead pipelines. State the status or condition of each feature. Provide applicable clearances determined by the survey party or by an authoritative source (e.g., the U.S. Coast Guard or U.S. Army Corps of Engineers). Include the geographic coordinates directly below the minimum clearance point. All such charted overhead features that no longer exist must also be listed. Include written documentation, if available, and photographs with the survey records. Invalid or uncharted overhead clearance information, or ongoing construction of bridges or overhead cables and pipelines, constituting a potential danger to navigation, should be reported to the U.S. Coast Guard and the U.S. Army Corps of Engineers.

Mention any submarine cables and pipelines and any associated crossing signs on the shoreline. Include coordinates for signage or the water entry point of the feature. Note ferry routes and list position of each ferry terminal, if not shown on the chart or contemporary NOS remote sensing maps.

For each drilling structure, production platform, and well head within the survey area (excluding temporary jack up rigs), make a comparison between the new survey position and the largest scale chart on which the feature is shown and discuss any differences.

Provide information of significant scientific or practical value resulting from the survey. Unusual submarine features such as abnormally large sand waves, shifting or migrating shoals, mounds, valleys, and escarpments should be described. Discuss anomalous tidal conditions encountered, such as the presence of swift currents not previously reported. Discuss any environmental conditions encountered, which have a direct bearing on the quality and accuracy of the hydrographic data. If special reports have been submitted on such subjects, refer to them by title, author, and date of preparation or publication.

Mention present or planned construction or dredging in the survey area that may affect the survey results or nautical charts. Recommend new surveys for any adjacent areas that need them. As appropriate, include recommendations for further investigations of unusual features or sea conditions of interest that go beyond routine charting requirements. Recommend insets to be shown on the published chart of the area, if requested by chart users or needed for clarity.

E. APPROVAL SHEET

The Chief of Party or Lead Hydrographer shall furnish, on a separate sheet, a signed statement of approval for the survey and all related records. The approval sheet shall contain the following:

- Approval of preliminary smooth sheet (signed and dated), Descriptive Report, digital data, and all accompanying records. This approval constitutes the assumption of responsibility for the stated accuracy and completeness of the hydrographic survey.

- A statement as to whether the survey is complete and adequate for its intended purpose or if additional work is required.

- The amount and degree of personal supervision of the work.

- Additional information or references helpful for verifying and evaluating the survey.

- List all reports and data not included with the survey records or Descriptive Report that have been submitted to the processing office or to another office (e.g., Data Acquisition and Processing Report, Vertical and Horizontal Report, Tides and Water Levels Package, Coast Pilot Report). Include date of the report or date of submission.

If appropriate, other personnel responsible for overseeing or directing operations on this survey sheet may also sign the Approval Sheet.

DESCRIPTIVE REPORT APPENDICES

The Appendices shall be inserted in the following order after the Descriptive Report Approval Sheet. The Appendices should not be included as part of the digital file that contains the main body of the DR. However, they may be submitted digitally as separate files.

I. DANGER TO NAVIGATION REPORTS

Include copies of Danger to Navigation Reports and correspondence. List each document by some type of unique identifier, such as date for a letter or e-mail.

II. LIST OF GEOGRAPHIC NAMES

The hydrographer shall investigate the geographic names that occur within the limits of the survey area. If corrections or new names are discovered, a list of these geographic names shall be prepared and included in this appendix with substantiating information about the source of the new information.

III. PROGRESS SKETCH

Include a copy of the final Progress Sketch (black and white or grey scale). See Section 8.1.1 for Progress Sketch requirements.

IV. TIDES AND WATER LEVELS

Include the following (if applicable):

- Field Tide Note
- Final Tide Note
- Abstract of Times of Hydrography (lists every day during which hydrography was conducted and the times between which hydrography was conducted during each day)
- A copy of the "Request for Approved Tides/Water Levels" letter
- Any other correspondence directly relating to tides and/or water levels

V. SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

Include any additional survey records not previously addressed in the Descriptive Report, Appendices or Separates (e.g., MapInfo tables). Any letter or email correspondence relating to the present survey should also be included.

VI. AWOIS

Include a copy of all updated AWOIS database records and associated graphic correlation output. Include any official salvage documentation that supports an AWOIS charting recommendation.

SEPARATES TO BE INCLUDED WITH THE SURVEY DATA

The following **"SEPARATES TO BE INCLUDED WITH THE SURVEY DATA"** supplementing the Descriptive Report shall be submitted with each survey. The Separates shall be bound, organized and clearly labeled. The SEPARATES should not be included in the digital DR file, but may be submitted digitally as separate files, if available.

I. ACQUISITION AND PROCESSING LOGS

Include all acquisition and processing logs from the present survey. Include positioning confidence checks and lead line and/or single beam to multibeam checks.

II. SIDE SCAN CONTACT LISTING AND IMAGES OF SIGNIFICANT CONTACTS

Include the side scan contact listing, along with images of all significant contacts. Side scan contacts are included as part of a normal Pydro data submission, which fulfils this requirement. Non-Pydro users must submit significant contact images in a manner which allows the Processing Branch to easily review and correlate specific contacts with other supporting data sets.

III. SOUND VELOCITY PROFILE DATA

Include a table, which identifies the specific sound velocity profiles used during the present survey. List the positions and dates of all casts used; the maximum cast depth; and the dates/times for which the profiles were applied. Refer to the location where the digital sound velocity files are located, and include a directory listing of the files. If appropriate, describe how the survey area was zoned to account for sound velocity variations from differing water masses. Printouts of individual sound velocity profiles are not required.

Include confidence check results. Include copies of sound velocity profiler calibration report(s), if calibration occurred after submission of the Data Acquisitions and Processing Report (DAPR).

IV. HYDROGRAPHIC SURVEY LETTER INSTRUCTIONS/STATEMENT OF WORK

Include copies of the Hydrographic Survey Letter Instructions or Statement of Work. Include all changes/modifications which apply to the present survey.

V. CROSSLINE COMPARISONS

Include the summary plot analysis as a function of beam number for the mainscheme/crossline intersections as required in Section 5.5.3. Include any other crossline quality reports required by the Hydrographic Survey Letter Instructions or Statement of Work.

8.1.4. Descriptive Report Supplemental Reports

8.1.4.1. Data Acquisition and Processing Report

The **Data Acquisition and Processing Report** (DAPR) is a project-wide report that shall be submitted before, or not later than, the submission of the first survey of the project. For contract surveys, the **Data Acquisition and Processing Report** shall be sent to the COTR and the appropriate Processing Branch specified in the Statement of Work. For NOAA field units, the DAPR shall be sent to the Chief, Hydrographic Systems and Technology Program (HSTP) and the appropriate Processing Branch specified in the Hydrographic Survey Letter Instructions. This report is separated into three sections, **Equipment, Quality Control, and Corrections to Echo Soundings**. These sections shall contain a detailed discussion on the project specific information addressed below.

A digital copy of the main text of the DAPR shall be provided in Word or WordPerfect format.

Include a cover sheet and title sheet which contain the following general information:

Cover Sheet. Include the type of survey(s), state, general locality and year. (Appendix 10)

Title Sheet. This contains additional descriptive information relative to the project. Include project number, date of Hydrographic Survey Letter Instructions/Statement of Work, vessel(s), field unit/contractor, sub-contractors, and Chief of Party/Lead Hydrographer.

A. Equipment

Describe the major operational systems used to acquire survey data or control survey operations. Include the manufacturer, firmware version and model number, operational settings and how the equipment was used. Include a description of the vessel(s) used.

Specifically discuss singlebeam, Multibeam and side scan sonar systems and operations in this section. Include range scales, number of beams, resolution, alongtrack coverage, and quality assurance tools used during data acquisition. Include discussion of other depth determination systems, such as, diver depth gages, lead line, sounding poles, etc. If applicable, explain the calibration or determination of correctors, the dates of most recent calibrations, state whether or not checks were made on their accuracy and describe any nonstandard procedures used.

Discuss the computer hardware and software used for all data acquisition and processing. Describe acquisition and processing methods, procedures, and parameters used. Provide a complete list of all software versions and dates.

Include a description of equipment used to conduct shoreline verification. Briefly describe the method of conducting shoreline verification, including the processing of detached positions and depiction of shoreline features on the preliminary smooth sheet.

B. Quality Control

Provide a description of the data processing routines for converting raw sounding data to the final smooth sounding values. Include a description of the methodology used to maintain data integrity, from raw sounding data to final soundings. Processing flow diagrams are helpful. Any methods used to derive final depths such as cleaning filters, sounding suppression/data decimation parameters, binning parameters, and excessing algorithms shall be fully documented and described in this section.

Discuss the methods used to minimize the errors associated with depth determination (see Section 5.4.5).

Methods and standards used to examine side scan sonar records should be noted and a brief description of processing procedures should be provided. Include the methods for establishing proof of swath coverage and the criteria for selecting contacts.

C. Corrections to Echo Soundings

This section addresses the methods used for the determination of all corrections to echo soundings that apply to the entire project. Describe the methods used to determine, evaluate, and apply the following corrections to echo soundings:

- Instrument corrections.
- All vessel configuration parameters, offsets, layback, etc include diagrams, pictures, or figures of the equipment as installed onboard.
- Static and dynamic draft measurements.
- Heave, roll, pitch biases, and navigation timing errors. State the manufacturer, model, accuracy, and resolution of heave, roll, and pitch sensor(s). Discuss accuracy and alignment test procedures and results. Include copies of system alignment, accuracy, and calibration reports.
- Discuss the source of tide or water level correctors used for data processing and final sounding reduction

D. Approval Sheet

The Chief of Party or Lead Hydrographer shall furnish, on a separate sheet, a signed statement of approval for all information contained within the **Data Acquisition and Processing Report.**

If appropriate, other personnel responsible for overseeing or directing operations on this project report may also sign the Approval Sheet.

8.1.4.2. Vertical and Horizontal Control Report

The **Vertical and Horizontal Control Report** is a project-wide report which shall be submitted before, or not later than, the submission of the last survey in project area.

A digital copy of the main text of the Vertical and Horizontal Control Report shall be provided in Word or WordPerfect format.

Include a cover sheet and title sheet which contain the following general information:

Cover Sheet. Include the type of survey(s), state, general locality and year.

Title Sheet. This contains additional descriptive information relative to the project. Include project number, survey registry numbers to which this report applies (with associated dates of survey and locality), date of Hydrographic Survey Letter Instructions/Statement of Work, vessel(s), field unit/contractor, sub-contractors, and Chief of Party/Lead Hydrographer.

A. Vertical Control

The **Vertical Control** section of the project **Vertical and Horizontal Control Report** shall document all Tide and Water Level activities that took place as part of this project. Specific information pertaining to an individual survey sheet and the Request for Approved Tides letter shall be documented in the Descriptive Report for the individual survey. This section shall contain a discussion of:

- All stations established by the field unit (include gauge model/type). Give station number, latitude/longitude, and the dates/times of operation.
- The method by which correctors for the field data were obtained and applied.
- The time meridian used to annotate the tide records.
- A list of any unusual tidal, water level, or current conditions.
- The height and time corrections, and zoning if different from that specified in the Hydrographic Survey Letter Instructions or Statement of Work.
- Ellipsoidal benchmark positioning techniques and procedures

B. Horizontal Control

The **Horizontal Control** section of the project **Vertical and Horizontal Control Report** shall document Hydrographic Position Control activities that took place as part of this project. Specific information pertaining to an individual survey sheet shall be documented in the Descriptive Report for the individual survey.

For horizontal control stations established by the field unit, describe the survey methods used to establish the station, and state the standards of accuracy used. Include position accuracy plots (see Section 3.2.2). For all horizontal control stations established by the field unit, list:

- The latitude to the nearest 1/1,000th of a second.
- The longitude to the nearest 1/1,000th of a second.
- The station elevation (ellipsoidal height).
- The geodetic station name and year it was established.

Briefly, describe the methods and adequacy of positioning system confidence checks.

C. Approval Sheet

The Chief of Party or Lead Hydrographer shall furnish, on a separate sheet, a signed statement of approval for all information contained within the **Vertical and Horizontal Control Report**.

If appropriate, other personnel responsible for overseeing or directing operations on this project report may also sign the Approval Sheet.

8.2. Preliminary Smooth Sheet

The preliminary smooth sheet is the final, legible, accurate plot of a hydrographic survey. In contrast to the field sheet plotted during field operations from preliminary field data, the preliminary smooth sheet is plotted from corrected data. The preliminary smooth sheet and survey information shown thereon shall conform to the cartographic standards and conventions described in this section. The preliminary smooth sheet shall contain only data that meet the accuracy standards in Section 5.2. Gridded or averaged Multibeam soundings shall not be displayed on the preliminary smooth sheet; only actual, corrected soundings. The scale of the preliminary smooth sheet will be specified in the Hydrographic Survey Letter Instructions or Statement of Work.

Following NOS inspection and administrative approval, a preliminary smooth sheet becomes the official smooth sheet, which is the permanent graphic record of a survey and is the principal authority for hydrographic data to be charted. Smooth sheets are referred to frequently during chart compilation. In addition, copies are often furnished to surveyors, engineers, geologists, lawyers (for use in the courts), and others with interests in marine surveys.

8.2.1. Specifications

Sheet Material

Preliminary smooth sheets and overlays shall be plotted only on stable polyester film 4.0-mils thick, semitransparent, and matte finished on both sides.

Sheet Size and Layout

Preliminary smooth sheet sizes shall not exceed 91.5 by 137.2 cm (36 by 54 inches). Overlays should be the same size as the preliminary smooth sheet they accompany. Preliminary smooth sheet limits should conform closely to those shown on the approved sheet layout with respect to area coverage, orientation, and size. The consolidation of separate survey areas onto a single preliminary smooth sheet shall be done using MicroStation reference files. The original coordinates of the surveyed data shall not be changed in the design file to accomplish single sheet plotting.

Plot preliminary smooth sheets at the scale of survey specified in the Hydrographic Survey Letter Instructions or Statement of Work. Plotter sheets shall have a plotter registration accuracy which does not exceed 3 mm in the longest dimension of the survey sheet.

Drafting Standards

Approved preliminary smooth sheets are official Government documents retained permanently in the National Ocean Service archives. Standards of accuracy for smooth plotting and detailing must reflect the high standards of accuracy of the collected data. Specifications are listed below.

Lettering Fonts

Lettering shall employ the MicroStation 224 (txt) or 1 (working) font.

Lettering Orientation

Symbols and lettering shall be aligned with parallels of latitude so they can be read from the south to the extent practical.

Both vertical and slant-style lettering are used on preliminary smooth sheets. Vertical characters shall be used for:

- Names and descriptions of topographic features that, in general, include all features above mean high water.
- Control station names and numbers.
- Projection line labels.
- Title-block information.

Slant-style characters shall be on a 15° to 25° slant and shall be used for:

- Names of hydrographic features; in general, all features below mean high water, and related descriptive notes.
- Elevations of bare rocks, rocks awash, piling, and other similar objects.
- Official names and designations of all aids to navigation.
- Bottom characteristics

Lettering Placement

For annotations, lettering shall be placed on preliminary smooth sheets in such a manner that there can be no doubt as to the item or feature it describes. Where practical, annotations should be separated from symbols by the space of approximately one letter, and be either on line with the symbol or placed as a subscript. Where the placement of a note could create doubt regarding its reference, a simple leader with arrow terminator shall be used. Extensive use of offset names, descriptions, and designations is undesirable.

Level/Layer Scheme

Digital data shall be separated onto different levels/layers as follows:

Name	Content
Projection	Geographic projection graticule lines and labels
Title	Title block and related notations
Soundings	Soundings
Contours	Depth curves
Shoreline	Shoreline and attached cultural features or other entity visible at mean high water
Features	Non-sounding features, e.g., wrecks, obstructions, etc.
Bottom	bottom samples descriptions
Misc.	Miscellaneous information

The naming of a level/layer does not necessarily imply that information of that type will be present in the drawing.

Line Style

All line work shall employ a line weight of zero and shall be a continuous style unless clearly documented in a key placed on the drawing. Custom linestyle or patterns are acceptable, however, all resource files, libraries etc. must accompany the digital survey data and be identified in the Data Acquisition and Processing Report list of software used. The use of splined lines shall be avoided. Polylines shall be used whenever possible.

Colors

With the exception of depth curves the preliminary smooth sheet shall be compiled using black color. The color table shall be the standard default table accompanying the CAD software.

Pen Tables

Plotter pen tables shall not be used to alter the appearance of the drawing.

Abbreviations

Abbreviations are acceptable but must be identified in a table placed on the drawing. Do not identify bottom characteristic abbreviations on the drawing.

Scale/Working Units

The preliminary smooth sheet shall be compiled in real-world units then plotted at the survey scale specified in Hydrographic Survey Letter Instructions or Statement of Work. The Working Units in MicroStation shall be Master Units in meters; Sub-Units in decimeters. The Resolution shall be set to 10 pu (position unit) per su (sub unit).

Blocks/Cells

Only those cells supplied by NOS shall be used in the preliminary smooth sheet drawings.

Prototypes/Seed Files

Prototype drawing files or customized seed files shall be delivered with the preliminary smooth sheets. If no customization was completed, then the records should specify the nature of the prototype/seed file in use. Use only 3D seed files.

Archiving

Finished drawings shall be saved as MicroStation design files (.dgn) that are loadable into MicroStation 95 version 5.05. MicroStation files shall be saved using the ARCHIVE function which will attach all related resource files. ***Precautionary note*: *A shift in positions of soundings has been noted when converting from AutoCad to MicroStation files. The hydrographer shall ensure that sounding positions within the MicroStation design file match original sounding positions***.

8.2.2. Cartographic Specifications and Conventions

Projection

The Universal Transverse Mercator projection shall be used. NAD 83 latitude and longitude lines shall be shown by continuous lines fine enough so that soundings will not be obscured. Labels for meridians and parallels shall be in degrees, minutes, and seconds and are placed in the sheet margins beyond the limits of hydrography.

Soundings

Soundings and related hydrographic detail needed to compile nautical charts are important observations of a hydrographic survey. It is essential that the final corrected soundings plotted on the preliminary smooth sheet be accurately and graphically displayed in a uniform manner. The soundings shall be actual corrected soundings. Gridding, averaging, or other sounding manipulation shall not be conducted.

Sounding numerals shall be between 1.8 (preferred) and 2.0 mm high and uniform across the preliminary smooth sheet. At this size, legible reproductions can be made at reduced scales. The center of the sounding numeral or group of numerals is the position of the sounding.

Sounding Units and Conversion

All soundings on the preliminary smooth sheet shall be plotted in units specified in the Hydrographic Survey Letter Instructions or Statement of Work. The following conversion factors shall be used:

- To convert soundings from meters to feet, 3.28084 ft/m.
- To convert soundings from meters to fathoms, 0.546807 fm/m.

When rounding corrected and converted soundings, regardless of units (meters, feet, or fathoms), the following procedures shall apply:

- When rounding to whole numbers, any depths less than X.750000 should be rounded to the shoaler number X, and any depth greater than or equal to X.750000 should be rounded to the deeper depth. For example, 35.75 becomes 36 and 35.74 becomes 35.

- When rounding to tenths, any depths less than X.Y75000 becomes X.Y, and any depth greater than or equal to X.Y75000 becomes X.(Y+1). For example, 35.574 becomes 35.5 and 35.575 becomes 35.6.

Spacing of Plotted Soundings

The spacing and density of soundings on preliminary smooth sheets shall be such that each depth curve is delineated adequately and the configuration of the bottom is fully revealed. Preliminary smooth sheet soundings are generally spaced uniformly at 4-7 millimeters apart. Soundings shall be clearly legible, and not plotted over adjacent soundings.

Selection of Soundings and Excessing

Soundings must be selected from valid filtered soundings from the hydrographic records to plot on preliminary smooth sheets using a shoal-biased selection routine. It cannot be overemphasized that the proper selection of soundings is essential for a complete and accurate portrayal of the bottom configuration.

With a Multibeam system, a relatively high percentage of preliminary smooth sheet soundings originating from only a few beams may indicate the presence of systematic or system specific errors in the acquisition or processing systems. The hydrographer shall construct a histogram showing the count, by beam number, of the selected soundings. The histogram and the hydrographer's analysis of the results shall be included in Section B of the Descriptive Report. If necessary, the data shall be re-processed and the preliminary smooth sheet re-drawn using the newly selected soundings.

When routine sounding lines overlap or cross, the shoaler soundings shall be plotted. If the difference is significant, then the data must be analyzed to determine the cause of the difference.

The selected data set shall be tagged (MicroStation) in a manner such that the selected data can be re-traced to the Multibeam or single beam data set. The attribute or tag shall include, but is not limited to, XY (latitude, longitude, NAD83), Z (depth in meters), year, day number, and time.

Hydrographic Features

Appendix 2, NOS Cartographic Codes and Symbols, contains the conventional symbols to be used on preliminary smooth sheets to depict the hydrographic features discussed in the following sections.

Submerged Obstructions

All submerged obstructions found during a hydrographic survey shall be shown on the preliminary smooth sheet using the appropriate symbol.

Obstructions are designated as submerged or sunken if their least depths are greater than or equal **to 0.8 m below the sounding datum**. If least depths could not be determined over unnatural features such as stubs or piles, ruins of piers and other structures, and wreckage of various kinds, the feature is shown by a 1-mm circle or by a dashed outline with appropriate annotation.

If the nature of an obstruction was not determined, the note "obstn" shall be used. Dashed lines are used to indicate an extension below the high water datum of marine railways, groins, breakwaters, sewer outfalls, or other unnatural features rising above the bottom. All annotations shall be in slanted lettering.

Visible Obstructions

In water areas, visible obstructions such as wrecks, piles, breakwaters, groins, fences, duck blinds, and fish houses are plotted on preliminary smooth sheets. Obstructions are considered **visible if their elevations are 0.7 m or greater above MHW in tidal waters**. Such obstructions are depicted by their distinctive symbols or, if necessary, by outlining the area of obstructions with dashed lines. Annotations are to be in vertical lettering for features rising above the shoreline datum for the area; otherwise, use slanted lettering.

Wrecks

Stranded wrecks should be depicted such that the small circle of the wreck symbol is the actual position of the wreck. Large hulks should be outlined and labeled accordingly, if the scale of the survey permits.

Sunken wrecks are covered at low water, but the masts may uncover. In such cases, the notation "masts" accompanies the sunken wreck symbol. When a least depth over a sunken wreck has been accurately determined and is greater than 0.2 m below the sounding datum, the depth with the notation "wreck" or "Wk" is shown instead of using a wreck symbol.

Rocks

Rocks are naturally occurring features either fixed to the seafloor in the form of bedrock or detached in the form of boulders, erratics, rubble, etc. Cartographic depiction of these features takes into account several conditions such as depth, elevation, and proximity of scattered rocks.

The elevation or depth of a rock determines if it is classified in one of the following zones: submerged, awash (covers/uncovers) and bare. The specific depth/elevation values that bound these zones are graphically depicted in Appendix 2.

The density of observed rocks determines the actual number and type of cartographic symbols used to depict the condition on the preliminary smooth sheet. The area required to depict a rock that covers/uncovers is approximately 1.8mm at the scale of the preliminary smooth sheet. Therefore, if similar rocks are clustered such that they are closer than 1.8mm apart, special provisions must be employed to ensure the most significant information is depicted. In these cases, an alternate form of depicting rocks in proximity to one another is to employ either a ledge or reef symbol, Cartographic Code 530, as appropriate. Another option is to reduce the number of symbolized rocks, depicting only those most significant. Significance is determined based on height and distance seaward from the shoreline or center of the rock cluster in the case of isolated offshore locations. The significance of rocks with heights above the sounding datum is directly proportional to their height. Conversely, the significance of submerged rocks is directly proportional to their depth. Rocks most distant from shore or the center of the rock cluster are also most significant. Areas containing numerous rocks may be considered foul. In such cases, only those rocks defining the seaward extent of the foul area should be located. The area should be bounded by a dashed line, Cartographic Code 894. Appropriate notation should be added to describe the condition, e.g., Cartographic Code 538, foul.

Depth Curves

Depth curves (isobaths or lines of equal depth) are comparable to topographic contours on land. Principles governing the portrayal of topographic contours are equally applicable when drawing depth curves, except that depth curves generally are drawn to include soundings equal to and less than the curve value. Depth curves are indispensable for a comprehensive interpretation and examination of a hydrographic survey. The

best gauge of the survey's completeness, adequacy, and accuracy is to be able to draw closely spaced depth curves with an assurance that the submarine relief is depicted accurately.

For the purposes of nautical chart compilation, depth curves shall be drawn based on soundings selected using the shoal-biased selection routine noted above. Standard depth curve intervals and colors required on survey preliminary smooth sheets are specified in Appendix 8. The standard depth curves shall be plotted in the prescribed colors. Supplemental depth curves shall be added where necessary and shall be drafted in brown ink.

Depth curves are broken into long dashes where not adequately defined by the soundings (e.g., extremely flat monotonous bottoms where the plotted soundings defy the drawing of a meaningful curve).

Aids to Navigation

All aids to navigation located within the survey limits shall be shown on the preliminary smooth sheet, indicated by the appropriate symbol in the proper color, labeling of the aid shall be in red.

Geographic Names

Geographic names shall not be placed on the preliminary smooth sheet.

Title Block

The information to be entered in the title block (Figure 8.2.1) of a hydrographic preliminary smooth sheet is extracted from the Title Sheet in the Descriptive Report. Title blocks shall be oriented with their base parallel to the sheet edge. Approximate dimensions for the title block are a height of 15 cm and a width of 20 cm. The hydrographer shall sign the preliminary smooth sheet in the title block.

Survey data or notes shall not, under any circumstances, be shown inside the title block. On most inshore surveys, there is adequate title-block space in land areas or in unsounded water areas. Offshore sheets must be laid out so there is sufficient space for the title block. No particular portion of a sheet is favored over another for the title block.

8.3. Sonar Coverage Plot

If applicable, the hydrographer shall produce three swath coverage plots (no smaller than specified survey scale) for all Multibeam surveys; one plot depicting color by depth of bottom coverage (see Section 5.3.1, Demonstration of Coverage) and two plots depicting sun-illuminated images of the area ensonified (see Section 5.5.4, Multibeam Sun-Illuminated Digital Terrain Model (DTM) Images). The hydrographer shall submit a digital image of each plot. Digital images shall be in an image format with associated geographic registration information.

FIGURE 8.2.1 Example of a Title Block.

<table>
<tr><td colspan="4">NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE</td></tr>
<tr><td colspan="4">HYDROGRAPHIC SURVEY H12345
STATE: ALASKA
LOCALITY: SOUTHERN ALASKA PENINSULA
SUB-LOCALITY: APPROACH TO KUJULIK BAY</td></tr>
<tr><td colspan="4">FIELD SHEET NUMBER: RA-10-20-98 PROJECT: OPR-P180-RA</td></tr>
<tr><td colspan="4">DATUM: HORIZONTAL: NORTH AMERICAN DATUM OF 1983 (NAD 83)
SOUNDING: MEAN LOWER LOW WATER</td></tr>
<tr><td colspan="2">PROJECTION: UTM - Zone 4</td><td colspan="2">CENTRAL MERIDIAN: 159°00'00"W
SCALE FACTOR: 0.9996</td></tr>
<tr><td colspan="2">SCALE OF SURVEY: 1:10,000</td><td colspan="2">SOUNDING UNITS: FATHOMS</td></tr>
<tr><td>SURVEYED BY:</td><td colspan="2"><*Signature*>
FIELD UNIT or CONTRACTOR XYZ</td><td>DATE: NOV-DEC 1998
MAR-APR 1999</td></tr>
<tr><td>APPROVED:</td><td colspan="3">CAPTAIN SAMUEL P. DE BOW, JR., NOAA DATE:
CHIEF, HYDROGRAPHIC SURVEYS DIVISION</td></tr>
</table>

8.4. Side Scan Sonar

8.4.1 Side Scan Sonar Mosaic

A separate side scan mosaic for each 100 percent coverage shall be used as a graphic means for demonstrating bottom coverage. Pixel resolution of the side scan mosaics should be 1 m by 1 m or less, dependent upon the equipment and speed of towing. The hydrographer shall submit a digital file of each 100% coverage (see Section 8.5.4). The digital file must be capable of producing plots at a scale not less than the preliminary smooth sheet scale listed in the Hydrographic Survey Letter Instructions or Statement of Work.

8.4.2. Side Scan Sonar Contact List and Plot

Contact List

A Sonar Contact List is required and must include the specific elements of information which the hydrographer needs to prepare the preliminary Sonar Contact Plot. Suggested column entries are described below, along with a brief discussion of how each is to be derived. Specific entries may vary by hydrographer. The format should be reviewed by the COTR and/or Processing Branch before data collection is conducted.

A digital copy of the contact list, ideally in spreadsheet format, shall be submitted with the survey deliverables.

Column 1: Search Track Number—identifies the particular search track from which the contact was observed.

Column 2: Contact Number—uniquely identifies the contact. An example of a contact number is a number based on the date/time the contact was observed, followed by a letter indicating the port or starboard (P or S) channel. For example, if a port-side contact is observed on day 181 at 150125, the contact number will be 181/150125P. Using signed (+ or -) contact range in column 4 eliminates the need for the P or S indicator.

Column 3: Towfish Layback—the approximate distance in meters from the positioning system antenna to the towfish. Unless computed by an automated system, the towfish may be assumed to be directly astern of the towing vessel and on the search track.

Column 4: Contact Range—the horizontal distance from the towfish track to the contact, expressed in meters.

Column 5: Contact Position—the preliminary position as determined by reconstruction of the vessel position, towfish layback, towfish position, port or starboard channel, and contact range at the time the contact was observed. The Contact Position shall be stated as a latitude/longitude.

Column 6: Estimate of contact height computed from range and shadow length.

Column 7: Remarks—used to denote first impressions of the contact's identity (e.g., wreck, rock, etc.), or to make any comments deemed appropriate. If, after examining the records and correlating targets from overlapping coverage, the hydrographer determines that a contact does not warrant further investigation, it shall be noted as such. A brief statement of the reasons must be made. Any abbreviations should be defined on the list.

Column 8: Comparison with shallow water Multibeam data—used to note the corresponding shallow-water Multibeam data (day/time, line number, etc.), the results of comparing the side scan sonar data with the Multibeam data (e.g., contact did not appear in the Multibeam data, swmb least depth = x.x—sss least depth = y.y).

Column 9: Contact is depicted on preliminary smooth sheet—answered in one of three ways: (1) yes, obstr, (2) yes, sounding only or (3) no.

Once added to the list, a contact should never be removed. If, after further processing, a contact is deemed not significant by the hydrographer, it shall be labeled as such in column 7.
The contact list, and any subsequent field examination lists and records developed from the contact list, shall be included with the data submission in both hard copy and digital forms.

Contact Plot

For clarity, the Contact Plot should be plotted at the same scale as the preliminary smooth sheet. It will show the position of all significant contacts entered on the Sonar Contact List. Only significant (Section 6.3.2.) contacts, along with the views from adjacent lines, need to be plotted on the Sonar Contact Plot.

In some areas, significant contacts may be clustered (e.g., debris, boulder field). Such an area may lend itself to being depicted as a single feature: a danger curve depicting the limit with accurately positioned least depth(s) (see Chart No. 1, Nautical Chart Symbols, Abbreviations and Terms). Contacts may be grouped if they lie closer to each other than 5 mm at the scale of the survey. Only the most significant contact(s) in the group needs least depth(s) and position(s) determined.

Contact Images

For each significant contact in the contact list, the hydrographer shall provide a digital and hard copy image of the contact. Digital images shall be in a standard image format (e.g., tif, gif, jpg). Hard copies of the images shall be included in the Separates, Section II. Digital file names and hard copy labels shall coincide with the contact name as depicted on the contact list.

8.4.3. Sonargrams

If sonargrams are recorded, annotation of the sonargram while on-line is mandatory during all side scan sonar operations. All annotations shall be made in the margins of the sonargram so that no portion of the trace is unduly obscured. Time references shall be made in Coordinated Universal Time (UTC). Additional annotations may be added during processing. Note: If sonar data is supplied in digital format only, the digital data needs to be similarly annotated.

Header Annotations

Header annotations are required to identify the sonar work and for ease of later reference. Header annotations shall include:

- Registry number.
- Item number (AWOIS, if applicable).
- Day of year and calendar date.
- Towing vessel.
- Tow Point.

Header annotations shall be made:

- At the beginning of a new paper roll.
- At the beginning of each day's work. (For 24-hour operations, these annotations shall be made at the beginning of the first complete track of the new day.)
- When there is a change in the towing configuration during a day's operation.

System-Status Annotations

System-status annotations are required to describe the recorder settings and the towing situation. System-status annotations shall include:

- Mode of tuning (manual or auto).
- Range-scale setting.
- Paper-speed setting.
- Left and right channel recorder settings.
- Operator's initials.
- Length of tow-cable deployed (tow point to towfish).
- Depressor in use (yes or no).
- Weather and sea conditions.

System-status annotations shall be made:

- Prior to obtaining the first position of the day.
- Prior to obtaining the first position on a new paper roll.
- At any time the recorder has been switched off and then back on.
- While on-line, approximately every hour, regardless of any changes made.

First Position/Last Position Annotations

The following annotations shall be made at the first position on each search track:

- Line begins (LB) or line resumes (LR).
- Tow-vessel heading (degrees true or magnetic).
- Towing speed (engine rpm, and pitch if applicable).
- Index number and time (at event mark).

The following annotations shall be made at the last position on each search track:

- Line turns (LTRA, LTLA), line breaks (LBKS), or line ends (LE) index number and time (at event mark).

Special Annotations

The occurrence of any of the following events shall be annotated on the sonargram margin at, or as soon after as possible, the time the event occurs:

- New index number (at event mark).

- Change in operator (new initials).
- Change in range-scale setting.
- Change in paper-speed setting.
- Confidence checks.
- Individual changes to recorder channel settings.
- Change in tow-cable length (tow point to towfish).
- Change in towing speed (engine rpm and pitch) or vessel heading.
- Change in tow point.
- Significant contact observed (flag using an arrow).
- Surface phenomenon observed (wakes, passing vessels, etc.).
- Passes by buoys or other known features within sonar range (identify object).
- Interference (state source if known).
- Time corresponding to the index marker.

The hydrographer shall make any other annotations necessary to note any occurrence which may later serve to reconstruct the operation. Too much information is always better than not enough.

Annotation Methods

Header and system-status annotations may be made using any of the following methods:

- Freehand on the sonargram.
- By use of a stamp.
- By use of an automatic annotator, if available.

The method is left to the hydrographer's discretion, but should be used consistently throughout the operation.

8.5. Digital Data Files

8.5.1. Media

Digital data shall be submitted on either 4 mm DDS (2,3, or 4), 8 mm AIT or DLT7000 tape, or CDROM. The data should be transferred to tape using NT backup or Windows 2000 backup or equivalent. The hydrographer shall include a directory listing of each tape, or other method to enable the Processing Branch to determine which tape holds which data sets and specify the exact backup or

archiving settings used to create the tape. Other formats may be allowed if agreed upon in advance with the appropriate Processing Branch. The hydrographer shall work with NOAA to ensure no compatibility problems exist after data submission.

Network Attached Storage Units, specifically MaxAttach or equivalent may also be used to submit data. The hydrographer should contact the appropriate Processing Branch ahead of time to determine proper shipping methods, directory structure and reach agreement on how long the Processing Branch will maintain custody of the device.

8.5.2. Single-beam Data

The single-beam data format will be specified in the Hydrographic Survey Letter Instructions or Statement of Work.

8.5.3. Shallow-Water Multibeam Data

The hydrographer's Multibeam data format shall provide complete traceability for all positions, soundings, and correctors including sensor offsets, biases, dynamic attitude, sound velocity, position, sensor position, date and time, vertical datum reducers, and sounding data from acquisition through postprocessing. Data quality and edit flags must be traceable.

Raw Multibeam Data

The hydrographer shall submit full resolution Multibeam data in a format readable by CARIS HIPS (Version 5.3, by CARIS). Full resolution multibeam data shall be delivered fully corrected for tides, sound velocity, vessel offsets, draft and settlement and squat. These corrections may be made within CARIS, with data submitted as a complete CARIS project (including HDCS files, sound velocity files, Vessel Configuration, CARIS tide files, etc.). Or the data may be submitted fully corrected, such that it will be read in CARIS HIPS using a 'zeroed' Vessel Configuration file (.vcf) and a 'zero' tide file (.tid), etc. Full resolution data are defined as all data acquired and logged during normal survey operations. Information and specifications on CARIS HIPS and data formats may be obtained from CARIS at 506-458-8533.

Edited Multibeam Data

The hydrographer shall submit an edited Multibeam data set in ASCII text format. Edited data are defined as fully corrected data that meet accuracy and resolution specifications (see Section 5, Depth Sounding) are cleaned of all anomalous soundings, and serve as the source for all preliminary smooth sheet soundings and sun-illuminated DTM's (see Section 5.5.4). Edited data sets shall contain XYZ, z' (tide corrector), date/time stamp, and a unique identifier which indicates whether the sounding is depicted on the smooth sheet. Coordinates (XY) shall be latitude/ longitude NAD 83 (decimal degrees to eight decimal places), and depth (Z) shall be in meters to nearest centimeter (fully corrected for tide (MLLW datum), sound velocity, dynamic and static draft, and all vessel offsets). Tide corrector (z') shall be in meters to the nearest centimeter. Time shall be UTC to the nearest second. Data shall be binned, line by line, at a bin size not less than 5 m + 5 percent of the depth, using shoal biased filtering. All depths shall retain their survey position and shall not represent the binned area centroid or other abstract position (i.e. binned, not gridded data).

Preliminary Smooth Sheet Data

The hydrographer shall submit the preliminary smooth sheet data set in ASCII text format. The smooth sheet data set shall contain XYZ. Coordinates (XY) shall be latitude/longitude NAD83 (decimal degrees to eight decimal places), and Z shall be depth in meters to the nearest centimeter (fully corrected for tide (MLLW datum), sound velocity, dynamic and static draft, and all vessel offsets).

Specific Multibeam Data

The hydrographer shall submit raw crossline data and data used for determining navigation time latency, pitch, roll, and yaw biases on separate media. Raw mainscheme lines which contain depths over dangers to navigation, wrecks, rocks or obstructions shall also be included on separate media. The data format shall be such that CARIS HIPS can convert the data, thus making it compatible as described earlier in this Section.

8.5.4. Side Scan Sonar Data

The hydrographer shall submit digital side scan data in a format readable by CARIS SIPS (version 5.3, by CARIS, phone: (506) 458–8533). Digital side scan sonar shall be geocoded using the towfish position. Information and specifications on CARIS SIPS and data formats may be obtained from CARIS.

Side Scan Contact Images

The hydrographer shall submit digital images of all significant side scan contacts within the contact list (see Section 8.4.2). Digital images shall be in a standard image format (e.g., .tif, .gif, .jpg). The file name shall coincide with the contact name as depicted on the contact list.

Side Scan Mosaics

The hydrographer shall submit an digital image file for each 100 percent coverage. The digital image file shall be in a standard geo-referenced image format.

8.5.5. Other Data

Tide and Sound Velocity Data

The hydrographer shall submit tide data and sound velocity data applied to all Multibeam depths on CD ROM or on the project data tapes. The hydrographer shall identify the data format and all data element descriptions (e.g., ASCII text file or Excel spreadsheet file; date/time referenced to UTC, tide relative to MLLW datum to the nearest centimeter).

Vessel Configuration File

The hydrographer shall submit a CARIS compatible Vessel Configuration file (VCF) for each vessel used during survey operations. CARIS-compatible VCF shall contain those static and dynamic correctors and offsets which are to be applied to the raw Multibeam data set submitted as referenced in Section 8.5.3. Information and specifications on the vessel configuration file format may be obtained from CARIS.

Digital Plot Files

Digital plot files are required for the preliminary smooth sheet and overlays. The format shall be HPGL/2 or Adobe Distiller version 5-based. Digital plot files shall be submitted on either CD ROM (preferred) or on one of the tape media described in Section 8.5.1.

Appendix 1

NOAA Form 77-12 Tide Station Report

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N/OMA121 Form 91-01 Next Generation Water Level Measurement System Site Report

NOAA FORM 77-12 (5-80) — U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.

TIDE STATION REPORT

INSTRUCTIONS: This form is to be fully completed and submitted on station installation and at annual inspection/maintenance. (All information will be verified correct and measurements retaken.) At other station visits and on removal, only changes need be recorded in the appropriate blocks.

STATION NAME | STATION NUMBER

LATITUDE | LONGITUDE | TIME MER.

TYPE OF STATION ☐ PRIMARY ☐ SECONDARY ☐ TERTIARY | REC'D BY NOS HQ

PROJECT ☐ CONTROL ☐ BOUNDARY ☐ CIRCULATORY ☐ HYDROGRAPHIC ☐ OTHER

☐ TEMPERATURE & DENSITY MEASUREMENTS AT THIS STATION

☐ ESTABLISHED ☐ INSPECTED ☐ REMOVED

BY: | DATE

APPROVED BY | DATE

WHARF

NAME

OWNER'S NAME AND LOCAL CONTACT

BUSINESS ADDRESS/TELEPHONE NUMBER

TIDE OBSERVER

NAME | TELEPHONE NUMBER *(Include Area Code.)* HOME ( ) BUSINESS ( )

NEW ☐ YES ☐ NO

HOME ADDRESS | DATE HIRED *(If new)* | PAY/MO.

TIDE HOUSE & PLATFORM

SIZE AND BRIEF DESCRIPTION OF INSTALLATION INCLUDING PLATFORM, ACCESS INFO *(Combination, contact, hours...)*

☐ *Continued on reverse.*

TIDE STAFF/ETG

☐ PORTABLE ☐ ELECTRIC ☐ FIXED | ☐ FIBERGLASS ☐ OTHER ☐ VITRIFIED | HINGED ☐ YES ☐ NO | STAFF/ETG CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION

LIMITS OF GRADUATIONS | TOTAL MEASURED LENGTH BETWEEN THE LIMITS OF GRADUATIONS FT. | GRADUATION CORRESPONDING TO RODSTOP/ETG WEIGHT FT. | INITIALS

PRECISE LOCATION, METHOD OF SECURING STAFF, TYPE AND CONDITION OF ROD STOP, AND ADDITIONAL REMARKS

☐ *Continued on reverse.*

GAGES

PRIMARY

TYPE AND MANUFACTURER | SERIAL NUMBER | GAGE CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION

POWER SOURCE ☐ COMMERCIAL ☐ BATTERY ☐ SOLAR ☐ OTHER _____ | FLOAT/ORIFICE DIAMETER INS. | RANGE/SCALE | ☐ NEGATOR SPRING ☐ COUNTERWEIGHT

BACK-UP

TYPE AND MANUFACTURER | SERIAL NUMBER | GAGE CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION

POWER SOURCE ☐ COMMERCIAL ☐ BATTERY ☐ SOLAR ☐ OTHER _____ | FLOAT/ORIFICE DIAMETER INS. | RANGE/SCALE | ☐ NEGATOR SPRING ☐ COUNTERWEIGHT

☐ ADDITIONAL GAGE(S) *(Give details on reverse.)*

REMARKS

☐ *Continued on reverse.*

FLOAT WELL

MATERIAL | INTAKE ☐ FIXED/MOLDED ☐ REMOVABLE | WELL CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION

LENGTH *(Overall)* FT. | LENGTH *(Top to intake)* FT. | INSIDE DIAMETER INS. | INTAKE MAT'L. | INTAKE SIZE *(Hole diameter)* INS. | ORIFICE POSITION

INSPECTION, CONSTRUCTION, INSTALLATION DESCRIPTION AND REMARKS | INTAKE CLEANED ☐ YES ☐ NO | OUTSIDE CLEANED ☐ YES ☐ NO | NO. OF SECURING CLAMPS

☐ *Continued on reverse.*

SUPERSEDES PREVIOUS EDITION. EXISTING STOCK MAY BE DESTROYED UPON RECEIPT OF REVISION.

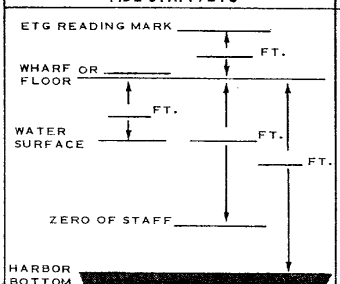
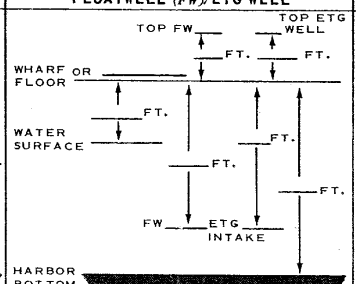
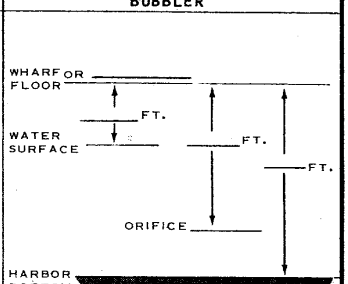
ETG WELL

MATERIAL			INTAKE ☐ FIXED/MOLDED ☐ REMOVABLE	WELL CHANGED ☐ YES ☐ NO	DATE OF INSTALLATION
LENGTH *(Overall)* FT.	LENGTH *(Top to intake)* FT.	INSIDE DIAMETER INS.	INTAKE MAT'L.	INTAKE SIZE *(Hole diameter)* INS.	ORIFICE POSITION
INSPECTION, CONSTRUCTION, INSTALLATION DESCRIPTION AND REMARKS			INTAKE CLEANED ☐ YES ☐ NO	OUTSIDE CLEANED ☐ YES ☐ NO	NO. OF SECURING CLAMPS

TELEMETRY EQUIPMENT

BRISTOL METAMETER TYPE	SERIAL NUMBER	DEDICATED TELEPHONE	GAGE TO METAMETER DIFFERENCE	
LOCATION OF RECEIVER			PERSON TO CONTACT *(MIC/NWS)*	TELEPHONE
DARDC/WLTS TERMINAL UNIT NO.	DARDC/WLTS POWER SUPPLY NO.	WLTS MODULE ☐ A ☐ B	MODULE NUMBER	DARDC/WLTS TELEPHONE

MEASUREMENTS

TIDE STAFF/ETG	FLOATWELL *(FW)*/ETG WELL	BUBBLER
		
STAFF/ETG OBSERVATION FOR MEASUREMENT FT. | TIME | DATE	STAFF/ETG OBSERVATION FOR MEASUREMENT FT. | TIME | DATE	STAFF/ETG OBSERVATION FOR MEASUREMENT FT. | TIME | DATE

LATEST LEVELS

DATE OF LEVELS TO TIDE STAFF	NO. OF MARKS CONNECTED	PBM CONNECTED ☐ YES ☐ NO	NO. OF MARKS ESTABLISHED	NO. OF MARKS RECOVERED
REMARKS *(Recommendations for new marks, etc.)*				

ADDITIONAL INFORMATION, SKETCH, AND/OR RECOMMENDATIONS *(For continuation, please indicate item. Use additional sheet, if necessary.)*

*U.S. GPO: 1988-554-006/81003

N/OMA121 FORM 91-01 NOAA/NATIONAL OCEAN SERVICE

NEXT GENERATION WATER LEVEL MEASUREMENT SYSTEM (NGWLMS) SITE REPORT

INSTRUCTIONS: This form is to be fully completed (all information shall be verified correct and measurements notated) and submitted on site installation and inspection. At other site visits (repair/modifications) and on removal, only changes need be recorded. This form shall be accompanied by the NGWLMS Well/Sounding Tube Worksheet or equivalent sketch.

SITE NAME | SITE ID NUMBER

LATITUDE (N/S) | LONGITUDE (E/W) | TIME MER. (E/W)

FACILITY

☐ ESTABLISHED ☐ INSPECTED ☐ REPAIRED ☐ REMOVED

BY: | DATE

APPROVED BY: | DATE

RECEIVED (NOS HQ) BY: | DATE

OWNER'S NAME (And Local Representative)

ADDRESS/TELEPHONE #

LOCAL CONTACT

NAME | HOME TELEPHONE # | BUSINESS TELEPHONE #

HOME ADDRESS | DATE HIRED | NEW? ☐ YES ☐ NO | PAY/MONTH

SHELTER & PLATFORM

DESCRIPTION, REMARKS (Size, construction, access, utilities, etc)

☐ Continued on reverse

9000 RTU

RTU S/N | DATE RTU INSTALLED | RTU TELEPHONE # | RTU POWER SOURCE ☐ AC ☐ SOLAR | OPERATING SYS VER | SOL PROGRAM VER

RTU BOARDS CHANGED? ☐ YES ☐ NO | PWR SUPPLY BD S/N | SAT/RADIO BD S/N | COMM CNTL BD S/N | GENERAL I/O BD S/N | MEMORY EXP BD S/N | CPU BD S/N

RTU DESICCANT CHANGED? ☐ YES ☐ NO | MODEM BD S/N | AQUATRAK BD S/N | BACKPLANE BD S/N | TRANSITION BD S/N | TERMINATION BD S/N | AC PWR STGN BD S/N

DESCRIPTION, REMARKS (Location, mounting, etc)

☐ Continued on reverse

PRIMARY WATER LEVEL SENSOR

AQUATRAK S/N | MATCHED TUBE S/N | SENSOR OFFSET | AQ. CHANGED? ☐ YES ☐ NO | DATE AQ. INSTALLED | TEMPERATURE SENSORS SEPARATION

DESCRIPTION, REMARKS

CPVC SOUNDING TUBE LENGTH (Level point to brass tube end) | BRASS TUBE LENGTH | # BAILS

☐ Continued on reverse

PROTECTIVE WELL

MATERIAL (diameter, schedule, color, etc) | PIPE LENGTH (flange to flange) | DATE WELL INSTALLED | INTAKE: DOUBLE CONE ☐ SHROUD ☐ SIDE ☐ | INTAKE/WELL (Cleaned by diver) ☐ YES ☐ NO

BRACKETS (number, type, material, etc) | TOP HAT? ☐ YES ☐ NO | COPPER INSERT? ☐ YES ☐ NO | PARALLEL PLATES? ☐ YES ☐ NO

DESCRIPTION, REMARKS (Well location, vent hose number/size/elevation, mounting, brackets, components, etc)

MARINE FOULING POTENTIAL: LIGHT ☐ MEDIUM ☐ HEAVY ☐ SEASONAL ☐

☐ Continued on reverse

GOES TRANSMISSION & SOLAR PANEL

ANTENNA S/N | DATE ANTENNA INSTALLED | CABLE LENGTH | LOW LOSS CABLE USED? ☐ YES ☐ NO | SMT OFFSET | AZIMUTH | LOCAL DEV. | ELEVATION

PLATFORM ID NUMBER | CHANNEL | TRANSMIT TIME | SOLAR PANEL MANUFACTURER & S/N | RATING | ANGLE

DESCRIPTION, REMARKS (Antenna mounting, etc)

☐ Continued on reverse

8200 DATA RECORDER

8200 S/N	DATE 8200 INSTALLED	PROGRAM VERSION	POWER SOURCE	DESICCANT CHANGED?	CPU S/N	INTERCONNECT S/N
			☐ DC ☐ SOLAR	☐ YES ☐ NO		

DESCRIPTION, REMARKS (Mounting, location, etc)	JUMP GAIN	SENSOR SLOPE

☐ Continued below

BACKUP WATER LEVEL SENSOR

SENSOR MANUFACTURER	SENSOR S/N	DATE SENSOR INSTALLED	SENSOR CONFIGURATION	PARALLEL PLATES?
☐ DRUCK ☐ IMO ☐ PAROSCIENTIFIC ☐ OTHER _____			☐ WATER ☐ BUBBLER	☐ YES ☐ NO

DESCRIPTION, REMARKS (Sensor location, installation details, etc)

☐ Continued below

OTHER SENSORS

AIR TEMPERATURE	DATE INSTALLED	BAROMETER S/N	DATE INSTALLED	CONDUCTIVITY S/N	DATE INSTALLED
☐ YES ☐ NO					
WATER TEMPERATURE	**DATE INSTALLED**	**WIND SENSOR S/N**	**DATE INSTALLED**	**MET TOWER TYPE**	**DATE INSTALLED**
☐ YES ☐ NO				STEEL ☐ FIBERGLASS ☐	

DESCRIPTION, REMARKS (Sensor/tower location, installation details, etc)

☐ Continued below

LATEST LEVELS

DATE OF LEVELS	NUMBER OF BENCH MARKS CONNECTED	NUMBER OF BENCH MARKS ESTABLISHED	NUMBER OF BENCH MARKS RECOVERED	PBM CONNECTED?	DOWNSHOT LEVELING FIXTURE REQUIRED?
				☐ YES ☐ NO, EXPLAIN	☐ YES ☐ NO

REMARKS

☐ Continued below

AQUATRAK COEFFICIENT 2A (PBM above site datum; from HG)

AQUATRAK COEFFICIENT 2B (Leveling point above PBM; from levels) +

AQUATRAK COEFFICIENT 2 (2A + 2B = 2) =

REMARKS (Continuations, recommendations, etc)

Appendix 2

NOS Cartographic Codes and Symbols

NOTE: Pages 2,4,14, and 18 were intentionally left blank in the original document. These pages contained no information and are not reproduced here.

SOURCE CARTOGRAPHIC CODES AND SYMBOLS
(Hydrographic)

The cartographic codes and symbols shown in the accompanying tables (A-1 through A6, B-1 through B-3 and C) shall be used to represent features on hydrographic survey smooth sheets and in digital hydrographic survey data files within the Hydrographic Surveys Branch. Control station codes are entered during hydrographic field work; the rest of the codes are entered as needed either during field work or office processing.

All symbols and notes are inked in black unless otherwise indicated.

Cartographic Codes Tables

Table A-1. Control Stations§

Single purpose cartographic codes - Point Features

Cartographic codes	Descriptions	Symbols and examples
139	Basic or supplemental control station*	**101** MORTON, 1959 [Symbol and lettering inked in red with center of symbol inked in black.]
243	Hydrographic station**	**213** TRAV-1, 1975 [Symbol and lettering inked in red with center of symbol inked in black.]
250	Basic or supplemental control station (recoverable) used as an electronic positioning system antenna site*	**102** **SANDY, 1973** [Symbol and lettering inked in red with center of symbol inked in black.]
252	Hydrographic station located by sextant fixes or cuts	**319** (chy) [Symbol and number inked in blue with center of symbol & (chy) inked in black.]
253	Hydrographic station located by unconventional methods¶	**327** (cup) [Symbol and number inked in green with center of symbol & (cup) inked in black.]
254	Undescribed, nonrecoverable station used as an electronic positioning system antenna site**	**117** **AA-74, 1974** [Symbol and lettering inked in red with center of symbol inked in black.]

§ Station names and numbers of tanks, gables, chimneys, piles, rocks, and similar recoverable objects used as signals shall be accompanied by a brief description in black ink in parentheses, unless described in the control station name. Signals in water areas always shall be described fully; temporary signals are accompanied by the note "(temp)."

* Use this symbol only to describe marked, recoverable stations and intersection stations of third-order class-II or higher accuracy. This symbol shall be used only for stations included, or intended for inclusion, in the NGS system of adjusted geodetic stations.

** Stations located by traverse, plane table, or photogrammetric (including aerotriangulation) methods, or, undescribed, nonrecoverable stations of third-order or lower accuracy.

¶ Station located by spotting its position on a topographic map or aerial photograph for transfer to the hydrographic sheet.

Table A-2. Dangers to Navigation and Soundings

Single purpose cartographic codes - Point Features

Cartographic codes	Descriptions	Symbols and examples
711	Sounding	13^2
367	Sounding, labeled hard	5^3 *hrd*
089	Rock or coral head (depth known or unknown)	+
165	Rock or coral head@ (with est. depth)	+ *covers* 0^5 *m at MLLW*
988	Islet	*(1)*
098	Wreck	
278	Dolphin	*dol*
279	Pile	*pile*
280	Pipe	*pipe*
281	Stake	*stake*
282	Stump	*stump*
283	Snag	*snag*
284	Obstruction	*obstr*
286	Crib (symbol)	*crib*
232	Deadhead (usually one end afloat)	*deadhead*
893	Ruins (symbol)	*ruins*
885	Duck blind (temporary structure)	duck blind
886	Duck blind ruins (temporary structure)	duck blind ruins
056	Oil or gas well	*well*
111	Platform - oil or gas	platform
248	Platform (survey)	survey platform
249	Platform (oil or gas), lighted	oil platform (lighted)
075	Sand waves (label only)	*sand waves*

Table A-2. Dangers to Navigation and Soundings (continued)

Single purpose cartographic codes - Point Features

Cartographic codes	Descriptions	Symbols and examples
533	Spoil (label only)	*spoil*
534	Waterfall (label only)	*waterfall*
535	Rapids (label only)	*rapids*
536	Eddies (label only)	*eddies*
537	Shoal (label only)	*shoal*
538	Foul (label only)	*foul*
539	Breakers (label only)	*breakers*
599	Kelp (label only -- used to indicate extensive kelp beds visible on the surface.)	*kelp*
103	Kelp (symbol) not to be used for bottom characteristic but to indicate small isolated patches visible on the surface.	
146	Tide rips (label only)	*tide rips*
090	Wire-drag clearance	42 *Wk-cleared by 40 ft*
957	Rock - side scan sonar depth	12^{5} *Rk (A)*
961	Wreck - side scan sonar depth	13^{5} *Wk (A)*
967	Obstruction - side scan sonar depth	19^{5} *Obstr (A)*

Table A-3. Buoys

Single purpose cartographic codes - Point Features

Buoy single purpose cartographic code = 124

Cartographic codes	Descriptions*	Symbols and examples
124	Vertically striped buoy, lighted,	
214	Vertically striped buoy (e.g., black and white midchannel can buoy, unnumbered)	 BW C [Lettering in red ink.]
182	Horizontally banded buoy, lighted, (e.g., red over green; lettering in red ink)	 RG
216	Horizontally banded buoy (e.g., red and black junction can buoy, unnumbered, lettering in red ink.)	 RB C
211	Diagonally banded buoy, lighted	
217	Diagonally banded buoy	
259	Open buoy symbol, lighted	
212	Open buoy symbol	
498	Mooring buoy, lighted	
215	Mooring buoy	
472	Checkered buoy, lighted	
218	Checkered buoy	
257	Red buoy, lighted (e.g., bell buoy, number 4) [Buoy diamond symbol & lettering in red ink.]	 BELL "4"
255	Red buoy (e.g., red nun buoy, number 32) [Buoy diamond symbol & lettering in red ink.]	 N "32"

*Description: color, function and/or special marking to be labeled as appropriate. The color sequence is from top to bottom where multiple colors are in horizontal bands. Where multiple colors are in vertical or diagonal stripes, the darker color is given first.

Table A-3. Buoys (continued)

Single purpose cartographic codes - Point Features

Cartographic codes	Descriptions*	Symbols and examples
258	Black buoy, lighted (e.g., bell buoy, number 5) [Buoy diamond symbol in black ink, lettering in red ink.]	 *BELL "5"*
256	Black buoy (e.g., black can buoy, number 33) [Buoy diamond symbol in black ink, lettering in red ink.]	 *C "33"*
482	Green buoy, lighted [Buoy diamond symbol filled in green ink.]	
481	Green buoy [Buoy diamond symbol filled in green ink.]	
787	Super buoy, lighted (tanker terminal)	
947	Articulated light	
950	Articulated daybeacon (inside of triangle and the note *"Art"* are inked in red]	 *Art*
951	Articulated daybeacon (inside of square filled with green ink and the note "Art" is inked in red]	 *Art*

*Description: color, function and/or special marking to be labeled as appropriate. The color sequence is from top to bottom where multiple colors are in horizontal bands. Where multiple colors are in vertical or diagonal stripes, the darker color is given first.

Table A-4. Bottom Characteristics

.gle purpose cartographic code -- Point Features

Bottom characteristics single purpose cartographic code = 550

Nouns	Examples	Adjectives	Examples	Colors	Examples
Ooze	*Oz*	Gritty	*gty*	Black	*bk*
Clay	*Cl*	Rocky	*rky*	White	*wh*
Silt	*Silt*	Fine	*fne*	Gray	*gy*
Mud	*M*	Medium	*med*	Brown	*br*
Sand	*S*	Coarse	*crs*	Red	*rd*
Gravel	*G*	Soft	*sft*	Yellow	*yl*
Shingle	*Sn*	Hard	*hrd*	Blue	*bu*
Coral head	*Co Hd*	Sticky	*stk*	Orange	*or*
Pebbles	*P*	Broken	*brk*	Green	*gn*
Stones	*St*	Speckled	*spk*	Violet	*vi**
Boulders	*Blds*	Light	*lt*		
Shells	*Sh*	Dark	*dk*		
Coral	*Co*	Small	*sml*		
Oysters	*Oys*	Large	*lrg*		
Sponge	*Spg*				
Seaweed	*Wd*				
Grass	*Grs*				

* The dot over the italicized "i" is to be eliminated when lettered on the smooth sheet.

Table A-4. Bottom Characteristics (continued)

Sediments Classified by Size

Type	Term	Grain Diameter (mm)
Clay		
	Mud	0.02-0.1
Silt		
	Fine	0.1-0.3
Sand	Medium	0.3-0.5
	Coarse	0.5-1.0
	Fine	1-2
Gravel	Medium	2-4
	Coarse	4-6
	Fine	6-10
Pebbles	Medium	10-20
	Coarse	20-35
Stones		50-250
Boulders		≥250

Careful inspection by sight and touch should enable the hydrographer to provide a reasonably accurate description of the material.

Close to shore and on the Continental Shelf, bottoms generally consist of sands, gravels, muds, and the remains of plant and animal life. Ledge rock may be exposed in a few areas close to shore where slopes are steep. Sediments are typed according to the size of their particles. It is not intended that the dimensions be measures. A careful estimation by eye is satisfactory.

Sediments larger than sand are easy to recognize and simple to classify by size. Generally, sand is recognizable as even the finer grained sands feel gritty when rubber between a finger and the palm of the hand. When dry, sand separates into grains visible to the naked eye.

Technically, there are two classes of material finer than sand. These are silt and clay. For practical purposes, silt and clay are classified under the general term, mud.

If the material feels gritty when rubbed between the fingers, it may be properly classified as silt. Clay is a finer grained deposit than silt and normally feels smooth and sticky to the touch.

Ooze is not soft mud, as commonly interpreted, but is a pelagic sediment containing more than 30% organic material and is found only in the greater ocean depths off the Continental Shelf on the abyssal plains.

Table A-5. Nonfloating Aids to Navigation and Landmarks

Single purpose cartographic code -- Point Features

Cartographic codes	Descriptions	Symbols and examples
086	Accurate fixed point (landmark*, marker, sign) of less than third-order accuracy	⊙ TANK, ELEVATED (Country Club Hills) (landmark: 60 ft above ground, 245 ft above MHW)
139	Structure, of third-order or better accuracy, used as a signal (Give station name and year, and U.S. Coast Guard Light List name if different)# [Triangle & lettering in red ink; triangle center in black ink.]	△ 108 SAND POINT LIGHTHOUSE, 1887 *(Bay Shaft Light)*
139	Structure, of third-order accuracy, not used during the survey, but suitable for use as a landmark§ [Triangle & station station name in red ink; triangle center in black ink.]	△ RADIO TOWER, WNOR, 1972 (landmark: 620 ft above ground 705 ft above MHW)
200	Lighted structure, not used as a signal and located by less than third-order methods (Give U.S. Coast Guard Light List name.)	⊙ *Bald Pt Lt*
208	Light, front range** (Use U.S. Coast Guard Light List name.)	⊙ *Range Front Light*
209	Light, rear range** (Use U.S. Coast Guard Light List name.)	⊙ *Range Rear Light*

* Landmarks of third-order or better accuracy that were not used to control the survey are shown using the triangulation station symbol and the landmark description; e.g., cartographic code 139. Cartographic code numbers 086 and 200 are also used for photogrammetrically determined positions.

** If such range lights are located in accordance with third-order accuracy requirements, they shall be indicated as cartographic code 139 in the hydrographic digital file and symbolized on the smooth sheet with the triangulation station symbol.

If used as a signal, but no longer in service, indicate as follows: (abandoned).

§ If an aid to navigation or landmark was located by less than third-order methods for use as a signal, the appropriate control station symbol takes precedence; e.g., cartographic code 243.

Table A-3. Nonlocating Aids to Navigation and Landmarks
(continued)

Cartographic codes	Descriptions	Symbols and examples
243	Aid to navigation, located photogrammetrically and used as a hydrographic signal; e.g., black daybeacon number 33.	⊙ 187 *(B Bn "33")* (Symbol circle & lettering in red ink; symbol center in black ink.)
223	Daybeacon (open) (color, function and/or special marking to be labeled as appropriate.)	△
219	Daybeacon (black)	▲ *"33"* (Lettering in red ink)
224	Daybeacon (red)	▲ *"32"* (Red ink)
767	Daybeacon (green)	▲ *"5"* (Lettering in red ink.)
229	Marker (privately maintained, lighted)	° priv marker (lighted)
261	Marker (privately maintained)	° priv marker
221	Marker, measured course--front (indicate nautical miles unless otherwise specified.)	° marker (mile)
222	Marker, measured course--rear (indicate nautical miles unless otherwise specified.)	° marker (mile)
246	Marker, front dredging range	° marker (dredging range)
247	Marker, rear dredging range	° marker (dredging range)
906	Daybeacon, front range (color to labeled as appropriate.)	△ *F Range Bn* (Lettering in red ink.)
907	Daybeacon, rear range (color to labeled as appropriate.)	△ *R Range Bn* (Lettering in red ink.)

Table A-6. Miscellaneous Features

Single purpose cartographic codes - Point Features

Cartographic codes	Descriptions	Symbols and examples
078	Data for which a symbol is not to be plotted. (This code also may be utilized for detached positions used to delineate features.)	(No symbol)
244	Tide or water level gaging station.	Tide Station (Symbol and lettering in blue ink.)
245	Current station.	Current Station (Symbol and lettering in blue ink.)
480	Anchorage (large vessels)	
702	Anchorage (small vessels)	
993*	Potential landmark (photogrammetrically identified)	Tower

* Cartographic code 993 is for field and AHS/PHS (data acquisition and processing) use only. Such features should be investigated during hydrographic survey field work and either rejected or upgraded to cartographic code 086 or 139.

Table B-1. Dangers to Navigation

Single purpose cartographic codes - Line Features

Cartographic codes	Descriptions	Symbols and examples
002	Shoal/shallow (area limits)	shoal
004	Stationary structure, floating or fixed (to scale); e.g., floating breakwater, float, ski jump, etc.	float crab pen (fixed structure)
009	Reef or ledge (area limits)	
011	Breakers (area limits)	breakers
044#	Wreck, hulk, visible (to scale)	hulk
045	Wreck, hulk (to scale)	
060	Danger area limits, obstructions (described)	
112	Sand waves (area limits)	sand waves
118	Submarine cable	subm cable
121	Fish trap (actual configuration)	fish trap
285	Ruins* (configuration or area limits)	ruins
314	Depth curve - approximate	
477	Wreckage (area limits)	wreckage
489	Platform, oil* or gas (drawn to scale-actual configuration)	oil platform
604	Depth curve	
791	Pipeline*	subm pipeline
802	Ramp--hydrographic feature (to scale)	ramp

* Use code 044 to designate a wreck, hulk, any part of which (hull or superstructure) protrudes above the sounding datum; i.e. MLLW. Use slanted lettering if the hulk is not visible at mean high water.

Table B-1. Dangers to Navigation
(continued)

Single purpose cartographic codes - Line Features

Cartographic codes	Descriptions	Symbols and examples
869	Living resources, oyster bed/bar (area limits)	oys
871	Kelp (area limits)	kelp
872	Grass (area limits)	Grs
892	Crib* (configuration or area limits)	crib
894	Foul (area limits)	foul
921	Floating barrier - log boom, hyacinth boom, oil* barrier, etc.	log boom
925	Piles,* poles, stakes, etc. (row or configuration)	piles

* The dot over the italicized "i" is to be eliminated when lettered on the smooth sheet.

Table B-2. Low Water Line and Associated Features

Single purpose cartographic codes - Line Features

Cartographic codes	Descriptions	Symbols and examples
008	Zero depth curve from photogrammetric shoreline maps or topographic surveys	
013	Zero depth curve drawn from corrected soundings	[orange ink]
188	Zero depth curve estimated and sketched from hydrographic data	[orange ink]
530	Ledge*	
530	Reef	
531	Ledge/reef (symbol at ½ scale)	

* See also figure B-4 for more detailed ways to depict ledges and reefs.

Table . 3. Shoreline and Alongsh. . Features

Single purpose cartographic codes - Line Features

The cartographic codes listed below may be included in the digital hydrographic file only if the features were identified and/or located by the hydrographer and if identical features are not shown on the shoreline map. When these features are included in the hydrographic file, they shall be smooth plotted in red ink. When they originate with the shoreline map (TP-sheet), they shall be smooth plotted in black ink; e.g., codes 001, 003, and 007. The above rules do not apply to submerged features represented by cartographic codes 026, 029, 042, 228, and 801. These five features should always be included in the hydrographic survey file whether located by the hydrographer or the photogrammetrist, and they shall always be plotted in black ink.

Cartographic codes	Descriptions	Symbols and examples
001	Approximate shoreline (HWL)	-------
003	Marsh, swamp, and mangrove (apparent shoreline as shown on the shoreline map)	______
007	Fast solid land	———
016	Floating pier* or pier section (single or double line)	_____ *floating pier*
026	Breakwater, jetty (submerged or awash)	------ *subm bkw*
027	Breakwater, jetty (single or double line)	______ breakwater
029	Breakwater, jetty (submerged area limits)	—— *subm bkw*
030	Pier* (single or double line)	_____ pier
031	Groin* (single or double line)	_____ groin
038	Wharf, bulkhead, seawall, riprap etc. (to be accompanied by an appropriate annotation)	_____ bkhd
039	Marine railway*	——— marine railway
040	Drydock	_____ drydock
041	Floating drydock*	____ *floating drydock*
042	Marine railway* (subm offshore limits)	------ *marine railway*

* Eliminate the dot over the "i" when lettered on the smooth sheet.

Table B-3. Shor. .ne and Alongshore Feature (continued)

Single purpose cartographic codes - Line Features

Cartographic codes	Descriptions	Symbols and examples
043	Lock	_____ lock
055	Ramp	_____ ramp
057	Bridge (general, actual configuration)	_____ bridge
059	Bridge (symbol, single line)	
144	Fast solid land (accurate shoreline revision sketched by the hydrographer)	____ *[red ink]*
145	Fast solid land (estimated shoreline revision sketched by the hydrographer)	------- *[red ink]*
189	Marsh, swamp, and mangrove (estimated revision of apparent shoreline sketched by the hydrographer)	*[red ink]*
190	Marsh, swamp, and mangrove (accurate revision of apparent shoreline sketched by the hydrographer)	_____ *[red ink]*
228	Groin (submerged portion)	----- *subm groin*
425	Bridge fender	____ bridge fender
483	Fence (linear feature)	
801	Pipeline--sewer outfall, cooling water intake, etc.(submerged)	— — — *subm sewer outfall*
808	Overhead cable (power/telephone)#	— — — ovhd power cable
862	Overhead pipeline#	— — — ovhd pipeline
877	Glacier (terminus limits)	------ glacier

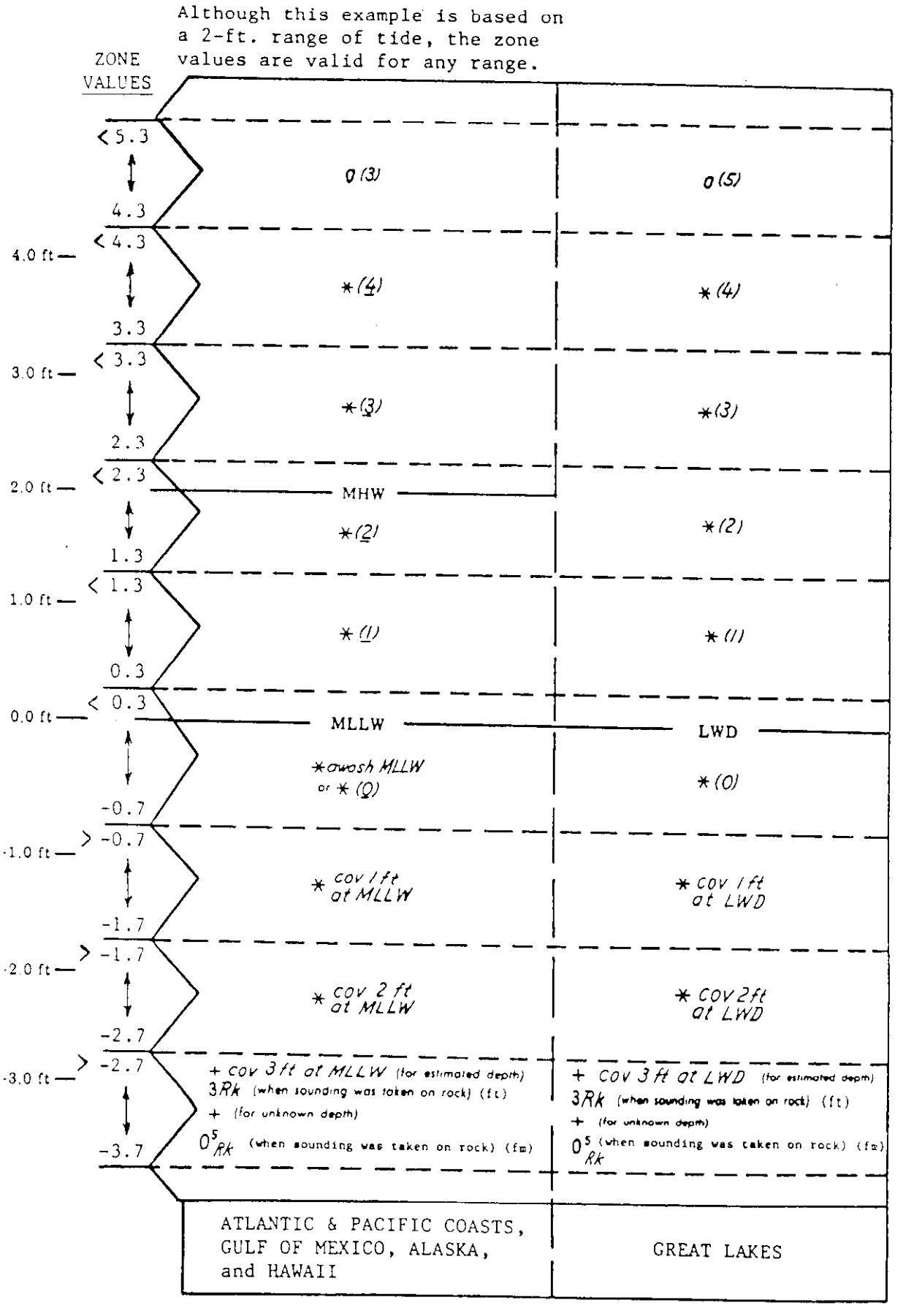
Cartographic codes 808 and 862 are symbolized on the smooth sheet by a short dashed black line extending shoreward of the MHW. Orient the dashed line so that its extension will indicate the direction of the feature over the water area. Use code 086 (table A-5) to indicate the positions of individual support poles in the water area (positioned either photogrammetrically or by detached positions). Code 862 may be used to identify a sewer outfall; the dashed line will extend to the end of the feature in the foreshore area, and a descriptive note in vertical lettering "sewer outfall" will be added to the smooth sheet.

Table C. Units

Single purpose cartographic codes - Units

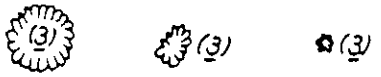
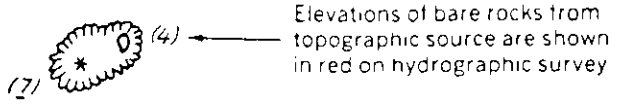
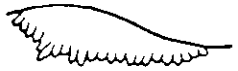
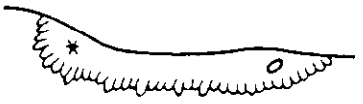
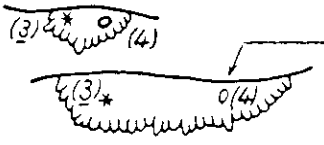
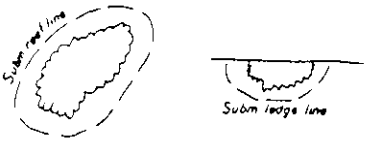
Units Positive (+) or Negative (-)	Cartographic Code
whole feet	126
feet and tenths	127
feet and fractions	128
whole fathoms	129
fathoms and tenths	130
fathoms and fractions	131
whole meters	710
meters and tenths	711

SYMBOLIZATION FOR ROCKS



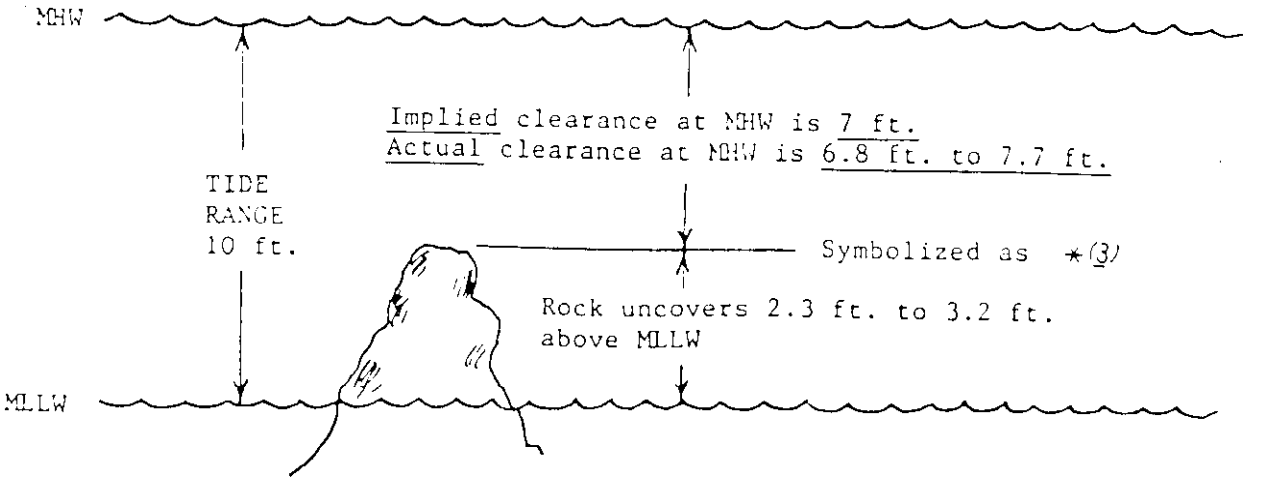
--- Rock and islet symbols and elevation references

CARTOGRAPHIC SYMBOLS

	Reef uncovers at sounding datum. (Elevation unknown)
	Reef uncovers 3 ft at sounding datum.
	Rocks (high points) atop reef. (Elevations unknown)
	Elevations of rocks are known.
	Ledge uncovers at sounding datum.
	Ledge indicates foreshore characteristic only; dotted line is low water line.
	Rocks (high points) atop ledge. (Elevations unknown)
	Elevations of rocks are known.
Co	Add this abbreviation if the features are coral.
*	Reef is smaller than 1.5 x 1.5 mm.
	Dashed line indicates that portion of reef or ledge covered at sounding datum.

Note: These two illustrations are generally found only on photogrammetric shoreline maps. Except on exposed coasts, developments on hydrographic surveys should be sufficient to provide soundings and depth curves which will supersede the submerged ledge areas delineated on the shoreline maps.

Symbols and elevation references for reefs and ledges


MHW
Implied clearance at MHW is 7 ft.
Actual clearance at MHW is 6.8 ft. to 7.7 ft.
TIDE
RANGE
10 ft.
Symbolized as *(3)
Rock uncovers 2.3 ft. to 3.2 ft.
above MLLW
MLLW

Appendix 3

NOAA Form 76-35A
Descriptive Report Cover Sheet

NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey

Field No.

Registry No.

LOCALITY

State

General Locality

Sublocality

CHIEF OF PARTY

LIBRARY & ARCHIVES

DATE

Appendix 4

NOAA Form 77-28
Descriptive Report Title Sheet

NOAA FORM 77-28
(11-72)

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

REGISTRY No

HYDROGRAPHIC TITLE SHEET

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.

State

General Locality

Sub-Locality

Scale **Date of Survey**

Instructions dated **Project No.**

Vessel

Chief of party

Surveyed by

Soundings by echo sounder, hand lead, pole

Graphic record scaled by

Graphic record checked by **Automated Plot**

Verification by

Soundings in fathoms feet at MLW MLLW

REMARKS:

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

U.S GOVERNMENT PRINTING OFFICE: 1976-665-661/1222 REGION NO.6

Appendix 5

NOAA Form 76-40

NOAA Form 76-40
(8-74)

Replaces C&GS Form 567

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSHERIC ADMINISTRATION

NONFLOATING AIDS OR LANDMARKS FOR CHARTS

ORIGINATING ACTIVITY

- ☐ COAST PILOT BRANCH
- ☐ GEODETIC PARTY
- ☐ PHOTO FIELD PARTY
- ☐ COMPILATION ACTIVITY
- ☐ FINAL REVIEWER
- ☐ QUALITY CONTROL & REVIEW GRP.
- ☐ COAST PILOT BRANCH

(See reverse for responsible personnel)

☐ TO BE CHARTED ☐ TO BE REVISED ☐ TO BE DELETED	REPORTING UNIT *(Field Party, Ship or Office)*	STATE	LOCALITY	DATE

*The following objects **HAVE** ☐ **HAVE NOT** ☐ been inspected from seaward to determine their value as landmarks.*

OPR PROJECT NO.	JOB NUMBER	SURVEY NUMBER	DATUM

CHARTING NAME	DESCRIPTION *(Record reason for deletion of landmark or aid to navigation. Show triangulation station names, where applicable, in parentheses)*	POSITION LATITUDE ° / // D.M. Meters	POSITION LONGITUDE ° / // D.P. Meters	METHOD AND DATE OF LOCATION *(See instructions on reverse side)* OFFICE	FIELD	CHARTS AFFECTED

RESPONIBLE PERSONNEL		
TYPE OF ACTION	NAME	ORIGINATOR
OBJECTS INSPECTED FROM SEAWARD		☐ PHOTO FIELD PARTY ☐ HYDROGRAPHIC PARTY ☐ GEODETIC PARTY ☐ OTHER *(Specify)*
POSITIONS DETERMINED AND/OR VERIFIED		FIELD ACTIVITY REPRESENTATIVE
		OFFICE ACTIVITY REPRESENTATIVE
FORMS ORIGINATED BY QUALITY CONTROL AND REVIEW GROUP AND FINAL REVIEW ACTIVITIES		☐ REVIEWER ☐ QUALITY CONTROL AND REVIEW GROUP REPRESENTATIVE

INSTRUCTIONS FOR ENTRIES UNDER "METHOD AND DATE OF LOCATION"

(Consult Photogrammetric Instructions No. 64)

OFFICE

1. OFFICE IDENTIFIED AND LOCATED OBJECTS
   Enter the number and date (including month, Day, and year) of the photograph used to identify and locate the object.
   EXAMPLE: 75E(C)6042
   8-12-75

FIELD

I. NEW POSITION DETERMINED OR VERIFIED
Enter the applicable data by symbols as follows:

F - Field	P - Photogrammetric
L - Located	Vis - Visually
V - Verified	
1 – Triangulation	5 – Field identified
2 – Traverse	6 – Theodolite
3 – Intersection	7 – Planetable
4 – Resection	8 – Sextant

A. Field Positions* require entry of method of Location and date of field work.
EXAMPLE: F-2-6-L
8-12-75

* FIELD POSITIONS are determined by field observations based entirely upon ground survey methods.

FIELD (Cont'd)

B. Photogrammetric field positions** require entry of method of location or verification, date of field work and number of the photograph used to locate or identify the object.
EXAMPLE: P-8-V
8-12-75
74L(C)2982

II. TRIANGULATION STATION RECOVERED
When a landmark or aid which is also a triangulation station is recovered, enter "Triang. Rec." with date of recovery.
EXAMPLE: Traing. Rec.
8-12-75

III. POSITION VERIFIED VISUALLY ON PHOTOGRAPH
Enter 'V-Vis.' And date.
EXAMPLE: V-Vis.
8-12-75

** PHOTOGRAMMETRIC FIELD POSITIONS are dependent entirely, or in part, upon control established by photogrammetric methods.

SUPERSEDES NOAA FORM 76-40 (2-71) WHICH IS OBSOLETE, AND
EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION.

U.S. GPO:1975-0-665-080/1155

Appendix 6

Abstract of Times of Hydrography

For Smooth Tides or Water Levels

Project:OPR-P385-KR[1]Registry No.: H-xxxxxx[1]

Contractor Name:Date:

Sheet Letter: [1]

Inclusive Dates: [2]

Field work is complete.

Day[3]	Time (UTC)		Year
	Start[4]	End[4]	

[1] Project Number, Registry Number, and Sheet Letter from SOW or Hydrographic Survey Letter Instructions.

[2] Dates of the first and last days of data acquisition.

[3] Day of the year (e.g. April 30, 1998 = 120).

[4] Start and end times of hydrography for the day.

Appendix 7

Example
Request for Smooth Tides/Water Levels Letter

TO: NOAA, National Ocean Service
Chief, Requirements and Engineering Branch
SSMC4, Station 6515, N/CS41
1305 East-West Highway
Silver Spring, MD 20910-3281

FROM: <Hydrographer>

SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Approved Tides/Water Level Note
2. Final Zoning in MapInfo format (or the Hydrographer may request the data in ArcView format)
3. Six Minute Water Level Data posted to CO-OPS web site.

Transmit the data to:

<Insert hydrographer's name and shipping address>

These data are required for the processing of hydrographic survey:
Project: OPR-xxxx-KR Registry Number: H-xxxxxx
Sheet Letter: A Locality: xxxxxxxxxxxxxxx

A progress Sketch or chartlet showing the survey area and Abstract of Times of Hydrography are attached.

Tide/water level data are required within 45 days of this receipt. If this schedule cannot be met, please advise the COTR at 301-713-2698 x114.

cc: COTR

Appendix 8

Standard Depth Curve Intervals and Color

Table 1: Standard Depth Curves

Curve *(fm)*	Curve *(ft)*	Curve Color
0	0	Orange
1	6	Green
2	12	Red
3	18	Blue
5	30	Red
10	60	Orange
20	120	Blue
30	180	Violet
40	240	Green
50	300	Red
100	600	Green

Table 2: Supplemental Depth Curves

Curve *(fm)*	Curve *(ft)*	Curve Color
0.5	3	Violet
4	24	Orange
6	36	Green
60	360	Blue
70	420	Green
80	480	Red
90	540	Violet

Appendix 8 (Con't)

Standard Depth Curve Intervals and Color

Table 3: Standard Metric Depth Curves

Curve *(m)*	Curve Color
0	Orange
1	Violet
2	Green
5	Red
10	Blue
15	Orange
20	Violet
25	Green
30	Red
40	Blue
50	Orange
60	Violet
70	Green
80	Red
90	Blue
100	Orange
120	Violet
140	Green
160	Red
180	Blue
200	Orange

Appendix 9

Example #1
Danger to Navigation Report

REPORT OF DANGERS TO NAVIGATION

Hydrographic Survey Registry Number: H10895

Survey Title: State: CALIFORNIA
Locality: SAN FRANCISCO BAY
Sublocality: 3.5 NM SSE OF YERBA BUENA ISLAND

Project Number: OPR-L304-KR-99

Survey Date: July 3, 1999 - July 12, 1999

Features are reduced to Mean Lower Low Water using predicted tides and are positioned on NAD 83.

Charts affected: 18649 60th Edition/Sept.19, 1998, scale 1:40,000, NAD 83
18650 49th Edition/May 01, 1999, scale 1:20,000, NAD 83

DANGER TO NAVIGATION

Shoaling was found in an area bounded by:

LATITUDE(N)	LONGITUDE(W)
37/46/28	122/20/26
37/46/23	122/20/43
37/43/42	122/19/28
37/43/40	122/19/43

As a result, both the 36-foot contour and the 30-foot contour have shifted to the west between .08 nm and .25 nm. Significant soundings defining these contours are as follows:

DEPTH (FT)	LATITUDE(N)	LONGITUDE(W)
36	37/45/31	122/20/20
36	37/45/14	122/20/10
36	37/44/21	122/19/43
36	37/43/55	122/19/35
28	37/45/32	122/20/07

Questions concerning this report should be directed to the Chief, Pacific Hydrographic Branch at (206) 526-6836.

(NOTE: This Example should be used with the graphic in Example #2 of this Appendix.)

Appendix 9

Example #2
Danger to Navigation Report

REPORT OF DANGERS TO NAVIGATION

Hydrographic Survey Registry Number: H10851

Survey Title: State: TEXAS
Locality: GULF OF MEXICO
Sublocality: 15 NM SSE OF GALVESTON

Project Number: OPR-L304-KR-99

Survey Date: July 10, 1999 - July 29, 1999

Features are reduced to Mean Lower Low Water using verified tides and are positioned on NAD 83.

Charts affected: 11323 55th Edition/July 5, 1997, scale 1:80,000, NAD 83
11330 11th Edition/September 30, 1999, scale 1:250,000, NAD 83

DANGERS TO NAVIGATION

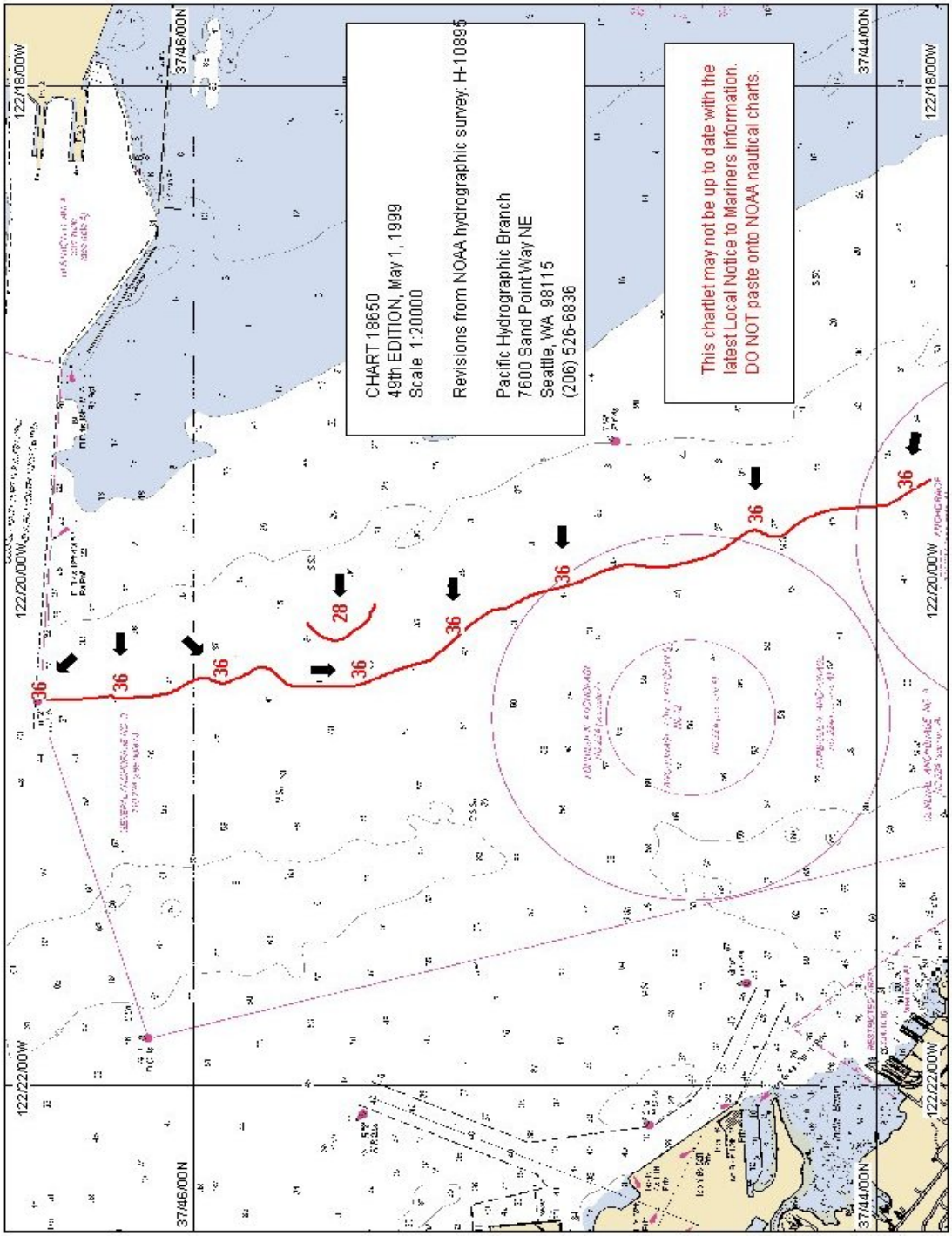
FEATURE	DEPTH (FT)	LATITUDE(N)	LONGITUDE(W)
Shoal	25	29/45/31	094/20/20
Obstruction	31	28/45/14	094/20/10
Wreck	39	29/44/21	094/19/43

Buoy R "2" which is charted at 29/30/15N, 094/23/35W, was not found at its charted location. The current position of buoy R "2" is 29/28/35N, 094/21/10W. The purpose of buoy R "2" is to mark the northeast entrance into the Galveston Ship Channel.

Questions concerning this report should be directed to the Chief, Atlantic Hydrographic Branch at
(757) 441-6746.

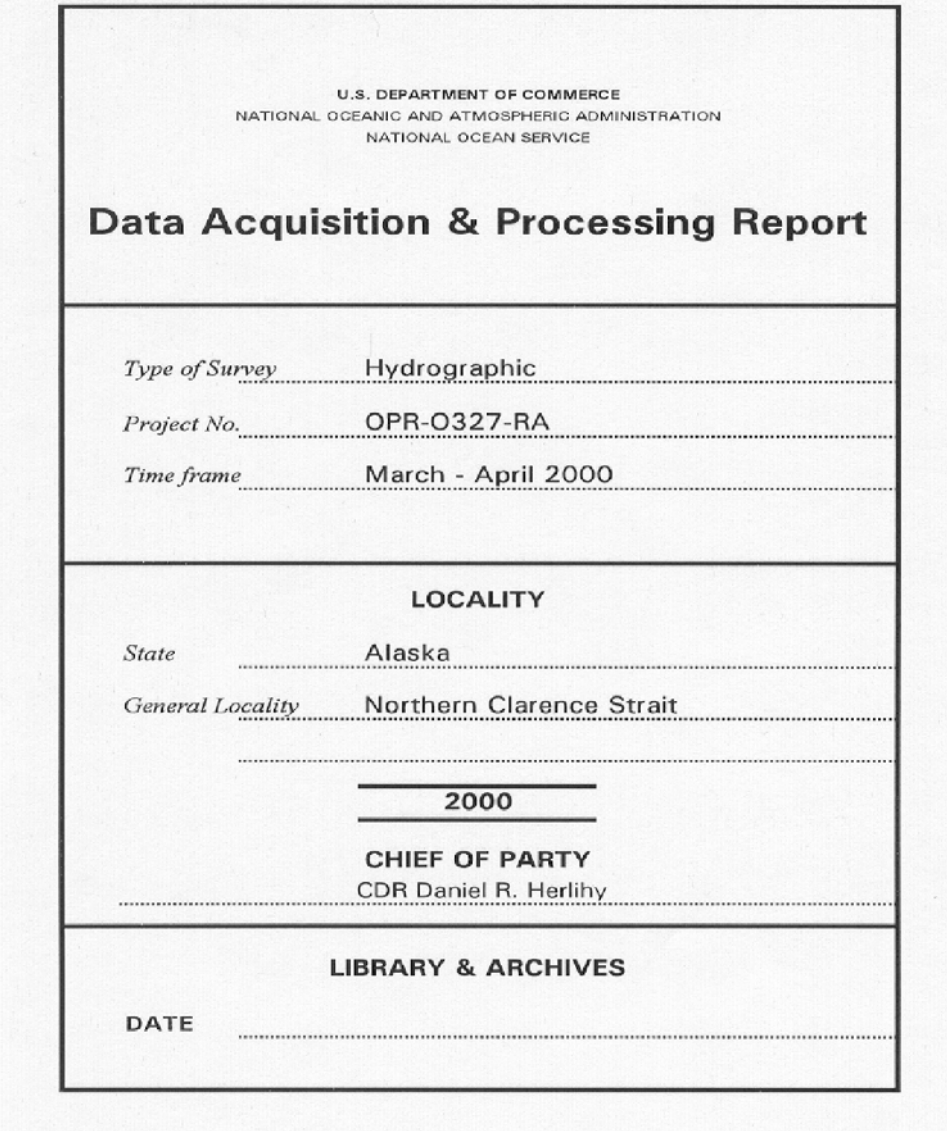
Appendix 9
Example #2 (Con't)

Chartlet to Accompany Danger to Navigation Report



Appendix 10

Data Acquisition and Processing Report



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

Data Acquisition & Processing Report

Type of Survey Hydrographic

Project No. OPR-O327-RA

Time frame March - April 2000

LOCALITY

State Alaska

General Locality Northern Clarence Strait

2000

CHIEF OF PARTY
CDR Daniel R. Herlihy

LIBRARY & ARCHIVES

DATE