NOS HYDROGRAPHIC SURVEYS SPECIFICATIONS AND DELIVERABLES

March 2016

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

Contents

1 Introduction

Contents

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, Fifth Edition, February 2008, specifically for Order 1a surveys. Hydrographic surveys classified as Order 1a are intended for harbors, harbor approach channels, recommended tracks, inland navigation channels, coastal areas of high commercial traffic density, and are usually in shallower areas less 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 Project Instructions for NOAA field units and contractors or in the Statement of Work (contractors only). Field units should contact the Contracting Officer's Representative (COR) or Hydrographic Surveys Division (HSD) Project Manager to ensure they are using the correct and approved version of any software mentioned in these Specifications.

1.1 Change Management

A new edition of the Hydrographic Surveys Specifications and Deliverables (HSSD) will be published in quarter two of each fiscal year by HSD Operations Branch. If a hydrographer has any questions on the interpretation of these Specifications or feels that there may be a "better way" to provide a deliverable, they should contact the COR or HSD Project Manager to discuss and clarify the issue. The Specifications will continue to evolve and can only improve with the input of all users.

Throughout the fiscal year, change requests by NOAA in-house personnel shall be made via HSSD ticket system on Hydroforum located at https://sites.google.com/a/noaa.gov/ocs-hydrography/hydro-help-desk. Change requests by contractors shall be made by contacting the COR who will update the HSSD ticket system. Hydroforum allows for a centralized location to collaborate on and manage HSSD change requests. All proposed changes will be vetted and compiled by HSD Operations Branch and presented to the Chief of HSD for final approval. Approved changes will be enacted and the new version of HSSD will be made available online at http://www.nauticalcharts.noaa.gov/hsd/specs/specs.htm and on NOAA-internal Navigator site.

At any time in the fiscal year there is a crucial need for a HSSD revision before the new edition of HSSD is published, a Hydrographic Technical Directive (HTD) may be issued to modify the current fiscal year HSSD. The Chief of HSD will determine the necessity of an HTD and if deemed crucial, will send an HTD memorandum to all field units indicating the HSSD change, purpose, policy, effective date, and responsibilities.

1.2 Definitions

1.2.1 Hydrographer

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.

1.2.2 Navigable Area Survey

All modern NOAA hydrographic surveys are Navigable Area Surveys, unless explicitly stated otherwise in the Hydrographic Survey Project Instructions. Navigable Area Surveys are basic hydrographic surveys with a restricted inshore limit of coverage.

The shoreline depicted on NOAA's nautical charts approximates the line where the average high tide, known as Mean High Water (MHW), intersects the coast and includes the attached cultural features that are exposed at MHW. In addition, nearshore natural and man-made features such as rocks, reefs, ledges, foul areas, aids to navigation, and mooring facilities are typically included in the colloquial definition of "shoreline." NGS Remote Sensing Division (RSD) is responsible for acquisition and compilation of shoreline data, which it provides directly to MCD for nautical chart updates. However, NOAA's hydrographic field parties may be tasked with verifying that shoreline details are adequately and accurately depicted in source data sets and the corresponding nautical charts.

The inshore limit of hydrography and feature verification for Navigable Area Surveys is the Navigable Area Limit Line (NALL), unless stated otherwise in the Hydrographic Survey Project Instructions. By default, the NALL is defined as the most seaward of the following:

1. The surveyed 4-meter depth contour.

2. The line defined by the distance seaward from the observed MHW line[1] which is equivalent to 0.8 millimeters at the scale of the largest scale nautical chart covering any portion of the survey area (e.g., for a 1:80,000 scale chart, this line would fall 64 meters seaward of the MHW line)[2]

3. The inshore limit of safe navigation for the survey vessel, as determined by the Chief-of-Party in consultation with his or her field personnel. If kelp, rocks, breakers, or other hazards make it unsafe to approach the coast to the limits specified in 1 and 2 above, the NALL shall be defined as the shoreward boundary of the area in which it is safe to survey.

In rare instances, the Chief-of-Party may determine that the NALL lies inshore of the limits defined in 1 and 2. For example, this could be the case in confined waters such as harbors or passes which are inshore of the NALL as defined above, but are regularly utilized by vessels depending on NOAA chart products for safe passage. It could also occur in deep water ports where modern bathymetry is required along wharf faces. In these cases, the Chief-of-Party shall consult with the Chief, HSD Operations Branch or COR, prior to dedicating significant survey resources to these areas.

Also, on some occasions the hydrographer may be tasked with investigation of specific items (e.g., Chart Evaluation File items or USCG Aids to Navigation) which fall inshore of the NALL as defined by criteria 1 and 2 above. The hydrographer may also encounter unassigned natural or anthropogenic features inshore of the NALL which are such exceptionally prominent aids to visual navigation that accurate positions for depiction on nautical charts are required. In these cases, the hydrographer shall proceed inshore of the NALL to accomplish investigation of these features, so long as this can be accomplished safely and in accordance criterion 3 above. Note that the hydrographer is not required to extend bathymetric coverage inshore of the NALL when investigating features with vertical extents above MLLW.

The hydrographer shall discuss in the Descriptive Report all areas where NALL definition deviated from the default criteria. Note that offshore surveys which do not approach the coast will end at their assigned survey limits.

Working near shore is inherently dangerous, and all field units are reminded that safety shall always be the primary consideration when conducting operations. Verification of near shore features should not be attempted unless conditions are favorable. Even though an initial assessment is made by the Chief-of-Party, conditions at the actual survey area may be different or degrade as the day progresses. In such cases, the launch or skiff personnel should defer near shore operations until conditions are favorable.

---

[1] For the purposes of this section "observed MHW line" means the approximate mean high water line estimated visually by the hydrographer from the survey launch.

[2] For surveys which cross a chart scale boundary (e.g., a portion of the survey area is covered at large scale, while the remainder is covered at a smaller scale), the MHW offset for the entire survey shall be based on the largest scale chart covering any portion of the survey area. (Contact the Operations Branch or COR for clarification if required.) Note that the chart scale referenced by this requirement is determined individually for each survey, not for an entire project, i.e., different surveys in the same project may have different maximum chart coverage scale, and thus different MHW offsets for the purpose of NALL determination.

1.3 Pre-Survey Assessment

The Chief of Party / Lead Hydrographer shall complete an informal pre-survey assessment before survey acquisition commences. This assessment shall review and validate the survey requirements in the Project Instructions / Statement of Work (e.g., acquisition method, grid resolution, survey limits, feature verification, etc.) based on conditions observed on the survey grounds and any contact with local stakeholders. Any concerns with the adequacy or appropriateness of the survey requirements as specified in the Project Instructions/Statement of Work shall be brought to the attention of the HSD Project Manager/COR for clarification or adjustment as soon as possible after the completion of this assessment.

1.4 Environmental Compliance

Section 7(a)(2) of the Endangered Species Act (ESA) requires Federal agencies to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat. When a Federal agency's action may affect listed species or critical habitat, formal consultation with National Marine Fisheries Service (NMFS) and/or the Fish and Wildlife Service is required (50 CFR 402.14(a)).

The Office of Coast Survey (OCS) consulted with the NMFS to assess how OCS hydrographic surveying operations and related activities may effect ESA-listed and proposed species and designated critical habitat. NOAA National Ocean Service also completed a programmatic environmental assessment (PEA) to analyze the potential environmental impacts associated with the National Ocean Service, Office of Coast Survey program of conducting hydrographic surveys and related activities in the marine environment.

The ESA Interagency Cooperation Division of NMFS formed a biological and conference opinion on the effects of OCS hydrographic surveying operations on ESA-listed and proposed species and designated critical habitat based on the actions identified in the PEA and subsequent conversations as well as the best available scientific and commercial data. Their opinion concluded that OCS hydrographic surveying operations and related activities "may affect, but [are] not likely to adversely affect" listed species (PCTS #: FPR-2013-9029).

Additionally, the Marine Mammal Protection Act states all marine mammals are protected. Sections 101(a)(5)(A) and (D) allow the incidental take of marine mammals under special circumstances, where "take" is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. §§ 1361-1421h). Harassment includes any annoyance which has the potential to injure a marine mammal or stock (Level A) or disrupt its behavioral patterns (Level B). Coast Survey's main concern is that of Level B harassment during survey activities due to the use of active acoustic sources in the water (Final Programmatic Environmental Assessment for the Office of Coast Survey Hydrographic Survey Projects, 2013).

To fulfill the Endangered Species Act Section 7 Requirements, Coast Survey requires protective measures to minimize adverse effects on listed endangered or threatened species and to minimize modification or destruction of critical habitat. The following protective measures shall be followed during transits to and during survey operations conducted by NOAA and Contractor vessels. In the event of unauthorized incidental take, the field unit shall contact the HSD project manager immediately.

1. Minimize vessel disturbance and ship strike potential
- Slow speeds (4 – 8 knots), when mapping
- Reduced speeds (<13 knots) when transiting through ranges of ESA-listed cetaceans (unless otherwise required, e.g., NOAA Sanctuaries)
- Reduced speeds (<13 knots) while transiting through designated critical habitat (unless slower speeds are required, e.g., < 10 knots in right whale critical habitat and management areas)
- Trained observers aboard all vessels; 100% observer coverage
- Species identification keys (for marine mammals, sea turtles, corals, abalone, and seagrasses) available on all vessels

2. Minimize noise
- Reduced speed (see above)
- Multibeam surveys using ≥ 50 kHz frequencies, lowest possible power and ping-rate
- Single beam surveys using ≥ 30 kHz frequencies, lowest possible power and ping-rate, and 12° beam angle.

3. Minimize vessel discharges (including aquatic nuisance species)
- Meet all EPA Vessel General Permits and Coast Guard requirements
- Avoid discharge of ballast water in designated critical habitat
- Use anti-fouling coatings
- Clean hull regularly to remove aquatic nuisance species
- Avoid cleaning of hull in critical habitat
- Avoid cleaners with nonylphenols
- Rinse anchor with high-powered hose after retrieval

4. Minimize anchor impact to corals, abalone, and seagrass
- Use designated anchorage area when available
- Use mapping data to anchor in mud or sand, to avoid anchoring on corals
- Avoid anchoring in abalone habitat (California vessels return to port, rather than anchor)
- Avoid anchoring in seagrass critical habitat
- Minimize anchor drag

5. Avoid collecting bottom samples in seagrass critical habitat

6. Avoid using tertiary tide gauges (i.e., pressure gauge component) throughout the ranges of ESA listed and proposed coral, abalone and seagrass species

7. Cetaceans
- Avoid approaching within 200 yards (182.9 m), 500 yards for right whales
- Avoid critical habitat, when possible
- Avoid using sonar frequencies < 180 kHz, when possible
- Suspend multibeam sonar transmissions of < 125 kHz, when susceptible ESA-listed species (i.e., Southern Resident killer whale and Cook Inlet beluga whale) are within hearing range
- Suspend single beam sonar transmissions of 30 kHz when ESA-listed species are within hearing range

8. Pinnipeds
- Avoid approaching in-water pinnipeds within 100 yards (182.9 m)
- When possible, maintain a vessel distance of at least 3 nautical miles (5.5 km) and a landbased distance of 0.5 miles (0.8 km) of Steller sea lion rookeries listed in 50 CFR 223.202 or Marmot Island
- Avoid nearshore surveys when Steller sea lions are observed onshore
- When possible, suspend sonar transmissions when ESA-listed species are within hearing range

9. Sea turtles
- Avoid approaching within 50 yards

1.4.1 Environmental Compliance Deliverables

All NOAA Field Units shall provide a list of all trained marine mammal observers (e.g. all officers, deck, and survey personnel) who are required to view the Marine Species Awareness Training video provided by HSD Ops as a DVD or viewed at https://www.youtube.com/watch?v=KKo3r1yVBBA. This video is produced by the Navy and is endorsed by the National Marine Fisheries Service's Office of Protected Resources. The viewing of this video is considered sufficient for the purposes of declaring a crew member a "trained observer". The observation of marine mammals should be conducted in conjunction with both ship and small boat operations and the Marine Species Awareness Training must be completed prior to the start of the field season. A list of trained marine mammal observers and the date each observer viewed the training video (including new personnel who arrive mid-project) shall be included in the DR Appendix II folder and provided to the OCS Environmental Compliance Coordinator, (jay.nunenkamp@noaa.gov) with a CC to the HSD Project Manager/COR.

Marine mammal observations shall be recorded in the provided PDF form (included in the HSD project instructions and shown in Appendix K, for reference). Digital photographs of observations shall be taken, if possible. The marine mammal observation log and associated photographs shall be submitted to pop.information@noaa.gov (with a CC to the HSD Project Manager/COR) at the end of each project.

Sea turtle sightings shall be recorded for each project and an email including the species (if known), number, size, date, time, coordinates, and sea state shall be sent (with a CC to the HSD Project Manager/COR) to:

- Larisa Avens on the East Coast (larisa.avens@noaa.gov)
- Jeff Seminoff on the West Coast (jeffrey.seminoff@noaa.gov)
- George Balazs in Hawaii and Pacific Islands (george.balazs@noaa.gov)

1.5 Dangers to Navigation

As soon as practicable after discovery, the hydrographer shall submit a Danger to Navigation. 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 reported.

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 pose an imminent danger to the mariner or to be inadequately charted as described below. Potential dangers shall be evaluated in the context of the largest scale nautical chart of the area. Unless specified otherwise in the Hydrographic Survey Project Instructions, 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.

When surveying a USACE maintained channel, the hydrographer shall conduct a comparison of survey depths with the controlling depths, tabulated depths, reported depths, and with the DRVAL1 found in the ENC's DRGARE of all maintained channels. When survey soundings or obstructions located in the channel are found to be shoaler than the controlling depth of that channel then the hydrographer shall immediately report these results to the HSD Project Manger/COR. The HSD Project Manager/COR will inform the NOAA Navigation Manager, who will to address the issue with the USACE, USCG and communicate the findings to the local Pilots. The field unit shall document this correspondence in Section D of the DR for the affected survey. Copies of all correspondences shall be included in DR Appendix II.

Dangers to Navigation shall be recommended 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
- Exposed or leaking submerged pipelines
- Other submerged or visible features, or conditions considered dangerous to surface navigation

Note on DTONs in Uncharted Areas: If there are no charted depths in the survey area, consult with the HSD Project Manager/COR as appropriate to develop DTON selection criteria appropriate to the navigational use of the area.

Once all dangers to navigation 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 include the date that the feature data was acquired and 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.

Dangers that are too complex to be adequately identified as discrete features shall be depicted as area features. For example, widespread shoaling would be represented as a selection of the shoalest depths with a selection interval of 3mm at the largest scale.

NOAA field units shall submit all Dangers to Navigation via e-mail directly to Marine Chart Division's (MCD) Nautical Data Branch at e-mail address ocs.ndb@noaa.gov, with courtesy copies to HSD Project Manager, Operations Branch chief and to the chief of the appropriate Hydrographic Branch, in accordance with Section 4.4.2.1.6 of the OCS Field Procedures Manual.

NOAA field unit DTON recommendations shall be submitted as follows using Pydro software:

1. A PDF letter in the format shown in Appendix D).
2. An XML file of the Pydro DTON report.
3. Screen Captures of Side Scan Sonar images, Multibeam images or chartlets (if applicable) of the DTON.

These files shall be submitted as a .zip file.

Contractors shall submit all Dangers to Navigation via e-mail to the HSD Project Manager/COR and the appropriate Hydrographic Branch stated in the Hydrographic Survey Project Instructions (ahb.dton@noaa.gov or phb.dton@noaa.gov).

Contractor DTON recommendations shall be submitted as follows:

1. An S-57 .000 feature file attributed in accordance with Section 7.5 Feature Attribution. Filenames shall contain only letters, numbers, and underscores; no spaces nor special characters other than an underscore . In addition, the following NOAA attributes shall be populated as follows:
    a Special Feature Type (sftype)=DTON
    b Images (images) shall include associated images such as chartlets, Multibeam and side scan imagery of the danger (see Appendix D)
    c Observed Time (obstim) – observed time in the format YYYYMMDDThhmmss.

The Hydrographic Branches will review the DTON .000 feature file, import the .000 file into Pydro, and create the .xml file. A letter and .xml file will then be forwarded to the Nautical Data Branch at ocs.ndb@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. Within three days of DTON report submission, MCD's Nautical Data Branch (NDB) will send an email (i.e. DREG registration email) to the field unit (NOAA in-house surveys) or the originating Hydrographic Branch and associated contractor and HSD Project Manager/COR (contract surveys) confirming that DTON data has been received and released from NDB to the Production Team. If a DTON submission is not confirmed by NDB within one week, the hydrographer should promptly contact MCD via an inquiry email to (ocs.ndb@noaa.gov) to verify that the report has been received and released from NDB to the Production Team. MCD will notify the submitting party of any changes made to the Dangers to Navigation Report by return e-mail.

The Hydrographic Branches will submit any dangers to navigation detected during office processing to MCD as stated above. If the Hydrographic 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 DTON recommendation files (i.e. DTON Reports) and the DTON verification e-mail from NDB (e.g. the DREG registration e-mail, which the contractors receive as courtesy copies from the Hydrographic Branch) shall be included in the Appendix II Supplemental Survey Records and Correspondence folder of the DR. See Appendix J Descriptive Report Appendices below. DTON features shall remain in the .000 Final Feature File.

1.5.1 Charted Feature Remove Request (Anti-DTON)

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 (Section 7.3.4). 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.

If local authorities request the hydrographer to investigate a feature that has not been assigned, contact HSD Operations 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 follow the same submission procedure and format requirements as Dangers to Navigation. See Appendix D for an example of a Danger to Navigation Report.
Contractors shall submit Charted Feature Removal Request through the same process as a DTON request (i.e. via appropriate Hydrographic Branch for verification).

1.6 Changes from May 2015

Several clerical changes have been made in the 2016 Edition of this document. Significant technical and organizational changes are summarized below:

Chapter 1 Introduction

- Section 1.1 Change Management, new section
- Section 1.3 Pre-Survey Assessment, new section
- Section 1.4 Environmental Compliance, new to Chapter 1
- Section 1.4.1 Environmental Compliance Deliverables, new to Chapter 1 and additional deliverable required
- Section 1.5 Dangers to Navigation, new loction for this section

Chapter 2 Datums

- Section 2.1 Horizontal Datums, the horizontal datum is WGS84 (G1674).

Chapter 3 Hydrographic Position Control

- Section 3.2 Position Augmentation, renamed section and removed verbiage stating NOAA hydrographic surveying does not utilize non-U.S. GPS GNSS. Added note that USCG DGPS provides position augmentation in NAD 83 datum.
- Section 3.2.2 DGPS Site Confirmation, added note that FAA WAAS provides position augmentation in WGS84 datum.

Chapter 4 Tides and Water Level Requirements

- Section 4.1.6.1 Estimated Errors, updated measurement error table

- Section 4.2.2 Water Level Measurement Systems and Data Transmissions updated section to include radar sensors and additional bottom mounted pressure gauge and DCP requirements

- Section 4.2.2.1 Bottom Mounted Pressure Gauges, updated section, BMPG mooring specifications, and tide staff reading specifications

- Section 4.2.2.2 GPS Tide Buoys, added criteria for tide buoy operations

- Section 4.2.5 Bench Marks, updated section.

- Section 4.3.2 Data Processing, Tabulation and Harmonic Analysis of the Tides, if TCARI is used by contractor, harmonic constituents shall be generated in WALI

- Section 4.5 Computation of Harmonic Constituents, new section

- Section 4.5.1 Computational Procedures, new section

- Section 4.5.2 Quality Control, new section

- Section 4.6.4 Tidal Constituents and Residual Interpolation (TCARI), TCARI is available for contractors at OCS discretion

- Section 4.7.1 Station Documentation, removed NOAA/Google chartlet and USGS quadrangle map deliverable and processed water level data download no longer a deliverable

- Section 4.7.3 Tabulations, Tidal Datums and Harmonic Constituents, tidal datums and harmonic constituents, updated deliverables

- Section 4.8 Guidelines and References, removed chartlet and USGS quad map

Chapter 5 Depth Soundings

- Section 5.1.3 Uncertainty Standards, 95% of grid nodes must meet TVU and those that do not shall be discussed in the Descriptive Report.

- Section 5.2. Multibeam and Other Echosounders, removed ban on PMBS

- Section 5.2.1.2 General Requirements, updated and relocated feature guidance to Chapter 7.

- Section 5.2.1.2.3 Designated Soundings, updated designated sounding guidance. Designated sounding guidance is now located in Section 7.4 and Section 5.2.1.2.3. Section 5.2.1.2.3 describes designated soundings created to override the gridded surface model.

- Section 5.2.2 Coverage and Resolution, clarified and updated the definitions for the four coverage classifications

- Section 5.2.2.1 Bathymetric Splits, new section and location of bathymetric split information

- Section 5.2.2.2 Object Detection Coverage, added 'collinear' to holiday definition. Added 200% SSS with concurrent multibeam as Option B to obtain object detection coverage.

- Section 5.2.2.3 Complete Coverage, added 'unpopulated' to holiday definition. Option B is 100% SSS with concurrent multibeam

- Section 5.2.2.5 Trackline Specifications, removed reference to IHO

- Section 5.2.2.5.1 Transit Surveys, water level correctors need to be applied and described

- Section 5.2.2.5.2 Reconnaissance Surveys, water level correctors need to be applied and described

- Section 5.2.3.2 Dynamic Draft, replaced 'determined' annually with 'confirmed' annually

- Section 5.2.3.3 Speed of Sound Corrections, calibration period relaxed from six months to annually

Chapter 6 Acoustic Backscatter

- Section 6.1.2.2 Speed, removed maximum vessel speed example for a conventional single pulse side scan sonar.

- Section 6.1.3.2 Side Scan Sonar Contacts, removed "significant" vs. "insignificant" language to describe a SSS contact, removed guidance to find 0.5m contacts as the minimum object required to be detected is 1m x 1m x 1m. Added if a contact will lead to a FFF feature, to follow the feature development guidance in Section 7.3.3 which is different than SSS contact development guidance in this section.

- Section 6.1.3.3 Side Scan Sonar Contact Attribution, table is new to this chapter and updated what attributes are mandatory/conditional

- Section 6.1.3.4 Side Scan Sonar Contact Correlation, can be accomplished using the "remrks" extended attribute and/or the discretionary "prmsec" attribute

- Section 6.1.3.5 Identification of Features, updated section to reference FFF development section

- Section 6.2 Multibeam Echosounder Seafloor Backscatter, all multibeam echosounder surveys require concurrent time series backscatter acquisition

Chapter 7 Features

- Chapter 7 replaces the May 2015 Chapter 7 (Other Data) with a consolidated chapter on features

- Section 7.1 Feature Definition, new section. A feature is defined as any anthropogenic or natural object that may merit cartographic representation. The size of feature required to be found is different for object detection and complete coverage requirements

- Section 7.2 Composite Source File and Project Reference File, new location for this information and updated guidance. If no PRF/CSF is provided by HSD the field unit shall contact HSD Project Manager/COR. Removed AWOIS reference from the PRF.

- Section 7.2.1 Maritime Boundary Points, new location for this information and clarified language

- Section 7.2.2 Bottom Characteristics, new location for this information.

- Section 7.3 Final Feature File, new section that describes what to include in the FFF.

- Section 7.3.1 Assigned Features, new section the describes how to address CSF features that are assigned

- Section 7.3.2 New Features, new section that describes what newly surveyed features shall be included in the FFF

- Section 7.3.3 Feature Developments, all submerged features required for inclusion in the FFF that are detected with bathymetry shall be developed to better estimate a reliable least depth. A development can be achieved with multibeam water column, diver least depth gauge, wire drag, mechanical sweep, or an additional acquired line of multibeam data oriented perpendicular to the mainscheme hydrography.

- Section 7.3.4 Feature Disprovals, new location for this information and clarified language

- Section 7.3.5 Aids to Navigation, added USCG light list link and guidance that if a USCG maintained AtoN is on station and serving its intended purpose it shall not be included in the FFF

- Section 7.4 Designated Soundings, this guidance is now located in Section 7.4 and Section 5.2.1.2.3. Section 7.4 describes designated soundings created to facilitate feature management.

- Section 7.5 Feature Attribution, new location for feature attribution guidance.

- Section 7.5.1 S-57 Attribution, new location for this information. There shall not be any spaces after comma separated values in SORIND. Added in a reference to Appendix F for the WATLEV of WRECKS, UWTROC, and OBSTRN features. For UWTROC features, added note for foul area delineation. For SBDARE point features, the COLOUR attribute was changed from mandatory to conditional and additional information was added into the note section. For SLCONS features, added note regarding the bathymetry collected underneath these features.

- Section 7.5.2 NOAA Extended Attribution, new location for this information. The guidance for "descrp" has been updated. The guidance for "images" has been updated.

- Section 7.5.3 NOAA Discretionary Attribution, new location for this information.

Chapter 8 Deliverables

- Section 8.1.1.1 Weekly Progress Reports, added coverage geoTIFF requirement.

- Section 8.1.2 Survey Outline, added M_COVR attribute table

- Section 8.1.3 Coast Pilot, new location for this information

- Section 8.1.4 Descriptive Report (DR), junctions shall be evaluated between junctions listed in the Project Instructions as well as between sheets of current project.

- Section 8.2.1 Side Scan Sonar Mosaic, added naming convention for mosaics and guidance for feature disproval SSS line submission

- Section 8.2.2 Side Scan Sonar Contact File, removed "insignificant" and "significant" verbiage.

- Section 8.3.1 Media, updated section for NOAA field unit raw-only deliverable

- Section 8.3.2 Bathymetric Data, naming convention for grid deliverable changed to include "_Final" for .BAG and .CSAR deliverables. Caris users shall submit source .CSAR grids to the Hydrographic Branch. Field units shall not submit combined grids to the Hydrographic Branch.

- Section 8.3.6 Other Data, added NCEI sound speed data submission requirement

Appendices

- Appendix J: Data Directory Structure, NOAA and Contractor Directory Structure is the same for the raw and processed deliverable. Removed Project Name from the title of the parent folder.

2 Datums

Contents

2.1 Horizontal Datum

All horizontal positions will be referenced to the World Geodetic System of 1984 (WGS84 (G1674)). 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; including the S-57 Final Feature File (Section 7.3). Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or adjusted to WGS84 (G1674). In addition, all software used on a survey must contain the correct datum parameters.

2.2 Sounding Datum

With some limited exceptions, 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).

Exceptions to the use of MLLW as a sounding datum will fall into one of three categories. In non-tidal coastal areas, sounding data will be reduced to Low Water Datum (LWD) which is Mean Sea Level (MSL) - 0.5ft. In Great Lakes, all sounding data will be reduced to Great Lakes Low Water Datum as referenced to the current International Great Lakes Datum (IGLD). In areas charted to 'Special Datums' such as Columbia River Datum, Hudson River Datum, Mississippi River Datum, etc., the sounding data will be reduced to the specific special datum.

2.3 Time

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

3 Hydrographic Position Control

Contents

3.1 Position Uncertainty and Precision

3.1.1 Horizontal Position Uncertainty

The NOS specification for hydrographic positioning is that the Total Horizontal Uncertainty (THU) in position of soundings, at the 95 percent confidence level, will not exceed 5 m + 5 % of the depth. This accuracy requirement is independent of survey scale. For hydrographic surveys using single-beam echosounders, the uncertainty of the vessel position can be considered the THU 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 uncertainty 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. See Section 5.2.3.6, "Uncertainty Budget Analysis for Depths", for a more detailed discussion of those specifications related to horizontal positioning uncertainty.

Positions reported in survey records and deliverables shall be recorded in meters, with a precision of at least decimeters. This precision shall be maintained throughout the processing pipeline and digital data.

3.1.2 Vertical Position Uncertainty

This section applies to depths or heights obtained through 3D-positioned surveying. Total allowable vertical uncertainty for reduced soundings is detailed in Section 5.1.3, "Uncertainty Standards". There is no intrinsic maximum allowable uncertainty prescribed for vertical positioning accuracy. The hydrographer must account for all of the uncertainties which contribute to the vertical position, and ensure that their combined effect does not cause the total vertical uncertainty for soundings to exceed the allowable limits.

3.2 Position Augmentation

The term differential GPS refers to the general positioning methodology wherein two or more GPS receiver-antenna units are used to position an unknown point relative to a known (control) point or control network. Differential GPS aims to improve upon the positioning accuracy (relative to the control) otherwise attainable in standalone GPS point-positioning methods.

The acronym DGPS refers to the particular technique of differential GPS techniques whereby reference receiver-satellite pseudo range corrections observed at the control point(s) are used to improve the imprecise pseudo range observations made elsewhere in real time. DGPS correctors may 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. The USCG DGPS service provides position augmentation in the NAD83 datum. The horizontal position datum requirement is WGS84 (see Section 2.1).

Kinematic GPS (KGPS) refers to the form of differential (mobile) positioning which uses matched GPS carrier-phase measurements to achieve centimeter-level precision in positioning relative to survey control. An Ellipsoidally-Referenced Survey (ERS) is hydrographic surveying using high-accuracy GPS positioning techniques such as Inertially-Aided Post-Processed Kinematic (IAPPK) or Precise Point Positioning (PPP). In contrast to the practice of using DGPS for horizontal positioning of heights and depths measured relative to the in situ water level, ERS hydrography is made with respect to a reference ellipsoid in three dimensions. ERS specifications are discussed in Section 9; the remainder of this section is devoted to DGPS specifically.

3.2.1 DGPS Specifications

Unless specified otherwise in the Hydrographic Survey Project Instructions, the following specifications are recommended 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 should not exceed 20 seconds; and any horizontal positioning interpolation must not exceed the uncertainty 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 can be 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.

Any deviations from the above specifications shall be clearly documented in the Descriptive Report with an explanation and supporting data to show that the resulting positions meet the accuracy requirement in Section 3.1.1.

3.2.2 DGPS Site Confirmation

If any non-USCG differential reference stations are used (e.g. a ”fly-away” DGPS beacon established by the hydrographer, the Federal Aviation Administration’s Wide Area Augmentation Service (FAA WAAS), or commercial satellite-based correction services), the hydrographer shall conduct a certification to ensure that no multipath or other site specific problems exist. The system shall be re-certified annually for each project area in which the non-USCG correctors are utilized. The FAA WAAS system provides position augmentation in the WGS84 datum (see Section 2.1).

Certification of non-USCG differential correctors shall be accomplished as follows:

1. Identify a point ashore in close proximity to the project area for which the position is known to at least the THU given in Section 3.1.1
2. Occupy this position with a GPS receiver utilizing the non-USCG correctors for at least 24 hours, logging data at 1-second intervals.
3. Create a plot compare surveyed positions to the known position. Certification is successful if the surveyed and

established positions agree to the requirements of Section 3.1.1
4. Include a description of the certification process plots in the Horizontal Control Report for each project (see Section 8.1.5.2)

Additionally, all sources of GPS correctors must be checked periodically while utilized for NOAA hydrographic surveying. Many large scale differential correction systems, such as the USCG differential beacons, FAA WAAS, and commercial services such as C-Nav and Starfire, have integrated 24-hour monitoring and quality assurance, which fulfills this requirement. However, differential beacons or other high accuracy positioning sources established by the hydrographer must be monitored and validated by the survey team. See Section 3.4 below.

3.3 Kinematic GPS

Kinematic GPS (KGPS) refers to the form of differential (mobile) positioning which uses matched GPS carrier-phase measurements to achieve centimeter-level precision in positioning relative to survey control. An Ellipsoidal Referenced Survey (ERS) is hydrographic surveying using GPS centimeter-level positioning such as KGPS. In contrast to the practice of using DGPS for horizontal positioning of heights and depths measured relative to the in situ water level, ERS hydrography is made with respect to a reference ellipsoid in three dimensions. ERS specifications are discussed in Section 9.

Real Time Kinematic (RTK) and Post Processed Kinematic (PPK) may be used for positioning during hydrographic surveys. If RTK or PPK techniques are used, the hydrographer must ensure that all positions meet the accuracy requirements of Section 3.1.

3.4 Position Uncertainty Checks for Reference Stations

The positions of all base stations maintained by the hydrographer shall be verified at least once per week while utilized for survey operations. This verification shall typically be performed computing a new position solution for the base station through the National Geodetic Survey Online Positioning User Service (OPUS), and comparing this with the accepted station position (the published position of the reference bench mark or position established at station inception). Differences between the accepted and check positions exceeding the 95% confidence interval shall be investigated and corrected if possible. Alternate methods of verification may be utilized if approved by the HSD Project Manager/COR. The method and results of these position checks shall be included in the Horizontal and Vertical Control Report.

4 Tides and Water Levels Requirements

Contents

4.1 General Project Requirements and Scope

4.1.1 Scope

The requirements and specifications contained in this section cover the water level based vertical datum requirements for operational support of hydrographic surveys and photogrammetric surveys conducted as part of the NOAA Nautical Charting Program. ERS vertical datum requirements are discussed in Section 9. The scope of this support is comprised of the following functional areas:

1. Tide and water level requirements planning
2. Preliminary tidal zoning development
3. Control water level station operation, monitoring, and maintenance
4. Subordinate water level station installation, operation, monitoring, maintenance, and removal
5. Data quality control, processing, and tabulation
6. Tidal datum computation and tidal datum recovery
7. Generation of water level reducers and final tidal zoning
8. Quality control check of contractor submitted data to CO-OPS

For NOAA in-house hydrographic surveys, personnel from the NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) are responsible for functional areas 1, 2, 3, 5, 6 and 7. NOS hydrographers shall be responsible for functional area 4 above.

For NOAA contract hydrographic surveys, NOS CO-OPS personnel are responsible for functional areas 1, 2, 3 and 8. NOAA contract hydrographers shall be responsible for functional areas 4 through 7 above. NOS CO-OPS will be responsible for operating, maintaining, and processing data from the National Water Level Observation Network (NWLON) control stations.

4.1.2 Objectives

The work performed according to the requirements and specifications of this document is required for NOS major program areas of navigational products and services. The first objective is to provide time series water level data and associated water level reducers that can be applied to hydrographic soundings for correction to chart datum. The second objective is to establish and/or recover tidal datums relative to local bench marks at each station that can be used for continuing and future hydrographic surveys in the area. The third objective is to provide new information or updated information that can be used to update NOAA tide prediction products and tidal zoning to promote safe navigation applications.

4.1.3 Planning and Preliminary Tidal Zoning

CO-OPS is responsible for all assessments and 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 the preliminary zoning scheme and develop a final zoning scheme using correctors derived from the subordinate stations installed during the survey. Refer to Section 4.6.2 for further details.

4.1.4 NOS Control Stations and Data Quality Monitoring

National Water Level Observation Network

CO-OPS manages the NWLON of approximately 210 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 transmitter, near real-time (within about 18 minutes of collection) preliminary data are made available to all users through the CO-OPS Web homepage at www.tidesandcurrents.noaa.gov. 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 for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house hydro gauges equipped with satellite transmitter using the NOS satellite message format and that are installed by either CO-OPS, NOAA Ships, Navigational Response Teams (NRT), or CO-OPS IDIQ contractors for NOAA in-house hydro projects only. Once these gauges are transmitting data, they will be listed on the hydro hot list by CO-OPs. 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. It is recommended that all NOAA hydrographers confirm operating status of required control stations each morning prior to commencing survey operations. In addition to the support by CORMS, NOAA hydrographers may utilize the DiagTool diagnostic monitoring function available from the Hydro Hot List (www.tidesandcurrents.noaa.gov/hydro). As stated in Section 4.1.1, for NOAA hydrographic contract surveys, the contractor is responsible for all data monitoring, repairs, and proper functioning of the subordinate gauges during survey operations that require data from that subordinate station.

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. The final determination of an appropriate control station for the subordinate station datum computation must result from a direct comparison of the collected subordinate station observations with all nearby potential control stations such that the station best matching in tidal characteristics and ranges will be used as the final control for datum computation.

In non-tidal coastal areas soundings will be reduced to Low Water Datum (LWD) which is Mean Sea Level (MSL) - 0.5 ft. In great lakes all soundings will be reduced to Great lakes Low Water Datum as referenced to the current International Great Lakes Datum 1985 (IGLD85). In areas which are charted to 'Special Datums' such as Columbia River datum, Hudson River Datum, Mississippi River Datum, etc., the soundings will be reduced to the specific special datum. If a subordinate station has a currently published datum, every effort must be made to set the station datum for the new installation to the historic station datum via re-occupation, so that all newly collected observations are on the same zero reference as the currently accepted datum. If the length of the new series of observations is shorter than that of the accepted datum time series, the newly submitted datum may be validated as acceptable for survey use but may not supersede the longer already published datums.

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 0.10m and 0.45m (at the 95% confidence level) depending on the complexity of the tides.

Following the present CO-OPS hydrographic survey error budget analysis procedure for determination of the estimated error at the 95% Confidence Interval (CI):

1. 95% CI = b + 1.96 (s)

Where b = systematic errors and biases; s = random errors at the one standard deviation level.
Systematic errors are additive:

2. $b_{total} = b_1+b_2+b_3+\ldots..b_n$

Random errors are treated as independent, with the total determined by squaring the individual errors (one standard deviation) and computing the square root of their sum:

3. s_{total} = square root $(((s_1)^2+(s_2)^2+(s_3)^2+\ldots.(s_n)^2))$

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

1. Measurement Error and Processing Error: 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. An estimate for a typical processing error is 0.10 m at the 95% confidence level.

2. The Datum Error: 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. the 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 Zoning Error: 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 and reliable water level gauges, and optimization of the use of zoning schemes, control stations, the number of subordinate stations 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

4.1.6.1 Estimated Errors

Estimated error budget for deployments used over the past several years:

A) Measurement Error

Calibration	<0.009m	(bias)
Dynamic draw-down or other bias effects (waves, currents, density)	<0.050m	(bias)
Barometric pressure correction	<0.010m	(random)
Staff-to-gauge readings	<0.010m	(random)
Leveling errors	<0.012m	(random)
Interpolation to times of soundings (hydrography)	<0.030m	(random)

B) Tidal Datum Computation Error (West Coast)

(with a control station)

30 days	0.043m	(bias)
90 days	0.036m	(bias)
180 days	0.026m	(bias)
365 days	0.020m	(bias)

(first reduction – no control station – western and northern AK)

30 days	0.148m	(bias)
90 days	0.108m	(bias)

180 days	0.073m	(bias)
365 days	0.038m	(bias)

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. Breaks in the water level measurement series affects the accuracy of datum computations and result in an 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 Hydrographic Survey Project Instructions. 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 CO-OPS and the hydrographer (and COR 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. Preferably, the duration of continuous data acquisition would be a full calendar month which could significantly reduce the error in the datum calculated. 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. Levels shall be conducted as soon after installation as is realistically feasible but within 14 days of installation (applicable for primary and secondary stations) as datums must be computed based on water level data of at least 30 days that are bracketed by levels. 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 areas where lack of data limits CO-OPS’ understanding of the tidal regime, it is possible that if insufficient water level data is collected concurrent with the survey, CO-OPS may not be able to provide tide control within the required vertical specification.

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, parts of Pamlico Sound, and parts of Florida Bay 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 permanent stations will provide water level data referenced to an established Low Water Datum relative to International Great Lakes Datum of 1985 (IGLD 85).

4.2.2 Water Level Measurement Systems and Data Transmissions

Water Level Sensor

CO-OPS is in the process of transitioning the Microwave Water Level (MWWL) sensor to operations. Generally, the acoustic or MWWL system shall be preferred for hydrographic or photogrammetric subordinate station installations. In cases where acoustic wells or MWWL sensor support arm cannot be installed due to terrain, or in cold climates, installation of a portable digital bubbler system is authorized. For projects in the Great Lakes, the MWWL sensor is acceptable during ice-free periods of data collection.

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. At stations where the acoustic sensor cannot 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 the *Paroscientific Inc. Digiquartz® Pressure Instrumentation*). CO-OPS has approved the microwave radar sensor for selected projects in consultation with CO-OPS. (For further information, refer to the NOAA Ocean Systems Test and Evaluation Report, Limited Acceptance of the Design Analysis WaterLog ® H3611i Microwave Radar Water Level Sensor – NOAA Technical Report NOAA CO-OPS 061), http://tidesandcurrents.noaa.gov/publications/NOAA_Tech_075_Microwave_Water_Level_2014_Final.pdf. CO-OPS has also approved the use of Bottom Mounted Pressure gauges (BMPGs) in locations where standard water level gauges (e.g. acoustic, MWWL, vented pressure) are not possible or offshore data is required. Specifications for use of BMPGs can be found at the end of this section.

The water level sensor shall be a self-calibrating air acoustic, MWWL, pressure (vented), or other suitable type that is approved by CO-OPS. All sensors falling within the "other" category shall be submitted to CO-OPS for approval during the planning phases of each survey it is requested to be used. It may not be assumed that because CO-OPS approved an "other" sensor for one survey in one year, that sensor is approved for all future surveys in future years. 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.

In each and any case, the water leveling sampling/averaging scheme, which works as a digital filter, shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor or MWWL sensor is preferred over pressure sensor whenever possible. Where the air acoustic sensor or MWWL can not be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to the User's Manual for the WaterLog® Series H-355 Pump). 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.

When pressure sensors are used to collect the water level data, orifice should be mounted on a vertical surface such as a piling of a wharf so that the precise elevation of orifice below the staff stop could be measured with a steel tape, and the elevation of the staff stop can be measured via differential leveling to the nearest bench mark and with the primary bench mark. If the orifice can not be mounted to a vertical surface (i.e. if the elevation of the orifice can not be determined precisely with the primary bench mark) then staff-to-gauge readings are required to relate the water level datums to the bench marks. Refer to additional information about staff and staff observations in Section 4.2.4.

Installation of a vented pressure sensor requires a series of gauge/staff comparisons be observed 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. The staff-to-gauge comparison criteria are general requirements. When these staff-to-gauge observation frequency or time requirements cannot be met, then refer to Section 4.2.4. Staff Observations for further information.

Data Collection Platform (DCP) and Transmissions

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, as well as the number of outliers. 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 transmitter system shall be within 1 second so that channel "stepping" does not occur. Non-satellite radio transmitter 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 Data Transmissions requirements are applicable where CO-OPS is monitoring the gauges as described in Section 4.1.4 above. 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 hourly. 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 4.8 for References). Once the 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 on electronic formats currently used such as, CD-ROM, DVD-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 4.7.2 for further details on the water level data format specifications.

Close coordination is required between hydrographer and Engineering Division (ED) 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 ED Configuration and Operational Engineering Team (COET) (nos.coops.oetteam@noaa.gov). Test transmissions conducted on site are outside this requirement. The station and DCP information must be configured in DMS before data transmissions begin so that the data will be ingested in DMS. The metadata required prior to transmission in field can be documented in the eSite Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 4.7 Data Submission 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 compressed air. The air 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 of air for widest range of surf conditions encountered by most coastal surveys.

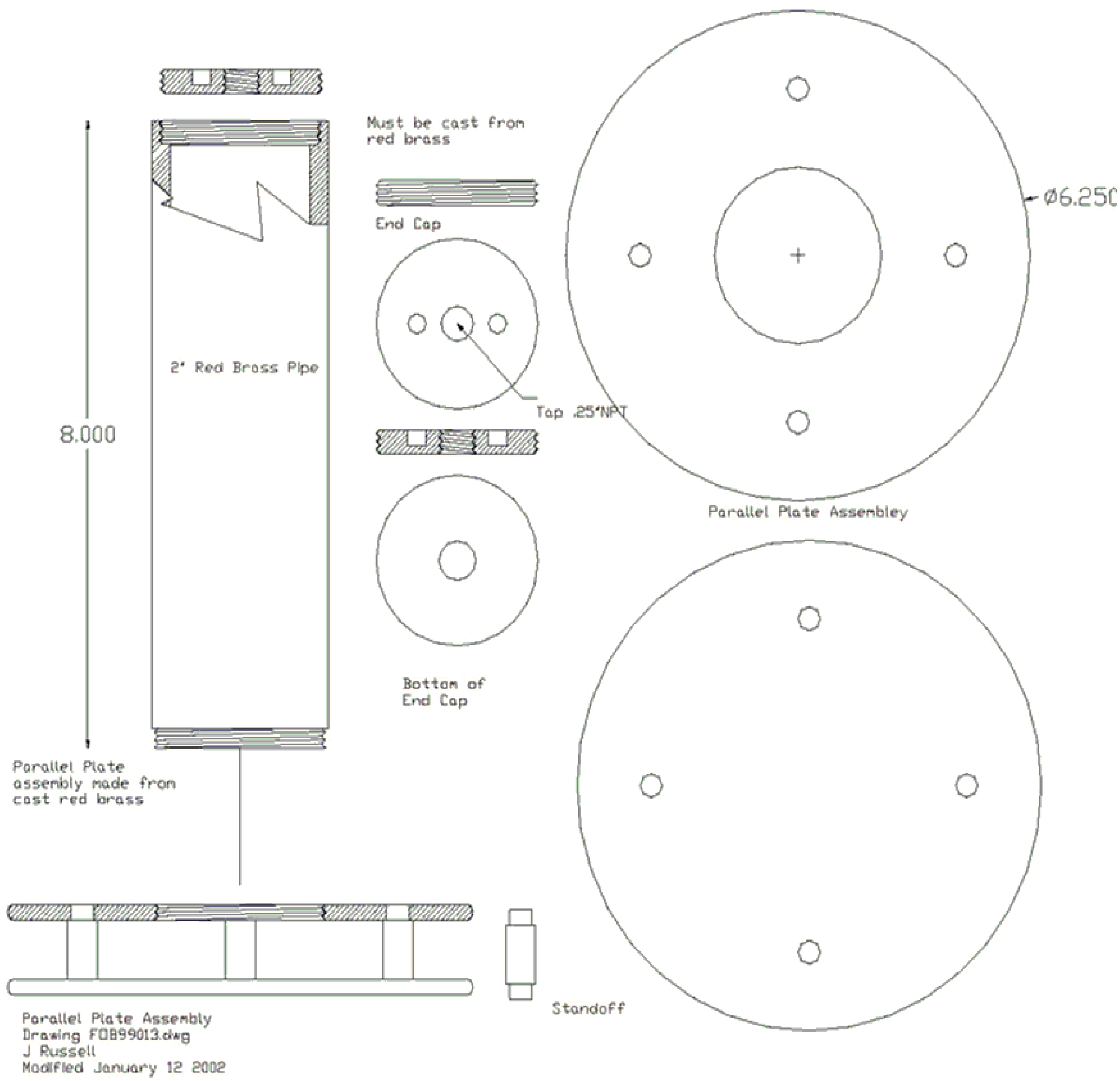


Figure 4.1: Bubbler Orifice Bottom Assembly

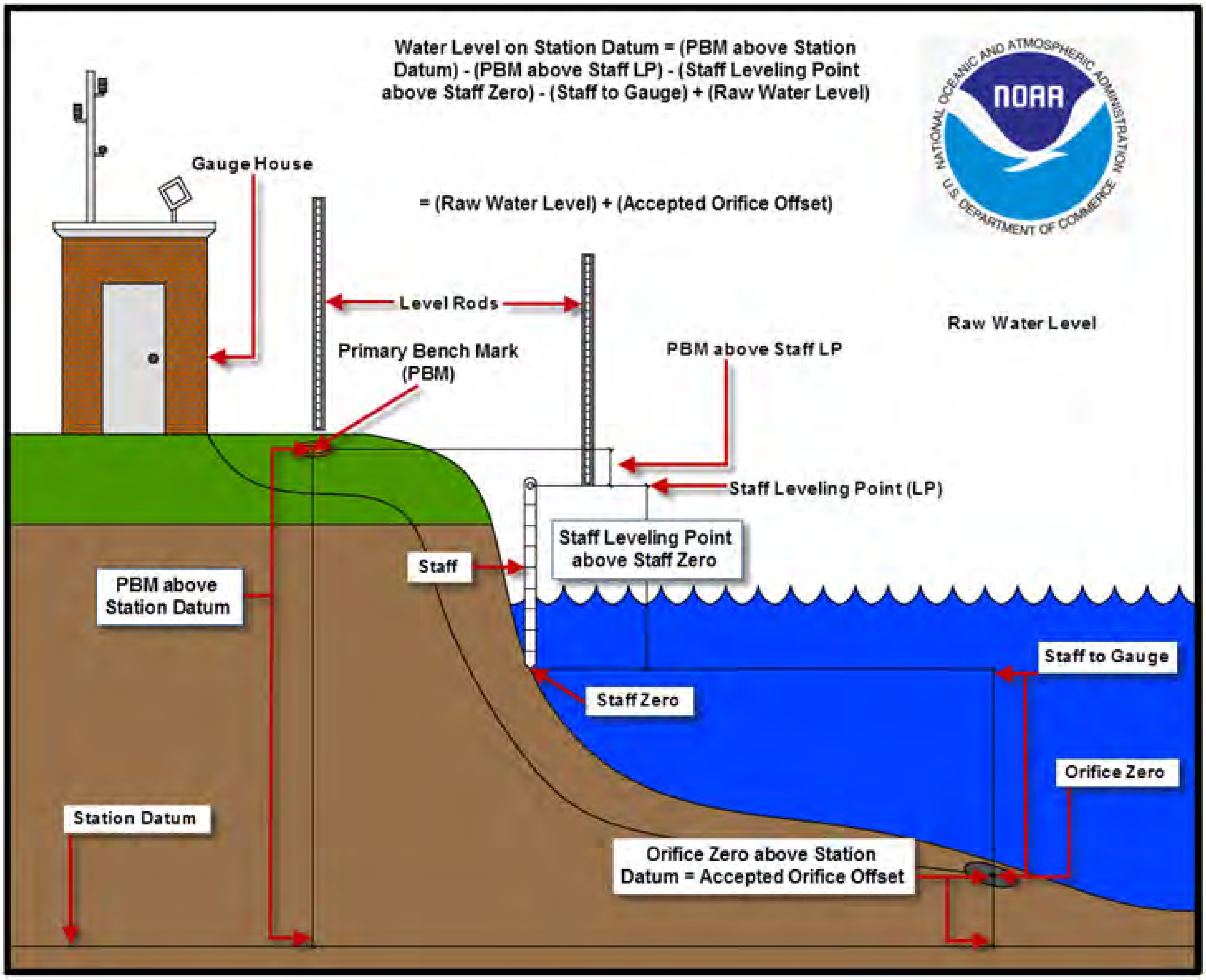


Figure 4.2: Relationship of Station Datum, Orifice, and Staff

PRESSURE TIDE GAUGE RECORD

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

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

Table 1: Example Tide Gauge Record

4.2.2.1 Bottom Mounted Pressure Gauges

BMPGs may be used by NOS hydrographic survey contractors to collect water level data only after the following conditions have been met:

1. For zoning gauges or other supplementary data that is in addition to the required subordinate stations as stipulated in the Project Instructions (communications with the Hydrographic Planning Team (HPT) about the placement of this station are suggested).

2. To replace a required subordinate installation where traditional shore-based water level stations with gauges mounted on near shore infrastructure are not possible during the summer months (non-ice deployments). This includes areas where the low tide line is far off shore and the full range of tide cannot be measured with typical MWWL, acoustic, or bubbler gauges. Communications with the HPT and the Configuration and Operational Engineering Team (COET) detailing the reason why standard methodologies for data collection are not viable are required.

BMPG station consists of bottom-mount moorings and recovery lines, water level sensors (as specified below), water density sensors (conductivity sensor or hydrometer), barometric pressure sensor, tide staff (fixed scale, or leveling-to-water's edge rod equipped with wave stilling tube(staff shots)), five tidal bench marks, and connection to WGS84 ellipsoid datum via GPS observations. The BMPG requires the configuration of two water level collection platform systems for redundancy.

Specifications for BMPG water levels:

Water level pressure sensor shall be Paroscientific Digiquartz or equivalent. The sensor shall have a documented calibration and checkout by the manufacturer. The contractor or instrument lab shall perform a documented acceptance check on sensor operation prior to deployment. The system shall have internal recording capability with a sampling scheme that produces a pressure reading every 6-minutes, similar to the DQAP 36 five-second averages. The system shall keep accurate internal time with no noticeable drift over a 3-month deployment period, e.g. less than 5 seconds drift over a 3-month period. The system shall be deployable for a minimum of 30-days without having to be retrieved for maintenance or data collection. The water level is obtained from BMPGs by applying corrections for barometric pressure and for water density to the pressure measurements using standard manufacturer software and the hydrostatic equation relationships. Barometric pressure shall be measured at a location within 5 miles of the BMPG deployment site and at a minimum sampling rate of hourly observations. Real time data telemetry is desirable so that data can be monitored.

Specifications for BMPG moorings:

The hydrographic survey contractors shall design and install their own mooring systems such that sensor platform shall not move in a manner that would impact the accuracy of the water level sensors. Streamlined designs shall be employed to reduce drag and the risk of the sensor platform being dragged by trawling operations. Typical installations require self-contained sensors in trawl-resistant mounts held in place by an anchor with a buoy line (depending on water depth) and a drag line attached to an additional anchor, or similar mooring system. The mooring system shall be designed considering the worst-case expected drag on the sensor platform (considering currents, deployment depth, sea state, bottom characteristics, length of deployment, drag coefficient of the system, etc.). The objective is to have a mooring that will not move horizontally or vertically during deployment, to ensure the viability of the data series. A description of the mooring design and anticipated drag load on the sensor platform shall be included in the station documentation submittal on the sensor elevation diagram (see Section 4.7.1) or a separate system design document. The sensor platforms shall be deployed offshore far enough (200 -1500 m) to ensure measurement of the lowest expected water level.

Specifications for BMPG water density:

Water density shall be obtained every six-minutes by using a bottom mounted conductivity and temperature (CT) sensor. Conductivity and temperature sensors shall undergo documented manufacturer recommended calibrations and field team acceptance tests prior to each deployment.

Specifications for BMPG barometric pressure:

Barometric pressure shall be obtained every six minutes using a nearby reliable existing source (NWLON station, NWS, airport, etc.). If these sources are not available, then a separate barometric pressure sensor shall be installed at the tide station location or on land as close to the BMPG location or as close as practicable for the duration of the survey. Barometric pressure sensors shall also have documented manufacturer recommended calibrations and acceptance tests performed by the field teams prior to each deployments. This correction is an added correction to those needed for a normal in-house shore-based pressure gauge(s) vented to the atmosphere. The correction should be of suitable accuracy, when a standard industry barometric pressure sensor is installed.

Specifications for BMPG tide staff readings:

Routine tide staff readings at the shore shall be taken in order to complete a simultaneous staff-to gauge comparison. This comparison provides offsets that are applied to the water level data to reference them to a Station Datum, the tidal bench marks, and to tidal, geodetic, and ellipsoidal datums. A fixed scale tide staff shall be installed at shore-mounted pressure (bubbler) tide gauges by mounting on existing infrastructure or by driving a piling or post just offshore; close enough to be leveled to the local bench marks and be easily read.

At most locations requiring BMPG deployments a "virtual tide staff" procedure may be required. This procedure requires repeat geodetic leveling from a bench mark or temporary bench mark (backsight) to a level rod held at the water's edge (foresight staff shots). The water level shall be read off the level rod scale, taking into account wave action (a small stilling tube attached to the rod helps with this reading). Foresight water level readings shall be made every 6-minute for a three-hour period after initial deployment of the pressure sensors and just prior to retrieval of the sensors. Back sight closures to the bench mark shall be made at the beginning and end of the three hour periods with the leveling instrument set-up remaining undisturbed.

Interim tide staff readings during the deployment period shall be taken periodically and spread over the month as specified. Interim tide staff readings shall be taken a minimum of (a) eight - 1 hour observations spread out over each month (e.g. two times a week) at a six minute interval, or (b) four - 2 hour observations spread out over each month (e.g. one time per week) at six minute interval. The interim, installation, and removal staff readings should remain constant throughout the set of observations and show no increasing or decreasing trends. A higher number of independent staff readings decreases the uncertainty in transferring the measurements to station datum and bench marks.

Specifications for BMPG final water levels:

Pressure gauge readings are first converted to water level via application of documented barometric pressure and water density corrections prior to performing the staff to-gauge comparisons. Staff-to-gauge constants are determined for each separate deployment. Often, the systems are recovered, checked out, batteries refreshed, etc., and then re-deployed during a survey period. Staff-to-gauge differences are analyzed for outliers and consistency prior to determination of the final constant(s) to be applied to the data. The water level data, level abstracts, and metadata shall be are submitted in CO-OPS specified formats.

4.2.2.2 GPS Tide Buoys

The National Ocean Service is exploring the use of GPS buoys to support hydrographic surveys in low-current, low-energy environments. Performance of buoys as water level collection systems is degraded in some operating environments, including areas with strong currents and high waves. Buoys should not be deployed in an environment where the currents regularly exceed 1 knot. The referenced GPS base station should not be more than 40km from the buoy deployment area and GPS solutions should be realized using the Inertially Aided Post Processed Kinematic approach, employing both in situ inertial or tilt sensors and post processed GPS positions, following the guidance in Section 9.1.1. Other methods of GPS processing may be approved on a case-by-case basis.

If the hydrographer determines that the deployment of a GPS buoy is necessary and warranted for the support of a project, the hydrographer should consult with HSD and CO-OPS prior to deployment.

4.2.3 Station Installation, Operation and Removal

Hydrographers shall obtain all required permits and permissions for installation of the water level sensor(s), DCPs, 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 the position of all water level gauges installed before hydrography begins, including those that were not specified in the Hydrographic Survey Project Instructions, as appropriate. The positions, generated from a hand-held GPS receiver, of bench marks and stations installed or recovered shall be documented as latitudes and longitudes (degrees, minutes, and tenth of seconds).

Water level station and its various components (tide house, Data Collection Platform, all sensors, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed or installed by contractors, shall be installed and maintained as prescribed by manufacturers, installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Technical Representative (COR), if applicable. Water level station and all installed components shall be structurally sound, secure, and safe to use for NOS, local partners, and general public, as appropriate.

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

Station Installation

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

- 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.
- The recovery and/or installation of a minimum of five bench marks and a level connection between the bench marks and the water level sensor(s), and tide staff, as appropriate.
- Required series of gauge/staff comparisons, at a minimum of three hours, through a significant portion of a tidal cycle observed and documented.
- The preparation of all documentation and forms which shall be submitted to CO-OPS within 15 days of installation.

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 Diagnostic web page http://www.TidesandCurrents.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 4.7.1 Station Documentation) 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, sensor offset, or time; field party; parts/components replaced; component serial numbers; tests performed; etc. Documentation of any site visits associated with the operations and maintenance of a station shall be submitted to CO-OPS within 15 days of the site visit.

Removal

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

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

- Removal of the water level system and restoration of the premises, reasonable wear and tear accepted.

- Required series of gauge/staff comparisons, at a minimum of three hours, through a significant portion of a tidal cycle (when applicable) observed and documented.

- The preparation of all documentation, forms, data, and reports which shall be submitted to CO-OPS within 15 days of removal.

4.2.4 Tide Staff

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 on the sea floor in the case of pressure based bubbler gauges. Whether a pressure gauge can be leveled directly or not, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column overtime. 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 staff stop shall be measured before the staff is installed and after it is removed and the staff 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 of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before gauge has been removed. Frequent gauge/staff comparisons during deployment shall be required to assist in assuring measurement stability and minimizing processing-type errors. The staff-to-gauge observations at the installation and removal of the water level gauge shall consist of a minimum of three hours of observations at a 6 minute interval. The staff-to-gauge observations shall be performed two times per week, during each week of the project, with at least an hour long observations at a 6 minute interval for each time. Where staff-to-gauge observations cannot be performed two times a week as required then an explanation is required for the deficiency of number of observations and staff-to-gauge observations shall be performed at least:

(a) minimum eight times spread out over each month (e.g. two times per week) and at each time at least 1 hour of observations at 6 minute interval, or
(b) minimum of four times spread out over each month (e.g. one time per week) and at each time at least 2 hours of observations at 6 minute interval.

The performed staff-to-gauge observations shall be forwarded to CO-OPS ED and the HSD Project Manager/COR within 15 business days or sooner, if practicable.

The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. After the water level data has been collected, the averaged staff-to-gauge shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Table 1 an example pressure tide gauge record.

If the staff is found destroyed during the deployment, then a new staff shall be installed for the remainder of the deployment and a new staff-to-gauge constant shall to be derived by staff-to-gauge observations. 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.

For water level historic stations that are reoccupied, NOS CO-OPS will provide the station datum (SD) information for the station. This information is generally given about the Primary Bench Mark (PBM) above the historic SD. In that case, for pressure sensors that require staff-to-gauge observations, all the water level data shall be placed on the station datum using the following equation:

Water level data on the SD = (Preliminary pressure water level data on an arbitrary datum as collected by the gauge) + (PBM above SD) - (Staff zero below PBM) - (weighted staff-to-gauge constant)

Staff zero below PBM = (Staff stop below PBM) + (Staff zero below Staff stop)

The staff-to-gauge constant shall be derived as a weighted average of all the staff-to-gauge readings done for the project. The staff zero below PBM is obtained generally by (a) leveling from PBM to staff stop and (b) then measuring the staff stop to staff zero elevation with a steel tape and (c) then combining the two (a and b) elevation values. The staff zero below PBM is obtained by averaging the elevations differences during the opening (installation) and closing (removal) leveling runs for short term occupations.

4.2.5 Bench Marks

According to the NGS geodetic glossary, a bench mark is a relatively permanent, natural or artificial, material object bearing a marked point whose elevation above or below an adopted surface (datum) is known. A bench mark is set to monitor stability and used as a reference to the vertical and/or horizontal datums.

Bench marks in the vicinity of a water level 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.

Unless specified otherwise in the work order or contract documents, the total number of bench marks in the leveling network shall be a minimum of five marks for subordinate stations installed for hydrographic and photogrammetric surveys, special projects, or contract projects for the U. S. Army Corps of Engineers, unless otherwise directed by CO-OPS Engineering Division (ED).

Descriptions shall be checked by verifying distances with tape measurements in metric units, verifying cited landmarks, verifying the location using a hand-held GPS and using a compass to confirm directions.

The handheld GPS coordinates of each mark shall be entered in the description file for electronic levels, or noted on the published bench mark sheet or equivalent (for optical levels). The latitude and longitude fields of the bench mark shall be reported in the following format: degrees/minutes/seconds and tenths of seconds. For example, 40 degrees, 45 minutes, 35.2 seconds.

New bench mark diagram shall use CO-OPS' standard bench mark diagram title block.. If a digital diagram is used, submit the digital file in JPEG format with the leveling files and photos. Submission of updated bench mark diagrams are required only when necessary to document newly established marks or physical changes in the area. A template diagram in fillable pdf format is provided in Figure 4.3.

If a bench mark is discovered disturbed or mutilated during the visit to a station, include it in the level run to determine if it is holding its elevation relative to the Primary Bench Mark (PBM) and report it to CO-OPS ED and the supporting FOD field office. If the disturbed or mutilated bench mark is the PBM and it is not holding it's elevation, contact CO-OPS ED for assistance in selecting another PBM and determining its elevation above Station Datum.

Before installing a new mark, perform a 1.6 kilometer (1 mile) radial search from the tide station (DCP) location at NGS web site, http://www.ngs.noaa.gov/cgi-bin/datasheet.prl or the NGS OPUS database http://geodesy.noaa.gov/OPUS to check if any NAVD 88 marks are available that are not part of the local leveling network. Inclusion in the local leveling network of an existing mark(s) that has a NAVD88 elevation, located within a 1.6 KM (1 mile) leveling distance of the station location, is desirable and shall be preferred over installing a new mark. If the bench mark is replaced, then the stamping of the bench mark shall have a new letter designation (assigned by CO-OPS ED) and present year so that the new stamping is different from the original stamping of the mark and the stamping of other marks in the local leveling network.

BENCHMARK SKETCH

NOAA FORM 76-199

Station Name:

Station Number:

North Arrow

Field Unit:

Body of Water

NOAA Chart:

USGS Quad:

Latitude:

Longitude:

Drawn By:

Date:

Revised By:

Date:

Figure 4.3: Benchmark Diagram Template

4.2.5.1 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. The required minimum separation between the bench marks is 200 ft. (61.0m). Each water level station will have one bench mark designated as the PBM, which shall be leveled on every run. The PBM is typically the most stable mark in close proximity to the water level station. The surveyor shall select a PBM at sites where the PBM has not already been designated. For historic water level station reoccupations, CO-OPS will furnish the designation/ stamping of the PBM and PBM elevation above station datum, 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 User's Guide for GPS Observations At Tide and Water Level Station Bench Marks.

If the PBM is determined to be unstable, another mark shall be designated as PBM. Contact CO-OPS ED for assistance in selecting another PBM and determining its elevation above Station Datum 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.

4.2.5.2 Digital Photographs of the Bench Marks

Digital photographs of water level station components (station, DCP, sensors, well, supporting structure, equipment, and bench marks) shall be taken and submitted. GPS photos shall be taken according to the User's Guide for GPS Observations At Tide and Water Level Station Bench Marks, Updated March 2013.

A minimum of four photos for each bench mark shall be taken: close-up of the disk face; chest or waist level view of disk and setting; and horizontal views of location of bench mark from two different (perpendicular) cardinal directions. Photos shall also be taken of station components such as protective wells, staffs, houses, shelters, met towers (if applicable), DCPs, sensors, etc. One general location photo shall be taken showing the water level station in relationship to its supporting structure and the local body of water. All digital photographs shall be submitted in JPEG format. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the acoustic sensor photo for DCP1 at Los Angeles shall be named as 94106601 sensor A1.jpg.

The station components and bench mark photographs are required when a new station is installed. The bench mark photographs shall be updated whenever any changes are noticed, such as damaged bench mark disk, or changes to settings, etc, or as requested in the station specific requirements.

All digital station bench mark photo files should be named such that the name of the file will indicate the station number, dash, PID number (if available), dash, stamping or designation, dash, photo type, dash, date, dot.jpg. For a new mark, the PID is not applicable as it is unavailable. Close-up photo vertically taken of the bench mark is photo type 1, chest or waist level photo vertically taken of the bench mark is photo type 2, and the horizontal view taken of the bench mark is photo type 3. For photo type 3 include the cardinal direction (N, NE, S, SE, etc) that the camera is pointing. If there are more than one type of photo is taken then rename them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use designation instead of stamping for the naming of the file. Use a maximum of 30 alphanumeric characters to the left of the dot. So if you are exceeding 30 alphanumeric characters in the name, then truncate the stamping or designation so that maximum characters in the name are 30. For example, the bench mark E close-up photo for Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

Sample file names for photo files

New bench mark without a PID and disk face photo	9414290-4290A2008-1-20090101.jpg
Existing bench mark with a PID and eye level view photo	9410660-DY2512-BM N-2-20090101.jpg
Existing bench mark without a PID and north direction photo	9447130-7130E1990-3N-20090101.jpg

In addition, put a caption for each photograph, indicating the stamping or designation of the mark, PID, photo type with cardinal direction, and the date of photograph taken.

The above naming convention for the bench mark photo files shall be applicable for all of CO-OPS' work and OCS hydrographic surveys.

4.2.5.3 Obtaining and Recording of Positions of Stations, Data Collection Platform, Sensors, and Bench Marks Using a Handheld GPS Receiver

Latitude and longitude of the station, DCP, all sensors, and bench marks shall be recorded using a hand-held GPS receiver and recorded as degrees, minutes, seconds, and tenth of seconds (e.g. 45 degrees, 34 minutes, 32.6 seconds). The positions of the primary and backup DCP (if applicable) and all sensors that are installed in a tide house (gauge house) shall be recorded as that of a station. This position will be obtained in front of the tide house (gauge house) at the center of the front door/front wall of the tide house (gauge house). The front portion of the roof of the tide house (gauge house) may also be used as applicable if the GPS satellites are blocked from the structure. For standalone DCP or met sensors that are 3 m (10 ft) or greater from the station, obtain positions and report appropriately on the Site Report.

For Aquatrak sensors, MWWL sensors, or Paroscientific sensors that are installed 3 m (10 ft) or greater from the station location, obtain the positions of the sensors at the center of the sensor. If the Aquatrak sensor or Paroscientific sensor is installed inside a tide house (gauge house), then report the latitude and longitude as that of the station.

For bench marks, obtain positions using the hand-held GPS receiver and placing the receiver on the (horizontal) bench mark. For bench marks that are installed vertically, obtain the position as close to the mark as satellite coverage will allow.

4.2.6 Leveling

At least, geodetic third-order levels (refer to reference 2 in Section 4.8, but 2nd order class I levels are preferred) shall be run at short-term subordinate stations operated for less than one-year. Requirements for higher order levels will be specified in individual Hydrographic Survey 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 water level 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 preferable. 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 with Translev and WinDesc.

The leveling connection to an acoustic sensor shall be done at the Aquatrak Leveling Point (AQLP). The AQLP is defined as the top shoulder of the mounting plate collar on the calibration tube. In order to facilitate rod holding, a prefabricated leveling fixture may be slipped over the acoustic sounding tube to rest on the leveling point. The height of the leveling fixture, as inscribed on the fixture, shall be compensated for in the leveling record (abstract). The level abstract shall show the elevation of the leveling point only. A barcoded rule or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used in lieu of the leveling fixture by holding the rule directly on the leveling point. In cases where the leveling point is too high for a rod shot, the leveling fixture designed for a down shot shall be utilized and the readings recorded to reflect the down shot.

The leveling connection to a MWWL sensor shall be done at the MWWL Leveling Point (LP). The MWWL LP is located on the top of the flange as shown in the picture below (Figure 4.4).

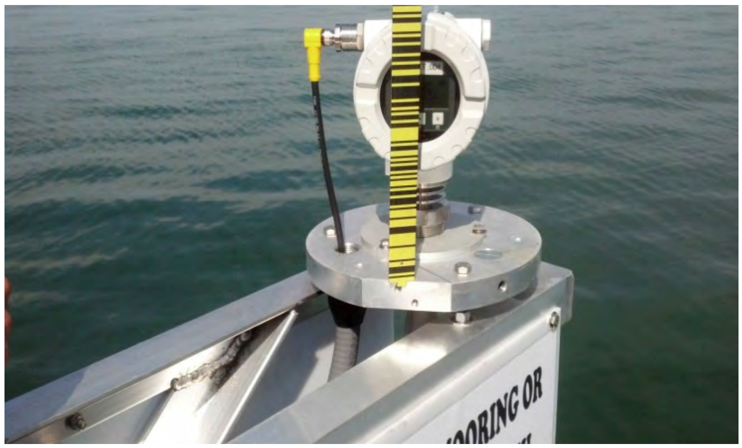


Figure 4.4: MWWL Leveling Point

4.2.6.1 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 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 an interval of six (6) months during the station's operation, and are recommended after severe storms, hurricanes, and earthquakes to document stability (see stability discussed below). Bracketing levels to appropriate number of bench marks (five for 30-day minimum stations) are required (a) if a gauge is in operations for more than 30 days but less than 12 months (b) or if final tides are required, or (c) after 6 months for stations collecting data for long term hydrographic projects.

4.2.6.2 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 0.006 m, the hydrographer shall verify the apparent movement by re-running the levels between the sensor zero or tide staff to the PBM. If the vertical stability cannot be verified, contact CO-OPS Engineering Division. This threshold of 0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

4.2.7 Water Level Station Documentation

The field team shall maintain a documentation package for each water level station installed for hydrographic projects. The documentation package shall be forwarded to CO-OPS and HSD Project Manager/COR after a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, and d) removal of the station. Refer to time frames for submission of documentation Section 4.7.5.

Generally, all documentation shall be submitted when a station is installed. For removal and intermediate site visit(s), only information that has changed shall be submitted (e.g., levels and abstract for bracketing or removal levels, Site Report for maintenance and repair or station removal, etc.). Refer to Section 4.7.1 for Documentation Submission Requirements and Section 4.7.5 for specific documentation submission time frames.

4.2.7.1 NOAA Nautical Charts and USCG Quad Maps

NOAA Raster Navigational Charts

The link below provides an interactive map to search for NOAA Raster Navigational Charts. This link will provide Chart numbers which CO-OPS uses on documents such as the bench mark diagram and published bench mark sheet. http://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml

USGS Quad Names

The USGS quad name is required on both the bench mark diagram and for use on the header of the published bench mark sheet. A digital image of the quad map showing the station location is not required. There is a Google Earth layer which will display USGS Quad names within the US. The only input needed is the latitude and longitude information. It is also listed by states if GPS information is not available. USGS quad maps (7.5 minute x 7.5 minute) can be obtained using this Google Earth layer. See the following link to download the Google Earth layer: http://www.usgsquads.com/index.php/map-indexes/mapfinder

4.2.8 Additional Field Requirements

1. Generally upon completion of the data acquisition for each gauge installed, the data must be sent as a batch for a 30-day minimum station unless the data are transmitted via satellite. For long term surveys, with additional data acquisition where subordinate acoustic or MWWL sensors have been installed for more than 1 year, contractors or NOAA field platforms may submit interim water level data deliverables at 3 month intervals unless the data is transmitted via satellite.

2. All water level data from a gauge shall be downloaded and backed up at least weekly, regardless of whether the gauge data have been sent via satellite.

3. For new stations without assigned station numbers, submit latitude and longitude of the gauge site to CO-OPS and HSD Project Manager/COR at least three business days prior to installation . A new station number will be provided prior to installation.

4. 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 bench mark diagram, field tide note, eSite Report, Xpert Site report, Site Report or Tide station report.

4.2.9 Geodetic Connections and Datums Relationship

Tidal datums are local vertical datums which may change considerably within a geographic 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 Spatial Reference System (NSRS) and is officially supported by the National Geodetic Survey (NGS) through a network of GPS Continuously Operating Reference Stations (CORS). Elevations can also be referenced to the ellipsoid and the current accepted ellipsoid is GRS80.

The relationship of tidal datums to geodetic datums and ellipsoidal datums is needed to support many coastal mapping, hydrographic surveying, VDatum, engineering and oceanographic applications including monitoring sea level changes, surveying on ellipsoid, and the deployment of GPS electronic chart display and information system, etc.

GPS requirements are specified in the latest published edition of CO-OPS "User's Guide for GPS Observations at Tide and Water Level Stations". All GPS work shall be done according to this document and the required deliverables shall be submitted as specified.

For Surveying on ellipsoid and Ellipsoidally Referenced Surveys (ERS), select the most stable bench mark that is obstruction free for GPS observations and collect minimum of a 4-hours of GPS observations and submit the data through OPUS and submit the published OPUS datasheet. Where OPUS is not able to provide solutions (e.g. in remote Pacific Islands), provide the data to HSD Project Manager/COR. These data will be submitted to NGS for a solution through the PAGES software. The tidal, geodetic, and ellipsoidal datums connection is required for VDatum modeling and supports coastal applications decision making.

Publish your OPUS solution using http://geodesy.noaa.gov/OPUS with options: publish and the following criteria:

Careful Field Procedures

- 4+ hour GPS data file
- Verify antenna type, height, and plumb
- Fixed height tripod recommended, brace the legs with sandbags or chain

Permanent Mark of Public Interest

- Durable, stable setting, with good satellite visibility
- Description & photos to aid future recovery

High-quality OPUS Solution Involves

- ≥ 70% observations used
- ≥ 70% ambiguities fixed
- ≤ 3 cm RMS
- ≤ 4 cm peak-to-peak, lat. & long.
- ≤ 8 cm peak-to-peak, ellipsoid height

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 transmitter. 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 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 4.7 Data Submission Requirements for details.

4.3.2 Data Processing, Tabulation and Harmonic Analysis of the Tides

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 Figure 4.5 and Figure 4.7 for tide stations and Figure 4.6 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.* CO-OPS has completed the development of a web based Water Level Interface (WALI) for the purpose of efficient loading and processing of water level data and computing tidal datums. The use of WALI is now a mandatory requirement for contractors to facilitate loading, processing and verification of products. If the project utilizes a TCARI approach, then harmonic constituents will also need to be generated within the WALI application. However, contractors are NOT required to utilize WALI derived products for final deliverables to OCS. Contractors may choose to also process data using company specific software and use these products for final OCS deliverables. For access to a WALI account please use the following link: https://access.co-ops.nos.noaa.gov/wali/login.do.

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 Figure 4.5. Greenwich High and Low Water Intervals (HWI and LWI) are not required for mixed diurnal or diurnal tide stations. For purposes of monthly mean computation, monthly means shall not be computed if gaps in data are greater than three consecutive days. For partial months of data, tide by tide comparison with the control station data shall be performed.

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.

Jan 31 2007 14:09 HIGH/LOW WATER LEVEL DATA July, 1998
National Ocean Service (NOAA)

Station:	9414290	T.M.:	0 W
Name:	SAN FRANCISCO, SAN FRANCISCO BAY, CA	Units:	Meters
Type:	Mixed	Datum:	STND
Note:	> Higher-High/Lower-Low [] Inferred Tide	Quality:	Verified

	High		Low			High		Low	
Day	Time	Height	Time	Height	Day	Time	Height	Time	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:	MHHW	3.641								
	MHW	3.433	DHQ	0.208						
	MTL	2.832			GT	1.720	HWI	7.57	Hrs
	DTL	2.781			MN	1.203	LWI	0.76	Hrs
	MSL	2.816							
	MLW	2.230	DLQ	0.309					
	MLLW	1.921							

Figure 4.5: High and Low Water Data and Monthly Mean Data

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 4.6: Hourly Water Level Data for a Tide Station

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

Figure 4.7: Hourly Height Water Level Data for a Great Lakes Station

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 subordinate stations where datum control does not exist, a first reduction datum computation must be used on 30 days of continuous data. 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. A tide by tide datum computation (TBYT) should only be used when a full calendar month of data is not available. Data series of less than a full calendar month may not meet NOS quality control standards, therefore, if data collection is anticipated to be less than a calendar month for logistical reasons survey personnel should notify HSD Project Manager/COR at their earliest convenience to determine data utility for survey support. For stations that collect complete months of data a simultaneous comparison of full months (MMSC) must be used for datum computations. Datum computations for data series of a year or more should be computed on complete years of data using MMSC methodology. Datum computations of complete months and complete years reduces error due to any seasonal bias in the data. Examples of a tide by tide and a monthly mean simultaneous comparison for datum determination are found in Figure 4.7 and Figure 4.8. 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 Tidal 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 at least two existing bench marks (three bench marks are preferred) with a published tidal elevation. All possible effort must be applied to attempt to recover as many historic tidal benchmarks as possible. 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 bench mark 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 4.9.

Begin: Jun 15 2005 00:00
End: Jul 14 2005 23:54
Run: Jan 31 2007 16:30

COMPARISON OF SIMULTANEOUS OBSERVATIONS

Tidal Epoch: 1983-2001
Expected Diff: 0.55 Hrs
* Exceeds 2 Standard Dev

(A) Subordinate Station: 9414863 RICHMOND, CHEVRON OIL PIER — Verified — T.M.: 0W — Tide Type: Mixed
(B) Standard Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY — Verified — T.M.: 0W — Tide Type: Mixed

(A) STATION Time of				(B) STATION Time of				(A) - (B) Time Difference		(A) STATION Height of		(B) STATION Height of		(A) - (B) Height Difference	
2005	HW Hour	Date	LW Hour	Date	HW Hour	Date	LW Hour	HW Hours	LW Hours	HW Meters	LW Meters	HW Meters	LW Meters	HW Meters	LW Meters
Jun 15	2.3 HH	Jun 15	8.4 L	Jun 15	2.0 HH	Jun 15	7.5 L	0.3	0.9	5.091	4.266	3.304	2.546	1.787	1.720
Jun 15	13.6 H	Jun 15	19.7 LL	Jun 15	13.2 H	Jun 15	19.0 LL	0.4	0.7	4.745	3.890	2.970	2.222	1.775	1.668*
Jun 16	3.0 HH	Jun 16	9.3 L	Jun 16	2.5 HH	Jun 16	8.4 L	0.5	0.9	5.193	4.065	3.412	2.362	1.781	1.703
Jun 16	15.0 H	Jun 16	20.5 L	Jun 16	14.6 H	Jun 16	19.7 L	0.4	0.8	4.731	4.070	2.953	2.350	1.778	1.720
Jun 17	3.4 HH	Jun 17	10.0 LL	Jun 17	3.0 HH	Jun 17	9.1 LL	0.4	0.9	5.347	3.861	3.566	2.144	1.781	1.717
Jun 17	16.1 H	Jun 17	21.4 L	Jun 17	15.7 H	Jun 17	20.6 L	0.4	0.8	4.736	4.140	2.960	2.418	1.776	1.722
Jun 18	4.0 HH	Jun 18	10.8 LL	Jun 18	3.5 HH	Jun 18	10.1 LL	0.5	0.7	5.400	3.657	3.612	1.919	1.788	1.738
Jun 18	17.4 H	Jun 18	22.2 L	Jun 18	17.0 H	Jun 18	21.6 L	0.4	0.6	4.793	4.265	3.015	2.539	1.778	1.726
Jun 19	4.5 HH	Jun 19	11.8 LL	Jun 19	4.1 HH	Jun 19	11.1 LL	0.4	0.7	5.528	3.440	3.728	1.714	1.800	1.726
Jun 19	18.6 H	Jun 19	23.0 L	Jun 19	18.1 H	Jun 19	22.4 L	0.5	0.6	4.833	4.365	3.057	2.626	1.776	1.739
Jun 20	5.2 HH	Jun 20	12.6 LL	Jun 20	5.0 HH	Jun 20	11.9 LL	0.2*	0.7	5.603	3.249	3.806	1.503	1.797	1.746
Jun 20	19.5 H	Jun 20	23.8 L	Jun 20	19.1 H	Jun 20	23.2 L	0.4	0.6	4.893	4.452	3.107	2.722	1.786	1.730
Jun 21	5.8 HH	Jun 21	13.4 LL	Jun 21	5.5 HH	Jun 21	12.9 LL	0.3	0.5	5.681	3.127	3.887	1.368	1.794	1.759
Jun 21	20.4 H	Jun 22	0.6 L	Jun 21	20.1 H	Jun 22	0.1 L	0.3	0.5	4.961	4.482	3.167	2.753	1.794	1.729
Jun 22	6.5 HH	Jun 22	14.2 LL	Jun 22	6.2 HH	Jun 22	13.6 LL	0.3	0.6	5.727	3.026	3.933	1.248	1.794	1.778
Jun 22	21.3 H	Jun 23	1.6 L	Jun 22	20.9 H	Jun 23	1.0 L	0.4	0.6	4.984	4.498	3.192	2.766	1.792	1.732
Jun 23	7.6 HH	Jun 23	15.0 LL	Jun 23	7.2 HH	Jun 23	14.4 LL	0.4	0.6	5.736	2.999	3.936	1.230	1.800	1.769
Jun 23	22.1 H	Jun 24	2.5 L	Jun 23	21.7 H	Jun 24	1.9 L	0.4	0.6	5.024	4.476	3.230	2.755	1.794	1.721
Jun 24	8.2 HH	Jun 24	15.9 LL	Jun 24	7.8 HH	Jun 24	15.1 LL	0.4	0.8	5.711	3.054	3.935	1.307	1.776	1.747
Jun 24	22.9 H	Jun 25	3.5 L	Jun 24	22.3 H	Jun 25	2.9 L	0.6	0.6	5.084	4.436	3.309	2.714	1.775	1.722
Jun 25	9.2 HH	Jun 25	16.6 LL	Jun 25	8.8 HH	Jun 25	15.7 LL	0.4	0.9	5.615	3.164	3.839	1.415	1.776	1.749
Jun 25	23.7 H	Jun 26	4.5 L	Jun 25	23.1 H	Jun 26	4.0 L	0.6	0.5	5.165	4.387	3.394	2.678	1.771	1.709
Jun 26	10.3 HH	Jun 26	17.5 LL	Jun 26	9.9 HH	Jun 26	16.6 LL	0.4	0.9	5.453	3.316	3.674	1.577	1.779	1.739
Jun 27	0.4 H	Jun 27	5.7 L	Jun 26	23.7 HH	Jun 27	5.1 L	0.7*	0.6	5.243	4.299	3.477	2.579	1.766*	1.720
Jun 27	11.4 HH	Jun 27	18.1 LL	Jun 27	10.8 H	Jun 27	17.3 LL	0.6	0.8	5.257	3.478	3.467	1.744	1.790	1.734
Jun 28	1.2 HH	Jun 28	6.9 L	Jun 28	0.6 HH	Jun 28	6.4 L	0.6	0.5	5.313	4.167	3.538	2.451	1.775	1.716
Jun 28	12.6 H	Jun 28	18.7 LL	Jun 28	12.1 H	Jun 28	18.1 LL	0.5	0.6	5.007	3.639	3.217	1.921	1.790	1.718
Jun 29	1.9 HH	Jun 29	8.2 L	Jun 29	1.4 HH	Jun 29	7.5 L	0.5	0.7	5.381	3.997	3.591	2.274	1.790	1.723
Jun 29	14.0 H	Jun 29	19.5 LL	Jun 29	13.6 H	Jun 29	18.9 LL	0.4	0.6	4.883	3.908	3.094	2.210	1.789	1.698
Jun 30	2.6 HH	Jun 30	9.3 LL	Jun 30	2.1 HH	Jun 30	8.7 LL	0.5	0.6	5.486	3.850	3.711	2.119	1.775	1.731
Jun 30	15.6 H	Jun 30	20.6 L	Jun 30	15.2 H	Jun 30	20.1 L	0.4	0.5	4.824	4.151	3.047	2.445	1.777	1.706
Jul 1	3.3 HH	Jul 1	10.3 LL	Jul 1	2.9 HH	Jul 1	9.8 LL	0.4	0.5	5.521	3.694	3.741	1.957	1.780	1.737
Jul 1	17.1 H	Jul 1	21.8 L	Jul 1	16.7 H	Jul 1	21.2 L	0.4	0.6	4.867	4.347	3.083	2.625	1.784	1.722
Jul 2	4.2 HH	Jul 2	11.3 LL	Jul 2	3.7 HH	Jul 2	10.7 LL	0.5	0.6	5.554	3.565	3.768	1.816	1.786	1.749
Jul 2	18.4 H	Jul 2	22.7 L	Jul 2	17.9 H	Jul 2	22.2 L	0.5	0.5	4.943	4.500	3.152	2.770	1.791	1.730
Jul 3	4.7 HH	Jul 3	12.2 LL	Jul 3	4.3 HH	Jul 3	11.5 LL	0.4	0.7	5.590	3.464	3.809	1.712	1.781	1.752
Jul 3	19.4 H	Jul 3	23.5 L	Jul 3	18.9 H	Jul 3	23.1 L	0.5	0.4	4.963	4.519	3.180	2.797	1.783	1.722
Jul 4	5.6 HH	Jul 4	12.9 LL	Jul 4	5.1 HH	Jul 4	12.2 LL	0.5	0.7	5.571	3.379	3.782	1.637	1.789	1.742
Jul 4	20.1 H	Jul 5	0.4 L	Jul 4	19.6 H	Jul 4	23.9 L	0.5	0.5	5.016	4.579	3.230	2.853	1.786	1.726
Jul 5	6.0 HH	Jul 5	13.5 LL	Jul 5	5.5 HH	Jul 5	12.7 LL	0.5	0.8	5.540	3.354	3.751	1.598	1.789	1.756
Jul 5	20.9 H	Jul 6	1.2 L	Jul 5	20.3 H	Jul 6	0.6 L	0.6	0.6	5.029	4.598	3.244	2.861	1.785	1.737
Jul 6	6.9 HH	Jul 6	14.1 LL	Jul 6	6.3 HH	Jul 6	13.5 LL	0.6	0.6	5.521	3.354	3.734	1.601	1.787	1.753
Jul 6	21.5 H	Jul 7	1.9 L	Jul 6	20.9 H	Jul 7	1.3 L	0.6	0.6	5.056	4.584	3.272	2.860	1.784	1.724

(a)
Figure 4.8: Tide-By-Tide Comparison

COMPARISON OF SIMULTANEOUS OBSERVATIONS

Begin: Jun 15 2005 00:00
End: Jul 14 2005 00:00
Run: Jan 31 2007 16:30

Tidal Epoch: 1983-2001
Expected Diff: 0.55 Hrs
* Exceeds 2 Standard Dev

(A) Subordinate Station: 9414863 RICHMOND, CHEVRON OIL PIER Verified T.M.: 0W Tide Type: Mixed
(B) Standard Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY Verified T.M.: 0W Tide Type: Mixed

(A) STATION Time of				(B) STATION Time of				(A) - (B) Time Difference		(A) STATION Height of		(B) STATION Height of		(A) - (B) Height Difference	
2005	HW Hour	Date	LW Hour	Date	HW Hour	Date	LW Hour	HW Hours	LW Hours	HW Meters	LW Meters	HW Meters	LW Meters	HW Meters	LW Meters
Jul 7	7.4 HH	Jul 7	14.8 LL	Jul 7	7.2 HH	Jul 7	13.9 LL	0.2*	0.9	5.510	3.380	3.715	1.622	1.795	1.758
Jul 7	22.0 H	Jul 8	2.4 L	Jul 7	21.4 H	Jul 8	1.9 L	0.6	0.5	5.037	4.533	3.248	2.822	1.789	1.711
Jul 8	8.0 HH	Jul 8	15.3 LL	Jul 8	7.6 HH	Jul 8	14.5 LL	0.4	0.8	5.444	3.397	3.660	1.654	1.784	1.743
Jul 8	22.5 H	Jul 9	3.0 L	Jul 8	21.9 H	Jul 9	2.4 L	0.6	0.6	5.016	4.478	3.225	2.775	1.791	1.703
Jul 9	8.7 HH	Jul 9	15.8 LL	Jul 9	8.2 HH	Jul 9	15.1 LL	0.5	0.7	5.375	3.453	3.587	1.719	1.788	1.734
Jul 9	23.1 H	Jul 10	3.7 L	Jul 9	22.5 H	Jul 10	3.2 L	0.6	0.5	5.036	4.462	3.245	2.760	1.791	1.702
Jul 10	9.5 HH	Jul 10	16.2 LL	Jul 10	8.9 HH	Jul 10	15.5 LL	0.6	0.7	5.267	3.541	3.476	1.802	1.791	1.739
Jul 10	23.6 H	Jul 11	4.5 L	Jul 10	23.1 H	Jul 11	4.0 L	0.5	0.5	5.059	4.432	3.260	2.728	1.799	1.704
Jul 11	9.9 HH	Jul 11	16.8 LL	Jul 11	9.5 HH	Jul 11	16.0 LL	0.4	0.8	5.153	3.622	3.365	1.900	1.788	1.722
Jul 12	0.1 H	Jul 12	5.5 L	Jul 11	23.7 H	Jul 12	4.9 L	0.4	0.6	5.110	4.359	3.325	2.651	1.785	1.708
Jul 12	10.8 H	Jul 12	17.2 LL	Jul 12	10.4 H	Jul 12	16.5 LL	0.4	0.7	4.992	3.705	3.211	1.998	1.781	1.707
Jul 13	0.6 HH	Jul 13	6.3 L	Jul 13	0.1 HH	Jul 13	5.8 L	0.5	0.5	5.155	4.294	3.362	2.565	1.793	1.729
Jul 13	11.7 H	Jul 13	17.8 LL	Jul 13	11.3 H	Jul 13	17.1 LL	0.4	0.7	4.875	3.899	3.090	2.204	1.785	1.695
										HHW	HLW	HHW	HLW	HHW	HLW
						SUMS				152.709	122.201	102.699	74.045	50.010	48.156
						ITEMS				28	28	28	28	28	28
						MEANS				5.454	4.364	3.668	2.644	1.786	1.720
						STD DEV								0.007	0.011
										LHW	LLW	LHW	LLW	LHW	LLW
						SUMS		25.60	36.50	138.919	97.465	88.944	48.861	49.975	48.604
						ITEMS		56	56	28	28	28	28	28	28
						MEANS		0.46	0.65	4.961	3.481	3.177	1.745	1.785	1.736
						STD DEV		0.11	0.13					0.008	0.024

(b)
Figure 4.8: Tide-By-Tide Comparison (continued)

```
Begin:  Jun 15 2005 00:00            COMPARISON OF SIMULTANEOUS OBSERVATIONS            Tidal Epoch:   1983-2001
End:    Jul 14 2005 00:00                                                              Expected Diff:  0.55 Hrs
Run:    Jan 31 2007 16:30                                                              * Exceeds 2 Standard Dev

(A) Subordinate Station:  9414863  RICHMOND, CHEVRON OIL PIER            Verified   T.M.:  0W  Tide Type:     Mixed
(B) Standard    Station:  9414290  SAN FRANCISCO, SAN FRANCISCO BAY      Verified   T.M.:  0W  Tide Type:     Mixed

Mean Difference in HWI:   0.46                            Mean Difference in LWI:   0.65
Mean HHW Height at (A):   5.454                           Mean HLW Height at (A):   4.364
Mean LHW Height at (A):   4.961                           Mean LLW Height at (A):   3.481
DHQ             at (A):   0.246                           DLQ             at (A):   0.442
Mean HW Height  at (A):   5.208                           Mean LW Height  at (A):   3.923
MN              at (A):   1.285                           MTL             at (A):   4.565
GT              at (A):   1.973                           DTL             at (A):   4.467

Mean HHW Difference:      1.786                           Mean HLW Difference:      1.720
Mean LHW Difference:      1.785                           Mean LLW Difference:      1.736
DHQ      Difference:      0.001                           DLQ      Difference:     -0.008
Mean HW  Difference:      1.785                           Mean LW  Difference:      1.728
MN       Difference:      0.058                           MTL      Difference:      1.757
GT       Difference:      0.050                           DTL      Difference:      1.761
MN       Ratio:           1.047                           DHQ      Ratio:           1.003
GT       Ratio:           1.026                           DLQ      Ratio:           0.982
MSL (100.00%)   at (A):   4.548
MSL (100.00%)   at (B):   2.782
MSL      Difference:      1.766

                          HWI    LWI    MTL     MN      MSL     DHQ     DLQ
                         Hours  Hours  Meters  Meters  Meters  Meters  Meters
Accepted  for B:          7.53   0.85   2.792   1.248   2.773   0.186   0.346
Differences and Ratios:   0.46   0.65   1.757   1.047   1.766   1.003   0.982
Corrected for A:          7.99   1.50   4.549   1.307   4.539   0.186   0.340

                              FINAL/PRELIMINARY DATUMS   Standard Method

                              MHHW  ---|---   5.388
                                       |            DHQ   0.186
                              MHW     -|-     5.202
                                       |
                              DTL     -|-     4.472
                                       |                         GT    1.833
                              MTL     -|-     4.549
                                       |                         MN    1.307
                              MSL     -|-     4.539
                                       |
                              MLW     -|-     3.895                                         Date         ID
                                       |            DLQ   0.340
                              MLLW  ---|---   3.555              HWI:  7.99    Comparison  ___________  ____

                              On Staff Of:                       LWI:  1.50    Verified    ___________  ____
```

(c)
Figure 4.8: Tide-By-Tide Comparison (concluded)

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005) — Feb 01, 2007
1983-2001 TIDAL EPOCH

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER — Product — TM (OW) — TIDE TYPE (M)
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY — Product — TM (OW) — TIDE TYPE (M)

Mon Year	M T L			M S L			H W I			L W I			M N		
	A	B	A - B	A	B	A - B	A	B	A - B	A	B	A - B	A	B	A / B
	METER	METER	METER	METER	METER	METER	HRS	HRS	HRS	HRS	HRS	HRS	METER	METER	RATIO
Jan 2005	4.665	2.900	1.765	4.650	2.876	1.774	7.890	7.450	0.440	1.380	0.750	0.630	1.293	1.212	1.067
Feb 2005	4.639	2.875	1.764	4.626	2.853	1.773	7.970	7.520	0.450	1.430	0.800	0.630	1.315	1.239	1.061
Mar 2005	4.593	2.813	1.780	4.575	2.791	1.784	7.890	7.450	0.440	1.320	0.690	0.630	1.288	1.207	1.067
Apr 2005	4.503	2.740	1.763	4.485	2.713	1.772	7.890	7.500	0.390	1.380	0.720	0.660	1.276	1.199	1.064
May 2005	4.563	2.805	1.758	4.542	2.773	1.769	7.890	7.480	0.410	1.430	0.720	0.710	1.281	1.209	1.060
Jun 2005	4.535	2.780	1.755	4.517	2.750	1.767	7.870	7.450	0.420	1.430	0.710	0.720	1.274	1.210	1.053
Jul 2005	4.607	2.856	1.751	4.590	2.826	1.764	7.950	7.490	0.460	1.460	0.840	0.620	1.284	1.231	1.043
Aug 2005	4.604	2.864	1.740	4.593	2.838	1.755	7.970	7.520	0.450	1.490	0.880	0.610	1.279	1.230	1.040
Sep 2005	4.571	2.838	1.733	4.565	2.819	1.746	7.880	7.460	0.420	1.420	0.830	0.590	1.273	1.225	1.039
Oct 2005		2.809			2.787			7.420			0.810			1.235	
Nov 2005		2.781			2.751			7.440			0.830			1.229	
Dec 2005		2.840			2.805			7.460			0.800			1.245	

Mon Year	D H Q			D L Q			M H W			M L W		
	A	B	A / B	A	B	A / B	A	B	A - B	A	B	A - B
	METER	METER	RATIO	METER	METER	RATIO	METER	METER	METER	METER	METER	METER
Jan 2005	0.227	0.224	1.013	0.401	0.406	0.988	5.312	3.506	1.806	4.019	2.294	1.725
Feb 2005	0.207	0.204	1.015	0.350	0.354	0.989	5.296	3.494	1.802	3.981	2.255	1.726
Mar 2005	0.154	0.152	1.013	0.329	0.324	1.015	5.237	3.417	1.820	3.949	2.210	1.739
Apr 2005	0.156	0.156	1.000	0.388	0.380	1.021	5.141	3.339	1.802	3.865	2.140	1.725
May 2005	0.179	0.179	1.000	0.431	0.427	1.009	5.204	3.409	1.795	3.923	2.200	1.723
Jun 2005	0.246	0.245	1.004	0.439	0.439	1.000	5.172	3.385	1.787	3.898	2.175	1.723
Jul 2005	0.258	0.257	1.004	0.429	0.441	0.973	5.249	3.471	1.778	3.965	2.240	1.725
Aug 2005	0.218	0.216	1.009	0.376	0.393	0.957	5.244	3.479	1.765	3.965	2.249	1.716
Sep 2005	0.161	0.156	1.032	0.305	0.324	0.941	5.207	3.451	1.756	3.934	2.226	1.708
Oct 2005		0.140			0.324			3.427			2.192	
Nov 2005		0.204			0.417			3.395			2.166	
Dec 2005		0.256			0.487			3.462			2.217	

Mon Year	D R L(TL)			G T			M H H W			M L L W		
	A	B	A - B	A	B	A / B	A	B	A - B	A	B	A - B
	METER	METER	RATIO	METER	METER	RATIO	METER	METER	METER	METER	METER	METER
Jan 2005	4.579	2.809	1.770	1.921	1.842	1.043	5.539	3.730	1.809	3.618	1.888	1.730
Feb 2005	4.567	2.800	1.767	1.872	1.797	1.042	5.503	3.698	1.805	3.631	1.901	1.730
Mar 2005	4.505	2.728	1.777	1.771	1.683	1.052	5.391	3.569	1.822	3.620	1.886	1.734
Apr 2005	4.387	2.628	1.759	1.820	1.735	1.049	5.297	3.495	1.802	3.477	1.760	1.717
May 2005	4.438	2.680	1.758	1.891	1.815	1.042	5.383	3.588	1.795	3.492	1.773	1.719
Jun 2005	4.439	2.683	1.756	1.959	1.894	1.034	5.418	3.630	1.788	3.459	1.736	1.723
Jul 2005	4.521	2.764	1.757	1.971	1.929	1.022	5.507	3.728	1.779	3.536	1.799	1.737
Aug 2005	4.526	2.776	1.750	1.873	1.839	1.018	5.462	3.695	1.767	3.589	1.856	1.733
Sep 2005	4.498	2.755	1.743	1.739	1.705	1.020	5.368	3.607	1.761	3.629	1.902	1.727
Oct 2005		2.718			1.699			3.567			1.868	
Nov 2005		2.674			1.850			3.599			1.749	
Dec 2005		2.724			1.988			3.718			1.730	

(a)
Figure 4.9: Monthly Mean Simultaneous Comparison Example

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005) Feb 01, 2007
1983-2001 TIDAL EPOCH

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

	M T L	M S L	H W I	L W I	M N
	A - B	A - B	A - B	A - B	A / B
	METER	METER	HRS	HRS	RATIO
TOTAL MONTHS	9.000	9.000	9.000	9.000	9.000
SUMS	15.809	15.904	3.880	5.800	9.494
MEANS	1.757	1.767	0.431	0.644	1.055
ACCEPTED FOR B	2.792	2.773	7.535	0.848	1.248
CORRECTED FOR A	4.549	4.540	7.966	1.492	1.317

	D H Q	D L Q	M H W	M L W
	A / B	A / B	A - B	A - B
	RATIO	RATIO	METER	METER
TOTAL MONTHS	9.000	9.000	9.000	9.000
SUMS	9.090	8.893	16.111	15.510
MEANS	1.010	0.988	1.790	1.723
ACCEPTED FOR B	0.186	0.346	3.416	2.168
CORRECTED FOR A	0.188	0.342	5.206	3.891

	D R L(TL)	G T	M H H W	M L L W
	A - B	A / B	A - B	A - B
	METER	RATIO	METER	METER
TOTAL MONTHS	9.000	9.000	9.000	9.000
SUMS	15.837	9.322	16.128	15.550
MEANS	1.760	1.036	1.792	1.728
ACCEPTED FOR B	2.712	1.780	3.602	1.822
CORRECTED FOR A	4.472	1.844	5.394	3.550

METHOD	DATUM	VALUE
MODIFIED RANGE RATIO	MHHW =	5.394
MODIFIED RANGE RATIO	MLLW =	3.550
MODIFIED RANGE RATIO	DHQ =	0.187
MODIFIED RANGE RATIO	DLQ =	0.340
STANDARD	MHW =	5.207
STANDARD	MLW =	3.890
STANDARD	MHHW =	5.395
STANDARD	MLLW =	3.548
DIRECT	MN =	1.315
DIRECT	GT =	1.844
DIRECT	DHQ =	0.188
DIRECT	DLQ =	0.342

FINAL/PRELIMINARY DATUMS

MHHW	5.395	DHQ 1.88
MHW	5.207	
MTL	4.549	GT 1.846
DTL	4.472	MN 1.317
MSL	4.540	
MLW	3.890	DLQ 0.342
MLLW	3.548	

ON STAFF OF:

TABULATED ____________________

VERIFIED ____________________

(b)
Figure 4.9: Monthly Mean Simultaneous Comparison (continued)

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005) Feb 01, 2007
1983-2001 TIDAL EPOCH

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

O U T L I E R   R E P O R T

(MEAN DIFFERENCE EXCEEDS 2 STD. DEV. (MAX/MIN))

	M T L	M S L	H W I	L W I	M N	D H Q	D L Q	M H W	M L W	D T L	G T	M H H W	M L L W	
Std.Dev.	0.009	0.007	0.014	0.034	0.007	0.008	0.016	0.013	0.005	0.007	0.008	0.013	0.004	Std.Dev.
MAX	1.774	1.780	0.459	0.712	1.069	1.025	1.021	1.816	1.734	1.774	1.052	1.818	1.736	MAX
MIN	1.739	1.754	0.404	0.577	1.041	0.995	0.956	1.765	1.713	1.745	1.020	1.766	1.719	MIN
MON YEAR														
Jan 2005														Jan 2005
Feb 2005														Feb 2005
Mar 2005	1.780	1.784						1.820	1.739	1.777	1.052	1.822		Mar 2005
Apr 2005			0.390				1.021						1.717	Apr 2005
May 2005													1.719	May 2005
Jun 2005				0.720										Jun 2005
Jul 2005			0.460										1.737	Jul 2005
Aug 2005					1.040						1.018			Aug 2005
Sep 2005	1.733	1.746			1.039	1.032	0.941	1.756	1.708	1.743		1.761		Sep 2005
Oct 2005														Oct 2005
Nov 2005														Nov 2005
Dec 2005														Dec 2005

(c)
Figure 4.9: Monthly Mean Simultaneous Comparison (concluded)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Page 1 of 8

Station ID:	9414290	PUBLICATION DATE:	04/21/2003
Name:	SAN FRANCISCO CALIFORNIA		
NOAA Chart:	18649	Latitude:	37° 48.4' N
USGS Quad:	SAN FRANCISCO NORTH	Longitude:	122° 27.9' W

To reach the tidal bench marks, proceed west along U.S. Highway 101 in the direction of the Golden Gate Bridge, then NW along Crissey Field Avenue (before the bridge) to the Golden Gate National Park (Presidio). The bench marks are located mostly along the coast in the vicinity. The tide gauge is located on the NE side of the National Parks Service wharf.

T I D A L   B E N C H   M A R K S

PRIMARY BENCH MARK STAMPING: 180 1936
DESIGNATION: 941 4290 TIDAL 180

MONUMENTATION:	Tidal Station disk	VM#:	967
AGENCY:	US Coast and Geodetic Survey (USC&GS)	PID:	HT0702
SETTING CLASSIFICATION:	Concrete sea wall		

The primary bench mark is a disk set in the top of a 1 m (3 ft) high concrete seawall in Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, 15 m (50 ft) east of the NE corner of the Sanctuaries building, 6.10 m (20.0 ft) south of the south side of the garage building, and 1.07 m (3.5 ft) north of an angle in wall.

BENCH MARK STAMPING: BM 174 1925
DESIGNATION: 941 4290 TIDAL 174
ALIAS: TIDAL 174

MONUMENTATION:	Tidal Station disk	VM#:	971
AGENCY:	US Coast and Geodetic Survey (USC&GS)	PID:	HT0697
SETTING CLASSIFICATION:	Concrete monument		

The bench mark is a disk set in a concrete post flush with the ground inside a circle of bricks in the pavement, 38.10 m (125.0 ft) west of the extended west edge of Engineer's Dock where it crosses Marine Drive, at the center of "Y" between Marine Drive and the road leading SE to Fort Winfield Scott, 12.95 m (42.5 ft) SW of the fire hydrant, and 8.69 m (28.5 ft) south of the south edge of an iron manhole cover.

(a)
Figure 4.10: Published Bench Mark Sheet

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: BM 176 1925
DESIGNATION: 941 4290 TIDAL 176
ALIAS: TIDAL 176

MONUMENTATION: Tidal Station disk VM#: 972
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0705
SETTING CLASSIFICATION: Concrete step

The bench mark is a disk set in the west end of the lowest concrete step at the main entrance to the porch of the building at No. 651 Mason Street, 29.87 m (98.0 ft) SE of the intersection of Crissey Field Avenue and Mason Street, 15.24 m (50.0 ft) south of the centerline of Mason Street, and 0.21 m (0.7 ft) above sidewalk.

BENCH MARK STAMPING: 181 1945
DESIGNATION: 941 4290 TIDAL 181
ALIAS: TIDAL 181

MONUMENTATION: Tidal Station disk VM#: 973
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0701
SETTING CLASSIFICATION: Sea wall

The bench mark is a disk set in NW corner of a sea wall at the Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, 62 m (204 ft) west of the inshore end of the pier, 45.87 m (150.5 ft) NW of a flag pole, 21.64 m (71.0 ft) NE of the north corner of Building S.F. 19.4 (paint shop and storage building), and 1.22 m (4.0 ft) above ground.

(b)
Figure 4.10: Published Bench Mark Sheet (continued)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Page 3 of 8

Station ID: 9414290	PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO CALIFORNIA	
NOAA Chart: 18649	Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH	Longitude: 122° 27.9' W

T I D A L   B E N C H   M A R K S

BENCH MARK STAMPING: NO 2 1948
DESIGNATION: CLARK RM 2
ALIAS: 941 4290 TIDAL 183

MONUMENTATION:	Triangulation Station disk	VM#:	975
AGENCY:	US Coast and Geodetic Survey (USC&GS)	PID:	HT0700
SETTING CLASSIFICATION:	Sea wall		

The bench mark is a disk set flush in the top of a sea wall west of the public fishing pier, 11.43 m (37.5 ft) west of the west edge of the pier, 8.08 m (26.5 ft) NE of the NE corner of corrugated iron building No. 985, and about 0.91 m (3.0 ft) above ground.

BENCH MARK STAMPING: CLARK 1948
DESIGNATION: CLARK
ALIAS: 941 4290 TIDAL 185

MONUMENTATION:	Triangulation Station disk	VM#:	976
AGENCY:	US Coast and Geodetic Survey (USC&GS)	PID:	HT0698
SETTING CLASSIFICATION:	Concrete sea wall		

The bench mark is a disk set in the top of a concrete sea wall west of the public fishing pier, about 549 m (1800 ft) NW of the Gulf of Farallons National Marine Sanctuary headquarters in Golden Gate National Park, 24.23 m (79.5 ft) west of the west edge of the pier, 6.86 m (22.5 ft) NE of the NW corner of corrugated iron building No. 985, 3.05 m (10.0 ft) west of the NW corner of a stucco paint locker building, and 1.07 m (3.5 ft) above ground.

(c)

Figure 4.10: Published Bench Mark Sheet (continued)

Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: 4290 K 1976
DESIGNATION: 941 4290 K TIDAL

MONUMENTATION: Tidal Station disk VM#: 978
AGENCY: National Ocean Service (NOS) PID: HT2255
SETTING CLASSIFICATION: Bedrock

The bench mark is a disk set vertically in bedrock on the south side of Marine Drive, 24 m (79 ft) SSW of the SE corner of the National Park Service building # T989, 14.69 m (48.2 ft) NW of bench mark BM 174 1925, and 2.44 m (8.0 ft) south of the road curb.

BENCH MARK STAMPING: 4290 L 1976
DESIGNATION: 941 4290 L TIDAL

MONUMENTATION: Tidal Station disk VM#: 979
AGENCY: National Ocean Survey (NOS) PID: HT2253
SETTING CLASSIFICATION: Bedrock

The bench mark is a disk set in bedrock on the south side of Marine Drive, 114 m (375 ft) west of the National Park Service building # T989, 15.70 m (51.5 ft) SE of the eastern-most concrete and steel safety chain stanchion on the seawall, 7.77 m (25.5 ft) from the centerline of Marine Drive, and 1.22 m (4 ft) above street level.

(d)
Figure 4.10: Published Bench Mark Sheet (continued)

Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L   B E N C H   M A R K S

BENCH MARK STAMPING: 4290 M 1982
DESIGNATION: 941 4290 M TIDAL

MONUMENTATION: Tidal Station disk VM#: 980
AGENCY: National Ocean Survey (NOS) PID: HT3538
SETTING CLASSIFICATION: Concrete foundation

The bench mark is a disk set flush in concrete foundation in front of Stilwell Hall (building # 650) on Mason Street, 27.34 m (89.7 ft) south of the centerline of Mason street, 10.30 m (33.8 ft) east of the NE corner of the west wing of the Stilwell Hall, 6.07 m (19.9 ft) west of the west edge of the sidewalk leading to the entrance of Stilwell Hall, 0.30 m (1.0 ft) SE of the NW corner of the foundation, and 0.12 m (0.4 ft) above ground level.

BENCH MARK STAMPING: BM 175 1925
DESIGNATION: 941 4290 TIDAL 175
ALIAS: TIDAL 175

MONUMENTATION: Tidal Station disk VM#: 1829
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0696
SETTING CLASSIFICATION: Sea wall

The bench mark is a disk set in top surface of the sea wall, near the National Park Service building at the intersection of the pavement and the seawall, 65.23 m (214.0 ft) NE of bench mark 4290 L 1976, 58.67 m (192.5 ft) west from the NW corner of the National Park Service building, 28.90 m (94.8 ft) WNW of the northern-most post of pedestrian gate, 6.86 m (22.5 ft) north of the centerline of Marine Drive, and 0.73 m (2.4 ft) south from the north edge of the sea wall.

(e)
Figure 4.10: Published Bench Mark Sheet (continued)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Station ID:	9414290	PUBLICATION DATE:	04/21/2003
Name:	SAN FRANCISCO CALIFORNIA		
NOAA Chart:	18649	Latitude:	37° 48.4' N
USGS Quad:	SAN FRANCISCO NORTH	Longitude:	122° 27.9' W

T I D A L   B E N C H   M A R K S

BENCH MARK STAMPING: 4290 N 1995
DESIGNATION: 941 4290 N

MONUMENTATION:	Tidal Station disk	VM#:	15436
AGENCY:	National Ocean Service (NOS)	PID:	AE5209
SETTING CLASSIFICATION:	Concrete sea wall		

The bench mark is a disk set in a concrete seawall in Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, near an inshore end of a walkway leading to a pier, 13.70 m (44.9 ft) north of bottom of stairs leading to the Sanctuary building, 3.96 m (13.0 ft) east of a step in seawall, and 3.20 m (10.5 ft) west of the center of the walkway.

(f)
Figure 4.10: Published Bench Mark Sheet (continued)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Station ID:	9414290	PUBLICATION DATE:	04/21/2003
Name:	SAN FRANCISCO CALIFORNIA		
NOAA Chart:	18649	Latitude:	37° 48.4' N
USGS Quad:	SAN FRANCISCO NORTH	Longitude:	122° 27.9' W

T I D A L D A T U M S

Tidal datums at SAN FRANCISCO based on:

LENGTH OF SERIES:	19 Years
TIME PERIOD:	January 1983 - December 2001
TIDAL EPOCH:	1983-2001
CONTROL TIDE STATION:	

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

HIGHEST OBSERVED WATER LEVEL (01/27/1983)	= 2.640
MEAN HIGHER HIGH WATER (MHHW)	= 1.780
MEAN HIGH WATER (MHW)	= 1.595
MEAN TIDE LEVEL (MTL)	= 0.970
MEAN SEA LEVEL (MSL)	= 0.951
MEAN LOW WATER (MLW)	= 0.346
MEAN LOWER LOW WATER (MLLW)	= 0.000
NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)	= -0.018
LOWEST OBSERVED WATER LEVEL (12/17/1933)	= -0.877

Bench Mark Elevation Information — In METERS above:

Stamping or Designation	MLLW	MHW
180 1936	3.972	2.378
BM 174 1925	5.013	3.418
BM 176 1925	4.814	3.219
181 1945	3.987	2.392
NO 2 1948	4.221	2.626
CLARK 1948	4.233	2.639
4290 K 1976	5.828	4.234
4290 L 1976	6.620	5.025
4290 M 1982	3.705	2.111
BM 175 1925	4.160	2.566
4290 N 1995	3.646	2.051

(g)
Figure 4.10: Published Bench Mark Sheet (continued)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

D E F I N I T I O N S

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88).

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at http://www.ngs.noaa.gov/cgi-bin/ngs_opsd.prl?PID=HT0702&EPOCH=1983-2001.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level observed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at http://www.ngs.noaa.gov/cgi-bin/ngs_opsd.prl?PID=HT0702&EPOCH=1983-2001.

NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

The Vertical Mark Number (VM#) and PID# shown on the bench mark sheet are unique identifiers for bench marks in the tidal and geodetic databases, respectively. Each bench mark in either database has a single, unique VM# and/or PID# assigned. Where both VM# and PID# are indicated, both tidal and geodetic elevations are available for the bench mark listed.

The NAVD 88 elevation is shown on the Elevations of Tidal Datums Table Referred to MLLW only when two or more of the bench marks listed have NAVD 88 elevations. The NAVD 88 elevation relationship shown in the table is derived from an average of several bench mark elevations relative to tide station datum. As a result of this averaging, NAVD 88 bench mark elevations computed indirectly from the tidal datums elevation table may differ slightly from NAVD 88 elevations listed for each bench mark in the NGS database.

(h)
Figure 4.10: Published Bench Mark Sheet (concluded)

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. Every effort should be made to bracket at least 30 days of data with levels to ensure stability of the time series and reduce the error involved with tidal datum computation. 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.

4.5 Computation of Harmonic Constituents

It is the astronomy, namely the relative periodic motions of the earth, moon, and sun, that determines the frequencies at which tidal energy is found. The contribution to the tide by the energy at each tidal frequency is usually represented by a tidal harmonic constituent, for which there will be an amplitude and a phase lag. The pairs of amplitudes and phase lags are referred to as harmonic constants. Which of these tidal constituents can be included in a harmonic analysis depends on the length of the data times series one has available. The longer the time series the more tidal constituents that can be included in the analysis and the more accurate the tidal predictions will be. Attempting to include in the analysis more tidal constituents than can be resolved with the available length of the time series can lead to erroneous results, or even to no results at all because in such cases numerical instability can cause the harmonic analysis program to fail. Even when the appropriate tidal constituents are included in a harmonic analysis, one must remember that the energy of the tidal constituents that could not be included in the harmonic analysis (because they were too close in frequency to other larger tidal constituents) will still affect the constituents that were included in the analysis. As a result one may see errors, namely, differences between the tide predictions and the actual water level data, that slowly oscillate in time due to the missing tidal constituents. Such errors may be significant if one has analyzed only 15 days of data or even 29 days.

4.5.1 Computational Procedures

The general methodology for extracting tidal constituents from a data time series, taking advantage of our *a priori* knowledge of the frequencies where the tidal energy will be found, can be seen with a simple demonstration. If one would like to see the contribution to the tide of, for example, the M2 tidal constituent, which has a period of approximately 12.4206 hours, one simply takes a water level time series and breaks it up into consecutive pieces, each 12.4206 hours long. One then superimposes these 12.4206-hour-long pieces (i.e., adds them up) and averages them. For each of these pieces the M2 contribution will be in sync, that is, the maximum M2 contribution will be at the same time within each piece of the chopped up data time series, but the other tidal constituent frequencies will not stay in sync. For S2, which has a period of 12.0000 hours, the time of the maximum S2 contribution to the tide (within each 12.4206-hour piece) will slowly shift earlier as one moves from piece to piece. This is illustrated in Figure 4.11. The top plot in this figure shows the contributions of M2 and S2 for the first 12.4206-hour piece. The M2 maximum and the S2 maximum start out in sync, but by the end of the second segment the S2 maximum is slightly to the left of the M2 maximum. In the next plot below it, showing the next consecutive 12.4206-hour piece from a couple of days later, the S2 maximum has shifted even more to the left. By the fourth plot down (about 7.38 days after the first data point), the S2 maximum occurs at the same time as the M2 minimum. After enough pieces (about 14.76 days after the first data point), the S2 maximum will come back to the same time (within the piece), and again be in sync with the M2 maximum.

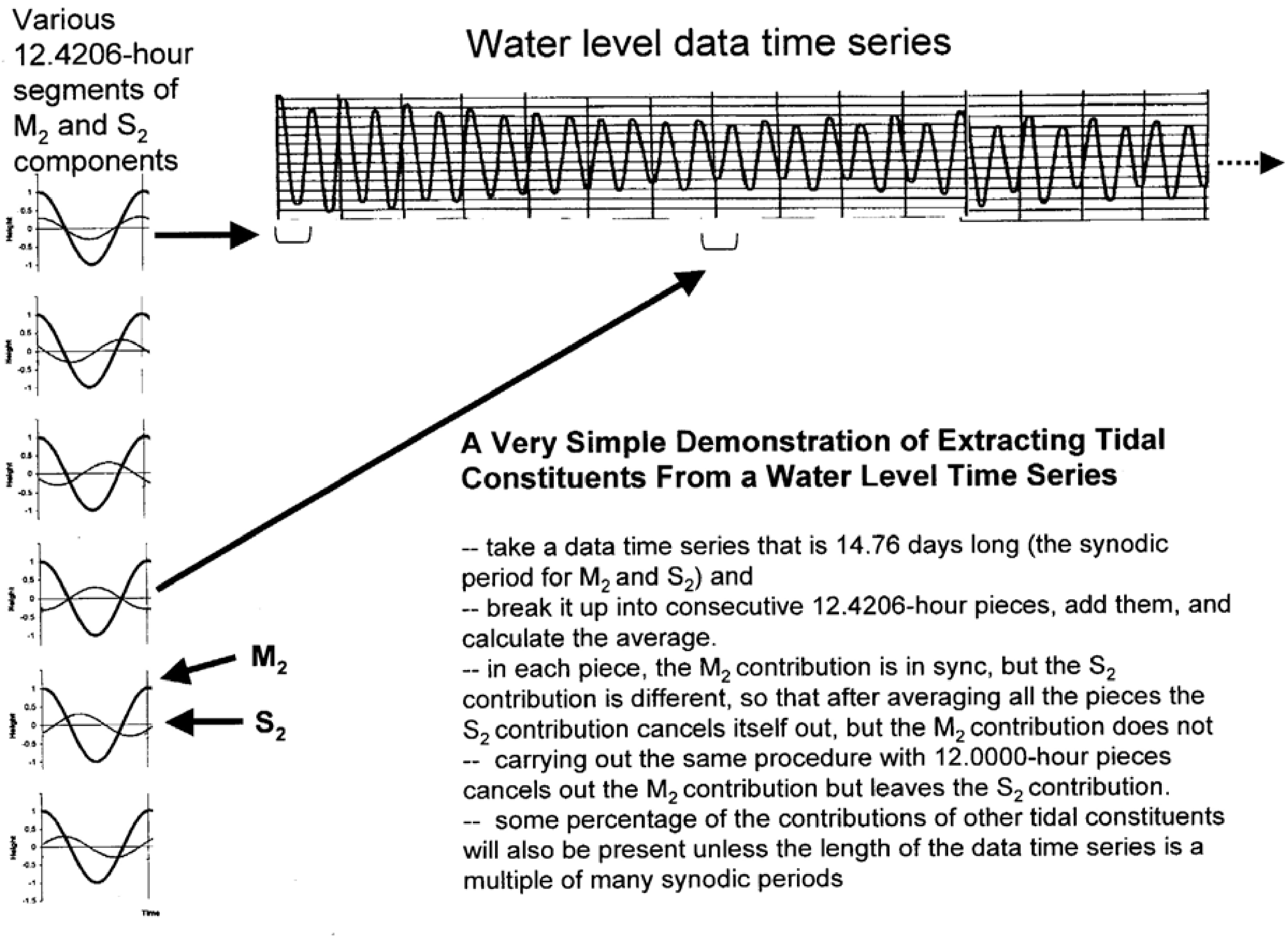


Figure 4.11 A very simple demonstration of extracting tidal constituents from water level data

When one adds up all the 12.4206-hour pieces of the data time series, the S2 portion of the tide will cancel itself out. The same thing will happen with the other tidal constituents – all that will be left will be the M2 contribution. For the moment it has been assumed that one has a very long time series so the contributions of all the other tidal constituents will cancel out. The result of averaging all these M2-period-long pieces is an average M2 cycle, from which one can obtain the M2 amplitude (half the M2 range, i.e., half the height difference between the M2 high water and the M2 low water). One can also obtain the M2 phase lag, which is the time of the maximum M2 high water from the beginning of the mean curve (which itself will have a time relationship to some other time reference point, such as the time of the moon's transit over a particular time meridian).

The closer in tidal period a tidal constituent is to M2, the longer the data times series must for its effects to be completely canceled out. The period of N2 is 12.6583 hours. The difference between the periods of M2 and N2 is 0.2377 hour. This is smaller than the difference between the period of M2 and S2, so it will require a longer time series to cancel out the N2 contribution. In this case it requires 27.560 days long (12.6583/0.2377= 53.25 M2 cycles), or some multiple of that. The period of K1 (23.9345 hours) is not close to that of M2, and thus only 1.1 days of data (or some multiple of that) are needed to cancel out the effect of K1. The period of K1 is closer to the period of O1 (25.8193 hours) and so 13.66 days are needed to cancel out the O1 effect when calculating K1 and vice versa.

One can obtain the contribution of another tidal constituent by going through the same procedure, but choosing a different time period for chopping the time series up into pieces. For S2, one would chop the time series up into consecutive pieces, each with a length of exactly 12 .00 hours long. For N2, one would chop the times series up into pieces, each with a length of 12.658 hours long. And so on. When doing this procedure for K1 (23.094 hours), the two closest important tidal constituents are O1 (25.819 hours) and P1 (24.066 hours). For O1 therefore, 13.66 days of data (or some multiple) are required to cancel out the O1 contribution when trying to extract K1. For P1, since it is much closer to K1, 182.6 days of data (or some multiple) are required.

There have been two primary techniques within the idea of harmonic analysis for extracting harmonic constants from a data time series – using a Fourier series technique or using a least squares technique. In Fourier-based harmonic analysis, each tidal constituent is solved for separately, and this type of analysis resembles to some extent our demonstration. In the least-squares-based harmonic analysis, all the tidal constituents are solved for simultaneously, the approach being to minimize the squared differences between measurements and computed tidal predictions. The least squares method has many advantages and is the method generally used today.

Although in CO-OPS a harmonic analysis program based on the least squares technique is the primary method for extracting tidal harmonic constants from data, there is still in use a program based on the Fourier analysis technique developed by Schuremen (1958) for time periods of 15 or 29 days. This latter program, written by Dennis and Long (documented in 1971) has remained in use because it is easy to use. Its inference and elimination routines infer some constituents that cannot be solved for with only 15 or 29 days of data and correct the solved-for constituents for the adverse effects of the unsolved-for constituents.

4.5.2 Quality Control

The typical way to evaluate the quality of the final set of harmonic constants (amplitudes and epochs) that result from a harmonic analysis process (including any inference and elimination and node factor application done after the actual least squares analysis) is to produce a tide prediction time series with that set of those harmonic constants and then evaluate the quality of those tide predictions. The need for a set of harmonic constants has been specifically referred to, because no matter how accurate the constants may be for individual tidal constituents, it is the entire set that is important. It does little good to have very accurate constants for M2 and K1, but not have other constituents, since an accurate tide prediction can only be made if the harmonic constants for all the important constituents are available (so that as much as possible of the tidal energy has been accounted for).

In addition to making tide predictions, one also subtracts these predictions from a simultaneous observed water level data time series to create a so-called residual time series. This observed water level time series might be the data that were analyzed to produce the set of harmonic constants, or it might be from another time period. If it is the data that were analyzed, then the prediction for that time period is referred as a self-prediction. There are some limitations on using a self-prediction to assess the quality of the set of harmonic constants, versus using predictions for other time periods, but often one has no other data other than that which were analyzed. The residual series will show all the variations in the time domain that are left over once the tide predictions have been removed.

It should be noted that, there may be water level variations in the observed series caused by nontidal phenomena, such as wind, atmospheric pressure changes, river discharge, and changing salinity and water temperature (steric effects), and which will not be in the predicted tide time series. The residual series may have predominantly those nontidal water level variations (unless one has poor harmonic constants, in which a great deal of tidal variations will show up in the residual series). Because of these nontidal variations (which of course can be very large when there is a storm or a heavy river flow event), the tide prediction can be very different than the actual water level data on some days and be very close to the water level data on other days. The ideal final set of harmonic constituents will produce tide predictions which on average match the water level time series as well as possible.

4.6 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".

4.6.1 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 Section 4.6. "Summary files" shall be created for each subordinate tide station occupied for the survey. These summary data facilitate the development of co-range and co-phase 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. An example of a tide station datum summary is provided in Figure 4.10.

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

4.6.2 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 (NOS also used TCARI, see Section 4.6.4). 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/Tropic 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 spatial placement of summary data in a commercial GIS compatible format to assess spatial variations in tidal characteristics. Co-range and co-phase 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. It is expected that new water level data collected during the survey may change the understanding of the tidal regime in the area and that the orientation of the co-tidal lines and thus the geometry of the tidal zoning will change. 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, usually 0.45m as defined by the IHO. 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 Figure 4.12, Figure 4.13, Figure 4.14, Figure 4.16 and Figure 4.17.

4.6.3 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. For the contractors, time series data collected in six-minute intervals and reduced to chart datum as specified, both from subordinate gauges 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 4.16.

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.tidesandcurrents.noaa.gov.

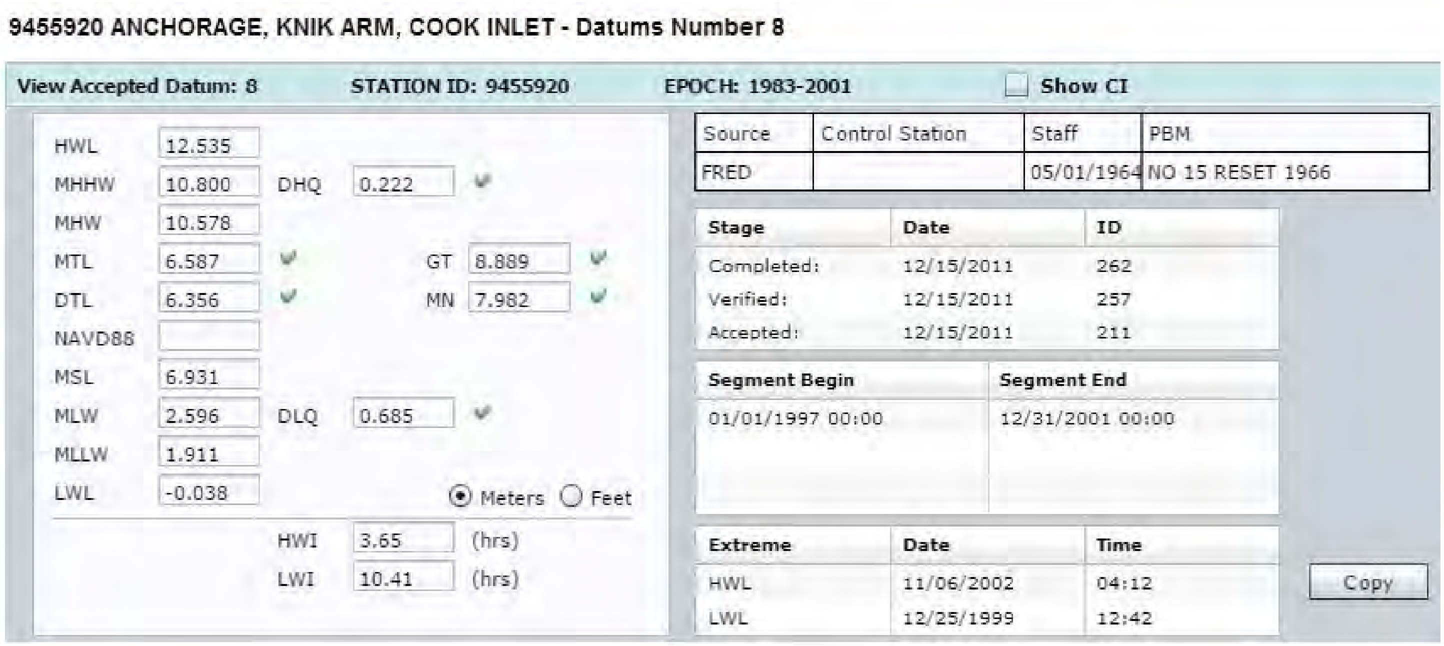


Figure 4.11: Tide Station Datum Summary

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,1916	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	0.38	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	1.84	19.86	41-59	2Mo,Jun-Jul78	N/A	Seldovia		60.545000000	-151.218333333
9455760	NIKISKI	AK	1.22	7.60	N/A	N/A	17.69	0.70	2.06	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,Jul78	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			60.986666667	-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
9455848	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 4.12: GIS Summary Data File

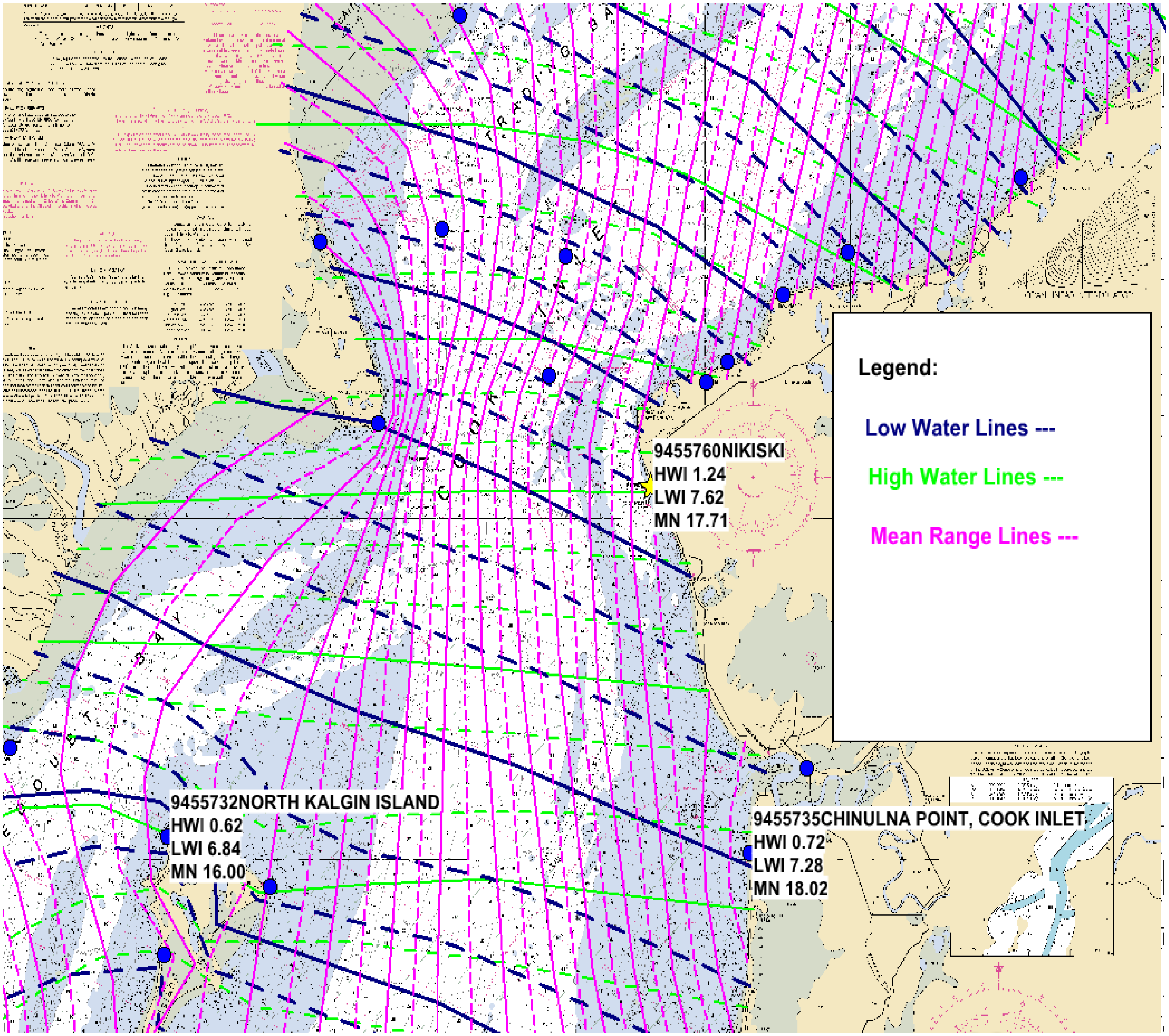


Figure 4.13: Co-phase and Co-range Lines of Greenwich, High and Low Water Intervals (in hours) and Range of tide (ft)

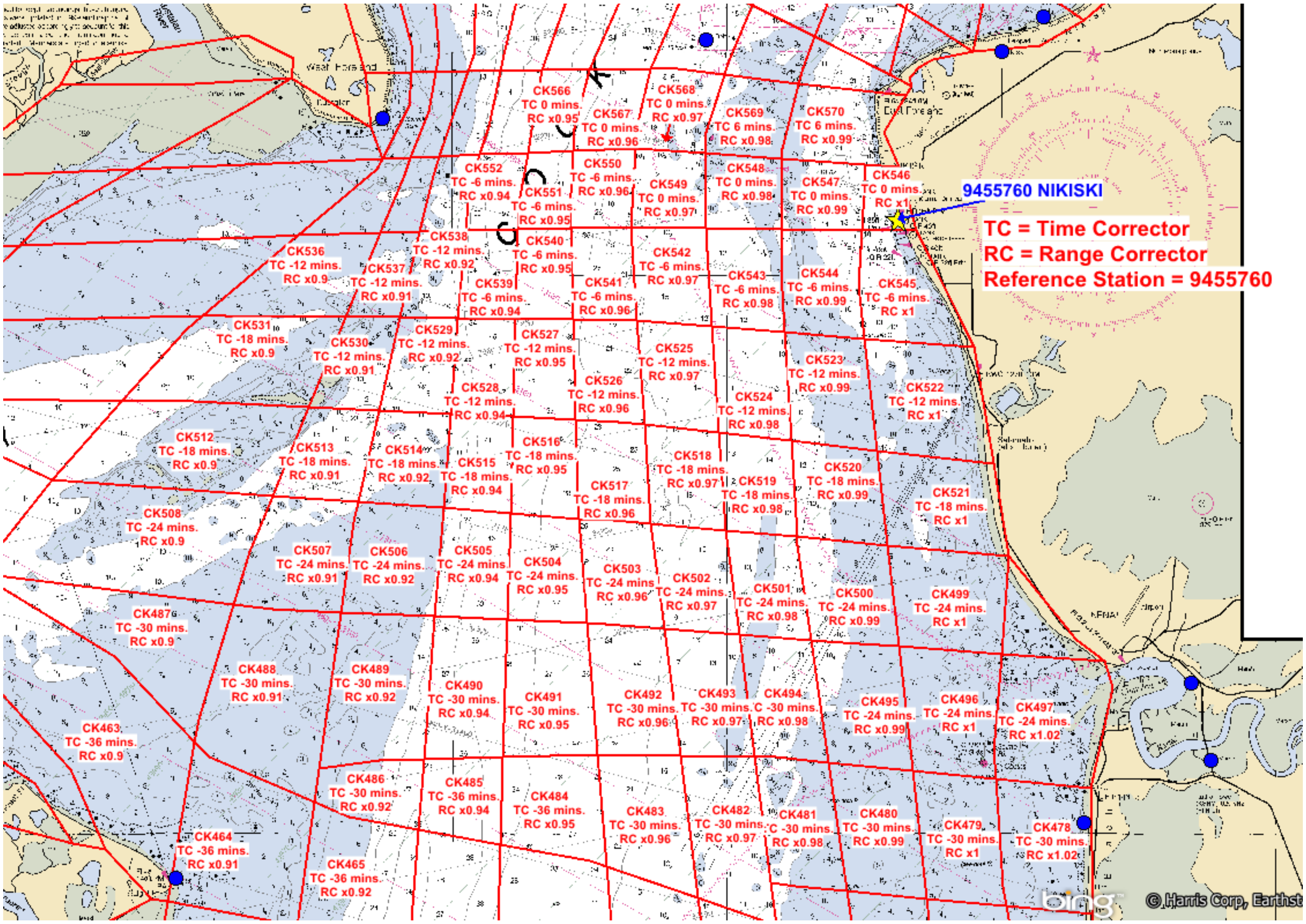


Figure 4.14: Tidal Zoning for Approaches to Nikiski, Alaska

STATION	DATE/TIME utc	WL VALUE on MLLW meters	WL SIGMA meters	quality control flags: inferred	flat	rofc	temp
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

Figure 4.15: Example Tide Reducer File from NOAA Acoustic System

4.6.4 Tidal Constituents and Residual Interpolation (TCARI)

The Office of Coast Survey (OCS) designed Tidal Constituent and Residual Interpolation (TCARI) to provide tidal corrections relative to Mean Lower Low Water (MLLW) at selected hydrographic survey areas along the coast utilizing the spatial interpolation of tidal data. The model spatially interpolates the harmonic constants (used to predict the astronomic tide), tidal datums, and residual water levels (i.e. the non-tidal component or the difference between the astronomically predicted tide and the observed water level) using the values at a combination of operational and historical stations. The method works best in regions where there is an abundance of high quality tidal data surrounding the survey area. Just as in discrete zoning, the use of TCARI requires the oceanographer to evaluate and understand the tidal characteristics of the survey areas. Success in both methods requires that tide stations be in operation during survey operations as well as information from historical tide stations and other sources. Gaps in information limit both methodologies. A revised TCARI grid will not be provided for surveys conducted while the required tide gauges are not in operation.

TCARI first requires the development of a model grid to cover the survey area. TCARI then requires a spatial field of accepted harmonic constituents from historical stations for the interpolation instead of just the average time and range of tide which tidal zoning requires. Finally, TCARI planning requires an analysis of the non-tidal residual across the survey area to determine the location and number of stations to be in operation during the survey. TCARI grid files, interpolation weighting functions, and harmonic constant files are created during planning and delivered to the survey platform. Survey platforms must obtain the observed data from the specified tide stations during the survey so that TCARI can apply the interpolated water level residuals to the tide reducing process. The final TCARI grid will also need to incorporate the residuals, harmonics and datums from any and all new subordinate installations.

Historically, TCARI was used for NOAA in-house hydro projects only. TCARI may be made available for contracted projects at OCS's discretion.

4.7 Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for each of the installation of stations, site visits for maintenance of stations, and the removal of stations, along with 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.

In the unique cases where one subordinate installation may support the tide reduction of multiple survey sheets, NOAA platforms may request final tide notes to be completed prior to the actual removal of the subordinate gauge. The same documentation requirements of a station removal apply to the interim tide note submissions including at least 30 days of water level data collected, bracketing levels, completed datum offset computation worksheet, staff-to-gauge observation worksheet, benchmark descriptions, and an updated site report. These documents will need to be submitted at the time of the final tide request, as if the station was removed, and in accordance with the timelines outlined in Section 4.7.5.

4.7.1 Station Documentation

The documentation package shall be forwarded to CO-OPS and HSD Project Manager/COR after a.) installation of a station, b.) performance of bracketing levels, c.) gauge maintenance and repair, d.) removal of the station, and e.) interim tide note requests. Refer to Section 4.7.5 for time frames for documentation submission requirements and Figure 4.16, Water Level Station Documentation Check-off List. The station documentation generally includes, but is not limited to the following:

1. Transmittal letter (PDF format).

2. Field Tide Note (PDF format), if applicable.

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

4. eSite Report, Water Level Station Xpert Site Report, or Tide Station Report (NOAA Form 77-12), or equivalent. (eSite report application is in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format).

5. Sensor test worksheet (JPEG and PDF format).

6. Sensor elevation drawing (JPEG and PDF format) showing sea floor, pier elevation and sensor(s) elevation if sensor is mounted vertically. For stations with Aquatrak sensors, provide the Aquatrak Sounding Well Diagram. For BPMGs, provide the design currents, depth and other information pertaining to the mooring design.

7. Water level transfer form (applicable for Great Lakes stations only, in JPEG and PDF format).

8. Large-scale bench mark location diagram of the station site 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 bench mark sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from handheld GPS) of the gauge, NOAA chart number and USGS Quad map name (JPEG and PDF format).

9. New or updated description of how to reach the station from a major geographical landmark (in Microsoft Word and PDF format). (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS).

10. Bench mark descriptions with handheld GPS coordinates (in WinDesc for digital and optical leveling). (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).

11. Digital photographs of bench mark disk face (close-up), setting, bench mark locations from two different (perpendicular) cardinal directions, station, DCP, equipment, underwater components, and vicinity (JPEG and PDF format). 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. Bench mark photo file names start with mark designation followed by either "face" or "location" and direction of view, with jpg extension (e.g. 8661070 B location south.jpg). All other station component photo file names start with station number, component, and view name (e.g. 8661070 tide station view south).

12. Level records (raw levels) including level equipment information (electronic files) and field notes of precise leveling, if applicable.

13. Level abstract (electronic file for optical and barcode levels (Translev)).

14. Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing

how sensor “zero” measurement point is referenced to the bench marks.

15. Calibration certificates for Invar leveling rods, if applicable (in PDF format).

16. Staff-to-gauge observations, if applicable (in Microsoft Excel and PDF format).

17. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (in PDF format).

18. Other information as appropriate, or as specified in the contract (in PDF format).

19. Water level data download (preliminary, as applicable).

20. All required GPS deliverables (OPUS published data sheet, NGS OPUS solution report, and bench mark photos) as specified in CO-OPS “User’s Guide for GPS Observations at Tide and Water Level Station Bench Marks”

I. For Each Water Level Station:

PROJECT DOCUMENTATION AND DATA CHECKOFF LIST

Project Number: ______________ **Locality:** ______________________

Station Number: ______________ **Station Name:** __________________

A. Field Tide Note (Required only for Hydrographic /Photogrammetry Surveys)

	1. Verify station latitude and longitude with handheld GPS.
	2. Verify work 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 of the station (ensure that this is the same as on the field tide note for Hydro/Photo surveys). Provide latitude and longitude in d/m/s.x format as determined by handheld GPS for the primary sensor.
	3.. Note UTC time and date the datum offset and sensor offset entered or changed in the DCP
	4. Provide metadata for ancillary sensors, if installed and as required
	5. Provide notes on results of diving inspection, and cleaning of underwater components.
	6. Provide status of valid tie to NAVD 88 geodetic marks, if applicable, in level section remarks area.
	7. Provide notes of excessive movement of water level sensor or bench marks in level section remarks area.

C. Chart Section

	1. Ensure that station location is clearly depicted with circle and station number.
	2. Standard title block includes : station number, station name, lat/long as d/m/s.x,, NOAA chart number, edition, date, and scale, USGS quad name all in caps.
	3. Provide a digital copy of the chart section in jpg format

D. Bench Mark/Station Location Sketch

	1. Ensure Gage/staff and bench marks are shown, and local body of water is labeled.
	2. Ensure Standard Title block includes: station number and station name, field unit, date of revision
	3. Ensure North arrow depicted.
	4. Include hard copy sketch and GIS digital format on diskette.
	5. Ensure All active (recovered and not recovered) bench marks are identified by designations
	6. Ensure bench marks that are confirmed as destroyed are removed from the sketch.
	7. Provide a digital copy of the sketch saved in jpg format.

(a)

Figure 4.16: Project Documentation and Data Checkoff List

E. Digital Photographs

	1. Provide digital photographs of gauge, staff, surrounding area, wells and brackets, DCP. Provide tide gauge photos from two perpendicular directions.
	2. Station component file name starts with station number followed by the specific component view, with jpg extension (e.g. 86610170 well.jpg)
	3. Provide several shots of met towers and sensors from different directions (e.g. 8661070 met tower looking SW.jpg)
	4. Provide digital bench mark photos – close up of disk face, without GPS handheld in view, and setting view, two photos from different directions (90 degrees apart, if possible) showing general location for all new marks. File names start with mark designation followed by either "face" or "location" and direction of view, with jpg extension (e.g. 866 1070 B location south.jpg)

F. Bench Mark Descriptions/Recovery Notes

	1. Stampings for new and recovered marks verified.
	2. Descriptions for new marks provided in NOS format (MS Word).
	3. Recovery notes provided for all historical marks. RAD/xxx noted for all marks recovered as described, where xxx is party chief, or contractor initial.
	4. Provide handheld GPS position in d/m/s.x format at the end of the text description.
	5. For electronic levels, make sure HA files codes are completed accurately
	6. For electronic levels, text description begins with a statement on how to reach the mark, followed by the description in NOS format
	7. For electronic levels, provide handheld GPS position in d/m/s format at the end of the text in HA file since HA file does not accept decimal seconds s.x

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 type 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.
	8. For multi year projects, or for NWLON, all marks must be connected every two years
	9. Levels include marks specially noted in station specific requirements of the project instructions
	10. Explanation provided for any marks not leveled during this level run.
	11. Provide sectional and overall closure tolerances and ascertain they are within allowable limits.
	12. Compute level abstract starting with PBM accepted elevation and ending with primary sensor elevation
	13. Check for valid tie to NAVD 88, as applicable.

(b)

Figure 4.16: Project Documentation and Data Checkoff List (continued)

	14. For electronic levels, provide original IN file in separate folder if modified IN file is provided.
	15. For electronic levels, all file dates must be chronologically consistent, i.e. the HA and INX files can not have dates more recent than the ABS file
	16. For electronic levels, provide Invar rod calibration certificates for the first time digital leveling
	17. For electronic levels, error flags are not allowed on sectional distances of the ABS file

H. Datum Offset Computation Worksheet

	1. Submit for stations that have Vitel or Sutron DCP with Aquatrak sensor.

I. Data Submitted on Diskettes or CD-ROM or DVD

	1. Label diskettes with contractor name and list of files on each diskettes.
	2. Data files should be named in the following format: xxxxxxx1.w1.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.w1.da1, da2, etc.
	3. Check the begin and end dates of data submitted with dates of hydrographic surveying operations, or project duration for special projects.
	4. Check data continuity.

J. Transmittal Letter

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

K. 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.

II. For the Project:

A. Files

	1. Contractor created station summary files for subordinate stations
	2. Documentation of tidal zoning development steps; including methodology of tidal reducer computation and geographical presentation
	3. GIS compatible digital final zoning files (Mapinfo© or ArcGIS© format)
	4. Final Tide Reducer Files for each H-Sheet

B. Final Tide Notes

	1. Final Tide Note for each H-Sheet

(c)

Figure 4.16: Project Documentation and Data Checkoff List (continued)

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.

(d)

Figure 4.16: Project Documentation and Data Checkoff List (concluded)

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: December 22, 1999

HYDROGRAPHIC BRANCH: Pacific
HYDROGRAPHIC PROJECT: OPR-342-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. 60° 20.2'N Lon. 151° 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.

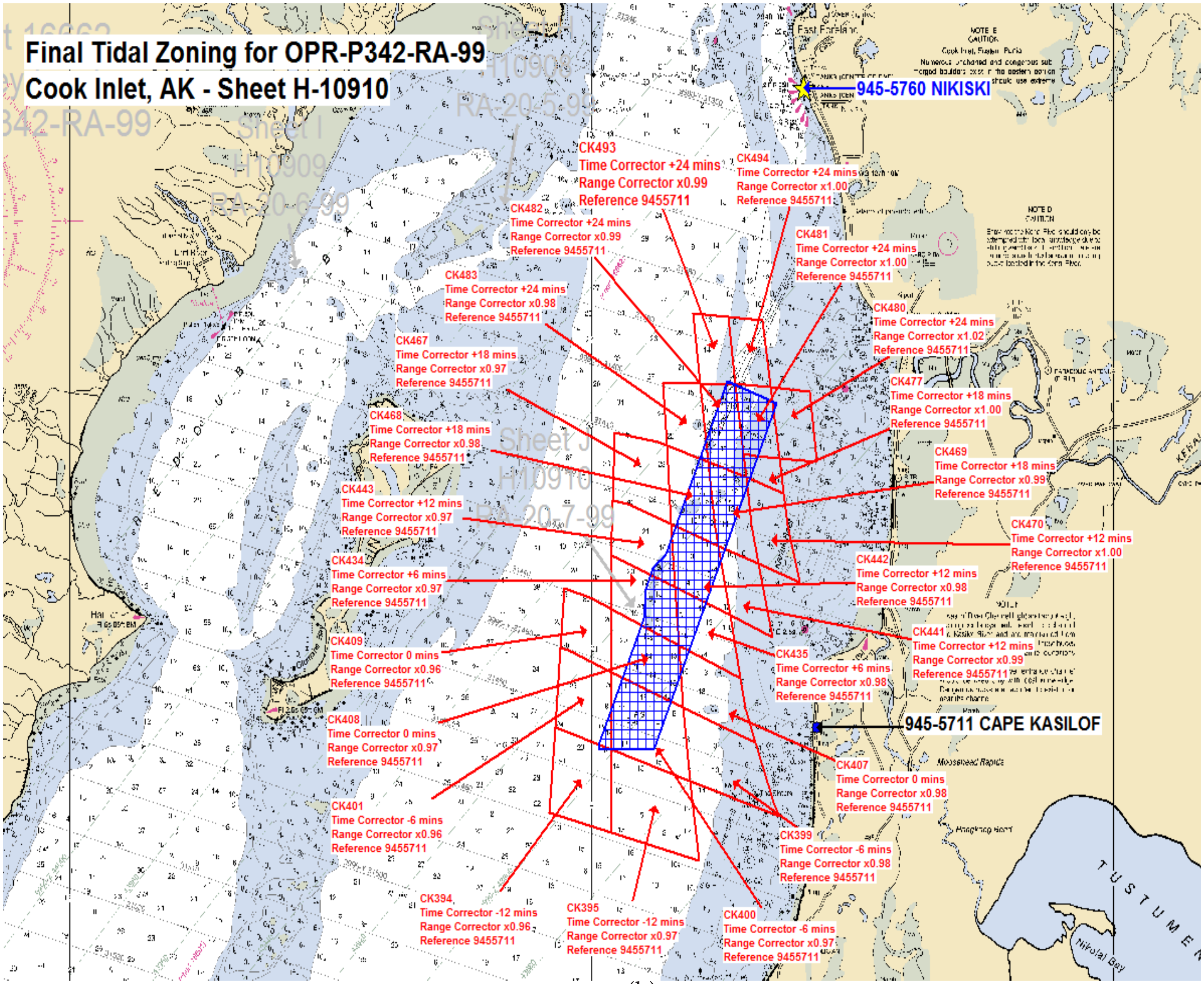
Note 2: Nikiski, AK served as datum control for subordinate tide stations and for tidal zoning in this hydrographic survey. Accepted datums for this station have been updated recently and have changed significantly from previous values.

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.

(a)

Figure 4.17: Final Tide Note and Final Tidal Zoning Chart



(b)

Figure 4.17: Final Tide Note and Final Tidal Zoning Chart (continued)

4.7.2 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 shall provide the water level data in the format specified below from the water level gauges installed.

The preliminary water level data and the correctors used to convert the data to chart datum shall be retained by the contractor for a period of not less than three years after the survey is completed or as stipulated in the contract, whichever is longer. 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. The preliminary water level data and documentation supporting algorithms and correctors applied to the data shall be submitted to CO-OPS.

All digital water level and ancillary data shall be transmitted 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, 1/2003). 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 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.w1.DAT, where xxxxxxx is the seven digit station number, y is the DCP number (usually 1), w1 is the product code for 6-minute data, and DAT is the extension (Use T = 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. Each water level data file (XXX.BWL or XXX.ACO) shall have only 3 months of data. If the water level station was operational for more than three months, please submit multiple xxxxxxxy.DAT files, each file with only three months of data. Additionally, to expedite the provision of interim deliverables for long term surveys, interim station packages (including leveling and water level data) may be submitted at 3 month intervals.

Multiple DCPs may have been used to collect 6-minute water level data for a particular site, and backup or redundant DCP data may be used to fill the gap in the primary DCP data, but, water level data shall be submitted for single DCP (numbered as 1). All the water level data shall be on station datum. Each input record (including the final record) ends with a carriage return and excludes any extraneous characters such as trailing blank spaces for all types of water level data (6-minute water level data, hourly height, high/low, monthly means, and station datum).

The 6-minute interval data (acoustic sensor, microwave radar, and pressure sensor examples follow) shall have the following format for CO-OPS database to accept.

Acoustic Sensor Data (XXX.ACO format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)

Column 8- 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 20-20 Blank

Column 21-22 Hours in 24 hour format (i.e. 00, 01, ..., 23)

Column 23-23 : (colon)

Column 24-25 Minutes (00,06,12, ..., 54)

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 2007 05:00 1138 23 0 308 297A1 D

85169901AUG 17 2007 05:06 1126 26 0 308 298A1 D

85169901AUG 17 2007 05:12 1107 26 1 309 298A1 D

MLLW Radar, and Pressure Sensor or Generic Data (XXX.BWL format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)

Column 8- 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 20-20 Blank

Column 21-22 Hours in 24 hour format (i.e. 00, 01, ..., 23)

Column 23-23 : (colon)

Column 24-25 Minutes (00-54)

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 Sensor temperature (tenth of degrees C in integer format)

Column 51-52 Sensor type (Z1 for generic or pressure)

Column 53-53 blank

Column 54-54 Data Source (S for Satellite, D for Diskette)

Sample data:

85169901AUG 17 2007 05:00 1138 23 0 308Z1 D

85169901AUG 17 2007 05:06 1126 26 0 308Z1 D

85169901AUG 17 2007 05:12 1107 26 1 309Z1 D

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

4.7.3 Tabulations, Tidal Datums and Harmonic Constituents

Contractors shall provide digital-copies of tabulations of staff/gauge differences. Through WALI, contractors shall provide 6-minute quality controlled and quality assured data, hourly heights, high and low waters, monthly means, water level datums, and harmonic analyses (when required) for the entire time series of observations from each water level station. Within the WALI Processing Package, contractors shall include the final contractor computed tidal datums, and 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. A typical WALI submitted processing package will include but is not limited to: Initial time series query; Offline QC checks (pre- and post edit); 6-min plot before editing or filling any breaks; Filling of breaks: Before plots, Sheets showing fill information from another sensor or station (if any), and After plots; Tabulation sheet; 6-min plot with higher highs and lower lows that have been paired (when applicable); Tide checks; High and Low tides report; Monthly means; Final time series query; tidal datum computations; Bodnar Analysis (if applicable); final datums; harmonic analysis computations (if applicable); final harmonic analysis constituents.

4.7.4 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 shall provide the final tidal zoning scheme digitally in ArcGIS© compatible format and in CARIS compatible format. A 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 and HSD Project Manager/COR:

- Contractor created summary files
- Documentation of NOS summary files utilized for final zoning
- *GIS compatible zoning development steps in ArcGIS© and CARIS© formats including geographical presentation of summary data and co-phase/co-range maps, if appropriate
- GIS compatible digital final zoning files
- Final TCARI grid (if applicable)
- Final tide reducer data files
- Final Tide Note
- GIS compatible survey outline

The final zoning schemes shall be fully supported by documentation of data and methodology which derived the final zoning model. Methodology shall include an oceanographic analysis.

*If no subordinate water level station was installed, then preliminary tidal zoning may be used as final tidal zoning pending availability of verified water levels and confirmed stability during periods of survey operations at the designated control stations.

4.7.5 Submission and Deliverables – Documentation and Time lines

The checklist in Figure 4.16 shall be used to check and verify the documentation that is required for submission.

All documentation, raw water level data, processed data including hourly height, high/low data, monthly means data, and computed datums, OPUS published data sheet and bench mark photos (as listed in Section 4.7), and other reports (as listed above in Section 4.7.4) as required , shall be forwarded within 15 business days of the removal of the water level stations. Appropriate documentation shall also be submitted within 15 days of station installation as well as within 15 days of any intermediate site visits, including the request for interim final tide deliverables. Final zoning schemes with methodological documentation shall be submitted within 45 days of the removal of the stations/gauges. For long-term surveys with additional water level data acquisition is required for more than one year, contractors and field units may submit interim station packages (including leveling and water level data) to CO-OPS at 3 month intervals. Explanations of any delays in submissions of final zoning schemes beyond the 45 days shall accompany any submissions that are submitted beyond the 45 day requirement. All contractors and NOAA field units shall copy the OCS COR or project manager, as appropriate, on all final water level station and zoning packages submitted to CO-OPS.

Submit a transmittal letter to the appropriate Contracting Officer's Representative (COR) listing what is being forwarded to CO-OPS. Submit a duplicate transmittal letter, all data and documentation to CO-OPS POC, as listed below.

All data and documentation shall be submitted in digital format. Please refer to Sections 4.7.1, 4.7.2, 4.7.3, and 4.7.4 for details about various data and documentation.

Standard station documentation package includes the following:

1. Transmittal letter
2. Field Tide note, if applicable
3. Calibration records for sensors, if applicable
4. e-Site Report, Xpert Site Report, or water level station report
5. Sensor test worksheet
6. Sensor elevation drawing
7. Water level transfer form (Great Lakes stations only)
8. Bench mark diagram
9. "Station To Reach" statement
10. Bench mark descriptions
11. Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
12. Levels (raw) (electronic files) and field notes of precise leveling

13. Abstract of precise leveling

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

15. Calibration certificates for Invar leveling rods, if applicable

16. Staff-to-gauge observations, if applicable

17. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable

18. Other information as appropriate, or as specified in the contract

19. Water level data, preliminary 6-minute data, all tabulated data, such as hourly heights, high and low, monthly means, and station datum data in the specified format (refer to Section 4.7.2 and Section 4.7.3).

20. GPS data and documentation, NGS OPUS Solution Report, OPUS published data sheet and 4 photos of GPS bench mark, as applicable per CO-OPS document (reference 8 in Section 4.8).

21. Contractor created summary files, final zoning, final tide reducer data, final tide note, and co-phase, co-range maps, if appropriate, etc. Zoning files must be in GIS format with all associated metadata included. (Metadata includes but is not limited to water level stations, intervals of tide, ranges of tide, tidal datums, and any other information on which the revised zoning is based. All metadata on which the zoning scheme is based must be included.) If this information is not included, CO-OPS will not be able to validate the zoning. JPEGs, PDFs, or other simple image files are not acceptable.

Generally, for established water level stations, the bench mark diagram, and "To Reach" statement need only be submitted if those items have been revised during the station maintenance.

When using the electronic/barcode system, the data disk and hard copies of the abstract and bench mark description or recovery notes shall be submitted. For optical levels, submit the raw levels and the leveling abstract.

For submission in electronic format, the station documentation shall be organized by various folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media such as DVD/CDROM etc. Here is a template of a complete Hydro Station Package:

- Agreements, Contracts, etc
- Annual Inspection Checklist
- Bench Mark Sketch
- Calibration Certs. Rods
- Calibrations, Sensors
- Diving Documents
- FOD Downloads
- GPS Data
- Levels
- Levels (non-digital)
- Other
- Records Evaluation
- Sensor Elevation Drawing
- Sensor Test Worksheet
- Site Report
- Station Well Diagram
- Transmittal Letter

Additionally, a folder containing final zoning and all supporting documentation should be submitted per Section 4.7.4 if applicable.

Submit one copy of all the documentation, preliminary and quality controlled water level data, including NGS OPUS Solution Report, OPUS published data sheet and 4 photos of GPS bench mark, final tidal zoning, final tidal reducers, final tide note, etc., in required digital formats.

Submit the completed station package to:

Chief, Engineering and Development Branch
NOAA/NOS/CO-OPS/ED/EDB
SSMC 4, Station # 6507
1305 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 2897 X 190

4.8 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.

Most of these documents are available on CO-OPS web site at http://tidesandcurrents.noaa.gov/.

The latest version of the documents can be found on the CO-OPS publication page http://tidesandcurrents.noaa.gov/pub.html or the CO-OPS Field Library http://tidesandcurrents.noaa.gov/fieldlibrary/Welcome.

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 mark Descriptions, NOAA/NOS, Updated January 2011

4. Users Guide for Electronic Levels with Translev and WinDesc updated March_2013

5. Standing Project Instructions for Coastal and Great Lakes Water Level Stations, Updated October 2013

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

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

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

9. User's Guide for GPS Observations At Tide and Water Level Station Bench Marks, NOAA/NOS, updated March 2013.

10. Tidal Datums and Their Applications, Special Publication No. CO-OPS 1, NOAA/NOS, June 2000.

11. Manual of Tide Observations, U.S. Department of Commerce, Publication 30-1, Reprinted 1965.

12. Tidal Datum Planes, U.S. Department of Commerce, Special Publication No.135, Marmer 1951.

13. Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, January 2000.

14. NOAA Technical Report NOS 64 "Variability of Tidal Datums and Accuracy in Determining Datums from Short Series of Observations", Swanson, 1974.

15. Data Quality Assurance Guidelines for Marine Environmental Programs, Robert J. Farland, Office of Ocean Engineering, NOAA, March, 1980.

16. System Development Plan, CORMS: Continuous Operational Real-Time Monitoring System, NOAA Technical Report NOS OES 014, U.S. Department of Commerce, NOAA, NOS February, 1997.

17. NGWLMS GOES MESSAGE FORMATTING FOR HOURLY TRANSMISSIONS, Phil Libraro, September 2003.

18. Computational Techniques for Tidal Datums, NOAA Technical Report NOS CO-OPS 2, U.S. Department of Commerce, NOAA, NOS, DRAFT December 1998.

19. Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, September 1984.

20. NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3", November 1997.

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

22. Sutron Xpert Operations and Maintenance Manual, October 2006.

23. Upgrading an Existing Water Level Station or Installing a New Water Level Station, SOP-3.2.3.5, May 2011.

24. GOES-Enabled Portable Tide Gauge Setup, Configuration, and Data Export Procedures

25. 9210BXlite Data Logger Operations and Maintenance Manual

26. Paros User's Manual

27. Satlink2 Operations and Maintenance Manual

28. H-3551 Pump User's Manual

29. User's Guide for the e-Site Report Application

30. e-Site Report User Access Guide to Build, Submit, Reject, Advance and Approve Steps

31. NOAA Ocean Systems Test and Evaluation Report, Limited Acceptance of the Design Analysis WaterLog® H3611i Microwave Radar Water Level Sensor – NOAA Technical Report NOA CO-OPS 061

5 Depth Sounding

Contents

5.1 General Standards for Depth

The requirements of this section shall apply to all depths included in bathymetric data products or feature attribution, regardless of source. Note that some depth sounding systems and processing techniques may produce individual measurements which do not conform to these standards. The hydrographer shall ensure that final depths delivered to NOS are compliant with these specifications.

5.1.1 Definition of Terms

For the purposes of this Section, technical terms will be used as defined in the Glossary of IHO Special Publication 44, 5th Edition.

Additional terms:

- Sounding: A measurement from the sea surface to the seafloor, regardless of method (echosounder, lidar, lead line, diver's least depth gauge, etc.). A "sounding" may be corrected for factors such as sound speed, vessel draft, and water levels, but remains the product of a single measurement sample.

- Depth: A fully processed seabed elevation value relative to an established vertical datum, portrayed in a gridded data set or product surface of a hydrographic survey. A surveyed "depth" may be computed based on statistical analysis and uncertainty estimates from a sample set of "soundings".

- Depth Value: A generic vertical seabed elevation value, inclusive of "soundings" and "depths".

5.1.2 Units and Rounding

Depth values shall be recorded in meters, with a precision of at least centimeters. This precision shall be maintained throughout the processing pipeline and all digital data products.

Uncertainty estimates for depth soundings and ancillary measurements shall be recorded with sufficient precision to support Total Propagated Uncertainty (TPU) estimates for depth values at centimeter precision.

Depths reported in the Descriptive Report (DR), other reports, or correspondence shall be accompanied with the associated estimate of TPU. Both depth and TPU shall be rounded to the nearest centimeter by standard arithmetic rounding ("round half up").

5.1.3 Uncertainty Standards

As mentioned in Section 1, these NOS Specifications are partly based on the IHO Standards for Hydrographic Surveys as outlined in Special Publication 44 (S-44), 5th Edition. IHO S-44 specifications are suggested minimum standards that member states may choose to follow. The IHO minimum standards for uncertainty are used in the NOS Specifications as a convenient point of reference. When the NOS Specifications refer to an IHO Order, it is usually in terms of the final uncertainty of a depth value. These specifications should not be interpreted to imply that NOAA Hydrographic Surveys "meet" a particular IHO survey order overall.

NOS standards for Total Vertical Uncertainty (TVU) in hydrographic surveys apply to general water depths and least depths 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,lidar, lead line, diver investigation, or other method.

The formula below shall be used to compute the maximum allowable TVU for all depth estimates included in bathymetric data products or feature attribution after application of correctors for all systematic and system specific errors. At least 95% of geographically distributed grid nodes shall meet this specification and the percentage of nodes that do not meet the maximum allowable TVU shall be discussed in the Descriptive Report.

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

Where:

- a represents that portion of the uncertainty that does not vary with depth
- b is a coefficient which represents that portion of the uncertainty that varies with depth
- (b x d) represents that portion of the uncertain that does vary with depth
- d is the depth

The variables a and b shall be defined as follows:

- In depths less than 100 meters, a = 0.5 meters and b = 0.013 (IHO Order 1)
- In depths greater than 100 meters, a = 1.0 meters and b = 0.023 (IHO Order 2)

The maximum allowable uncertainty in depth includes all inaccuracies due to residual systematic and system specific instrument errors; the speed 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).

5.1.4 Resolution and Feature Detection Standards

Bathymetric data resolution and feature detection are functions of the parameters of the sounding equipment, manner in which it is operated, and processing methods. NOS defines resolution and feature detection standards for bathymetric data in terms of the requirements of the final gridded data set (see Sections 5.2 and 5.3). Regardless of depth measurement technique, the hydrographer shall select and operate depth sounding equipment and process the resulting measurements in a manner adequate to meet these requirements.

5.2 Multibeam and Other Echosounders

Many Hydrographic Survey Project Instructions require the use of multibeam echosounders for NOS Hydrographic Surveys. However, there may be surveys which require single beam or other sonar-based techniques. Therefore, the standards included in this section will be valid for all echosounding data.

Note on Phase Measuring Bathymetric Sonars (PMBS): NOAA's investigation of PMBS systems (also known as interferometric sonars, or Phase Differencing Bathymetric Sonars) has shown that the discrete soundings generated by these systems may have unacceptably high uncertainty for use in nautical charting and that some systems may be incapable of reliably resolving features to the standards required in this manual. If bathymetry generated from PMBS systems is intended to be used to meet these Specifications, the system as used in the survey must demonstrably meet the object detection and depth uncertainty standards and be specifically authorized by the Chief, NOS Office of Coast Survey Hydrographic Surveys Division.

This guidance does not apply to phase-based detection algorithms of multibeam echosounders.

5.2.1 Gridded Data Specifications

5.2.1.1 Background

In the Navigation Surface approach, survey data are archived as a certified digital terrain model rather than as a set of verified soundings. HSD has determined that the highest resolution the data can support is rarely needed for navigation products. A compromise grid resolution between the highest resolution possible and a resolution required for navigation products has the advantage of preserving high-resolution data for other users without needlessly burdening NOAA field units and contractors. The nautical chart is then created from scale-appropriate generalizations of the Navigation Surface elevation model.

The Navigation Surface requires that each sounding have a horizontal and vertical uncertainty estimate. This requires robust, verified error models for all systems which contribute measurements to the final depth solution. These include not only echosounders, but positioning system, heave, pitch, and roll sensors, sound speed instruments, tide gauges, static and dynamic draft measurements, and anything else that contributes to the calculation of a depth value. Once this comprehensive error model is assembled, the uncertainties in each measurement may be propagated from the measurement platform to each individual sounding. Only when each sounding has an associated Total Propagated Uncertainty can we combine the soundings into a Navigation Surface with depth and uncertainty attributes for each node.

The open source Bathymetric Attributed Grid (BAG) format was developed as an open source exchange format for gridded data. The Open Navigation Surface Working Group (ONSWG) was formed to develop the format. ONSWG is comprised of government and private sector groups. The primary goals of the ONSWG are to define an open, platform independent, grid database file format suitable for access, archival, and interchange of Navigation Surface results, and to develop an open source software access library to operate on this format. For more information see http://www.opennavsurf.org.

5.2.1.2 General Grid Requirements

5.2.1.2.1 Management of Multiple Grids

This section defines grid resolution, feature detection, and coverage specifications as a function of depth and survey requirement. Many surveys will cover a sufficiently wide range of depths and echosounder properties to require bathymetric data at several different resolutions. Currently, the BAG standard supports only single-resolution grids. The CARIS Bathymetry with Associated Statistical Error (BASE) surface has variable resolution functionality; however, it is not presently approved for NOAA surveys. Therefore, the hydrographer is required to create and manage individual grids for each required depth/resolution band.

The hydrographer will adjust the extents and number of grids based on the bathymetry of the survey area, feature detection requirements, the type of echosounder used and other factors. However, adjacent grids shall always overlap in depth to ensure no gaps in coverage exist at the transition from one depth grid to another.

5.2.1.2.2 Multiple Echosounding Sources in a Single or Multiple Grids

In cases where multiple echosounding sources (e.g., single beam and multibeam) are used to cover a survey area, create different grids for different system types (i.e. single beam echo sounders or multibeam echo sounders). The exception to this is for crossline data; where main scheme and cross line system types differ, the resulting data will be submitted in a single grid provided doing so will not reduce the resolution of the strictest resolution requirement. In those cases where there is vast disparity between the coverage type and/or resolution of the different sounding sources (e.g., single beam main scheme soundings with scattered high resolution multibeam feature developments, or a mix of multibeam echosounders with varying specifications), multiple device-specific grids may be required. See Section 5.2.2 for additional guidance, and consult with the HSD Project Manager/COR if necessary.

5.2.1.2.3 Designated Soundings

The hydrographer has the responsibility to review the surface and ensure that it reflects the conditions in the survey area. Even in cases where the appropriate resolution was selected, it is possible that the grid may fail to portray some navigationally significant depths and features. An hydrographer may occasionally select "designated" soundings (also known as golden soundings) which override the gridded surface and force the model to recognize an estimated reliable least depth. When the distance between two soundings that would otherwise warrant individual designation, as described below, is less than 2mm at the scale of survey (i.e. 20m for 1:10,000 scale) then only the shoalest of those soundings shall be designated.

A designated sounding may be created for two reasons; 1) to facilitate FFF feature management (see Section 7.4) or 2) to override the gridded surface model to recognize an estimated reliable least depth (see below).

1. Facilitate Feature Management - Section 7.4

2. Override Gridded Surface Model - A designated sounding shall not be created to ensure the gridded surface reliably represents a significant shoaler sounding unless both of the following are true:

a. The top of the natural topography is greater than 1m proud of the surrounding seafloor, and

b. The difference between the gridded surface and reliable shoalest sounding is greater than:

   i. One-half of the allowable TVU in waters 0-20 meters
   ii. The allowable TVU in waters 20+ meters

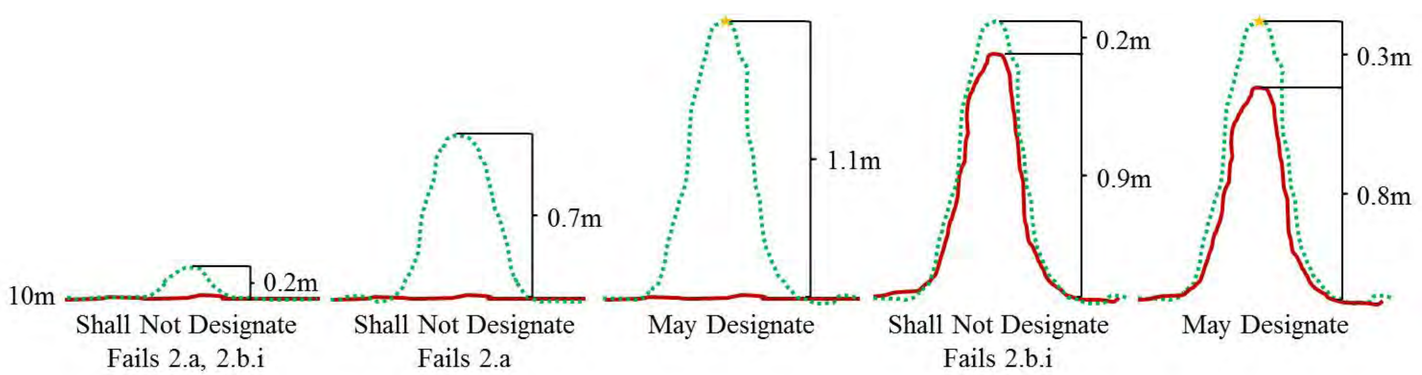


Figure 5.1: The designated sounding guidance above is applied to these example scenarios at depth of 10m. At this depth, the allowed TVU is 0.52m (see Section 5.1.3). Following the designated sounding guidance above, in this 10m depth example, the hydrographer may designate a sounding when the difference between the gridded surface and reliable shoalest sounding is greater than ½ allowable TVU, 0.26m. The red lines represent a gridded surface and the green dots represent reliable shoal soundings.

Departures from this designated sounding guidance shall be individually addressed in the DR.

If the hydrographer finds that large number of designated soundings are necessary to adequately portray the survey area for navigational use using the guidance above, a higher grid resolution may be required. The hydrographer may increase the resolution beyond that specified in Section 5.2.2 for small areas of the survey to increase grid accuracy and data processing efficiency. If large areas of higher resolution are required, the hydrographer shall consult with HSD Project Manager/COR for guidance. All surfaces will be assessed against the submitted resolutions, not the assigned resolutions (e.g. a field unit grids an area at 0.5m resolution for the purposes of minimizing designated soundings must then meet the density requirements for a 0.5m resolution surface).

If noisy data or 'fliers' are incorporated into the gridded solution, the surface may be shoaler than the seafloor. If these spurious soundings cause the gridded surface to be shoaler than the reliably measured seabed by greater than the maximum allowable TVU at that depth, the noisy data shall be rejected and the surface recomputed.

5.2.1.2.4 Attribution

Each node of the grid includes not only a depth value, but other attributes. The following minimum attributes shall be associated with each grid node:

- Depth Value

- Total Vertical Uncertainty: The uncertainty value for the grid node shall be the greater of the standard deviation of the soundings contributing to the depth solution, or the a priori computed uncertainty estimate. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology. The hydrographer shall examine the finalized grids and explain in the DR any areas of unusually high uncertainty.

The following additional attributes shall be included if supported by the hydrographer's data processing software:

- Shoal Depth: Depth value of the shoalest measurement which contributed to the depth solution

- Sounding Density: Number of soundings contributing to the depth solution

- Standard Deviation: Standard deviation of the depths within the capture radius of the node

5.2.2 Coverage and Resolution

The following coverage and resolution requirements shall be followed by contractors and NOAA field units unless stated otherwise in the Hydrographic Survey Project Instructions. If the requirements of the grid for an area do not seem appropriate, the hydrographer should notify COR/HSD Project Manager to discuss an alternative coverage requirement. If not discussed after the pre-survey assessment (Section 1.3), this discussion should occur early in the data acquisition phase of the project. An exemption (or contract modification) must be approved by the COR/HSD Project Manager. Any deviations from the requirements shall be discussed in the Descriptive Report and the written approval for deviation shall be included in the Descriptive Report Appendices.

There are four classifications of coverage: Object Detection Coverage, Complete Coverage, Set Line Spacing, and Trackline (transit and reconnaissance). The required survey coverage classification will be specified in the Hydrographic Survey Project Instructions. Within the definition of the coverage classifications, a SSS contact (see Section 6.1.3.2) and/or MBES feature (see Section 7.1) is defined by the minimum size of a feature required to be located and portrayed in the assigned coverage requirement at depth. Field operations shall be conducted such that the accuracy requirements in Sections 5.1.3 and 5.1.4 are met for the entire coverage. Bathymetric splits, if noted as required, are defined immediately following the four classifications of coverage in section 5.2.2.1. Specific requirements of each coverage classification are given below in Sections 5.2.2.2, 5.2.2.3, 5.2.2.4, and 5.2.2.5.

1. **Object Detection Coverage** is assigned for critical under keel clearance areas and may be accomplished with either:

   Option A) 100% bathymetric bottom coverage with multibeam sonars with object detection multibeam developments (i.e. 50cm grid resolution in 0-20m depth range) of contacts and features or

   Option B) 200% side scan sonar coverage with concurrent multibeam bathymetry collection with object detection multibeam developments (i.e. 50cm grid resolution in 0-20m depth range) of contacts and features. Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

2. **Complete Coverage** may be accomplished with either:

   Option A) 100% bathymetric bottom coverage with multibeam sonars with complete coverage multibeam developments (i.e. 1m grid resolution in 0-20m depth range) of contacts and features, or

   Option B) 100% side scan sonar coverage with concurrent multibeam bathymetry collection with complete coverage multibeam developments (i.e. 1m grid resolution in 0-20m depth range) of contacts and features. Bathymetric splits, where appropriate, are required (see Section 5.2.2.1). Note that 100% side scan sonar is insufficient to disprove a feature (see Section 7.3.4). Refer to Section 6.1.2 to confirm proper SSS acquisition parameters. Gaps in 100% SSS coverage should be treated as gaps in coverage and addressed accordingly.

3. **Set Line Spacing** is assigned when acquiring bathymetric data in areas too shallow for efficient full bottom coverage bathymetry or too hazardous for use of equipment. Set line spacing may be accomplished with single beam or multibeam, as specified in the Hydrographic Survey Project Instructions. If both single beam and multibeam are specified in the Hydrographic Survey Project Instructions, a separate single beam surface is required (See 5.2.1.2 Multiple Echosounding Sources in a Single or Multiple Grids). Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

4. **Trackline** survey operations can be classified as either Transit, which is intended to be used simply as an opportunity to collect data while a vessel transits from location A to location B; or Reconnaissance, which is intended to be used when the intended survey products will require a higher level of accuracy than Transit specifications will produce, but a traditional survey consisting of systematic line spacing or full bottom coverage is not required.

5.2.2.1 Bathymetric Splits

Additional lines may be required between the planned lines of set line spacing; these additional sounding lines run between main scheme lines are referred to as “splits.” Meeting object detection and complete coverage requirements with side scan sonar does not alleviate the requirement for bathymetric splits.

If a charted depth falls between 2 sounding lines and is shallower than the adjacent survey soundings, the field unit shall split the lines to verify or disprove the charted depth. Splits shall be acquired for both multibeam and single beam hydrography to adequately define shoals, contours and/or significant deeps indicated between main scheme lines, and to verify currently-charted depths that are shallower than any adjacent echosounder coverage.

Prudence and reason-based judgment on the part of the field hydrographer are of paramount importance in determining when splits should be run and when a shoal/contour/deep has been adequately developed. However, care should be taken to ensure that an excess of caution does not hinder field efficiency. The nature of the bottom must be considered. If it is rocky, there is more likelihood of dangerous pinnacles being present. If the bottom is composed of sand or mud, there is less chance that a natural danger exists. The importance of the region should be considered from the point of view of navigation. All shoal indications in areas of low under-keel clearance must be examined. In areas of lesser importance, the number of examinations may be reduced; however, the least depth over detached features surrounded by navigable waters shall be determined regardless of the importance of the area.

5.2.2.2 Object Detection Coverage

Option A: Object Detection Multibeam Coverage

- Detect and include in the grid bathymetry all significant features measuring at least 1m x 1m x 1m in waters up to 20 meters. In depths greater than 20 meters, detect and include in the grid bathymetry features measuring approximately 5% of depth vertically.

- Object Detection Coverage surfaces shall have the following grid-resolution thresholds as a function of depth range, unless an exception is approved as described in Section 5.2.2.

Depth Range (m)	Resolution (m)
0-20	0.5
18-40	1
36-80	4
72-160	8
144-320	16

The application of depth range thresholds to bathymetric surfaces shall only occur during the finalization stage and all final submitted grids shall include only the grid coverage within the specified depth ranges listed above. In cases of steep slopes, the overlap between grids of different resolutions may need to be increased to prevent gaps in their junction. In these cases, the courser resolution grid should have its shoaler extent modified to prevent this coverage gap.

- At least 95% of all nodes on the surface shall be populated, with at least 5 soundings.

- The maximum propagation distance shall be no more than the grid resolution divided by √2.

- For Object Detection Coverage, a holiday is defined as: three or more collinear contiguous nodes sharing adjacent sides in the surface created at the required resolution. Figure 5.2a and 5.2b demonstrate object detection holidays. Figure 5.2c is not an object detection holiday because the three nodes are not collinear and does not require additional coverage. There shall be no holidays in the grid over the tops of potentially significant features.

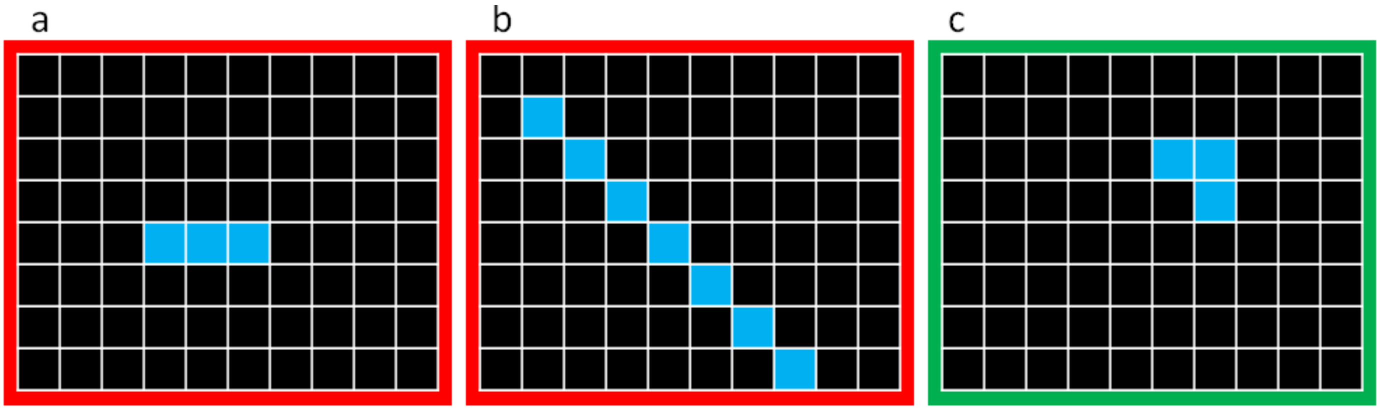


Figure 5.2a and 5.2b: Examples of Object Detection holidays. Figure 5.2c: Not an Object Detection holiday

Option B: 200% side scan sonar coverage with concurrent multibeam

- Line spacing shall be such that at least 200% of seafloor is ensonified with side scan sonar coverage. Gaps in 200% side scan sonar coverage should be treated as gaps in coverage and addressed accordingly.

- Multibeam sonar data shall follow object detection coverage multibeam coverage specifications, excepting the data density requirements for which at least 80% of all nodes on the surface shall be populated with at least 5 soundings. Extended gaps in multibeam coverage resulting from underlap between adjacent survey lines is not considered a holiday when using SSS to determine line spacing.

- 200% side scan sonar data is sufficient to disprove a feature. Refer to Section 6.1.2 to confirm proper SSS acquisition parameters.

- Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

5.2.2.3 Complete Coverage

Option A: Complete Coverage Multibeam

- Detect and include in the bathymetry surface all significant features measuring at least 2m x 2m horizontally, and 1m vertically in waters up to 20 meters. In depths greater than 20 meters, detect and include in the grid bathymetry features measuring approximately 5% of depth vertically.

- Complete Coverage multibeam surfaces shall have the following grid-resolution thresholds as a function of depth range, unless an exception is approved as described in Section 5.2.2:

Depth Range (m)	Resolution (m)
0-20	1
18-40	2
36-80	4
72-160	8
144-320	16

For depths greater than 320 meters, the grid resolution shall be 5% of the water depth, not to exceed 32m resolution. The application of depth range thresholds to bathymetric surfaces shall only occur during the finalization stage and all final submitted grids shall include only the grid coverage within the specified depth ranges listed above. In cases of steep slopes, the overlap between grids of different resolutions may need to be increased to prevent gaps in their junction. In these cases, the coarser resolution grid should have its shoaler extent modified to prevent this coverage gap (e.g. change 2 meter resolution depth range to 16-40 meters).

- At least 95% of all nodes on the surface shall be populated, with at least 5 soundings.

- The maximum propagation distance shall be no more than the grid resolution divided by √2.

- All significant shoals or features found in waters less than 20m shall be developed to complete coverage standards (i.e. 1m resolution surface in depths 0-20m).

- For Complete Coverage, a holiday is defined as: at least three by three unpopulated nodes in the surface at the required resolution. Figure 5.3a is an example of two holidays in the complete coverage surface that require additional multibeam coverage. Figure 5.3b demonstrates adequate complete coverage in the multibeam surface with no holidays and no additional coverage required. There shall be no holidays in the grid or over tops of potentially significant features.

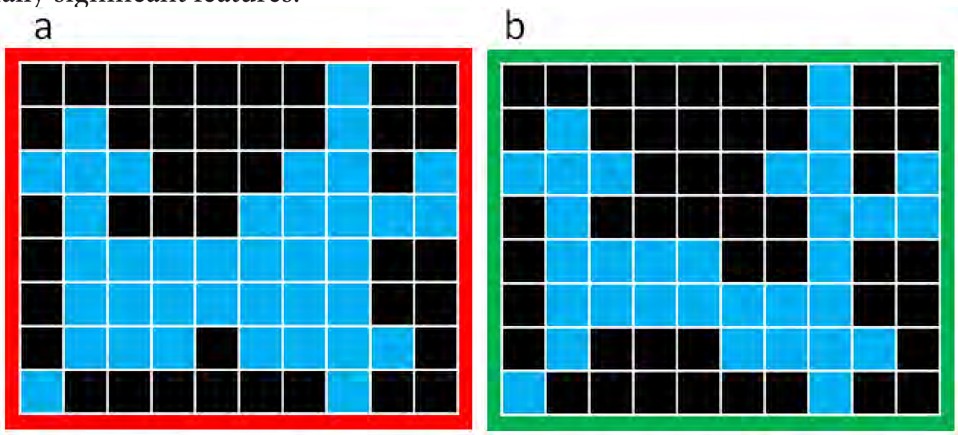


Figure 5.3a: Example of a Complete Coverage holiday Figure 5.3b: Not a Complete Coverage holiday.

Option B: 100% side scan sonar coverage with concurrent multibeam

- Line spacing shall be such that at least 100% of seafloor is ensonified with side scan sonar coverage. Gaps in 100% side scan sonar coverage should be treated as gaps in coverage and addressed accordingly.

- Multibeam sonar data shall follow complete coverage multibeam coverage specifications, excepting the data density requirements for which at least 80% of all nodes on the surface shall be populated with at least 5 soundings. Extended gaps in multibeam coverage resulting from underlap between adjacent survey lines is not considered a holiday when using SSS to determine line spacing.

- 100% side scan sonar data is insufficient to disprove a feature. Refer to Section 6.1.2 to confirm proper SSS acquisition parameters.

- Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

5.2.2.4 Set Line Spacing

The hydrographer shall conduct multibeam and/or single beam acquisition at the line spacing specified in the Hydrographic Survey Project Instructions. Bathymetric splits, as appropriate, are required (see Section 5.2.2.1). Note: neither 200% SSS with concurrent multibeam, nor 100% SSS with concurrent multibeam are considered "Set Line Spacing" surveys, as they respectively define Object Detection and Complete Coverage standards.

The following four set line spacing coverage possibilities exist. Contact the HSD Project Manager/COR with any question as to which set line spacing coverage is required.

1. Multibeam sonar set line spacing without concurrent side scan sonar coverage

    - At least 80% of all nodes on the surface shall be populated, with at least 5 soundings.

    - The maximum propagation distance shall be no more than the grid resolution divided by √2.

    - Continuous along-track coverage is required. For depths up to 20m, no holiday spanning more than 3 nodes along-track shall exist; for depths deeper than 20m, hydrographers discretion shall be used so long as no other requirements are violated, notwithstanding any violation of other coverage requirements.

    - All charted depths falling between sounding lines and shallower than adjacent surveyed soundings shall be verified or disproved.

    - In depths greater than 20m, any shoal indications rising more than 10% of the surrounding depths should be investigated.

    - All significant shoals or features found in waters less than 20m deep shall be developed to either object detection or complete coverage standard, as assigned in the Project Instructions.

    - The following grid-resolution thresholds as a function of depth range shall be used unless an exception is approved as described in Section 5.2.2. In cases of steep slopes, the overlap between Set Line Spacing multibeam coverage grids shall include only the grid coverage within the specified depth ranges as listed below.

Depth Range (m)	Resolution (m)
0-80	4
72-160	8
144-320	16

2. Single beam sonar set line spacing that is not the primary sounding technique of the survey
    - This data is acquired incidental to complete coverage or object detection coverage

    - Example of this type is nearshore single beam data for NALL definition

    - These soundings shall be processed and delivered as separate grids from other sounding sources (i.e. multibeam echosounder).

    - Due to the potentially sparser sounding sets produced by single beam echo sounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets be fully "cleaned" (e.g., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids be computed with a "shoal" layer.

3. Single Beam Sonar set line spacing that is the primary means of bathymetric coverage

- Gridded at 4m resolution, regardless of depth

- Due to the potentially sparser sounding sets produced by single beam echo sounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets be fully "cleaned" (e.g., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids be computed with a "shoal" layer.

4. In rare instances, NOAA may require that single beam sounding resolution be scaled with depth.

   - This will be specified in the Hydrographic Survey Project Instructions or other communication from the HSD Project Manager/COR. In these cases, grid resolution shall be between 20% and 40% of depth.

   - Due to the potentially sparser sounding sets produced by single beam echo sounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets be fully "cleaned" (e.g., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids be computed with a "shoal" layer.

5.2.2.5 Trackline Specifications

The following specifications are intended solely for field units conducting Trackline survey operations as specified in Project Instructions from HSD Operations. Unless specifically noted below, the requirements in the Hydrographic Surveys Specifications and Deliverables (HSSD) shall be met.

Generally, due to the sparse nature of the data and relaxed standards only trackline data that is shoaler than existing charted data will be represented on the nautical chart product. Trackline data may not be used by the hydrographic branches to disprove or modify charted features. If the hydrographer would like a feature disproved or modified, they must consult with the HSD Project Manager/COR and subsequently develop the area with Complete Coverage or Object Detection requirements.

5.2.2.5.1 Transit Surveys

- Horizontal Control at a minimum shall be stand-alone GPS. The recommendation is DGPS or WAAS.

- Water level correctors need to be applied and described in the DR Summary. A zerotide file application is appropriate for transit surveys.

- Sound Speed Profiles are not required, the use of sound speed profiles derived from World Ocean Atlas data is acceptable. The sound speed uncertainty values shall be determined by the VelociPy Variance Wedge SOP.

- Shoal and feature developments are not required. Further development of DtoNs and significant shoals may occur if determined to be critical by the hydrographer and/or after consult with the HSD Project Manager/COR. A FFF is only required if a DtoN or new features have been developed.

- There is no defined along track sounding rate.

- The coarsest gridding resolution shall follow the table below. The field unit may submit finer resolution grids, if warranted.

Depth Range (m)	Resolution (m)
0-40	4
40 and greater	16

- The recommended gridding algorithm is uncertainty. Swath and CUBE are acceptable.

- There is no grid node density requirement.

- Holidays are acceptable. If holidays, defined as at least three by three nodes in the surface at the required resolution, occur, document their existence in the Descriptive Report as "Holidays exist in the delivered data due to the acquisition technique of this survey".

- No crosslines are required.

- Acquisition of MBES acoustic backscatter is required as per Section 6.2.

- Bottom samples are not required.

- A Microsoft Word DR Memo (see HTD 2013-5) is required. A Data Acquisition and Processing Report is not required as long as the DR contains the pertinent processing information. A Horizontal and Vertical Control Report is not required.

- The field unit shall document in the chart comparison section of the Descriptive Report all areas where there are significant discrepancies between soundings collected and charted soundings.

- Field unit shall report off-station ATONs or ATONs not serving their intended purpose in the Descriptive Report.

5.2.2.5.2 Reconnaissance Surveys

- Horizontal Control at a minimum shall be stand-alone GPS. The recommendation is DGPS or WAAS.

- Water level correctors need to be applied and described in the DR Summary. Vertical Control will be determined by HSD Operations during the project planning stage.

- A minimum of 1 sound speed profile per day is required. A new sound speed profile can be acquired when there is greater than or equal to a 2 m/s difference between the surface sound speed value and the surface sound speed from the latest full sound speed profile. Sound speed profiles must be obtained through in-situ measurement (e.g. CTD, MVP, etc) by either XBT, XCTD, CTD or MVP equipment. The sound speed uncertainty values shall be determined the VelociPy Variance Wedge SOP.

- Shoal and feature developments are not required. Further development of DtoNs and significant shoals may occur if determined to be critical by the hydrographer and/or after consult with the HSD Project Manager/COR. A Final Feature File (see Section 7.3) is only required if a DtoN or new features have been developed.

- The required along track resolution is 3.2 pings/3m in depths less than or equal to 40m. In depths greater than 40m, there is no required along track resolution requirement.

- The coarsest gridding resolution shall follow the table below. The field unit may submit finer resolution grids, if warranted.

Depth Range (m)	Resolution (m)
0-40	4
40 and greater	16

- The recommended gridding algorithm is uncertainty. Swath and CUBE are acceptable.

- There is no grid node density requirement.

- Holidays are acceptable. If holidays, defined as at least three by three nodes in the surface at the required resolution, occur, document their existence in the Descriptive Report as "Holidays exist in the delivered data due to the acquisition technique of this survey".

- Crosslines shall be collected on an opportunistic basis during round trip voyages.

- Acquisition of MBES acoustic backscatter is required as per Section 6.2.

- Bottom samples are not required.

- The HSD Project Instructions will specify which format of a Descriptive Report (DR) is required: DR Summary (see HTD 2013-15) or XML DR. A Data Acquisition and Processing Report is not required as long as the DR contains the pertinent processing information. A Horizontal and Vertical Control Report is not required.

- The field unit shall document in the chart comparison section of the Descriptive Report all areas where there are significant discrepancies between soundings collected and charted soundings.

- Field unit shall report off-station ATONs or ATONs not serving their intended purpose in the Descriptive Report.

5.2.3 Corrections to Echo Soundings and Uncertainty Assessment

To meet the accuracy and resolution standards specified in Section 5.1, and to create a BAG that includes an accurate uncertainty layer, the hydrographer must conduct an error analysis of their survey systems.

Precise and accurate measurements are fundamental to the field of hydrography. Synchronization of multiple sensors with the sonar system is essential for meaningful spatial analysis of the data. All measurements, however careful and scientific, are subject to some uncertainties. Error analysis is the study and evaluation of these uncertainties with the purpose of estimating the extent of the uncertainties and when necessary, reducing them.

Uncertainty-based processing has fundamentally altered bathymetric data processing and product creation. The validity and usefulness of the results are directly correlated to the accuracy of the individual estimates that compose the error model. For example the error model for CARIS contains uncertainties associated with the sensor and sonar, physical offsets, latency, draft, loading, sound speed and zoned water levels (NOAA field units may refer to Section 4.2.3.6 of the OCS Field Procedures Manual for more information). Non-CARIS users must build a similar model of all the correctors to the depth measurement and the associated uncertainties.

An important distinction exists between such corrections to echo soundings measured relative to the in situ water level (discussed above), to that of 3-D positioning of echo soundings relative to an ellipsoid as is done in ERS hydrography (Section 9). In ERS, the KGPS height uncertainty of the survey platform encompasses the otherwise individual correctors associated with draft and heave. Additionally, the uncertainty associated with zoned water levels is replaced by uncertainties present in the vertical datum transformation.

In recognition of the possibility that some discrepancies in soundings may not be detected until the final 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 should be applied in such a way that the on-line values may be removed and replaced with a revised set of correctors during office 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.

- Dynamic draft corrections shall be applied to soundings to correct the vertical displacement of the transducer, relative to its position at rest, when a vessel is underway.

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

- Attitude corrections shall be applied to multibeam soundings to correct the effect of vessel motion caused by waves and swells (heave, roll, pitch) and the error in the vessel's heading.

5.2.3.1 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 at least once per week between the nadir (vertical) beam of the multibeam and a single beam system or lead line. On surveys where multiple vessels collect data that overlaps with each other to allow comparison of depths, the frequency of formal confidence checks can be reduced to once per survey. In addition, frequent checks should be made between the overlap of mainscheme and crosslines collected on different days. These comparisons should be made frequently during data collection to find errors promptly, and not saved until final data processing after the field party has left the working grounds.

Comparisons should be conducted during calm sea conditions, preferably in areas with a relatively flat 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 explained in the Descriptive Report (DR) section B.2, Quality Control.

5.2.3.2 Draft Corrections

The corrections for draft account for the depth of the transducer reference point 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 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. In addition to the draft values, to complete the vessels' error model, the hydrographer must determine the uncertainty associated with all draft values.

Static Draft

The static draft, as an echo-sounding correction, refers to the depth of the transducer reference point 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 at least the nearest 0.1 m. Measurements are required with sufficient frequency to meet this criterion. When sounding in waters deeper than 30 m, the static draft shall be observed and recorded to at least 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 at least 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.

Loading and static draft uncertainties typically represent a small percentage of the total error budget. However, the accuracy of the error model and the results of BAG surface processing are dependent on knowledge of all the uncertainty values that compose the model.

Dynamic Draft

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. Major factors that influence dynamic draft are hull shape, speed, and depth of water beneath the vessel.

Settlement is the general difference between the elevations 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.

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. Conversely, if attitude corrections are not used in single beam data processing, the dynamic draft correction must include any appreciable effects due to vessel trim.

Combined effects of dynamic draft at the full range of sounding speeds must be confirmed (i.e. performed and then compared to or averaged with similar past dynamic draft analyses) by the hydrographer at least once a year to at least 0.05 meter precision for each vessel, including launches and skiffs used for hydrographic surveying in shoal or moderate depths. Follow up measurements should be made if there are any major changes to the loading or change to the vessel power plant. 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 dynamic draft.

The uncertainty value for Dynamic Draft will be dependent on the method that Dynamic Draft was calculated. Typically, several runs at various speeds will be used to calculate the Dynamic Draft. The uncertainty value could then be the standard deviation calculated for each speed measurement.

5.2.3.3 Speed of Sound Corrections

General

To ensure that the overall depth measurement accuracy criteria specified in Section 5.1.3 are met, speed of sound observations should be taken with sufficient frequency, density, and accuracy. The certainty at which the speed of sound can be determined is a complex function of the measurement of salinity, temperature and depth, or alternately, sound speed and depth.

Sound Speed values derived from Conductivity, Temperature, and Depth measurements shall be calculated using the Chen-Millero equation. Use of Wilson's equation is no longer authorized.

The speed of sound through water shall be determined using instrumentation capable of producing sound speed profiles with errors no greater than 2 meters per second.

The hydrographer shall calibrate sound speed profiler(s) annually. Calibration correctors shall be applied to all profiler data. These instrument(s) shall be re-calibrated at intervals no greater than twelve months during the service life of the instrument while in operational support of OCS hydrographic survey operations. In addition, the instrument(s) must be recalibrated when they are removed from operations or at the end of their service life. Copies of calibration data shall be included in Separate II, Sound Speed Profile Data (see Section 8.1.4). The sound speed profile must reach the deepest depths of the survey but the physical measurement of sound speed 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 speed 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 speed correctors must be determined accurately and often enough to ensure that the depth accuracy requirements in Section 5.1.3 are met. If changes in the temperature or salinity in the water column dictate that updated correctors are needed, additional sound speed profiles shall be acquired. Additionally, the hydrographer should establish a means of monitoring changes in the water column between subsequent speed casts.

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

Regardless of the sound speed determination system employed, an independent sound speed measurement system must be used to establish a confidence check. Confidence checks shall be conducted at least once every 30 days during field operations. Include confidence check results in Separate II, Sound Speed Profile Data (see Section 8.1.4).

Sound Speed 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 speed may be required more frequently.

Sound Speed Corrections for Multibeam Surveys

The sound speed profile must be known accurately in multibeam swath sounding for two reasons. First, as in all echosounding, the depth is computed from the product of the speed 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 speed 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 speed, practical limitations may require the hydrographer to use a small number of discrete points on the speed profile for the purpose of correcting echo soundings. If the hydrographer chooses the inflection points of the smooth speed profile as the discrete points for layer boundaries, the speed 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 speed profile frequency and application:

- One sound speed 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. If the surface sound speed sensor value differs by 2 m/s or more from the commensurate cast data, another sound speed cast shall be acquired. Any deviations from this requirement will be documented in the descriptive report. If the field unit has an alternate method to determine the frequency requirement during survey operations, a full description of the method used shall either be included in the Descriptive Report or Data Acquisition and Control Report.

- Sound speed profiles shall be acquired within the survey limits where subsequent data acquisition will occur or within a 250m range limitation of the survey's hydro limits.

- When using an undulating velocimeter, the real time sound speed 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).

The uncertainty value of the sound speed measurements must be part of the vessel's error model. One method used by NOAA, is to use the manufacturers uncertainty values for the measured components of conductivity, temperature and pressure. These values must then be used to compute a total uncertainty for the profile by computing how each components uncertainty is propagated through the sound speed computations.

A probe that measures speed of sound directly, could use the manufacturers advertised uncertainty value.

Ideally, sound speed uncertainty should be computed based on both the unit's accuracy and the spatial and temporal error associated with sound speed variation over the entire survey area. However, such advanced error analysis is not currently available in NOAA's processing pipeline. Therefore, NOAA field units and contractors may use the uncertainty associated with measuring the speed of sound at a specific location.

5.2.3.4 Attitude Corrections

Heave, roll, pitch, heading, and navigation timing error corrections shall be recorded in the data files and applied to all multibeam soundings. Heave and heading shall be applied for all single beam data. NOAA field units should refer to Section 4.2.3.6 of the OCS Field Procedures Manual for more guidance on corrections to single beam data.

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.

The uncertainty value for heave, roll and pitch will typically be the manufacturer's values, assuming that the equipment is properly installed and maintained. The hydrographer must explain any variance from the manufacturer's values.

Hydrographers using Kinematic GPS shall compensate for squat if attitude is not corrected for single beam.

5.2.3.5 Error Budget Analysis for Depths

The hydrographer shall discuss (in Section B.2 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, dynamic draft error, sound speed 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 speed).

The error ranges provided below are first order estimates to allow hydrographers to get a basic 'feel' for the possible range in errors that may occur in practice. Hydrographers should note that the root sum square of the individual errors is used in the computation of TPU. The required depth accuracy requirements cannot be achieved if the worst error for each sensor shown below is used.

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.

Dynamic Draft error: Conventional methods of determining dynamic draft 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 dynamic draft is greater in shallow water. The practical expected minimum is 0.05 meter and the allowable maximum is 0.20 meter.

Sound speed error: The factors associated with this error include (1) the ability to accurately measure sound speed or calculate sound speed from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound speed throughout the survey area and (3) how the sound speed 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.

5.2.3.6 Uncertainty Budget Analysis for Depths

The hydrographer shall discuss (in Section B.2 of the Descriptive Report) the methods used to minimize the uncertainty associated with the determination of depth (corrections to echo soundings). A sample of uncertainty components and common values are presented below. These uncertainties are inherent to hydrographic surveying and all have practical minimums that are usually achievable only under ideal circumstances or with highly specialized equipment. The survey system uncertainty components and key survey system component offsets shall then be used to calculate the depth uncertainty estimate for the soundings per the Total Propagated Uncertainty Model.

The hydrographer shall also discuss (in Section B.2 of the Descriptive Report) the methods used to quantify the survey systems uncertainty model. Uncertainty estimates for all components of the sounding measurement shall be provided.

The uncertainty component values provided below are estimates to allow hydrographers to get a basic “feel” for the possible uncertainty values that may occur in practice. The values discussed below are at the 68% confidence level (i.e. 1 sigma).

Motion Sensor Uncertainties: These values include heave, pitch and roll measurement uncertainties and can include gyro measurement uncertainty. A common value for gyro, pitch and roll measurement uncertainty is 0.02°. A common value for heave uncertainty is 5% of the heave amplitude or 0.05m, whichever is greater.

Navigation Sensor Uncertainty: This value includes the uncertainty in the determination of the vessels position. This value will depend on the method of positioning used (C/A. DGPS, PPK/RTK) and is commonly reported at 1m.

Timing Uncertainty: These values include the uncertainty in the measurement of time stamps used in the survey system and include Navigation Sensor timing, Gyro Sensor timing, Heave Sensor timing, Pitch Sensor timing and Roll Sensor timing. A commonly reported value for this is between 0.005 and 0.01 seconds.

Vessel Offsets: These values include the uncertainty in the measurements made to determine the survey system offsets. Ranges will depend on how accurately the offsets were measured but are commonly reported between 0.001m and 0.1m.

Vessel Speed: This value includes the uncertainty in the measurement of vessel speed. It is commonly reported as 0.03m/s plus the average current in the area.

Loading: This value includes the uncertainty in draft changes throughout the survey due to factors such as fuel consumption, etc. Commonly reported values range between 1 and 30cm, depending on the vessel, fueling frequency and frequency of draft measurements.

Draft: This value includes the uncertainty in measurement of draft. Commonly reported values range between 1 and 20cm depending on how accurately the draft of the vessel can be measured.

Delta Draft: This value includes the uncertainty of the vessels dynamic draft measurements. Commonly reported values are between 1 and 3cm depending on dynamic draft measurement methodology and magnitude.

MRU Alignment: This value includes the uncertainties in the patch test determined bias measurements of yaw, roll and pitch. Commonly reported values are less than 1°.

Tides: This value includes the uncertainties in the measurement of tides and the uncertainty of the tide zone model. Tidal uncertainties have been discussed in detail in Section 4.1.6.

Sound speed: This value includes the uncertainties in the measurement of sound speed for full depth profiles and surface measurements. The factors associated with this uncertainty estimate include (1) the ability to accurately measure sound speed or calculate sound speed from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound speed throughout the survey area and (3) how the sound speed profile is used to convert measured time to depth. Commonly reported values range between 0.3 and 4m/s.

5.2.4 Quality Control

5.2.4.1 Multibeam Sonar Calibration

Prior to commencing survey operations, the hydrographer shall conduct a system accuracy test (i.e. patch 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 and the uncertainty of these values. These values will be used to correct the initial alignment, calibrate the multibeam system and used in the computation of the Total Propagated Uncertainty (TPU) for each sounding. 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, dynamic draft corrections, sound speed 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 (yaw). Deviations from this order or other variations on the accepted calibration methods shall be explained in the project documentation

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 degree 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 ensonified 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 (yaw) 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 Section A. Equipment and optional Section B. Quality Control 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 5.1.

5.2.4.2 Positioning System Confidence Checks

See Sections 3.2.2 for details.

5.2.4.3 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 soundings and positions. Crosslines shall be acquired and processed to the same accuracy and data quality standards as required for mainscheme lines, and shall be included in the grids that are submitted as the final bathymetric product of the survey. As a quality control tool, the benefits of crosslines are most readily derived when they are acquired at or near the beginning of survey operations. With crosslines in hand, the field unit has a ready tool to identify systematic errors that may otherwise go undetected for days.

Crosslines shall have good temporal and geographic distribution (across depth ranges, distinct water masses, and vessels) such that maximal nadir-to-nadir comparisons are achieved.

Crossline requirements are dependent on bathymetric coverage type assigned and achieved by the field unit, Section 5.2.2:

- Object Detection or Complete Coverage: Lineal mileage of crosslines shall be ~4% of main scheme mileage in areas surveyed to meet object detection or complete bathymetric coverage requirements.

- Set Line Spacing: Lineal mileage of crosslines shall be ~8% of main scheme mileage in areas surveyed with set line spacing coverage using single beam or multibeam echosounders. This applies for mixed main scheme and crossline techniques, i.e. single beam main scheme with multibeam crosslines or vice versa

The primary purpose of crosslines in a set line spacing coverage area, is to identify systematic errors and blunders in the surveying system. Discrepancies between main scheme and crossline coverage indicate potential systematic errors in offsets, biases, or correctors or the application thereof, faulty positioning or echosounder operation, or other issues. Again, discrepancies cannot be identified until both main scheme and crossline data are in hand; to that end, an emphasis should be placed on acquiring the crossline data prior to main scheme acquisition. The hydrographer shall compare main scheme and crossline coverage to identify, evaluate, and rectify any such errors.

Crosslines are not the primary means of identifying systematic errors and blunders in multibeam echosounder data used to achieve 100% bathymetric bottom coverage. Most such issues are more readily and reliably identified in the bathymetric grid through examination of depth values and ancillary attributes such as uncertainty and standard deviation. However, crosslines in an object detection or complete bathymetric coverage do provide an additional semi-independent check for spatial and temporal correlation of the data set across the range of area, time, seabed relief and bottom types, survey vessels, and sonar systems represented. For this analysis to be valid, crosslines must be acquired with the same attention to accuracy and data quality as mainscheme data. Whenever possible, crosslines should be acquired under different conditions (vessel, sonar system, tide state, etc.) than main scheme data.

Two possible methods of conducting the independent analysis are beam by beam statistical analysis or difference surface (NOAA field units should refer to Section 5.1.2.2.2 of the OCS Field Procedures Manual for more information). Other methods may be used if approved in advance by the HSD Project Manager/COR. Regardless of method, the comparison shall be performed at the same resolution as the final survey product as required in Section 5.2.2.

Analysis and Documentation: The hydrographer shall evaluate each area of overlapping crossline and mainscheme coverage to ensure that at least 95% of depth values from the two data sets differ by no more than the maximum allowable TVU for the depth of the comparison area (as specified in Section 5.1.3). Any deviations from this standard shall be investigated, and the source of error identified and corrected. If unexplained or excessive discrepancies persist, additional crosslines shall be re-acquired to assist in resolution of the issue.

The hydrographer shall evaluate crossline to mainscheme agreement, and discuss the method and results in Section B of the Descriptive Report. If the magnitude of any discrepancies varies widely over the survey, the hydrographer shall make a quantitative evaluation of the disagreements area by area. If differences were found to be within the allowable maximum TVU, the hydrographer shall note this. Conversely, any errors identified through crossline analysis and the means by which they were corrected shall be discussed.

5.3 Lidar

5.3.1 Accuracy and Resolution Standards

All requirements outlined in Section 5.1 apply to bathymetric lidar data products and feature attribution. For project specific guidance the hydrographer shall refer to the Hydrographic Survey Project Instructions

5.3.1.1 Lidar Resolution Standards

Spatial resolution The hydrographer shall maintain and operate the lidar system,from data acquisition to processing to detect hazardous features. As the spatial resolution (i.e., the spacing of the lidar footprint on the seafloor) is dependent on a wide range of variables: 1.) propagation of light through the water 2.) the received signal strength 3.) the object detection algorithms used 4.) changes in water depth, and 5.) aircraft height above the surface the actual bottom resolution may not remain constant. The hydrographer shall make a statement in the Descriptive

Report describing the areas within the survey where they are confident the specified spatial resolution was obtained.

5.3.1.2 Gridded Data Specifications

In the Navigation Surface approach, survey data are archived as a certified digital terrain model rather than as a set of verified or certified soundings. For lidar bathymetry, the archived elevation model should be saved at the highest resolution supported by the sounding data. For example,. if the laser spot spacing on the seafloor of a full-coverage lidar survey is 3 meters, the elevation model could be saved at a grid spacing of 3 meters. However, if environmental conditions (i.e. kelp, turbidity, or sea state) create differences in data density an alternative approach may be discussed with the HSD Project Manager/COR and clearly described in the Descriptive Report (DR). This practice has the advantage of preserving this high-resolution data for a variety of known and unknown future purposes, even if such resolution will never appear on a navigational or charting product. Charting products such as paper charts are created from scale-appropriate generalizations of the elevation model. In reality, the final resolution of the surface may be slightly coarser than "the highest resolution supported by the sounding data" due to depth ranges, bottom topography and other variables. Refer to Section 5.2.1 for more guidance. See also Section 7.4 for guidance on delineating and characterizing rocky seabed areas.

The data density and resulting grid resolutions created shall be discussed with the COR during the project planning phase. Any deviations from the plan, project instructions or Specifications and Deliverables shall be discussed with the COR and clearly described in the Descriptive Report (DR) and Data Acquisition and Processing Report (DAPR) If in rocky nearshore areas, the least depths of many features in a relatively small area fail to be preserved, see Section 5.2.1.2.3 for more guidance. See also Section 7.4 for guidance on delineating and characterizing this rocky seabed area.

Uncertainty: The Navigation Surface for lidar requires that each sounding have a horizontal and vertical uncertainty. The uncertainty value for the grid shall be the greater of the standard deviation and the a priori computed uncertainty estimate. To do this effectively, an error model is needed for all systems supplying measurements to compute the sounding; including the GPS sensors and anything else that contributes to the calculation of a sounding. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology.

The Navigation Surface for lidar requires that each sounding have a horizontal and vertical uncertainty. If a complete error model is not yet available to compute the TPU for each individual sounding then the hydrographer may apply a single uncertainty value to all grid nodes that reflect the vertical error budget for a given survey. Include a discussion in the DAPR on how the uncertainty was computed with a justification for that methodology. See Section 5.1.3 for additional guidance.

5.3.2 Coverage and Resolution

In general, there are two classifications of bathymetric lidar coverage: Complete and Reconnaissance coverage. The required spot spacing and survey coverage will be specified in the Hydrographic Survey Project Instructions.

Complete Coverage requires a minimum of 200% coverage, a minimum laser spot spacing of 4 meters, and conforms to the depth accuracy standards outlined in Section 5.1. In situations where poor water clarity and related environmental factors make complete coverage impossible the COR shall be notified. In addition the hydrographer shall identify (textually and graphically) those areas where full coverage was not obtained and/or further investigation using sonar may be required.

Reconnaissance coverage refers to range of coverage overlap and laser spot spacing requirements below the minimum specified for Complete coverage. Data products and feature information produced under Reconnaissance requirements are used to obtain general bathymetry for applications other than nautical charting (e.g. navigational safety, operational planning, and research). The Hydrographic Survey Project Instructions will identify if a given surveys is for reconnaissance purposes and the hydrographer shall indicate the requirement in the Descriptive Report.

Complete lidar coverage

- Grid resolution shall nominally be 3 meters - If survey data can support higher resolutions, then use hydrographer discretion and submit a higher resolution, if appropriate.

- Maximum surface uncertainty is IHO Order 1 for depths less than 100 meters. The hydrographer must ensure that accurate least depths are obtained on all significant features. Individual soundings that do not meet the Horizontal Position Accuracy as defined in Section 3.1.1 or do not meet the Vertical Uncertainty standards as defined in Section 5.1.3, shall not be applied to the grid.

As always, the hydrographer must ensure that the data accurately reflects the condition of the seafloor at the time of the survey and adjust operations if required. Any deviations from the specifications must be clearly explained in the Descriptive Report and discussed with the COR as they occur.

Attribution

By definition each node of the grid includes not only a depth value, but other attributes. The following minimum attributes shall be associated with each grid node

- Depth Value

- Total Vertical Uncertainty: The uncertainty value for the grid node shall be the greater of the standard deviation of the soundings contributing to the depth solution, and the a priori computed uncertainty estimate. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology. The hydrographer shall examine the finalized grids and explain and explain in the DR any areas of unusually high uncertainty.

- Shoal Depth: Depth value of the shoalest measurement which contributed to the depth solution.

- Sounding Density: Number of soundings contributing to the depth solution.

- Standard Deviation: Standard deviation of the depths within the capture radius of the node.

5.3.3 Corrections to Lidar Soundings

To meet the accuracy and resolution standards for measured depths specified in Section 5.2.3, and to create a Bathymetric Attributed Grid (BAG) that includes an accurate uncertainty layer, the hydrographer should conduct an error analysis of their survey systems. Precise measurements are fundamental to the field of hydrography. Synchronization of multiple sensors with the lidar system is essential for meaningful spatial analysis of the data. All measurements, however careful and scientific, are subject to some uncertainties. Error analysis is the study and evaluation of these uncertainties with the purpose of estimating the extent of the uncertainties and when necessary, reducing them. In recognition of the possibility that some discrepancies in sounding may not be detected until the final processing phase of the survey, the determination and application of corrections to soundings must be accomplished and documented in a systematic manner. In addition, it is preferable that all corrections be applied in such a way that the on-line values may be removed and replaced with a revised set of correctors during office processing. Corrections to 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. Roll, pitch, heading, and navigation timing error (latency) corrections shall be applied to lidar soundings to correct the effect of the aircraft's motion caused by turbulence, the error in the aircraft'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). The hydrographer shall also discuss (in Section B2. of the Descriptive Report) the methods used to quantify the survey systems error model. Uncertainty estimates for all components of the sounding measurement should be provided.

5.3.3.1 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 Lidar equipment using internal checks will often eliminate instrument error entirely. However, to ensure the proper operation of the lidar system "confidence checks" shall be conducted periodically. Frequent checks should be made between the overlap of main scheme and crosslines collected on different days. These comparisons should be made frequently during data collection to find errors promptly, and not saved until final data processing after the field party has left the working grounds. 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 explained in the Descriptive Report (DR) section B2., Quality Control.

5.3.4 Quality Control

5.3.4.1 Lidar Calibration

Field calibration is performed by the system operator through flights over a calibration site that has been accurately surveyed using GPS or conventional survey techniques such as triangulation or spirit leveling. Typically, the calibration site may include a large, flat-roofed building whose corners have been accurately surveyed with GPS and a large, flat parking lot and runway. The calibration may include flights over the site in opposing directions, as well as cross flights. The field calibration is used to determine corrections to the roll, pitch, and scale calibration parameters. Field calibrations must be performed for each project or every month, whichever is shorter. Prior to commencing survey operations, the hydrographer shall conduct a system accuracy test to quantify the accuracy, precision, and alignment of the lidar system. Testing shall include determination of residual biases in roll, pitch, heading, and navigation timing error and the uncertainty of these values. These values will be used to correct the initial alignment, calibrate the lidar system and used in the computation of the Total Propagated Uncertainty (TPU). 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 Section A. Equipment and optional Section B. Quality Control 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, reinstallations, reconfigurations, 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 5.2.3.

5.3.4.2 Positioning System Confidence Checks

See Sections 3.2.2 for details.

5.3.4.3 Lidar 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 soundings and positions. Crosslines shall have good temporal and geographic distribution.

Crosslines shall be acquired and processed to the same accuracy and data quality standards as required for mainscheme lines and shall be included in the grids that are submitted as the final bathymetric product of the survey. Lineal of crosslines shall be at least 4 % of main scheme mileage in areas requiring complete coverage (refer to 5.3.2).

Under certain conditions (e.g., steep terrain, airspace restrictions, or relatively narrow band of coverage) crosslines may not be possible. In such cases, a deviation from this requirement shall be requested from the COR and explained in the Descriptive Report.

The hydrographer shall make a general evaluation of the lidar crossline to main scheme 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.

An independent analysis of the crossline and main scheme data shall be conducted. Although any crossline/main scheme disagreements should be obvious in the attributes of the combined surface, an independent analysis is still required to ensure that the surface implementation is correct and to help find any hidden problems. Include a statement regarding the results of the comparison in Section B of the Descriptive Report. If created, the difference surface shall also be included in the final deliverables.

6 Acoustic Backscatter

Contents

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 bathymetric irregularities to meet object detection requirements. The use of side scan sonar to meet object detection requirements does not alleviate the responsibility of the hydrographer to investigate features or acquire splits as discussed in Section 5.2.2.1. Any requirement for side scan sonar coverage in conjunction with a hydrographic survey will be specified in the Hydrographic Survey Project Instructions.

6.1 Towed Side Scan Sonar

6.1.1 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 Project Instructions. 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.

6.1.2 Side Scan Acquisition Parameters and Requirements

6.1.2.1 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 1m x 1m x 1m from shadow length measurements.

6.1.2.2 Speed

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

6.1.2.3 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.

In areas with excessive bathymetry variability or when hull mounted systems are used, the hydrographer shall ensure that coverage and object detection are met. When the towfish height has exceeded the maximum threshold, either the hydrographer needs to take extra care in examining the data for contacts with reduced shadow lengths or re-acquire the data at an appropriate depth. Likewise if the minimum towfish height is not met, additional lines (or splits) may be required to meet coverage requirements.

6.1.2.4 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.

6.1.3 Quality Control

6.1.3.1 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.

6.1.3.2 Side Scan Sonar Contacts

In depths of water less than or equal to 20m, contacts shall be picked that have computed target heights (based on side scan sonar shadow lengths) of at least 1m. In depths of water greater than 20 m, contacts shall be picked that have computed target heights rising above the bottom at least 5 percent of the depth.

All contacts identified shall be developed with a multibeam echosounder using the object detection or complete coverage grid resolutions (defined in Section 5.2.2.2 and Section 5.2.2.3), as assigned in the Project Instructions to determine the least depth of the contact. The least depth measurement should be determined from a beam within 30 degrees of nadir unless multiple passes were made over the contact. When a contact is correlated to multibeam data acquired concurrently with side scan sonar operations, the contact shall be developed further if the correlating sounding is sourced from one of the multibeam system's outer beams. If a side scan sonar contact will lead to a FFF feature (see Section 7.3), follow the FFF feature development guidance in Section 7.3.3.

If a contact must be developed by a single beam echosounder, dive investigations shall be used to determine the contact's depth with a diver's least depth gauge when it is practical. The shoaler depth of the two methods shall be used for contact's reported depth. A dive investigation may be conducted to supplement data from a multibeam echosounder development.

For a 200% SSS with concurrent object detection multibeam survey, when multiple contacts are located during the first 100% side scan coverage of an area, the hydrographer may determine that is more efficient to survey the area completely with the multibeam echosounder rather than survey the second 100% and develop each contact individually. In this case the hydrographer shall meet the requirement for object detection stated in Section 5.2.2.2.

In areas where the water depth and the size of the area containing multiple contacts make this approach prohibitive an alternative gridding method may be used. Once 200% coverage has been achieved and all contacts correlated, the hydrographer may divide the area into 400 square meter investigation cells and develop the most significant contact in each investigation cell. If the developed contact's measured height off the bottom is significantly less that the contact height from the sonar record and is less than the next most significant contact height in the grid cell the hydrographer shall develop the next most significant contact.

6.1.3.3 Side Scan Sonar Contact Attribution

The following is a list of required NOAA Extended Attributes for Side Scan Sonar contact points to be delivered in the side scan sonar contact file (Section 8.2.2).

The following Attribute Legend shall be used for the subsequent table:

Attribute Legend:	
Mandatory	(red box)
Conditional	(yellow box)

$CSYMB (Cartographic Symbol)	S-57 object required for side scan sonar contact points in the side scan contact file	
Acronym	**SSS Contact Information**	**Description**
cnthgt	Contact Height	Computed contact height
images	Images	Images associated with a contact †
userid	Contact Number	Unique identification number of the contact (e.g. 0001, 0002, etc.)
remrks	Remarks	Additional comments not captured in other attributes
prmsec	Primary/Secondary	Indicates status of contact during correlation
† Images: • *Accepted formats: JPEG, PNG, GIF, TIFF* • *SSS contact images must have a unique identification name* • *Multiple images for one contact shall be semi-colon delimited* • *All SSS contact images shall be placed in the Multimedia folder. A copy of the side scan contact images should remain in the CARIS HDCS folder if CARIS software is used for processing.*		

6.1.3.4 Side Scan Sonar 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 conditional "remrks" extended attribute or the discretionary "prmsec" attribute.

6.1.3.5 Identification of Features

The hydrographer shall use the SSS Contact File, in conjunction with an analysis of echosounder least depths and BAG attributes (standard deviation, uncertainty, etc), to identify features which may require a development and inclusion in the FFF (see section 7.3).

6.2 Multibeam Echosounder Seafloor Backscatter

All multibeam echosounder surveys require concurrent time series backscatter acquisition to supplement the utility of hydrographic data for non-charting purposes.

6.2.1 Coverage

When specified in the Hydrographic Survey Project Instructions, seafloor backscatter data will be evaluated for gaps in backscatter coverage. A backscatter gap (holiday) has the same definition as the multibeam echosounder holiday (see sections 5.2.2.2 and 5.2.2.3).

6.2.2 Acquisition Parameters and Requirements

6.2.2.1 Accuracy

When specified in the Project Instructions, verification may be required to 'ground truth' seafloor backscatter data. Sampling locations should be judiciously selected to verify areas of obvious or apparent bottom composition change or to address specific requirements in the Project Instructions. Special handling instructions beyond normal bottom sample requirements will be specified in the Project Instructions.

Any understanding of the reported backscatter accuracy shall be recorded in the form of a backscatter offset or beam pattern. Any indication of misreported settings versus actual used settings (i.e. reported transmit power used versus actual transmit power) shall also be reported for the particular systems in use during the survey.

6.2.2.2 Acquisition Parameters

The adjustment of multibeam settings should be minimized to limit the likelihood of artifacts in the resulting backscatter products. All real time acquisition parameters that are needed to conduct post processing need to be included with the digital data.

6.2.2.3 Requirements

Efforts shall be made to avoid multibeam receiver acoustic saturation of the backscatter data.

7 Features

Contents

7.1 Feature Definition

A feature can be any anthropogenic or natural object that may merit individual cartographic representation (e.g. rocks, wrecks, obstructions).

The minimum size of a feature that is required to be found and represented in the submitted surface is different for water depths in object detection (i.e. features ≥ 1x1x1m) and complete coverage (i.e. features ≥ 2x2x1m) requirements, see Sections 5.2.2.2 and 5.2.2.3, respectively.

7.2 Composite Source File and Project Reference File

A Composite Source File (CSF) and Project Reference File (PRF) shall be provided with the Hydrographic Survey Project Instructions. If no PRF/CSF is provided by HSD, contact the HSD Project Manager/COR for advice on how to precede with feature verification. The CSF is an S-57 attributed (see Section 7.5) data set compiled from applicable sources (ENCs, preliminary ENCs, and geographic cells), providing the field unit with the largest scale and most up to date shoreline data. The CSF is the foundation for the Final Feature File (FFF) deliverable (see section 7.3).

The PRF is a NOAA Extended attributed (see Section 7.5) data set containing reference layers such as survey limits, junctions, recommended bottom sample locations and features which are specifically targeted for investigation (e.g. Maritime Boundary Points, Section 7.2.1).

The PRF features are represented by the following S-57 feature objects:

REFERENCE FEATURE	S-57 OBJECTS	DESCRIPTION
Investigation Items	CRANES	Lidar, Maritime Boundary investigation items
Survey Limits	TESARE	Outline survey limits
Junction Limits	TWRTPT	Outline of junction survey
Bottom Samples	SPRING	Recommended bottom sample locations

The PRF features are described with the following NOAA extended attributes:

REFERENCE FEATURE	ATTRIBUTION	DESCRIPTION
Maritime Boundary	asgnmt	Assigned or For Info Only
	invreq	Description requirements
	sftype	Maritime Boundary
Lidar	asgnmt	Assigned
	remrks	Lidar remarks and description
	sftype	Lidar investigation
Survey Limits	invreq	Survey, Priority, Name
Junctions	invreq	Survey, Platform, Year, Scale
Bottom Samples	asgnmt	Assigned
	invreq	Description of requirements

7.2.1 Maritime Boundary Points

Maritime Boundary Investigations are required because OCS is responsible for depicting the maritime zones: Three Nautical Mile Line (old territorial sea), Territorial Sea at 12 nautical miles, Contiguous Zone at 24 nautical miles, and Exclusive Economic Zone (EEZ) at 200 nautical miles, on NOAA nautical charts. These maritime zones, whose limits are measured using principles set forth in the United Nations Convention on the Law of the Sea (UNCLOS), define areas of U.S. jurisdiction for a variety of regulations.

The maritime boundary verification requests are compiled by HSD Project Managers, CORs, or NSD Technical Assistants and delivered with the Project Instructions in the PRF as the S-57 Object Crane (CRANES). The NOAA Extended Attributes Special Feature Type (sftype) is populated with "MARITIME BOUNDARY", Assignment (asgnmt) is populated with "Assigned" for rocks requiring verification and "For Info Only" for existing maritime boundary points which do not require verification. In addition, Investigation Requirements (invreq) is populated with a brief description of the verification requirements. A further description of verification requirements is as follows:

The maritime boundary points are placeholders (similar to suggested bottom sample locations) which indicate a location where the hydrographer is responsible for verifying the existence of the furthest offshore feature that is dry at MLLW (i.e. has a height relative to MHW). Verification techniques may include 100% MBES coverage to define the maritime boundary, taking detached positions with a range and bearing, or by direct occupation with a portable GPS system. The detached position should consist of latitude, longitude, height, and appropriate S-57 attribution for that feature. Verification also includes taking a digital photograph of the feature to be included in the NOAA Extended Attribute "images" and filed in the Multimedia folder. No further verification for defining the maritime boundary is required once the furthest offshore feature that is dry at MLLW is determined.

The accuracy for maritime boundary points shall meet the minimum horizontal position accuracy requirement set forth in section 3.1.1.

If the assigned Maritime Boundary Point is not found or is not dry at MLLW, then the next furthest offshore feature that is dry at MLLW shall be verified. The hydrographer shall not extend their maritime boundary point search outside of their assigned survey limits. The hydrographer shall use the existing baseline points ("For Info Only" Maritime Boundary points located in the PRF) to support maritime boundary point determination. The field unit shall contact HSD Project Manager/COR with any questions regarding addressing assigned maritime boundary points.

7.2.2 Bottom Characteristics

The character of the bottom shall be determined for nautical charting, particularly in harbors, designated anchorages, and in all other areas where vessels may anchor. In addition to furnishing information for selecting anchorages, charted bottom characteristics assist fisherman in selecting areas where fish may be found while avoiding places where equipment may be damaged.

In general, sampling the surface sediment layer is usually adequate to define the bottom characteristics for charting. Clamshell bottom snappers or similar type grab samplers should be used to obtain as large a sample as possible. If a more detailed study of the ocean floor is required the project instructions will specify the type of sampler to use.

When a field unit is assigned to conduct bottom samples, the field unit should review the bottom sample plan provided within the Hydrographic Survey Project Instructions to the survey data acquired. The field unit should contact HSD Project Manager/COR to discuss modifying the bottom sample plan if the data suggest more appropriate locations for the bottom samples (e.g. depth at specified sampling location is > 80 m, backscatter data indicate homogeneous bottom type, etc.). The survey data will often better differentiate varying bottom characteristics within the survey area when compared to the sample plan provided. This may increase or decrease the sample density but should closely maintain the same numbers of samples per survey as originally assigned.

In areas where bottom samples are not required but where the general trend of the newly surveyed depths has changed significantly since prior surveys, the field unit shall contact HSD Project Manager/COR as appropriate to determine if bottom samples are necessary and to define the sample density.

When sampling is required, the hydrographer shall record position for each sample obtained. In addition, each sample shall be described and completely attributed in the S-57 feature file. Refer to Section 7.5 for more detailed guidance on S-57 attribution of bottom samples.

7.3 Final Feature File

The Final Feature File (FFF) is the feature deliverable for an individual survey (i.e. HXXXXX_FFF). The FFF shall be in S-57 .000 format. The FFF shall contain attributed information on specific objects that cannot be portrayed in a simple depth grid (See Section 7.5). General soundings, contours, depth areas and area meta objects shall not be included in the FFF as these objects will be derived from finalized surfaces during chart compilation. In rare cases, an isolated sounding may be part of the FFF if it is a navigationally significant shoal and/or needs additional attribution. All Danger to Navigation features (see Section 1.5) shall be included in the FFF. Features to include in the FFF include are defined below:

7.3.1 Assigned Features

All Composite Source File (CSF) features with the NOAA extended attribute 'asgnmt' populated with 'Assigned' shall be addressed and included in the FFF. The following guidance shall be used to address an assigned feature:

- Assigned features located inshore the 0.8mm buffer: only address if assigned by COR/HSD Project Manager. These are rare and would likely be a maritime boundary point or a feature considered essential to safe navigation.

- Assigned features located between the field-surveyed NALL and the 0.8mm buffer: address by including all assigned features in the FFF with 'descrp'= "Not Addressed" and 'remrks'="Retain as charted, not investigated due to being inshore of NALL" (or, a feature can be more thoroughly investigated if deemed navigationally significant and safe to approach by the field).

Note: Navigational significance depends on several factors: location, proximity to shore, proximity to other features, and the marine traffic patterns/usage in the area. Ideally the person making the determination of navigational significance will be one who has extensive experience using nautical charts for navigation and can convey that perspective to the personnel conducting the field survey work. This is typically the NOAA vessel Commanding Officer (Chief-of-Party) or Field Operations Officer, Hydrographer-in-Charge, or the contractor's Lead Hydrographer.

- Assigned features located within survey coverage, offshore of the NALL: address by including in the FFF with appropriate attribution (see Section 7.4).

7.3.2 New Features

The following guidance shall be followed with respect to newly discovered features and their inclusion in the FFF:

- All new anthropogenic features (e.g. obstructions, wrecks, etc.) that meet the appropriate minimum required feature size for the assigned coverage requirement (e.g. 1m x 1m x 1m and greater for object detection) shall be included in the FFF.

- All new, submerged, natural features (i.e. rocks with attribute WATLEV=3) that meet the appropriate minimum required feature size for the assigned coverage requirement shall be appropriately represented in the submitted surface (see Section 7.4) but shall not be included in the FFF. Exception: all named rocks within the survey area shall be appropriately represented in the surface and included in the FFF.

- All new natural features, exposed at tidal datum (i.e. WATLEV = 1, 2, 4, or 5) that pose a danger to surface navigation shall first be considered for a Danger to Navigation submission (see Section 1.5) and also included in the FFF.

- Features with any horizontal dimension greater than 1.0mm at survey scale shall be treated as area features and delineated appropriately. Features with lesser horizontal dimensions shall be positioned and attributed as point features.

7.3.3 Feature Developments

All submerged features required for inclusion in the FFF, as defined in Section 7.3, that are detected with bathymetry shall be further developed to better estimate a reliable least depth. A development can be achieved with multibeam water column, divers least depth gauge, wire drag, mechanical sweep, or an additional acquired line of multibeam data oriented perpendicular to the mainscheme hydrography.

Note: Feature developments, as described above, have different requirements than SSS contact developments, as described in Section 6.1.3.2. Only a subset of SSS contacts will potentially become FFF features (Section 7.3).

7.3.4 Feature Disprovals

If a feature that needs to be addressed is not detected in the field, a formal feature disproval shall be undertaken. In certain cases (e.g. 100% SSS with concurrent multibeam), a disproval search radius will be assigned by HSD Operations in the Project Instructions. This search radius will be based on the status of the charted feature (e.g. PA, PD, ED) and the scale of the chart. If the formal disproval indicates the feature does not exist, the disproved feature shall be included in the FFF with the appropriate NOAA extended attribution (i.e. descrp=delete). In the case of unassigned offshore platforms and piers within the sheet limit that are not visible, the field unit shall consult with their HSD Project Manager/COR and then undertake a formal disproval.

Feature disproval techniques for an object detection survey:

- Object detection multibeam (see Section 5.2.2.2) or
- 200% side scan sonar coverage that conforms to Section 6.1.2

Feature disproval techniques for a complete coverage survey:

- Complete coverage multibeam (see Section 5.2.2.3) or
- 200% side scan sonar coverage that conforms to Section 6.1.2

Note: 100% side scan sonar coverage is not sufficient to disprove a feature.

7.3.5 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 (available online at http://www.navcen.uscg.gov/?pageName=lightlists), the hydrographer shall confirm the aid's characteristics and determine whether the aid adequately serves the intended purpose for which it was established.

If located on station and serving its intended purpose, USCG maintained aids to navigation shall not be included in the FFF.

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 (see Section 1.5) and also included in the FFF. The Navigation Manager for the survey area shall be CC'ed on the danger to navigation submission.

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). The uncharted aid to navigation shall be included in the FFF unless temporary in nature or repositioned frequently.

Other fixed and floating aids to navigation and landmarks within the survey area may require specific positioning methods which will be provided in the Hydrographic Survey Project Instructions.

7.4 Designated Soundings

The hydrographer has the responsibility to review the surface and ensure that it reflects the conditions in the survey area. Even in cases where the appropriate resolution was selected, it is possible that the grid may fail to portray some navigationally significant depths and features. A hydrographer may occasionally select designated soundings which override the gridded surface and force the model to recognize an estimated reliable least depth.

A designated sounding may be created for two reasons; 1) to facilitate FFF feature management (see below) or 2) to override the gridded surface model to recognize an estimated reliable least depth (see Section 5.2.1.2.3).

1. Feature Management - The criteria for designated soundings created to aid in feature management:

a. A designated sounding shall be selected over submerged addressed features required for inclusion in the FFF, as defined in Section 7.3.

b. Survey Scale: When the distance between two features that would otherwise warrant individual designation is less than 2mm at the scale of survey (e.g. 20m for 1:10,000 scale) then only the shoalest of those features shall be designated and included in the FFF.

c. In some cases, often in rocky nearshore areas, the least depths of many features in a relatively small area may fail to be preserved, even by very high resolution gridded surfaces. In these instances, the hydrographer shall designate the least depths on the most significant, shoalest features as required by the navigational use of the area and the scale of the survey. Only those features that meet the feature definition in Section 7.1 (i.e. may merit cartographic representation) shall be included in the FFF.

2. Override the gridded surface model - Section 5.2.1.2.3.

7.5 Feature Attribution

Features shall be attributed using the International Hydrographic Organization (IHO) Special Publication 57 (IHO S-57), the IHO Transfer Standard for Digital Hydrographic Data. The IHO intends for the standard to be used for the exchange of digital hydrographic data between hydrographic offices, and for the distribution of hydrographic data to manufacturers, mariners and other data users. It was developed so that the transfer of all forms of hydrographic data would take place in a consistent and uniform manner. IHO Special Publication 57 may be downloaded free of charge at www.iho.shom.fr.

These Specifications will not attempt to include all possible S-57 objects and attribution that may be used to support hydrographic survey data. They shall identify the objects and attribution that are required for NOAA hydrographic survey data. If the hydrographer has any questions on the appropriate attribution for an object, they should contact the COR/HSD Project Manager for clarification.

7.5.1 S-57 Attribution

The following Attribute Legend shall be used for the subsequent tables in Section 7.5.1:

Attribute Legend:

Mandatory

Conditional

All FFF (see Section 7.3) features shall have the attribution of SORIND and SORDAT populated.

<table>
<tr><th>Attribute</th><th colspan="2">Description</th></tr>
<tr><td>All Feature Objects</td><td colspan="2">ALL surveyed objects will have the following attributes populated.</td></tr>
<tr><td>SORIND</td><td>Source Indication</td><td>Information about the source of the object</td></tr>
<tr><td colspan="3">• Country Code - US
• US Authority code - US for OSC
• Source - graph
• ID code - registry number
• Ex: US,US,graph,H12345</td></tr>
<tr><td>SORDAT</td><td>Source Date</td><td>The last day of survey acquisition formatted as YYYYMMDD</td></tr>
<tr><td colspan="3">Instances which require altering SORDAT and SORIND:
• New feature
• Modification to the geographic position of a feature
• Modification to the geometry (shape) of a feature
• Modification to the geographic primitive of a feature (e.g. point becomes line)
• Modification to a feature's S-57 object class
• Modification or addition to a feature's attribution</td></tr>
<tr><td colspan="3">Note:
• There shall not be any spaces after comma separated values in SORIND
• Disproved and Retained features will always maintain the original SORDAT and SORIND from the CSF.</td></tr>
</table>

The following table includes mandatory and conditional S-57 Attribution requirements for the most common features found in an FFF (Section 7.3) as well as some specific guidance in the note sections for each feature class. The table includes the following feature classes: SOUNDG, WRECKS, UWTROC, OBSTRN, PILPNT, MORFAC, SBDARE, COALNE, SLCONS, LNDARE, and LNDELV. If a field unit has a question regarding attribution for a FFF feature class not listed, contact the HSD Project Manager/COR for guidance.

Object	Attributes	
	Acronym	**Description**
SOUNDG (Sounding)	TECSOU *	(Technique of sounding measurement)
	QUASOU **	(Quality of sounding measurement)

Note:
- *Only soundings for DTONs or other significant shoals should be included in the feature file.*
- *All depth units are in meters with at least decimeter precision.*

*

Technique of Measurement for Height or Depth (TECSOU)	***S-57 Attribute ID***
VBES (single beam) alone	*'1' found by echo-sounder*
Side Scan Sonar alone	'2' found by side scan sonar
Multibeam alone	'3' found by multibeam
Skunk Striping (full coverage SSS with partial coverage multibeam)	'3' found by multibeam, with CATZOC reflecting lack of full coverage
Diver depth	'4' found by diver
LIDAR alone	'7' found by laser
Heights on rocks or islets using rangefinder or visual estimation	'12' found by leveling

***QUASOU: All sounding features that were surveyed using a multibeam echo sounder, single beam echosounder, or lidar to NOAA/IHO standards are assumed to be QUASOU Depth Known. In these cases QUASOU should be left null. Attribute QUASOU only in the cases outlined below:*
- *Depth Unknown: Use this category for obstruction area objects, such as foul areas, where "Unknown" is used for VALSOU and WATLEV.*
- *Least Depth Known: Shall be populated with point objects (i.e. wrecks, rocks, and obstructions) under these circumstances:*
  - *Depth derived using Multibeam Echosounder (MBES) System*
  - *Diver investigation using Diver Least Depth Gauge (DLDG)*
  - *Manual Depth Measurement Equipment using lead line or sounding poles*
  - *Sounding "designated" from the Surface*
  - *Feature height derived by leveling*
- *Value Reported (not confirmed): Use this category for Side Scan Sonar contacts in which a sonar depth is not acquired and which the side scan contact has not been investigated.*

Object	Attribute	
	Acronym	**Description**
Features:	For all sounding-based features, see instructions for populating TECSOU and QUASOU attributes under DEPTHS, above.	
WRECKS (wreck)	CATWRK	(Category of wreck)
	WATLEV	(Water level effect)
	VALSOU	(Value of sounding)
	TECSOU	(Technique of sounding measurement)
	QUASOU	(Quality of sounding measurement)
Note: *Reference Appendix F for WATLEV attribution.*		
UWTROC (Underwater/Awash/Covers & Uncovers Rock)	VALSOU	(Value of sounding)
	WATLEV	(Water level effect)
	QUASOU	(Quality of Sounding Measurement)
	TECSOU	(Technique of sounding measurement)
Note: *Reference Appendix F for WATLEV attribution.* • *If several assigned rocks are found to be part of a inshore rocky area, the hydrographer may elect to delineate the area as foul area (OBSTRN area with CATOBS = Foul Area) and forgo investigating each individual rock (i.e. descrp=Not addressed, remrks= "Rock is part of foul area"). The hydrographer shall address any rocks that they feel are navigationally significant within the foul area.*		
OBSTRN (Obstruction)	VALSOU*	(Value of sounding)
	WATLEV**	(Water level effect)
	QUASOU	(Quality of Sounding Measurement)
	TECSOU	(Technique of sounding measurement)
	CATOBS	(Category of Obstruction)
	NATSUR	(Nature of Surface)
** <u>For line or area objects</u> - VALSOU should represent the shoalest depth representing the feature or within the area obstruction and should match either the shoalest grid node or designated data point. VALSOU should be left blank if depth not available.* ***<u>For line or area objects</u> - If VALSOU is not known, use WATLEV = "Unknown". If a VALSOU least depth is given, use WATLEV = Covers and Uncovers, Awash or Always Submerged.* *Reference Appendix F for WATLEV attribution.*		
PILPNT (Pile)	CATPLE	(Category of pile)
	CONDTN	(Condition)
Note: • *MBES data on pilings supporting and abutting piers and superstructures shall be rejected. The piers or structures shall be surveyed as shoreline construction (SLCONS) features.* • *Pile vs. Obstruction – a pile should be classified as an obstruction if it poses a threat to surface navigation.*		

MORFAC (Mooring/Warping facility)	CATMOR	(Category of mooring/warping facility)
	BOYSHP	(Buoy shape)
	COLOUR	(Color)
	COLPAT	(Color pattern)
	CONDTN	(Condition)
	NATCON	(Nature of construction)
	STATUS	(Status)

Note: *If a MORFAC is found to be submerged, the object shall be classified as an OBSTRN with CATOBS = 1 Snag/Stump*

SBDARE (Seabed area) *Point Objects*	NATSUR*	(Nature of surface)
	NATQUA*	(Nature of Surface - Qualifying Terms)
	COLOUR	(Color)

** Multiple characteristics, colors and qualifiers may be used. The constituents should be comma separated in order of predominance using the S-57 ID number. See Appendix H for further details on encoding bottom samples.*

Note*:*

A complete description of a bottom sample consists of: one adjective describing the grain size or consistency; one adjective designating the color; and one noun naming the class of bottom material. If the sample consists almost entirely of one constituent, only one noun shall be used. If the sample consists of two or more constituents, the nouns for the primary constituents shall be used and arranged in order of their predominance. For example, if a sample of fine black sand contains a smaller portion of broken shells and a couple of pebbles, the bottom characteristic shall be recorded as follows:

fne bk S brk Sh

Sediments are typed according to the size of the particles. Table 1, located in Appendix H, is a general guide for classification of sands and courser particles. It is not intended that the dimension be measured. A careful estimation by eye is satisfactory. 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 of, mud.

Consistencies of bottoms determined by feeling with lead line or sounding pole (without visual examination of the material) should usually be described as "hard" or "soft". The term "rocky" may be used only when it is known positively that the bottom is bedrock or consists of material larger than gravel, although a specimen was not obtained for examination. "Rock" is only used when solid rock or a rock ledge is visible to the hydrographer.

The return of an empty sampler is not a sufficient reason to label the bottom as "hard or "soft". If a bottom sample was attempted but no sample was recovered the NATSUR will be categorized as Unknown. Do not use the NATQUA "hard" attribute for unsuccessful samples.

<table>
<tr><td rowspan="4">SBDARE (Seabed area)
Line and Area Objects</td><td>NATSUR*</td><td>(Nature of surface)</td></tr>
<tr><td>WATLEV</td><td>(Water Level Effect) - reefs, ledges and rocky seabed areas</td></tr>
<tr><td>WATLEV</td><td>(Water Level Effect) - rocky seabed areas that extend to shore</td></tr>
<tr><td>NATQUA</td><td>(Nature of Surface - Qualifying Terms)</td></tr>
<tr><td colspan="3">* Use NATSUR = rock for rocky seabed areas
Note:
• SBDARE line or area objects may be used to characterize areas with numerous discrete submerged rocks (rather than encoding individual rock features) and/or areas of the seafloor that are rocky in nature. The extents of the area should be delineated and characterized as SBDARE (seabed area), and the attribute NATSUR (nature of surface) encoded as “rock”. See Sections 5.2.1.2.3 and 7.4 for more guidance on designating soundings in rocky areas.</td></tr>
<tr><td>COALNE (Coastline)</td><td>CATCOA</td><td>(Category of Coastline)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="3">SLCONS (Shoreline construction)</td><td>CATSLC</td><td>(Category of shoreline construction)</td></tr>
<tr><td>CONDTN</td><td>(Condition)</td></tr>
<tr><td>WATLEV</td><td>(Water level effect)</td></tr>
<tr><td colspan="3">Note:
Data under charted man made features (e.g. piers, anchor chains) will be rejected and not included in delivered products. This includes the MBES data on pilings supporting and abutting piers and superstructures. The exceptions to this rule are data under bridges and other features above the surface of the water that do not impede waterborne traffic and small marina style “finger” piers that are supported by standard pilings. In the case of “finger” piers, the pier structure should be rejected but the seafloor shall remain in the data. All assigned and any new (within sheet limit) piers or structures shall be surveyed as shoreline construction features and included in the FFF.</td></tr>
<tr><td>LNDARE (Land area)
Point, Line, or Area</td><td colspan="2">Used to characterize islets. Should be accompanied by LNDELV point or line object, denoting the highest point of the feature. LNDARE point objects accompanied by LNDELV point objects must share exact geographic positions to the maximum allowable precision by the S-57 encoding software using a “Copy Feature Geometry” or similar tool. See WATLEV Attribution Figure F.1 in Appendix F for vertical height requirements by geographic area. The minimum horizontal requirements for charting an islet as an area object are 0.65 mm by 0.5 mm at the largest scale chart of the area.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>LNDELV (Land elevation)</td><td>ELEVAT*</td><td>(Elevation)</td></tr>
<tr><td colspan="3">*Elevation is relative to the MHW datum</td></tr>
</table>

7.5.2 NOAA Extended Attribution

The hydrographer shall attempt to provide as much additional information as possible on a feature to facilitate the Hydrographic Branches in final chart compilation of the survey. The additional information shall be included with the feature in the NOAA Extended Attributes instead of the Descriptive Report. NOAA Extended Attribution is not part of the IHO S-57 Standard but is classified as mandatory and conditional using the guidance in this section.

The following Attribute Legend shall be used for the subsequent tables in Section 7.5.2:

Attribute Legend:	
Mandatory	
Conditional	

Assigned (Section 7.3.1), new (Section 7.3.2), and disproved (Section 7.3.4) features require these mandatory NOAA Extended Attributes:

Attribute	Description		
descrp	Description	Portrays the field charting action.	
		New	New features or new position
		Update	Modification to attribution, geometry, and/or feature object class. Exception: change of geometry for line and area features
		Delete	Disprovals or erroneous features
		Retain	Addressed items that are represented properly on the chart. Included a remark for informational purposes as necessary
		Not Addressed	'Assigned' items from the COR/HSD Project Manager which were not addressed. Include remark describing why the feature was not addressed

Examples (New/Delete vs. Update):

1. Charted feature is not submerged (e.g. wreck visible above MLLW) and the new position is greater than 2mm at the scale of the survey (e.g. 20m for 1:10,000) from the charted feature:
   - descrp = Delete for incorrectly charted feature
   - descrp = New for correctly charted feature
2. Charted feature is not submerged (e.g. wreck visible above MLLW) and is positioned within 2mm at the scale of the survey (e.g. 20m for 1:10,000) from the charted feature:
   - descrp = Update (populate surveyed height/depth of feature)
3. Charted feature is submerged and found in new position via multibeam, regardless of proximity to charted feature:
   - descrp = Delete for charted feature (delivered from CSF)
   - descrp = New for surveyed feature (derived from grid sounding)
4. Charted line or area feature geometry has changed.
   - descrp = Update; then manually edit the geometry to extents of bathymetry

   OR when extensive geometry changes are needed:
   - descrp = Delete for incorrectly charted feature
   - descrp = New for correctly surveyed feature

remrks	Remarks	Provides additional information about features that is not captured elsewhere in the digital data (e.g. s-57 attribution)
Note: • *See Section 7.3.1 for descrp/remrks of assigned features located between the surveyed NALL and 0.8mm buffer.* • *Do NOT include exact geographic positions (Latitude and Longitude), least depths, etc.*		
recomd	**Recommendations**	Charting Recommendations – As needed, include information to ensure proper charting of a feature.
Note: • *Only required for new features and charted feature disprovals.* • *Do NOT include exact geographic positions (Lat.- Long.), least depths, etc.*		
sftype	Special Feature Type	Indicates a feature with a special designation
	ATON	ATON investigations
	DTON	Dangers to Navigation
	Maritime Boundary	Maritime Boundary investigations
	Lidar Investigation	Lidar investigations
Note: Only required for special feature type objects		
dbkyid	Database Key ID	Unique ID for use in relational database
images	Images	Images associated with a feature (i.e. MBES or SSS screen-grabs or digital photos)
***Note*:** • *Required for DtoN, WRECKS, OBSTRN, OFSPLF, maritime boundary points, and significant baring/exposed features. WRECKS images shall include the approximate dimensions of the wreck.* • *The required format for all images (including 2-D graphics, 3-D graphics and photos) shall be JPEG, PNG, GIF, or TIFF.* • *Images shall have a unique identifier name.* • *Multiple images for one feature shall be semi-colon delimited.* • *All images (including SSS contact images) and photographs shall be placed in the Multimedia folder. A copy of the side scan sonar contact images shall remain in the CARIS HDCS folder if CARIS software is used for processing.* • *Do not include images in the S-57 PICREP attribute.*		
obstim	Observed Time	Observed time in the format YYYYMMDDThhmmss
Note: • *Required for contractor DTON submission (see Section 1.5)*		

7.5.3 NOAA Discretionary Attribution

The following is a list of additional NOAA Extended Attributes that are discretionary.

Attribute	Description		
acqsts	Acquisition Status	A tracking tool used during data processing that ensures features are fully investigated as necessary.	
		Investigate	Indicates that further field examination and analysis are required.
		Resolved	Indicates that field examination and analysis is completed.
asgnmt	Assignment Flag	Indicates assignment status of items delivered to the field by the HSD Operations or NSD project manager.	
		Unassigned	Not assigned
		Assigned	Assigned
		For Info Only	For Information Only
Note: • *See section 7.3.1 for how to address assigned features* • *For Information Only features are for reference only and do not need to be verified or addressed by the field unit.*			
cnthgt	Contact Height	Contact height of side scan sonar contacts.	
invreq	Investigation Requirements	Specific investigation requirements defined by the HSD Operations or NSD project manager.	
Example of invreq: • *Specific requests from customers about particular features, or questionable features that may warrant extra attention.* • *The survey limit feature (TESARE) includes: H number, Priority, Sheet Name.*			
keywrd	Keyword	Customized word used for processing or querying data.	
prkyid	Primary Key ID	Provides a means for manual correlation. The primary key ID can be populated for the secondary feature with the primary feature's Database key ID.	
prmsec	Primary/Secondary Status	Indicates the status of the feature during feature or contact correlation.	
		Primary	Principal feature that can be associated with one or more secondary features.
		Secondary	Indicates that the feature is correlated to the primary.
		Pending	Indicates that further analysis or examination is required.
userid	User ID	Provides a unique identifier.	

8 Deliverables

Contents

8.1 Field Reports

Reported horizontal positions shall be recorded in meters, with a precision of at least decimeters (refer to Section 5 regarding requirements for vertical (depth) positions). This precision shall be maintained throughout the processing pipeline and be maintained in the digital data.

All field units (in-house and contract) shall adhere to the hydrographic survey report naming conventions and format. Hydrographic survey report digital files submitted to and handled by HSD shall be delivered in separate reports and follow the standard naming convention as listed below:

Descriptive Report:

- Main Body
  (Sections A through D) in XML DR format:
  - Format: <Survey Registry Number>_DR.xml
  - Example: “H12345_DR.xml”
- Full Report
  (Cover Sheet, Title Sheet, Sections A through E) in Portable Document Format (PDF):
  - Format: <Survey Registry Number>_DR.pdf
  - Example: “H12345_DR.pdf”

- Appendices in Portable Document Format (PDF):

  I. Tides and Water Levels:
  * Format: <Survey Registry Number>_Tide_Request.pdf
  * Example: "H12345_Tide_Request.pdf"

  * Format: <Survey Registry Number>_Tide_Note.pdf
  * Example: "H12345_Tide_Note.pdf"

    (If applicable)
    - Format: <Survey Registry Number>_Vertical_Control_Memo.pdf
    - Example: "H12345_Vertical_Control_Memo.pdf"

    - Format: <Survey Registry Number>_VDATUM_Validation_Report.pdf
    - Example: "H12345_ VDATUM_Validation_Report.pdf"

    - Format: <Survey Registry Number>_Transmittal_Letter.pdf
    - Example: "H12345_ Transmittal_Letter.pdf"

  II. Supplemental Survey Records and Correspondence:

  DTON Files:
  (Use unique sequential numbering scheme for multiple reports)

    - Format: <Survey Registry Number>_DTON_Report_unique#.pdf
    - Example: "H12345_DTON_Report_1.pdf"

    - Format: <Survey Registry Number>_DTON_NDB_Verification_unique#.pdf
    - Example: "H12345_DTON_NDB_Verification_1.pdf"

  Other Correspondence (if applicable):
    - Format: <Survey Registry Number>_Description_Correspondence.pdf
    - Example: "H12345_Bomb_Ordinance_Area.pdf"

Separates:

- I. Acquisition and Processing Logs in Portable Document Format (PDF):

  - Format: <Survey Registry Number>_Aquisition_and_Processing_Logs.pdf
  - Example: "H12345_ Aquisition_and_Processing_Logs.pdf"

- II. Digital Data in Portable Document Format (PDF):

  Crossline Comparisons:
  - Format: <Survey Registry Number>_Crossline_Comparison.pdf
  - Example: "H12345_Crossline_Comparison.pdf"

  Sound Speed Data Summary:
  - Format: <Survey Registry Number>_Sound_Speed_Data_Summary.pdf
  - Example: "H12345_Sound_Speed_Data_Summary.pdf"

Descriptive Report Supplemental Reports:

- Data Acquisition and Processing Reports in Portable Document Format (PDF):

    - Format: <Project Number>_DAPR.pdf
    - Example: "OPR-A123-KR-10_DAPR.pdf"

- Data Acquisition and Processing Report Appendices in Portable Document Format (PDF):

    - Format: <Project Number>_DAPR_Appendices.pdf
    - Example: "OPR-A123-KR-10_DAPR_Appendices.pdf"

- Horizontal and Vertical Control Reports in Portable Document Format (PDF):

    - Format: <Project Number>_HVCR.pdf
    - Example: "OPR-A123-KR-10_HVCR.pdf"

In rare instances it may be necessary for a field unit to submit a revised version on a hydrographic survey report. This occurs most often when the DAPR submitted with the first survey of a long project (as required in Section 8.1.5.1) does not include all information required for later surveys.

Field units shall take all practical steps possible to avoid revision and resubmission of reports. However, when revisions are necessary, the following guidance shall apply:

- The revised report shall fully supersede all previous versions

    * For example, if a DAPR is submitted with the first survey of a project, and subsequently revised for the second survey, the revised DAPR shall apply to both surveys and replace the original submission

- Revised reports shall be identified by inclusion of a revision number in the name as follows:

    * Format: <Report Base Name>_rev<revision number>.<suffix>
    * Examples:
        - "OPR-A123-KR-10_DAPR_rev1.pdf" (the first of the DAPR for OPR-A123-KR-10; fully supersedes "OPR-A123-KR-10_DAPR.pdf"
        - "H12345_DR_rev2.xml (the second revision of the DR file for H12345; fully supersedes "H12345_DR_rev1.xml" and "H12345_DR.xml")

8.1.1 Progress Reports

8.1.1.1 Weekly Progress Reports

The purpose of the weekly progress report is to keep the project managers and Coast Survey staff apprised of ongoing fieldwork. The field unit shall submit a weekly progress report during field operations, no later than Monday (close-of-business), each week of field acquisition, emailed to the assigned HSD Project Manager with a CC to progress.sketches@noaa.gov.

Weekly Progress Report Contents:

a. Brief narrative summarizing the past week's activities and the anticipated plans for the coming week. The narrative shall discuss all activities related to mobilization/demobilization, control station installation, and data acquisition progress. Other major issues (e.g. significant weather delays, equipment failures, etc.) that may affect acquisition milestones shall be discussed.

b. Graphic showing an up to date coverage map, the project sheet limits, an appropriate chart, and a simple title block indicating the appropriate contractor/field unit name, plain language project name, and date of coverage. See example in figure, below.

c. An up to date coverage map geoTIFF that is 5MB or less with a white background, projected to the project's WGS84 UTM zone.

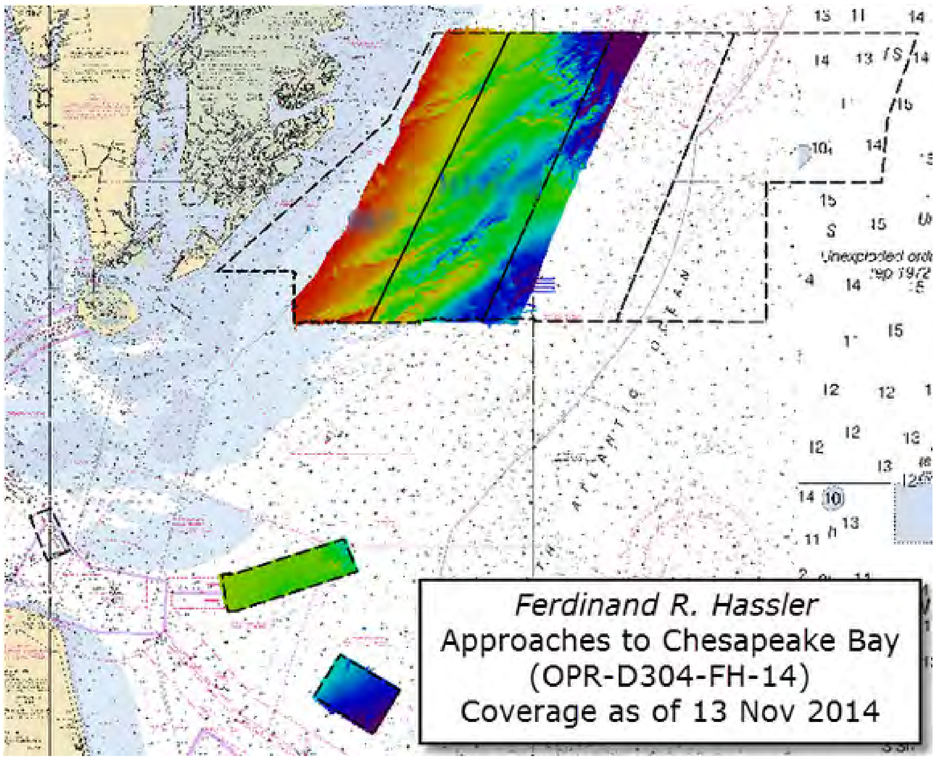


Figure 8.1: Example of a weekly progress report graphic.

8.1.1.2 Monthly Progress Report

The hydrographer shall report Monthly Survey Progress digitally as one Excel file in accordance with the guidance below by the fifth day of the month following survey operations. NOAA field units shall submit the report via email to progress.sketches@noaa.gov. Contractors shall submit the report via TOMIS, Task Order Management and Information System. To assist in the submission of this information, HSD Operations Branch will provide each ship and contractor with a Monthly Report Excel file with separate tabs as indicated below. See example (Figure G.1) in Appendix G.

a Survey Progress Estimate – This will be used to track estimated monthly survey progress by area within a given month. It will be a spreadsheet that consists of rows showing the vessel's current project and all associated survey sheets. Column titles are self-explanatory. For each month that data is acquired on a survey sheet (as well as sheets that are still incomplete) the cumulative percentage completed through the end of that month should be entered in the spreadsheet. Any modifications to the initial survey sheet layout must be reported.

b Project Statistics – This will be used to track monthly statistics other than square nautical miles. Since each row of the spreadsheet represents a specific project within a given month, the field is advised to maintain one sheet for the entire fiscal year and submit the updated version every month. The following provides clarification of the columns within the spreadsheet:

- The "LNM VBES" (vertical beam echo sounder), "LNM MB" (multibeam), and "LNM SSS' (side scan sonar) are for the purpose of reporting operations using only one sonar sensor.
- The "LNM Combo" is for reporting LNM if a combination of sensors is used., such as side scan and single beam or multibeam and side scan.
- The LNM above are to be subdivided between ship and launch platforms as appropriate.
- "Items Investigated" includes the number of assigned items or newly discovered items that require extra survey time.
- "Tide Gauges Installed/Removed" and "Bottom Samples" are the only other stats needed from NOAA survey vessels.
- Contractors are still required to report Days at Sea (on site working on the project) and days (or fraction of days) lost due to weather or equipment malfunction.

c Vessel Utilization – This is a requirement for NOAA vessels only. Refer to the OCS Field Procedures Manual, section 5.2.2.2.1 for details.

8.1.2 Survey Outline

After completion of all field work for a given survey sheet, the hydrographer shall provide a survey outline that shows the extent of hydrography completed for the registered survey (e.g. H number). This outline shall bound the extent of continuous survey data judged by the hydrographer to be adequate to supersede the chart. Along shore, the survey outline shall be coincident with the NALL as surveyed in accordance with the Hydrographic Survey Project Instructions and Section 1 of this document.

Careful attention should be paid in the near shore area to ensure that features and bathymetry inshore of the NALL are not included. The survey outline need not include all discrete features contained in the S-57 feature file deliverable (i.e. a rocky area or ledge may extend inshore of the survey outline). Also, the Survey Outline should not inscribe high water features positioned inshore of the NALL (e.g., Aids to Navigation).

The only exception to this is coverage acquired pursuant to investigation of assigned items from HSD Operations or NRB, which should be inscribed by the Survey Outline, and LIDAR surveys. The survey outline for a LIDAR survey shall be coincident with the MHW.

The final survey outline shall normally be a single, completely enclosed polygon bounding the final surveyed area as described above. In cases where this area includes an unsurveyed region (e.g., an island), the survey outline file will also include an interior limit (i.e., 'donut hole') following the NALL around this area. In cases where the survey includes a detached surveyed area (e.g., an assigned item with a search radius that does not intersect the main body of the survey), the final survey outline file shall include a separate polygon for the detached area.

The final survey outline should be compiled as the S-57 Feature Object Class M_COVR in a .000 format in the WGS84 datum, unprojected. The outline shall not be include in the FFF. The M_COVR feature shall be attributed as follows:

Object	Attribute	
	Acronym	Description
M_COVR (Coverage)	Used for survey outline.	
	CATCOV	(Category of coverage)
	INFORM	(Inform)
	NINFOM	(Information in national language)

***INFORM**: shall be populated with the following information separated by semi-colon in this order:*
- *Platform; State; Scale*

Example: FH; MD; 20,000

***NINFOM**: shall be populated with the technique of sounding measurement.*
- *Use the terms: Lidar, MBES, VBES, or SSS.*
- *If more than one technique was used separate the techniques by a semi-colon. Example: MBES; SSS.*

Final survey outlines shall be submitted via email survey.outlines@noaa.gov with a CC to the HSD Project Manager/COR. NOAA field units shall reference Section 5.2.2.3.2 of the OCS Field Procedures Manual for additional guidance.

The final survey outline should be submitted as soon as practical after completion of field work. If the outline has not been submitted within 30 days of completion of field work, the hydrographer shall contact HSD Project Manager/COR to explain the delay and provide an estimate for delivery. Any large differences (± 10%) between the total square miles reported via the Survey Progress Report for the survey and the area defined by the survey outline should be explained in the cover e-mail. Email the outline to survey.outlines@noaa.gov.

8.1.3 Coast Pilot

A field verification of Coast Pilot information, referred to as a Coast Pilot Review, shall be conducted for each assigned survey area. Additionally, information relating to the general operations area (e.g. areas frequently transited and facilities utilized during imports) should be reviewed and verified or updated to whatever extent practicable.

A Coast Pilot Field Report will be provided by HSD Operations. This report may contain specific questions about items in the Coast Pilot that require field verification or clarification. In addition, this report may contain the actual paragraphs from the Coast Pilot that are affected by the survey area.

Coast Pilots are updated on a weekly basis. Updated Coast Pilots can be downloaded from the Coast Pilot website (http://www.nauticalcharts.noaa.gov/nsd/cpdownload.htm). The hydrographer shall first download the latest edition of Coast Pilot and compare against the information contained in the Coast Pilot Field Report. In the event of a conflict between the two sources, the review shall be completed using the information in the downloaded Coast Pilot.

A Coast Pilot Review Report shall be submitted following the completion of operations within a project area, and no later than at the time of submission of the first Descriptive Report for that project. If an updated edition of the Coast Pilot was used, this shall be noted. In this report, the hydrographer shall respond to each question posed in the Coast Pilot Field Report. If the hydrographer is not able to address a specific question, that shall also be noted. In addition, the hydrographer shall make reasonable attempts to verify the text of the actual Coast Pilot paragraphs that are affected by the survey during field operations. Updates shall be made as follows:

- Deletions to the existing text shall be shown as strikethroughs.
- Recommended revisions, including any new information that would be beneficial to the mariner, shall be shown in red text.
- Existing text that has been reviewed and verified to be correct during field unit operations shall be changed to green text.
- Existing text that could not be verified or refuted during operations shall remain in black.

The consolidated Coast Pilot Review Report shall be submitted in a PDF format and shall include answers to the specific questions, updates to the actual paragraph text, and the original Coast Pilot Field Report. This file shall be named <Project Number>_Coast Pilot Review Report.pdf (Example: "OPR-A123-KR-15_Coast Pilot Review Report.pdf") and submitted via email to OCS.NDB@NOAA.GOV and Coast.Pilot@NOAA.GOV (with a CC to the HSD Project Manager/COR).

8.1.4 Descriptive Report (DR)

A Descriptive Report is required for each hydrographic survey completed, unless specified otherwise in the Hydrographic Survey Project Instructions.

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; and 4) provide 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 Project 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 the survey data with information that cannot be depicted or described in the digital data. The Descriptive Report describes the conditions under which the survey was performed, discusses important factors affecting the survey's 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.

The Descriptive Report shall be submitted electronically in both XML and Adobe PDF format as described below. The XML file shall validate against the latest version of the XML DR schema. The PDF file shall be generated using the latest version of the XML DR stylesheet. The schema will define the required structure, order, and information to be included in the DR. The stylesheet will ensure that the PDF are formatted in a consistent manner. NOAA field units shall generate the DR using the most recent version of the Pydro XML DR Application. Contractors will be provided an XML schema and stylesheet by their COR.

The XML file shall be named according to the Registry Number of the Survey (ex: H12345.xml). All images and other linked files shall be included in a folder named "SupportFiles" and shall be reference in the XML file using relative path names. Both the XML file and the SupportFiles folder shall be submitted as a single zip file, named according to the Registry Number of the Survey (ex: H12345.zip).

Submit the entire Report (Cover Sheet, Title Sheet, Sections A through E) in a single PDF file. The appendices shall be submitted as a separate PDF file.

The Descriptive Report shall not be encrypted, secured, or locked.

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

COVER SHEET & TITLE SHEET

The Cover Sheet is used to identify the survey, while the Title Sheet is often referred to for information pertaining to the survey. Both the Cover Sheet and the Title Sheet shall be populated from information entered into the Metadata section of the XML DR.

The following metadata will be included in the Project Letter Instructions: Project Number, Project Name, General Locality, Field Unit, Registry Number, Sheet ID, Sublocality, State, Country, and Scale.

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 major subcontractors. If applicable, include the UTM zone number.

Descriptive Report TEXT

General statements and detailed tabulations of graphically evident data, such as inshore rocks, shoals, or coral heads already shown in the S-57 final feature file should normally 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 digital products should be completely described in the Descriptive Report.

Include all information required for complete understanding of the field records. When referring to a hydrographic feature in the S-57 final feature file, give the latitude and longitude of the feature. Discussions and explanations should be written in a clear and concise manner. Avoid using geographic names in the text of the Descriptive Report that do not appear on the nautical chart. Avoid verbosity.

A. AREA SURVEYED

Provide general information about the area surveyed, the quality of the survey, and the survey coverage. In addition, include the dates of the survey, the square nautical miles (SNM), and the lineal nautical miles (LNM) acquired during the survey.

- Survey Limits shall be entered in decimal degree format.
- The Coverage Graphic shall be 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. A second small scale graphic should be included if necessary to provide additional geographic context of where the survey is located.
- When appropriate, simple statements indicating adherence to the Project Instructions, Statement of Work, or HSSD are acceptable (e.g. "Survey Limits were acquire in accordance with the requirements in the Project Instructions and the HSSD.")
- Lineal nautical miles that are deleted for any reason shall not be included.
- Specific dates of data acquisition shall reflect the days of work for the referenced survey only, not the total project.

B. DATA ACQUISITION AND PROCESSING

B1. Equipment

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, lidar system, vessel attitude system, positioning system, sound speed 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 8.1.5.1 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.

- Crosslines - State the percentage of crossline miles as compared to main scheme miles. Evaluate their general agreement. 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. See Section 5.2.4.3 for additional information.

- Uncertainty - Discuss the uncertainty values of the submitted CARIS generated surfaces (uncertainty or CUBE) and/or BAG(s). Explain and/or justify any areas that have an uncertainty greater than the IHO levels allowed as described in Section 5.2.2 and 5.3.2.

- Junctions - Junctions are made between adjoining contemporary surveys to ensure completeness and relative agreement of depths. Evaluate survey junctions as assigned in the Project Instructions and evaluate survey junctions between sheets of current project. 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.

- Sonar Quality Control Checks – Discuss whether there were any deviations from the Quality Control Checks described in the DAPR. In there were no deviations, a simple statement is adequate (e.g. "Sonar system quality control checks were conducted as detailed in the quality control section of the DAPR.").

- Equipment Effectiveness - 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. If the equipment operated as expected, a simple statement is adequate (e.g. "There were no conditions or deficiencies that affected equipment operational effectiveness.").

- Factors Affecting Soundings - 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. When appropriate, a simple statement indicating that none of these factors were present (e.g. "There were no other factors that affected corrections to soundings.").

- Sound Speed Methods - Provide a brief discussion on how the sound speed instruments (CTD, Moving Vessel profiler, Thermosalinograph etc.) were used and describe the frequency of the SVP casts. If appropriate, describe how the survey area was zoned to account for sound speed variations from differing water masses.

- Coverage Equipment and Methods - Discuss the specific equipment and survey methods used to meet the requirements for object detection and coverage for different areas of the survey. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All equipment and survey methods were used as detailed in the DAPR.")

B3. Corrections to Echo Soundings

- Corrections - Discuss any deviations from those described in the Correction to Echo Soundings section of the Data Acquisition and Processing Report. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All data reduction procedures conform to those detailed in the DAPR.")

- Calibrations - Discuss the results of any sounding system calibration (e.g. patch test) conducted after the initial system calibration that affect the survey data and were not included in the Data Acquisition and Processing Report. Comment on the reason a new calibration was conducted. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All data reduction procedures conform to those detailed in the DAPR.")

B4. Backscatter

Discuss whether backscatter data was acquired and include any additional comments. If applicable, a simple negative statement is acceptable (e.g. "Backscatter was not acquired for this survey.")

B5. Data Processing

- Software Updates - List any new software updates or additions that were not discussed in the DAPR. State the NOAA Extended Attribute files version number used during feature management processing (e.g. "NOAA Extended Attribute Files V#_#").

- Surfaces - Provide details of all submitted CARIS generated surfaces (uncertainty or CUBE), SSS mosaics, and/or BAG(s).

C. VERTICAL AND HORIZONTAL CONTROL

Provide a summary of the methods used to determine, evaluate, and apply tide or water level corrections to echo soundings on the survey. Discuss any additional information, not already included in the HVCR. When appropriate, a simple statement referencing the HVCR is acceptable (e.g. "Additional information discussing the vertical or horizontal control for this survey can be found in the accompanying HVCR.") See Section 8.1.5.2 for additional information to be provided in the project Horizontal and Vertical Control Report. NOAA field units should also refer to Section 5.1.2.3 in the OCS Field Procedures Manual.

C.1 Vertical Control
State the vertical datum used for the survey. Indicate which vertical control methods were used during the survey (Discrete Zoning, TCARI, ERZT, VDatum, and/or Constant Separation). List any NWLON or subordinate tide stations used during the survey. List any tide buoys used during the survey. If appropriate, state the names of the water level and tide corrector files that were used, as well as the dates that Final Tides were submitted and received. If preliminary zoning was used, describe how it was determined to be accurate and describe any changes that were

made to the preliminary zoning scheme. If appropriate, state the name of the ellipsoid-to-chart datum file.

C.2 Horizontal Control
State the horizontal datum used for the survey. Indicate which horizontal control methods were used during the survey (PPK, PPP, RTK, WAAS and/or DGPS). List any CORS or user installed base stations used during the survey. Explain in detail any difficulties that may have degraded the expected position accuracy.

D. RESULTS AND RECOMMENDATIONS

D.1 Chart Comparison

Compare the survey with all of the largest scale corresponding bathymetric products available (e.g. Electronic Navigational Charts (ENCs) and Raster Nautical Charts (RNCs)) to prove or disprove any exceptional natural seafloor or features attained by the survey coverage.

For each category, a simple statement can be included in instances when all features exist as charted or no features exist in the category, or no investigation was assigned. In instances when there was no investigation of assigned existing features, provide an explanation of why the investigation was not conducted.

- Methods – Discuss the methods used for the chart comparison in sufficient detail to demonstrate that the chart comparison was accomplished adequately. A method for accomplishing this is a comparison between the digital surfaces generated from the survey data and the largest scale ENC using appropriate GIS software.

- Charts - Comment on the degree of general agreement with charted soundings and discuss general trends, such as shoaling or deepening occurring in the survey area. A detailed evaluation of every charted sounding is not required. Identify the chart by number, scale, edition number, edition date, dates of the most recent Local Notice to Mariners and Notice to Mariners. In addition, Notices to Mariners affecting the survey area which were issued subsequent to the date of the Hydrographic Survey Project Instructions 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. A general chart comparison between survey depths and charted soundings should be conducted.

- Maritime Boundary Points - Discuss any Maritime Boundary features that were investigated during this survey.

- Charted Features – Discuss any charted features or soundings that contain the label PA, ED, PD, or Rep (see Chart No. 1 for definitions.). The source of the charted feature should be listed, if known. Describe the condition and distinguishing characteristics of all items mentioned.

- Uncharted Features – Discuss all new features not addressed as a DTON, as defined in Section 1.5. Describe the condition and distinguishing characteristics of all items mentioned.

- Shoal and Hazardous Features – Conduct a detailed comparison between the survey data and all charted shoals and potentially hazardous features. Describe the methods of investigation and include the least depths for significant changes. In indicate whether any Danger to Navigation Reports were submitted for this survey.

- Channels – 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 and range lines.

- Bottom Samples – Briefly discuss the results of any bottom samples acquired during the survey.

D.2 Additional Results

The field unit shall not list individual features or their coordinates in this section. Any features where the existence (including new features), position, minimum clearance, condition, or status deviate from the chart shall be included and attributed in the Final Feature File. For each category, a simple statement can be included in instances when all features meet their intended purpose, or all features exist as charted, or no features exist in the category. In instances when there was no investigation of existing features, provide an explanation of why the investigation was not conducted.

- Prior Surveys - If applicable, briefly discuss any prior survey comparisons. 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.

- ATONS - 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 7.3.5.) NOAA units should refer to Section 3.5.3.3 of the OCS Field Procedures Manual and Hydrographic Survey Project Instructions for specific guidance on positioning aids to navigation.

- Overhead Features - Discuss any bridges, overhead cables, and overhead pipelines. Any clearances that are provided shall be 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 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.

- Submarine Features - Discuss any submarine cables, submarine pipelines, tunnels, and any associated crossing signs on the shoreline.

- Platforms – Briefly discuss any drilling structure, production platform, and well head within the survey area (excluding temporary jack up rigs) and note any large discrepancies from the charted positions.

- Ferry Routes and Terminals - Discuss any ferry routes and ferry terminals if not shown on the chart or contemporary NOS remote sensing maps.

- Abnormal seafloor or environmental conditions - 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.

- Construction of Dredging – Discuss any present or planned construction or dredging in the survey area that may affect the survey results or nautical charts.

- New Survey Recommendations - 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.

- Inset Recommendations - 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 approval sheet with a digital signature shall be included in the PDF file. It is important to note that there is a distinct difference between a true digital signature and a digitized signature. The latter is simply an image or other capture of a person's pen-and ink signature. By using a document scanner or an electronic pen capture device, a person's signature may be digitized. However, simply attaching this type of signature to an electronic document is not the same as attaching a digital signature.

A digital signature, by contrast, appends a cryptographic "key" to the document that can be used to verify the identity of the signer (authentication), ensure that no changes have been made to the document since signing (integrity), and ensuring that the signer cannot deny having signed the document (non-repudiation). Until such time as an organization-wide digital signature solution is implemented, the nature of self-signed digital signatures will limit authentication and non-repudiation capabilities of the system. The mechanism of applying the digital signature may include a digitized version of a person's signature, or it may not.

The approval sheet shall contain the following statements:

- Approval of the deliverable files, 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.
- Indication of the completeness of the survey and adequacy for its intended purpose. Recommendation of 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 Hydrographic Branch 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 submitted as a separate PDF file.

I. TIDES AND WATER LEVELS Include the following (if applicable):

- Field Tide Note (see Section 4.2.2).
- Final Tide Note to include the final tidal zoning and final tide reducers used to reduce the data to chart datum
- Abstract of Times of Hydrography (lists every day during which hydrography was conducted and the start and end times hydrography was conducted each day)
- A copy of the transmittal letter for project water level data submitted to CO-OPS
- Any other correspondence directly relating to tides and/or water levels
    - Vertical Control Memo
    - VDATUM Validation Report

NOAA Field Units;

- Field Tide Note (see Section 4.2.2)
- Final Tide Note (see Section 4.6.3). If Final zoning and approved water levels were applied by the field unit, include the Final Tide Note in the DR Appendix. The Final Tide Note is the letter provided by COOPS.
- Abstract of Times of Hydrography (lists every day during which hydrography was conducted and the start and end times hydrography was conducted each day)
- A copy of the "Request for Approved Tides/Water Levels" letter
- Any other correspondence directly relating to tides and/or water levels
    - Vertical Control Memo
    - VDATUM Validation Report

II. SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

Include any additional survey records not previously addressed in the Descriptive Report, Appendices or Separates. In addition, include the DTON recommendation file (PDF file only) and verification e-mail from NDB (e.g. DREG registration e-mail). Contractors shall receive courtesy copies of these files from the Hydrographic Branch. Any survey related communications, including email and phone calls shall also be included.

SEPARATES TO BE INCLUDED WITH THE SURVEY DATA

The following Separates shall be submitted with each survey. The Separates shall be submitted in a digital format and reside in the Separates folder as noted in Appendix J. NOAA units should refer to Section 5.1.2.2.2 of the OCS Field Procedures Manual for additional guidance on the content of DR Separates.

I. ACQUISITION AND PROCESSING LOGS

Include all acquisition and processing logs in digital format from the present survey. Include positioning confidence checks and sounding system comparison checks.

II. DIGITAL DATA

Crossline Comparisons

Include the summary plot analysis as a function of beam number if conducted for the main scheme/crossline intersections as required in Section 5.2.4.3 and 5.3.4.3 if applicable. Include any other crossline quality reports required by Hydrographic Survey Project Instructions.

Sound Speed Data Summary

Submit a list that can be imported into a GIS for office verifiers to analyze the distribution and frequency of the SVP casts. This deliverable should identify the positions and dates of all casts used; the maximum cast depth; and the dates/times for which the profiles were applied. CARIS users can fulfill this requirement with the submission of the SVP data that is within the CARIS project. Contractors and NOAA field units should refer to the location where the digital sound speed files are located, and include a directory listing of the files.

A vessel with a Moving Vessel Profiler (MVP) may use thousands of profiles for a single survey. In such cases, a table of each individual cast is not required. Instead, replace the table with a brief discussion on how the MVP was used (frequency, which areas of the survey, vessels and/or lines it was used, etc.) If individual casts were conducted as well, those casts should be included in a table.

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

8.1.5 Descriptive Report Supplemental Reports

8.1.5.1 Data Acquisition and Processing Report

For NOAA field units, the Data Acquisition and Processing Report (DAPR) is an annual report that shall be submitted before, or not later than, the submission of the first survey of the field season. The DAPR shall be sent to the Chief, Hydrographic Systems and Technology Program (HSTP) and the appropriate Hydrographic Branch specified in the Hydrographic Survey Project Instructions. NOAA field units shall issue subsequent DAPR versions upon effecting a significant change to any item(s) retained in the report. For Contractors, the DAPR is a project-wide report that shall be submitted before, or not later than, the submission of the first survey of the project. The DAPR shall be sent to the COR and appropriate Hydrographic Branch specified in the Hydrographic Survey Project Instructions with each survey. Field units and contractors shall nor encrypt, secure, or lock the DAPR or HVCR reports.

The DAPR is separated into three sections: Equipment, Quality Control and Corrections to Echo Soundings. These sections shall contain a detailed discussion on the information addressed below.

A digital copy of the main text of the DAPR shall be provided in Adobe Acrobat format.

Include a cover sheet which contains the following general information:

Cover Sheet. Include the survey year, field unit/contractor, Chief of Party/Lead Hydrographer, date and version (see Figure E.1 in Appendix E).

A. Equipment

Describe the major operational systems used to acquire survey data or control survey operations. Include the manufacturer, firmware version, model number and serial number of all equipment. Indicate how the equipment was used, as well as any operational settings. If applicable, indicate most recent calibrations and accuracy checks. Include a description of the vessel(s) used to acquire survey data.

Specifically discuss echo sounding and lidar systems and operations in this section, as well as other depth determination systems such as diver depth gauges, lead lines, sounding poles, etc. Include discussion of system specifications (e.g., range scales, number of beams, resolution and along track coverage) and indicate most recent system calibrations and accuracy checks. State whether correctors were determined and describe any nonstandard procedures used.

Discuss the computer hardware and software used for all data acquisition and processing, and provide a complete list of all software versions and dates.

B. Quality Control

Describe all data acquisition and processing methods, procedures, and parameters used.

Specifically discuss data processing routines for converting raw sounding data to the final bathymetric grid deliverables. Attach processing flow diagrams. Include a description of the methodology used to maintain data integrity, from raw sounding data to final soundings. Any methods used to derive final depths, such as cleaning filters, sounding suppression parameters, data decimation parameters, gridding parameters, and surface computation algorithms, shall be fully documented and described in this section. Discuss how the surface computation methodology (e.g., radius of propagation, uncertainty weighting, etc.) is consistent with object detection requirements.

Discuss the methods used to minimize the errors and uncertainties associated with depth determination, and provide details of how total propagated uncertainty (TPU) is computed for each sounding (see Section 5.2.3.5 or 5.3.1.2 for multibeam and lidar, respectively). Any deviation from this requirement shall be explained here.

Discuss how under the navigation surface concept individual soundings are propagated or combined into a node that is consistent with any specific object detection requirements for the project.

Methods and standards used to examine side scan sonar data should be noted and a description of processing procedures should be provided. Include the methods used for establishing proof of swath coverage and the criteria used for selecting contacts. Additionally, include a brief description of how the review of side scan sonar data meets object detection and accuracy requirements as per Section 6.1.2. Any compression method used in the review of the side scan display must be discussed (e.g., whether an average or maximum pixel intensity within a regularly-spaced across track interval X meters is used).

C. Corrections to Echo Soundings

This section addresses the methods used for the determination of all corrections to echo soundings. Describe the methods used to determine, evaluate, and apply the following corrections to echo soundings, including the uncertainties for each item:

- Instrument corrections
- All vessel configuration parameters, offsets, and layback. Include pictures or figures of the equipment as installed on board
- Static and dynamic draft measurements
- Roll, pitch and heading biases and navigation timing errors. State the manufacturer, model, accuracy, and resolution of positioning and attitude sensor(s). Discuss accuracy and alignment test procedures and results. Include copies of system alignment, accuracy and calibration reports
- All sound speed data applied to echo soundings, including sound speed profiles and surface sound speed measurements
- 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 a digitally signed statement of approval for all information contained within the Data Acquisition and Processing Report using the procedures prescribed in Section E under the Descriptive Report Approval Sheet.

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

Data Acquisition and Processing Report Appendices. The Appendices shall be submitted as a separate Adobe Acrobat file from the DAPR and in a digital format only.

1. Vessel Reports: Include vessel offset reports, vessel layback reports, and dynamic draft reports.
2. Echosounder Reports: Include echosounder system accuracy test ("confidence check") and system alignment test ("patch test") reports. Additionally, include data processing flow diagrams. If applicable, include manufacturer calibration reports.
3. Positioning and Attitude System Reports: Include positioning and attitude sensor calibration reports (e.g. GAMS calibration report) and system configuration reports (e.g. POS/MV configuration report).
4. Sound Speed Sensor Report: Include sound speed calibration reports.

8.1.5.2 Horizontal and Vertical Control Report

Report is a project-wide report which shall be submitted before, or not later than, the submission of the last survey in project area. NOAA field units should also refer to Section 5.1.2.3 in the OCS Field Procedures Manual.

A digital copy of the main text of the Horizontal and Vertical Control Report shall be provided in Adobe Acrobat format.

Include a cover sheet which contain the following general information:

- Cover Sheet - Include the type of survey(s), state, general locality, year and months, project number, vessel(s), field unit/contractor*, and Chief of Party-Lead Hydrographer.

*Note: Subcontractors may be referenced in the body of the report

A. Vertical Control

The Vertical Control section of the project Horizontal and Vertical 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 Project Instructions.
- Ellipsoidal benchmark positioning techniques and procedures

B. Horizontal Control

The Horizontal Control section of the project Horizontal and Vertical 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 at least the nearest 1/100th of a second.
- The longitude to at least the nearest 1/100th 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 a digitally signed statement of approval for all information contained within the Horizontal and Vertical Control Report using the procedures prescribed in section E under the Descriptive Report Approval Sheet.

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

8.2 Side Scan Sonar Deliverable

8.2.1 Side Scan Sonar Mosaic

For an object detection survey with a 200% side scan requirement, a separate side scan mosaic for each 100 percent coverage shall be used as a graphic means for demonstrating bottom coverage. Naming convention should follow HXXXX_SSS_1m_100 and HXXXXX_SSS_1m_200.

For a complete coverage survey, if SSS is used for the specified radius of a feature disproval, a separate side scan mosaic for the second 100 percent disproval radius lines shall be submitted as a separate mosaic. Naming convention should follow HXXXXX_SSS_1m_100 to demonstrate complete coverage for the entire survey area and HXXXXX_SSS_Disproval for the features disproved with SSS.

All object detection and complete coverage SSS mosaics should be generated into a single geo-referenced image file for the entire survey coverage area. Pixel resolution of the side scan mosaics should be 1m by 1m. The hydrographer shall submit a digital file of each 100% coverage (see Section 8.3.3).

The border shall be white in color and is specified to be Red, Green, and Blue (RGB) color palette index established to color 255. The side scan mosaic intensity values shall be displayed in gray scale.

8.2.2 Side Scan Sonar Contact File

A Sonar Contact file of contacts (Section 6.1.3.2) shall be delivered in a .000 file format and submitted in the Feature folder. The side scan sonar contact points shall be delivered as the S-57 feature object cartographic symbol ($CSYMB) with the attribution described in Section 6.1.3.3.

8.2.3 Data Acquisition and Processing Logs

All sonargrams and data acquisition/processing comments shall be submitted digitally. Time references shall be made in Coordinated Universal Time (UTC).

The hydrographer shall have a system to clearly indicate the status of the side scan acquisition system. Historically, this was accomplished by annotating the paper sonargram as the data was being collected. Further annotations could be made during field and/or office review of the sonargrams. Modern survey systems acquire the data digitally, therefore, separate data acquisition/processing logs may be used to record the needed information.

The following comments (or annotations) shall be made in a manner that they can be correlated by time or other method back to the digital side scan sonar record.

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.
- Operator's name or 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.
- While on-line, whenever the system set up or status changes.

First Position/Last Position Annotations

The following annotations shall be made at the first position on each survey line:

- 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 survey line:

- 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 also be annotated:

- Change in operator (new name or initials).
- Change in range-scale 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.
- Contact observed.
- 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.

Annotation Methods

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

- By use of an automatic annotator, if available.
- Typed entries in the data acquisition system.
- Typed entries in a separate annotation file.

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

8.3 Digital Data Files

The survey data will be supplied in a digital format. Hard copy plots and hard copy printouts of reports are not required.

This section is provided as a summary for the major digital deliverables that may be required for a typical hydrographic survey. Not all sections will apply to all surveys. Deliverables shall follow the appropriate Data Directory Structure in Appendix J. If a folder is intentionally left empty, place a Readme.txt file in the folder stating as such. For both single beam and multibeam data, Contractors should separate digital deliverables into two data types: raw and processed. Raw should be uncorrected or with exception of online corrections. Processed data should include the Caris HDCS format or GSF. Field units and contractors shall email a PDF of the Letter Transmitting Data to the COR/HSD Project Manager cited in the Project Instructions.

8.3.1 Media

Digital data shall be submitted on USB 3.0 compatible hard drives following the data directory structure in Appendix J. Each registered survey shall be submitted on a separate USB drive unless prior agreement is obtained from the HSD Project Manager/COR or Hydrographic Branch. Survey data shall be accompanied by NOAA Form 61-29 Letter Transmitting Data, see Appendix I. The hydrographer shall work with NOAA to ensure no compatibility problems exist after data submission.

NOAA field units shall submit an offsite backup of the raw data to the Hydrographic Branch upon completion of data acquisition. The offsite backup shall follow the directory structure in Appendix J, Figure J.1 and be accompanied by a corresponding NOAA Form 61-29 Letter Transmitting Data in Appendix I, Figure I.3. A check sum is not required for the raw offsite backup submission. The NOAA field unit final deliverable is the same as the NOAA contractor final deliverable; the raw and processed data following the directory structure in Appendix J, Figure J.2. A check sum on the survey deliverable is required, as detailed below.

Prior to submitting digital data to NCEI, the field unit shall verify that all files are present and none have become corrupt during transfer to a portable media. Both field units and contractors shall perform a check sum and generate a UNIX/LINUX hexadecimal formatted MD-5 hash of the content of the entire directory structure and include it in the digital data submission. The relative directory data structure must be used to allow verification at the Hydrographic Branch.

Data shall be submitted to Pacific Hydrographic Branch for West Coast, Alaska, and Pacific Islands projects and Atlantic Hydrographic Branch for East Coast, Gulf of Mexico, and Caribbean projects. All data submittals shall be send attention to the Chief of that Hydrographic Branch.

Chief, Pacific Hydrographic Branch
NOAA
Room 1001A, Routing N/CS34
Building 3
7600 Sand Point Way NE
Seattle, WA 98115-6349

Chief, Atlantic Hydrographic Branch
NOAA
Routing N/CS33
439 West York Street
Norfolk, VA 23510-1114

8.3.2 Bathymetric Data

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

"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.

Full Resolution Echosounding Data

The hydrographer shall submit full resolution echosounding data in a format readable by CARIS HIPS. Full resolution echosounding data shall be delivered fully corrected for tides, sound speed, vessel offsets, draft and dynamic draft. These corrections may be made within CARIS, with data submitted as a complete CARIS project (including HDCS files, sound speed files, Vessel Configuration, CARIS tide files, etc.). CARIS HIPS users shall not utilize the "Carry over raw data files" to the HDCS project structure during raw data conversion capability unless an exemption is approved by the HSD Project Manager/COR. Field units shall deliver all grids in the Bathymetry and SSS folder. Field units that process with versions of CARIS HIPS/SIPS earlier than version 9.0 shall submit the fieldsheet directory in the Bathymetry and SSS delivery folder (See Appendix J).

Alternately, non-CARIS HIPS users may submit fully corrected, such that it will be read in CARIS HIPS using a 'zeroed' Vessel Configuration file (.vcf or .hvf) and a 'zero' tide file (.tid), etc.

Full Resolution Lidar Data

The contractor shall submit the full resolution lidar data in CARIS compatible format. The submission will include the appropriate CARIS converter, lidar data before conversion, and all necessary CARIS files so that NOAA can reconvert all files, if desired. Field units shall deliver all grids in the Bathymetry and SSS folder. Field units that process with versions of CARIS HIPS/SIPS earlier than version 9.0 shall submit the fieldsheet directory in the Bathymetry and SSS delivery folder (See Appendix J).

CARIS BASE Surface and/or BAG

The final depth information from the survey will be composed of a collection of grids. This collection of grids must reflect the state of the seafloor at the time of the survey, with resolution and attribution as described in Section 5.2, and/or the Hydrographic Survey Project Instructions. The hydrographer must take steps to ensure that all data has been correctly processed and that appropriate designated soundings have been selected (see Section 5.2.1.2.3 and Section 7.4). The collection of grids representing the final reviewed results of the hydrographic survey shall be submitted as CARIS BASE or BAG surfaces. NOAA field units typically process hydrographic data using CARIS HIPS software. CARIS' format for the Navigation Surface is a Bathymetry Associated with Statistical Error (BASE) surfaces, either an Uncertainty or CUBE Surface. CARIS users shall include the version, service pack and hotfix numbers used during the creation of the surfaces in the Comments section during Step 1 of the BASE Surface Creation Wizard. Non-CARIS users may submit their Navigation Surfaces as a Bathymetric Attributed Grid (BAG).

All grids must adhere to the following naming convention: <Survey registry number>_<sounding type>_<units of resolution>_<vertical datum>.bag.
Sounding types are 'MB' for multibeam echo sounder, 'VB' for single beam echo sounder, and 'LI' for lidar.

- All user shall submit finalized grids by resolution and sounding type:

<Survey registry number>_<Sounding Type>_<units of resolution>_<Vertical Datum>_Final.BAG/.CSAR

Examples:
H11000_MB_50cm_MLLW_Final.bag/.csar
H11000_VB_4m_MLLW_Final.bag/.csar
H11000_LI_3m_MLLW_Final.bag/.csar

- CARIS users shall also submit the source .CSAR surfaces. This deliveable is not required for field units that do not use CARIS software for grid creation.

Example:
H11000_MB_50cm_MLLW.csar

Field units shall not submit combined BAG/CSARs.

Multibeam Calibration Data

The hydrographer shall submit data used for determining navigation time latency, pitch, roll, and yaw biases in a separate directory on the submitted drive. The data format shall be such that CARIS HIPS can convert the data, thus making it compatible as described earlier in this Section.

Other Bathymetric Data

Bathymetry from other sources (e.g., diver's least depth gauge, lead line, sounding pole, etc.) shall be submitted in a format readily understood and compatible with CARIS HIPS. As with other sources of bathymetric data, these soundings shall be delivered fully corrected for all offsets, biases, sound speed, and other factors, with corresponding uncertainty estimates. These data shall also be included in the final grids as necessary and appropriate.

8.3.3 Side Scan Sonar Data

The hydrographer shall submit digital side scan data in a format readable by CARIS SIPS or SonarWiz. Digital side scan sonar shall be geocoded using the towfish position (towfish position corrected). Information and specifications on CARIS SIPS and data formats may be obtained from CARIS. Information and specifications on SonarWiz data formats may be obtained from SonarWiz.

Side Scan Contact Images

The hydrographer shall submit digital images of all side scan contacts within the contact file (see Section 8.2.2) and in the Multimedia folder. Digital images shall be in a standard image format (e.g., .tif, .gif, .jpg, png).

Side Scan Mosaics

The hydrographer shall submit a digital image file for each 100 percent coverage. The digital image file shall be in a standard geo-referenced image format (Section 8.2.1). Field units shall deliver all grids in the Bathymetry and SSS folder. Field units that process with versions of CARIS HIPS/SIPS earlier than version 9.0 shall submit the fieldsheet directory in the Bathymetry and SSS delivery folder (See Appendix J).

8.3.4 Backscatter Deliverables

The hydrographer shall submit raw backscatter data in a format readable by IVS Fledermaus Geocoder Toolbox. The raw backscatter data shall be delivered in the backscatter folder.

8.3.5 ERS Data Deliverables

Unless specified otherwise in the Hydrographic Survey Project Instructions, the following deliverables are required for surveys conducted as ERS:

- Raw rover observed dual frequency GPS and inertial data used to produce the IAPPK 3D vessel position
- Base Station Files in native format, if native format is other than RINEX
- Base Station Files in RINEX version 2.11+
    - Including navigation (.yyN) as well as observation files (.yyO)
    - RINEX files must include all types of dual-frequency observations, including manufacturers SNRs: C1, L1, L2, P2, P1, S1, and S2
    - RINEX header shall include at a minimum: station / marker name, receiver type / S/N, antenna type / S/N and antenna height
    - May use Compact RINEX (Hatanaka)
- Ephemerides used in IAPPK 3D vessel position
- Weekly user maintained base station OPUS reports and QC check reports as described in Section 3.4
- IAPPK 3D vessel position solution files in ASCII format to contain at a minimum:
    - Data rate
    - Time
    - Horizontal Position and uncertainty
    - Ellipsoidal Height and uncertainty
    - Heave
    - Roll, Pitch and Heading uncertainty
    - North, East and Down Velocity uncertainty
    - Number of SV's
    - PDOP
    - Baseline length (M)
    - KGPS processing mode
- All processing log files integral to the IAPPK 3D position quality
- Separation model file if not the one provided in one of the following two formats:
    - Comma separated values: decimal lat, decimal long, separation in meters
    - NGS GEOID BIN format
- No sounding data referenced to the ellipsoid is required. The Hydrographic Branches (AHB and PHB)will

create all ellispodally referenced products derived from the final approved MLLW referenced dataset

8.3.6 Other Data

Tide and Sound Speed Data

The hydrographer shall submit tide data and sound speed data applied to all multibeam depths on the project data drives. 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). All tide data required by Section 4 , shall be sent directly to the appropriate CO-OPS office.

NCEI Sound Speed Data

Sound speed data must be submitted to NCEI following the NetCDF template format outlined on the NCEI website at http://www.nodc.noaa.gov/access/dataformats.html. NOAA field units may use Velocipy to export a NetCDF file by selecting the NODC box upon export and specifying the export directory. Project, survey, NOAA Unit and instrument fields must be populated. The resulting file will have an .nc file extension. Each submission to NCEI should only contain data from one project. Additionally, the submission zip filename should contain the project number and timestamp of submission (e.g. OPR-B370-NRT5-_20150420.zip).

- NOAA Field Units: Submit files to NCEI via email attachment to NODC.submissions@noaa.gov with a courtesy copy to the HSD Project Manager.

- Contractors: Submit NetCDF files to NCEI via email attachment to NODC.submissions@noaa.gov or via the S2N tool on the NCEI website. Include the COR on all correspondence.

Vessel Configuration File

The hydrographer shall submit a CARIS HIPS compatible HIPS Vessel File (HVF) for each vessel used during survey operations. CARIS-compatible HVF shall contain those static and dynamic correctors, offsets and uncertainties which are to be applied to the "Full Resolution Multibeam Data" set submitted as referenced in Section 8.3.2 If the data is submitted fully corrected with uncertainties already associated with each sounding, then the CARIS HVF may be "all zeros". In such a case, the hydrographer must provide details on what values were derived for all the static and dynamic correctors, offset and uncertainties and other information that is usually contained within a HVF in the DR and/or DAPR. Information and specifications on the HVF format may be obtained from CARIS.

Metadata

The following reports shall be included on the submitted data drive in a clearly labeled directory;

- The Appendices and Separates to the DR in Adobe Acrobat .PDF format.
- The Data Acquisition and Processing Report in Adobe Acrobat .PDF format.
- The Horizontal and Vertical Control Report in Adobe Acrobat .PDF format.

Final Feature File

The S-57 final feature file shall be included on the submitted drive in the Final Feature File folder.

Supporting Data

- Any associated image files to support S-57 feature file objects shall be located in the Multimedia folder.
- Other interim data products that may help the Hydrographic Branch verify the survey and understand the pipeline from acquisition to final product.

9 Ellipsoidally-Referenced Surveys

Contents

This chapter covers the requirements for determining areas suitable for conducting three-dimensional ellipsoidally-referenced surveys (ERS), requirements for operationally conducting ERS, and requirements for vertical datum transformation and evaluating ERS survey results.

9.1 ERS Planning and Operational Requirements

Survey planning and review by NOAA's Office of Coast Survey (OCS) Hydrographic Surveys Division Operations Branch (N/CS31) shall include a component dedicated to the evaluation of specific regions for ERS.

The three principal factors which determine survey project ERS-eligibility pertain to the capabilities and infrastructure for:

1. Centimeter-level Global Navigational Satellite System (GNSS) kinematic positioning

2. Field unit capability

3. Ellipsoid-to-chart vertical datum (mean lower low water, MLLW) transformation

9.1.1 GNSS Positioning

The ideal technique for NOAA ERS-vessel positioning to obtain centimeter-level [height] accuracy is tightly coupled inertially-aided, post-processed kinematic GPS (IAPPK). A post-processed positioning methodology is preferred for reasons of enhanced quality control (QC). Quasi-independent forward- and reverse-time processing add to the QC otherwise available in "real time" (forward-only) processing. GPS is preferred over other GNSS (e.g. GLONASS); however, if the availability of 5 or more GPS satellites is unacceptably low in a particular survey environment, a hybrid GPS-GNSS solution may be leveraged.

Other GPS/GNSS-based highly-accurate positioning techniques may be used, such as real-time kinematic (RTK) or real-time Precise Point Positioning (PPP) on a case-by-case basis. ERS vessel positioning without any inertial-aiding of the GNSS positioning requires special consent through the HSD Project Manager/COR.

Limits to operational parameters expressed below represent conditions most favorable to achieve horizontal and vertical position uncertainty requirements.

9.1.1.1 GNSS Infrastructure

Percise Orbits

Satellite ephemeris products that are used in ERS must be of adequate quality to obtain the desired level of accuracy from GPS/GNSS. For carrier-phase differential GNSS/GPS (baseline) processing, all International GNSS Service (IGS) products are sufficient: Broadcast, Ultra-Rapid, Rapid and Final -- use the best available orbits and clocks at the time of baseline processing. For ERS inertially-aided PPP, Ultra-Rapid (or better) orbit and clock products suffice. Multiple IGS Analysis Centers compute products. Orbit and clock files used in a positioning solution must be consistent; do not mix products from different Analysis Centers.

Baseline Limits

Centimeter level accuracy in carrier-phase differential GNSS positioning restricts the length between reference station and survey vessel. For planning purposes, a maximum-baseline length of 40 km is used for the pair-wise, vessel-to-single reference station configuration. A combination of National Continuously Operating Reference Station (CORS) sites, field-installed temporary shore stations, and other approved stations are used to satisfy the nominal maximum-baseline constraint.

A Virtual Reference Station (VRS) system may be used by employing a network of four or more user-installed or continuously operating reference stations "surrounding" the ERS project area. For planning purposes, a maximum inter-station baseline length of 70 km is used. The ERS area should be contained within the convex hull formed about the network of stations; this may be visualized as the area contained by a "rubber band" stretched around the a map of the stations.

Data Rate

The nominal maximum required data rate for reference station data is equal to that of the vessel (rover) data: 1 Hz. Reference station data rates as low as 30 seconds are permitted when carrier-phase interpolation methods are used in IAPPK software.

Data Links

Field internet, radio-modem, and other data-link connectivity and bandwidth capabilities are important to the ERS planning and review process. Dual-frequency, all-inview GPS data for each reference station must be transferred to the mobile field unit's processing center day-to-day. At the nominal high-end data rate of 1-Hz (see section above), dual-frequency all-in-view GPS receiver binary or otherwise compact/compressed ASCII data equates to just under 20 MB per day. Reliable data link infrastructure must then be capable of timely download of up to 20 MB multiplied by the number of reference stations involved in the ERS (single base or networked bases).

Additionally, precise orbit and clock data must be transferred to the field unit; however, ephemerides data are orders of magnitude smaller than carrier-phase observable data and can be downloaded with a basic internet connection.

Access to online NGS infrastructure, including the Online Positioning User Service (OPUS) and NGS Datasheets are also required.

9.1.2 Field Unit Infrastructure

ERS capability shall be included in the Hydrographic Systems Readiness Review (HSRR) or contractor quality assurance plan. Some general items that affect the broad notions of ERS suitability criteria and procedures planning are listed below.

Hardware

At a minimum, inertially-aided GPS hardware present on survey vessels must be capable of logging dual-frequency, all-in-view, GPS code and carrier phase data, as well as high-rate inertial data.

Requirements for temporary reference stations are per that discussed above. The field unit must have a sufficient mix of CORS and/or GPS receivers for base stations in hand which can satisfy the reference station infrastructure (maximum baseline length) requirements.

Software

Tightly-coupled inertially-aided GNSS positioning software capable of reading data as logged by the inertial and GPS hardware for IAPPK solutions is required. There must be sufficient licenses or "keys" with the field unit in order to sustain the processing required to support the number of surveys to be conducted as ERS.

Personnel and Training

There must be sufficient personnel with the field unit with the knowledge, skills, and abilities required to conduct the aspects of ERS which differ from, or are in addition to, traditional tide-controlled hydrographic surveys. This includes, but is not limited to, establishing and maintaining base stations, establishing geodetic control when required, post-processing of kinematic GPS data, and application of 3D ellipsoidal navigation solutions to hydrographic data.

9.2 ERS Datum Transformation Requirements

The standard method for the ellipsoid-to-chart datum transformation is to utilize the National VDatum transformation framework and software developed and published by NOAA. However, certain ERS projects may proceed in areas lacking VDatum coverage using one of the alternative ellipsoid-to-chart datum separation (SEP) models described below. The method of datum transformation to be used will be prescribed in the Hydrographic Survey Project Instructions.

9.2.1 VDatum

VDatum software is developed jointly by the NOS Tri-Office VDatum Team. VDatum transformations utilize a combination of stepwise transformations between ellipsoidal, orthometric, and tidal datums, leveraging the best available hydrodynamic models and historical tidal and geodetic data at each step. At present time, uncertainties for VDatum are known only at the shore stations used for separation model creation and are still not fully assessed away from these shore stations for all VDatum models. Therefore, the sole use of VDatum without additional validation requirements and QC checks will be limited to instances in which there is confidence in the uncertainty of the separation model throughout the entire survey area.

VDatum QC Requirements

At the discretion of HSD, after reviewing the a priori uncertainty associated with the particular VDatum region, certain additional QC requirements for VDatum evaluation may be required. These steps will be determined by HSD and will be specified in the Hydrographic Survey Project Instructions. Final determination of the method to be used to reduce data to chart datum resides with HSD after evaluation of these QC checks and may be based on a recommendation from the Chief of Party.

1. Point-wise Ellipsoid-MLLW SEP QC
    * True validation of the accuracy of a VDatum ellipsoidal SEP value (e.g., ellipsoid- MLLW) is achieved by obtaining a GPS height observation at a point wherein the tidal datum is known. Presumably data from all tidal bench marks with historical datums are already incorporated into VDatum and QC requirements represent points/areas "far" from those nodal locations
    * Traditional water level observations tied to the ellipsoid, acquired for 30 days or more, provide an accurate point-check on the SEP. Such ellipsoid tidal datum observations may be conducted using an ellipsoidally-referenced radar gauge or a GPS tide buoy. Less accurate checks using water level observations of less than 30 days may be employed using the ERS vessel as a "tide buoy" or water level "altimeter", followed by traditional comparison to water levels from a primary NWLON station

2. ERS / Zoned Hydrography Comparisons
    * A basic test methodology that includes the acquisition and processing of sounding data in the "traditional" manner (i.e. reduction to MLLW using water levels, discrete zoning, and/or TCARI), and then compared to ellipsoidally-referenced data. Such VDatum verification survey lines should be conducted according to the following basic guidelines:
        - Line spacing is such that the high-frequency character of the overall SEP surface is sampled. These specific line spacing requirements are detailed in the PI and SOW and are dictated by the local geoid and topography of the sea surface (TSS)
        - Such spatial sampling is adequate to compute a ERZT separation surface as well (see Section 9.2.2)

In order for HSD to approve the use of VDatum as the method to transform final survey data to vertical chart datum, QC checks should reveal that the uncertainty in this transformation is equal to, or better than, utilizing traditional observed water level methods. The typical contribution of the error for tides and water levels to the total survey error budget falls between 0.20 m and 0.45 m (refer to Section 5.2.3.5), therefore these QC methods should show that using VDatum achieves results equal to or better than these values, while ensuring that data do not exceed total allowable vertical uncertainty limits (Section 5.1.3).

9.2.2 Ellipsoidally-Referenced Zoned Tides (ERZT)

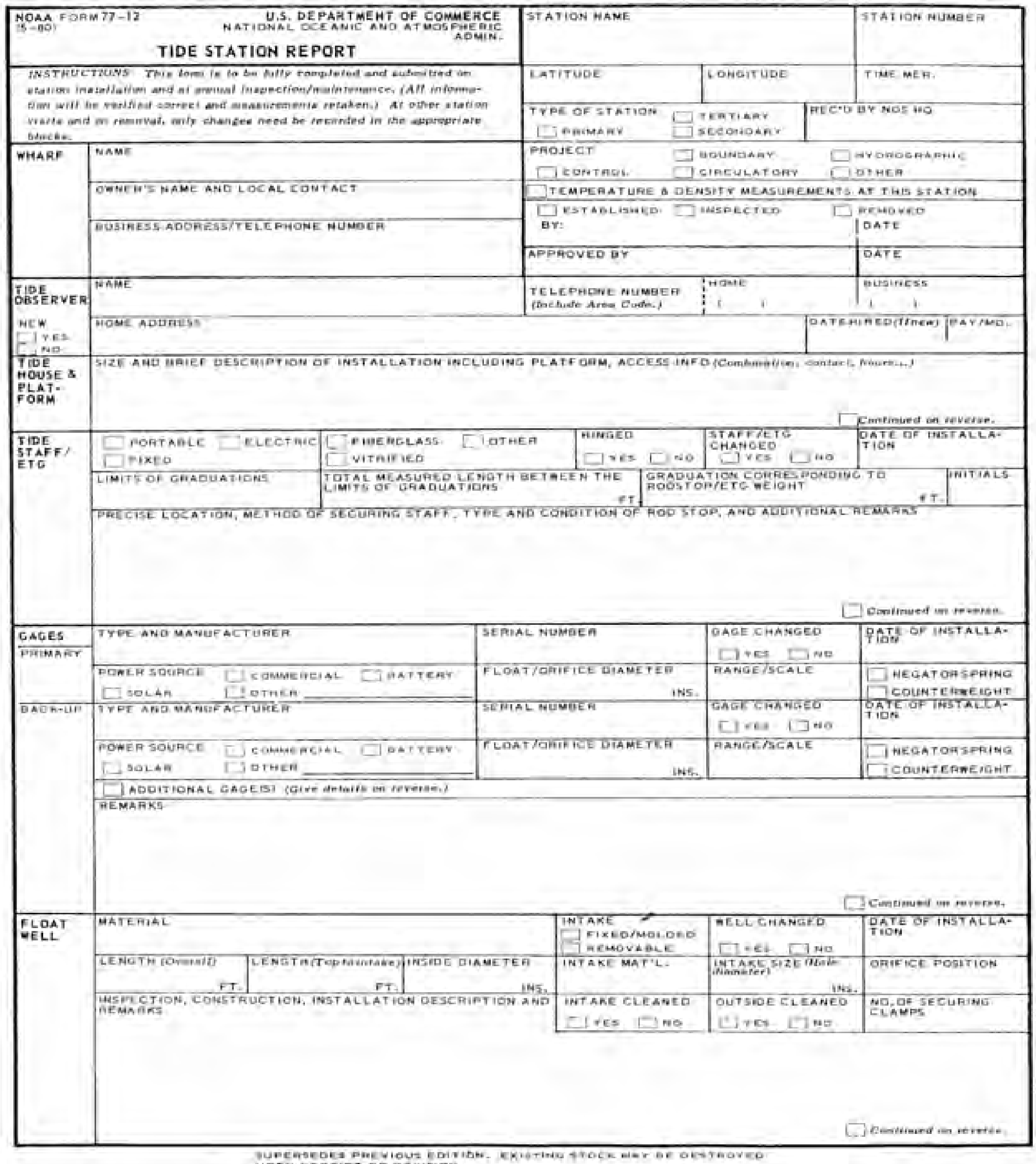
An alternative option in areas lacking a published VDatum model is to relate "traditional" zoned water levels to the ellipsoid. This is done by measuring the height of the GPS antenna to the water line. Then a SEP is created by adding this ellipsoidally-referenced water line measurement to the zoned water level "corrector." The SEP is then applied to the ellipsodially-referenced hydrography to reference it to chart datum. ERS-ERZT data may be readjusted at a later date when VDatum coverage becomes available.

9.2.3 Constant Value Separation Model

At the discretion of HSD, a constant SEP value for "small" survey areas in close proximity to known ellipsoid-to-chart datum SEP points may be used. Certain additional QC requirements for constant value SEP model may be required. These steps will be determined by HSD and will be specified in the Hydrographic Survey Project Instructions.

List of Appendices:

Appendix A: Tide Station Report and 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

STATION NAME | STATION NUMBER

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.

LATITUDE | LONGITUDE | TIME MER.

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

WHARF: NAME; OWNER'S NAME AND LOCAL CONTACT; BUSINESS ADDRESS/TELEPHONE NUMBER

PROJECT: CONTROL / BOUNDARY / CIRCULATORY / HYDROGRAPHIC / OTHER

TEMPERATURE & DENSITY MEASUREMENTS AT THIS STATION

ESTABLISHED / INSPECTED / REMOVED BY: | DATE

APPROVED BY | DATE

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; NEGATORSPRING / 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; NEGATORSPRING / 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

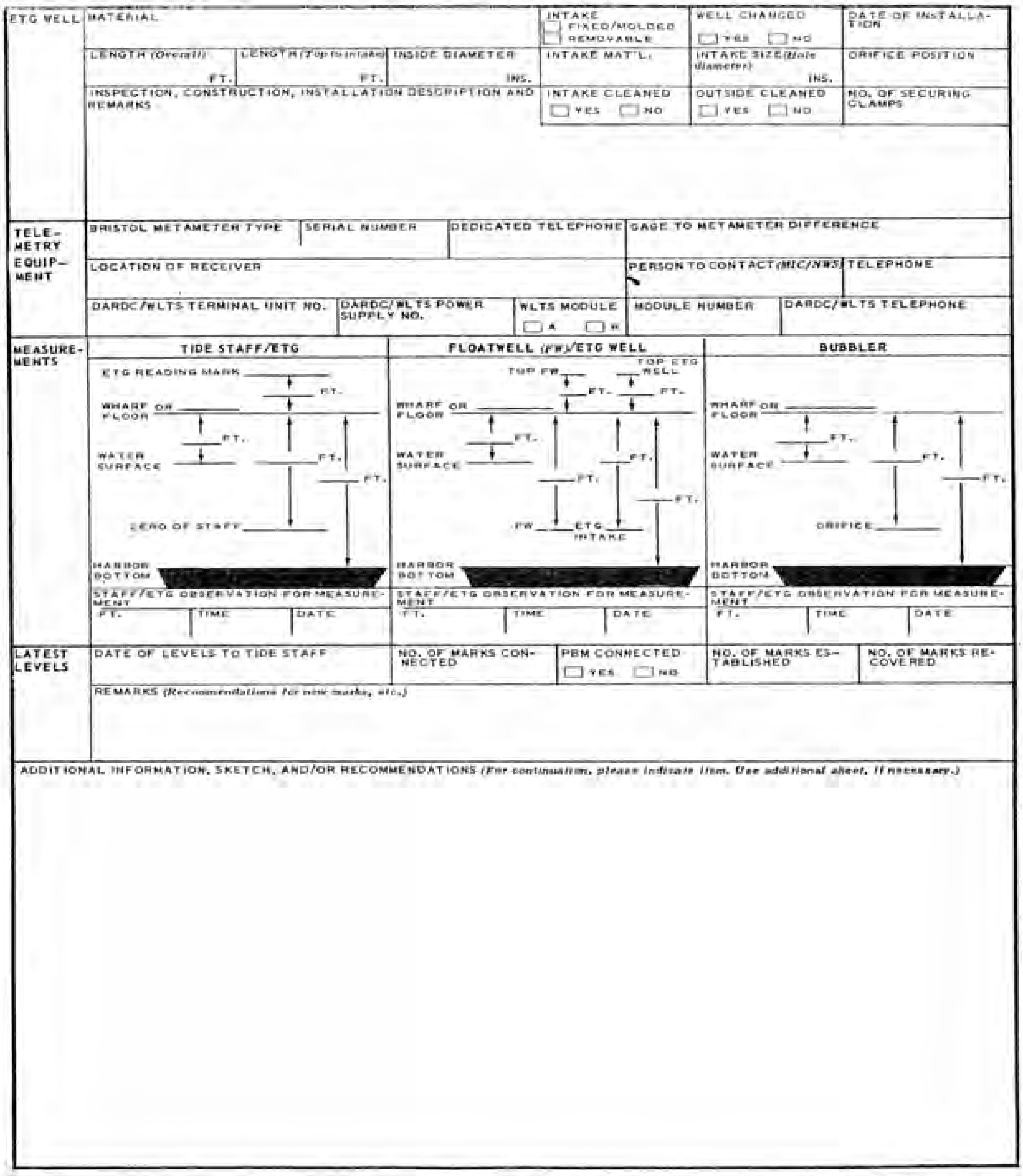
LENGTH (Overall) FT.; LENGTH (Top to intake) FT.; INSIDE DIAMETER INS.; INTAKE MAT'L.; INTAKE SIZE (Hole diameter) INS.; ORIFICE POSITION

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.

Figure A.1: NOAA Form 77-12 Tide Station Report



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
ETG READING MARK ___ FT. WHARF OR FLOOR ___ FT. WATER SURFACE ___ FT. FT. ZERO OF STAFF ___ HARBOR BOTTOM	TOP FW ___ TOP ETG WELL ___ FT. FT. WHARF OR FLOOR ___ FT. WATER SURFACE ___ FT. FT. FT. FW ___ ETG INTAKE ___ HARBOR BOTTOM	WHARF OR FLOOR ___ FT. WATER SURFACE ___ FT. FT. ORIFICE ___ HARBOR BOTTOM
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

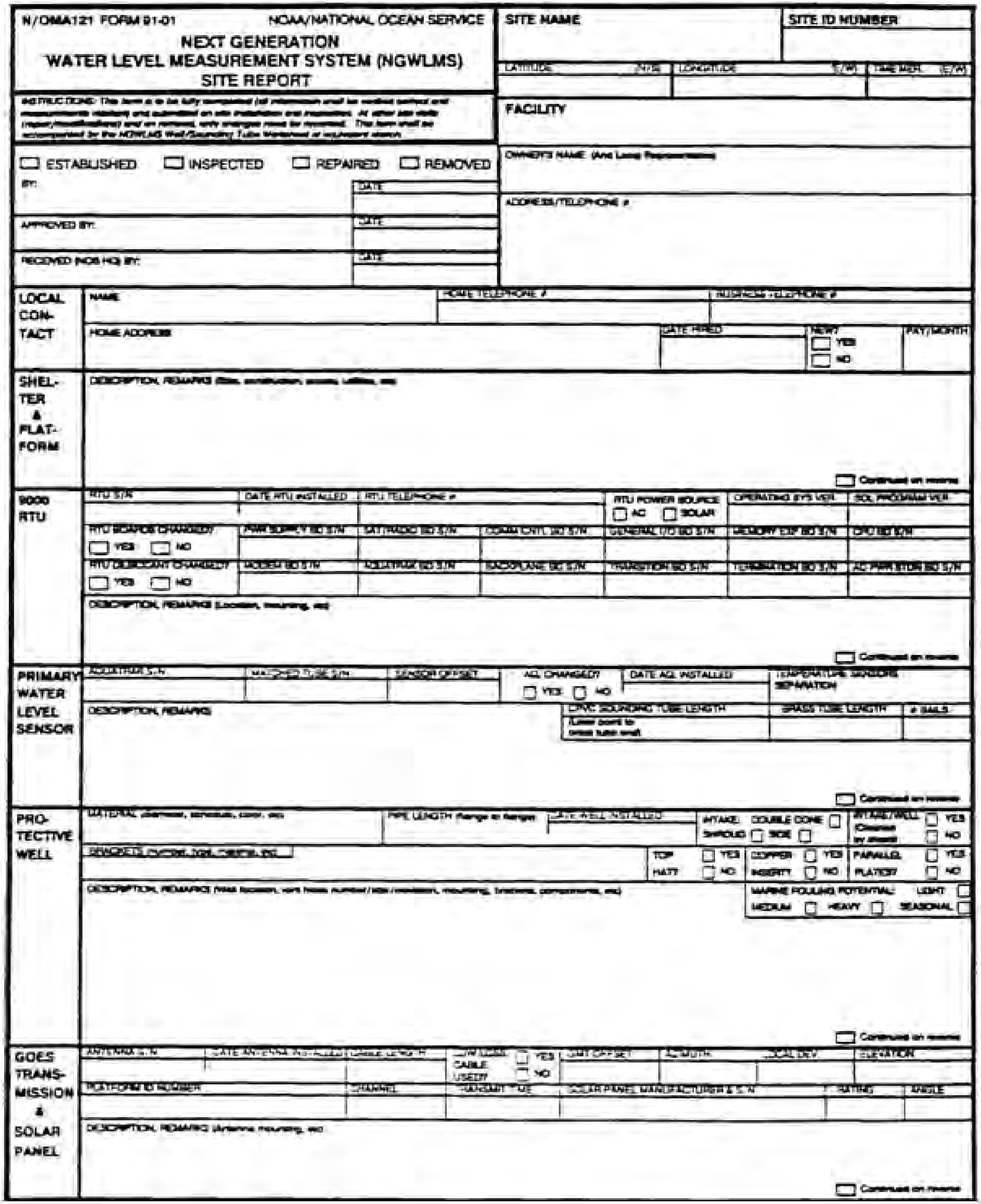
REMARKS *(Recommendations for new marks, etc.)*

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

Figure A.2: Tide Station Report (cont.)

8200 DATA RECORDER	8200 S/N; DATE 8200 INSTALLED; PROGRAM VERSION; POWER SOURCE ☐ DC ☐ SOLAR; DESICCANT CHANGED? ☐ YES ☐ NO; CPU S/N; INTERCONNECT S/N; [illegible]; [illegible]
	DESCRIPTION, REMARKS (Mounting, location, etc) ☐ Continued below
BACKUP WATER LEVEL SENSOR	SENSOR MANUFACTURER ☐ DRUCK ☐ [illegible] ☐ PAROSCIENTIFIC ☐ OTHER ____; SENSOR S/N; DATE SENSOR INSTALLED; SENSOR CONFIGURATION ☐ WATER ☐ BUBBLER; PARALLEL PLATES? ☐ YES ☐ NO
	DESCRIPTION, REMARKS (Sensor location, installation details, etc) ☐ Continued below
OTHER SENSORS	AIR TEMPERATURE ☐ YES ☐ NO; DATE INSTALLED; BAROMETER S/N; DATE INSTALLED; CONDUCTIVITY S/N; DATE INSTALLED
	WATER TEMPERATURE ☐ YES ☐ NO; DATE INSTALLED; WIND SENSOR S/N; DATE INSTALLED; MET TOWER TYPE: STEEL ☐ FIBERGLASS ☐; DATE INSTALLED
	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? ☐ YES ☐ NO, EXPLAIN; DOWNSHOT LEVELING FIXTURE REQUIRED? ☐ YES ☐ NO
	REMARKS ☐ Continued below; AQUATRAK COEFFICIENT 3A (PBM above site datum from HQ); AQUATRAK COEFFICIENT 3B (Leveling point above PBM from levels) =; AQUATRAK COEFFICIENT 3 (3A + 3B = 3) =
REMARKS (Continuations, recommendations, etc)	

Figure A.3: Tide Station Report (cont.)



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

NEXT GENERATION
WATER LEVEL MEASUREMENT SYSTEM (NGWLMS)
SITE REPORT

SITE NAME | SITE ID NUMBER

LATITUDE | LONGITUDE | TIME MER.

FACILITY

ESTABLISHED | INSPECTED | REPAIRED | REMOVED

BY: | DATE

APPROVED BY: | DATE

RECEIVED (NOS HQ) BY: | DATE

OWNER'S NAME

ADDRESS/TELEPHONE #

LOCAL CONTACT: NAME | HOME TELEPHONE # | BUSINESS TELEPHONE # | HOME ADDRESS | DATE HIRED | NEW? YES / NO | PAY/MONTH

SHELTER & PLATFORM: DESCRIPTION, REMARKS

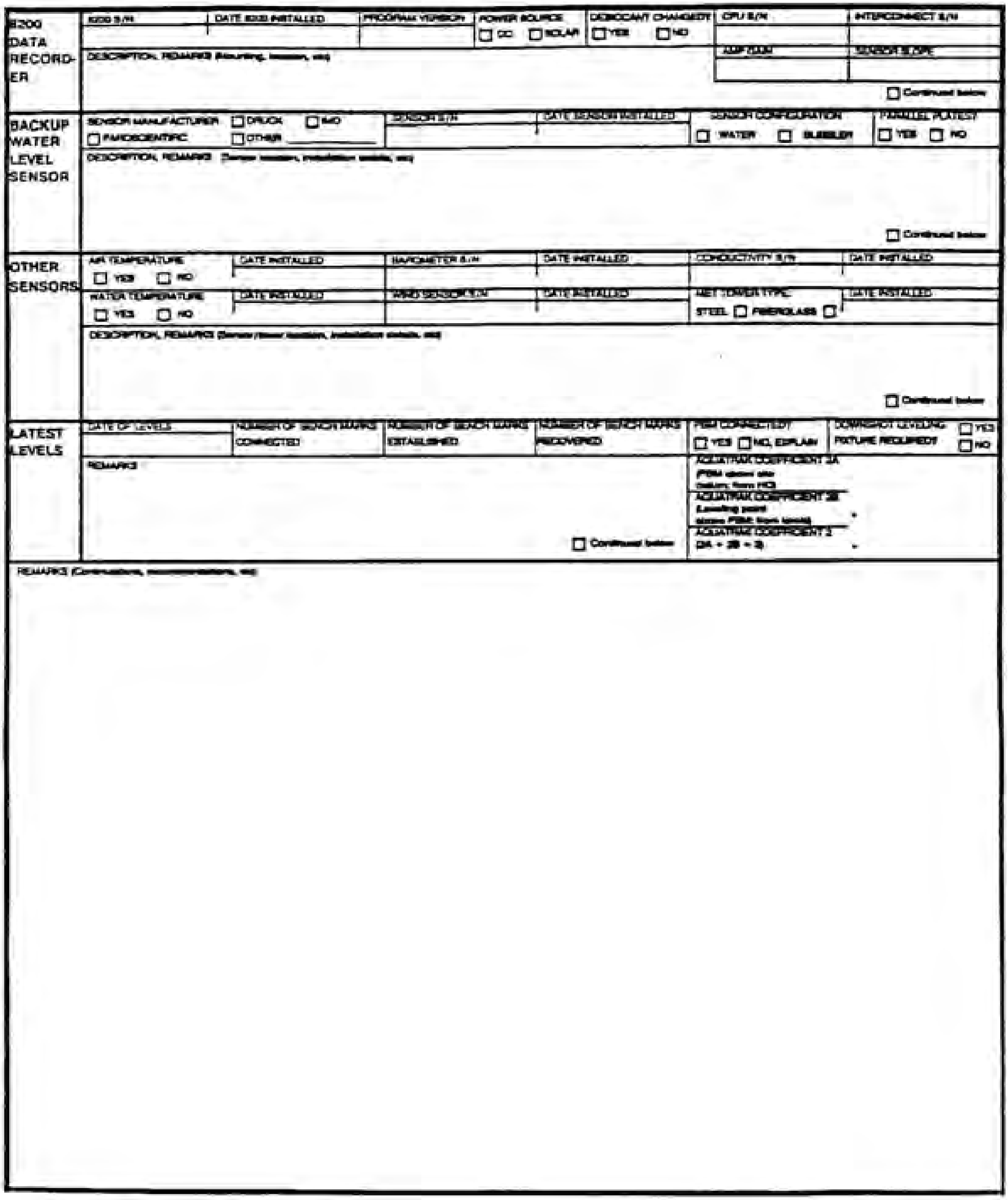
9000 RTU: RTU S/N | DATE RTU INSTALLED | RTU TELEPHONE # | RTU POWER SOURCE AC / SOLAR | OPERATING SYS VER. | RTU BOARDS CHANGED? YES / NO | RTU DESICCANT CHANGED? YES / NO | DESCRIPTION, REMARKS (Location, mounting, etc)

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 | BRASS TUBE LENGTH | # BAILS

PROTECTIVE WELL: MATERIAL | PIPE LENGTH | DATE WELL INSTALLED | INTAKE | DOUBLE CONE | SHROUD | SIDE | BRACKETS | TOP HAT? YES / NO | COPPER INSERT? YES / NO | PARALLEL PLATES? YES / NO | DESCRIPTION, REMARKS | MARINE FOULING POTENTIAL: LIGHT | MEDIUM | HEAVY | SEASONAL

GOES TRANSMISSION & SOLAR PANEL: ANTENNA S/N | DATE ANTENNA INSTALLED | CABLE LENGTH | LOW LOSS CABLE USED? YES / NO | SAT OFFSET | AZIMUTH | LOCAL DEV. | ELEVATION | PLATFORM ID NUMBER | CHANNEL | TRANSMIT TIME | SOLAR PANEL MANUFACTURER & S/N | RATING | ANGLE | DESCRIPTION, REMARKS (Antenna mounting, etc)

Figure A.4: N/OMA121 Form 91-01 Next Generation Water Level


8200 DATA RECORDER
8200 S/N | DATE 8200 INSTALLED | PROGRAM VERSION | POWER SOURCE ☐ DC ☐ SOLAR | DESICCANT CHANGED? ☐ YES ☐ NO | CPU S/N | INTERCONNECT S/N
DESCRIPTION, REMARKS
☐ Continued below

BACKUP WATER LEVEL SENSOR
SENSOR MANUFACTURER ☐ DRUCK ☐ PAROSCIENTIFIC ☐ OTHER | SENSOR S/N | DATE SENSOR INSTALLED | SENSOR CONFIGURATION ☐ WATER ☐ BUBBLER | PARALLEL PLATES? ☐ YES ☐ NO
DESCRIPTION, REMARKS
☐ Continued below

OTHER SENSORS
AIR TEMPERATURE ☐ YES ☐ NO | DATE INSTALLED | BAROMETER S/N | DATE INSTALLED | CONDUCTIVITY S/N | DATE INSTALLED
WATER TEMPERATURE ☐ YES ☐ NO | DATE INSTALLED | WIND SENSOR S/N | DATE INSTALLED | MET TOWER TYPE: STEEL ☐ FIBERGLASS ☐ | DATE INSTALLED
DESCRIPTION, REMARKS
☐ Continued below

LATEST LEVELS
DATE OF LEVELS | NUMBER OF BENCH MARKS CONNECTED | NUMBER OF BENCH MARKS ESTABLISHED | NUMBER OF BENCH MARKS RECOVERED | PBM CONNECTED? ☐ YES ☐ NO, EXPLAIN | DOWNSHOT LEVELING FIXTURE REQUIRED? ☐ YES ☐ NO
REMARKS
☐ Continued below
AQUATRAK COEFFICIENT 2A
AQUATRAK COEFFICIENT 2B
AQUATRAK COEFFICIENT 2
REMARKS

Figure A.5: Next Generation Water Level (cont.)

Appendix B: 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.

Time (UTC)

Day[3]	Start[4]	End[4]	Year

[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 time of hydrography for the day.

Figure B.1: Abstract of Times of Hydrography for Smooth Tides or Water Levels

Appendix C: 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 HSD Operations at 301-713-2702 x112.

Figure C.1: Example Request for Smooth Tides/Water Levels Letter

Appendix D: Danger to Navigation Report

H12471 DtoN#1 Uncharted OFSPLF

Registry Number: H12471
State: Louisiana
Locality: Approaches to Mississippi Sound
Sub-locality: 11 nm South of Horn Island
Project Number: OPR-J348-KR-12
Survey Dates: 10/10/2012 - 01/24/2013

Charts Affected

Number	Edition	Date	Scale (RNC)	RNC Correction(s)*
11373	50th	08/01/2012	1:80,000 (11373_1)	USCG LNM: 1/22/2013 (1/22/2013) NGA NTM: 4/9/2011 (2/2/2013)
11366	11th	01/01/2008	1:250,000 (11366_1)	[L]NTM: ?
11360	43rd	11/01/2008	1:456,394 (11360_1)	[L]NTM: ?
1115A	43rd	11/01/2008	1:456,394 (1115A_1)	[L]NTM: ?
11006	32nd	08/01/2005	1:875,000 (11006_1)	[L]NTM: ?
411	52nd	09/01/2007	1:2,160,000 (411_1)	[L]NTM: ?

* Correction(s) - *source: last correction applied (last correction reviewed--"cleared date")*

Features

No.	Name	Feature Type	Survey Depth	Survey Latitude	Survey Longitude	AWOIS Item
1.1	H12471 DTON #1 Uncharted Communication Tower	GP	[None]	29° 59' 00.6" N	088° 34' 59.9" W	---

Figure D.1: Example of Danger to Navigation Report

H12471 DtoN#1 Uncharted OFSPLF | 1 - Dangers To Navigation

1.1) H12471 DTON #1 Uncharted Communication Tower

DANGER TO NAVIGATION

Survey Summary

Survey Position: 29° 59' 00.6" N, 088° 34' 59.9" W

Least Depth: [None]

TPU (±1.96σ): THU (TPEh) [None] ; TVU (TPEv) [None]

Timestamp: 2013-024.19:23:44.000 (01/24/2013)

Dataset: H12471_DtoN_01.000

FOID: US 0000047691 00001(02260000BA4B0001)

Charts Affected: 11373_1, 11366_1, 1115A_1, 11360_1, 11006_1, 411_1

Remarks:

OFSPLF/remrks: DtoN 1.1 is an uncharted U. S. Air Force Communication Tower.

Feature Correlation

Source	Feature	Range	Azimuth	Status
H12471_DtoN_01.000	US 0000047691 00001	0.00	000.0	Primary

Hydrographer Recommendations

[None]

S-57 Data

Geo object 1: Offshore platform (OFSPLF)

Attributes: CATOFP - 3:observation / research platform
CONVIS - 1:visual conspicuous
INFORM - US Air Force Communication Tower
SORDAT - 20130124
SORIND - US,US,graph,H12471

Office Notes

This danger submission is preliminary. No data has been provided to AHB for verification. Feature will be reviewed and verified once the survey data has been submitted. Reference attached PDF document concerning the communication tower submitted by US Dept. of Interior.

Figure D.2: Example of Danger to Navigation Report

Feature Images

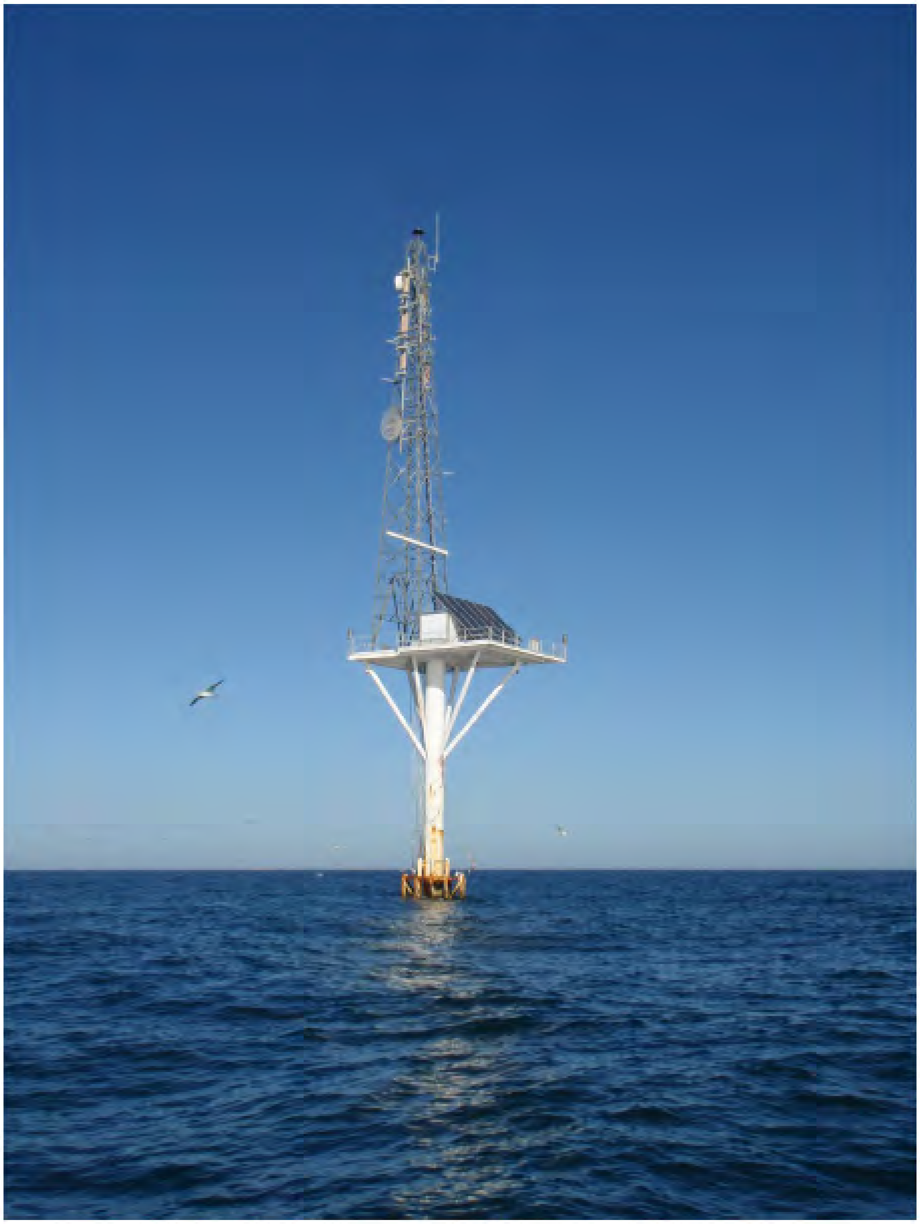


Figure 1.1.1

Figure D.3: Example of Danger to Navigation Report

Appendix E: 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 ....

Figure E.1: Data Acquisition and Processing Report

Appendix F: WATLEV Attribution

Atlantic Coast and Gulf of Mexico

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 1ft (0.3048m) below MLLW	< 1ft (0.3048m) above MLLW to 1ft (0.3048m) below MLLW	1ft (0.3048m) above MLLW to 1ft (0.3048m) above MHW	>1ft (0.3048m) above MHW
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 1 foot (0.3048 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.

**When the depth of an obstruction or wreck is greater than 1 foot (0.3048 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Pacific Coast and Alaska

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 2ft (0.6096m) below MLLW	< 2ft (0.6096m) above MLLW to 2ft (0.6096m) below MLLW	2ft (0.6096m) above MLLW to 2ft (0.6096m) above MHW	> 2ft (0.6096m) above MHW
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 2 feet (0.6096 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.

**When the depth of an obstruction or wreck is greater than 2 feet (0.6096 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Figure F.1: WATLEV Attribution

Great Lakes (LWD = Low Water Datum)

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 2ft (0.6096m) below LWD	< 2ft (0.6096m) above LWD to 2ft (0.6096m) below LWD	2ft (0.6096m) above MLLW to 4ft (1.2192m) above LWD	> 4ft (1.2192m) above LWD
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 4 feet (1.2192 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.

**When the depth of an obstruction or wreck is greater than 4 feet (1.2192 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Figure F.2: WATLEV Attribution

NOAA Extended Attributes Schema

NOAA has created extended attributes in the acquisition and processing software to provide further flexibility than can be obtained via the S-57attribute standards. The following extended attributes are global to all S-57 object classes.

Acronym	Name	Description	ISO8211 ID	Type
acqsts	Acquisition status	Status of acquisition	2007	(E)numeration
asgnmt	Assignment status	Indicates whether a feature is (un)assigned	2001	(E)numeration
cnthgt	Contact height	Contact Height	2008	(F)loat
dbkyid	Database key ID	Unique ID for use in relational database	1041	Free text (S)tring
descrp	Description	Field recommended charting action	2000	(E)numeration
images	Images	List of comma-delimited file name(s); do not include path(s)	2003	Free text (S)tring
invreq	Investigation requirements	Specific instructions for investigation requirements	2009	Free text (S)tring
keywrd	Keyword	List of comma-delimited user keyword(s)	2006	Free text (S)tring
onotes	Office notes	Office notes	2004	Free text (S)tring
prmsec	Primary / secondary correlation status	Indicates whether a feature is the primary contact or a secondary view	2002	(E)numeration
prkyid	Primary key ID	For Secondary feature(s); the Primary feature dbkyid	2010	Free text (S)tring
recomd	Recommendations	Charting recommendations	1119	Free text (S)tring
remrks	Remarks	Remarks	1118	Free text (S)tring
sftype	Special feature type	Indicates special features	2005	(E)numeration

Figure F.3: NOAA extended attributes parameters

Acronym	ISO8211 Code	Enumeration ID	Meaning
descrp	2000	1	New
		2	Update
		3	Delete
		4	Retain
		5	Not Addressed
asgnmt	2001	1	Unassigned
		2	Assigned
		3	For Info Only
prmsec	2002	1	Primary
		2	Secondary
		3	Pending
sftype	2005	1	ATON
		2	AWOIS
		3	DTON
		4	MARITIME BOUNDARY
		5	LIDAR INVESTIGATION
acqsts	2007	1	Investigate
		2	Resolved

Figure F.4: Expected input values for NOAA enumeration attributes

Appendix G: Survey Progress Estimate

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
2	Survey Progress Estimate -- (Month of Report)																	
3																		
4	FY 2010 Task Order Number XX																	
5																		
6	OPS					FIELD												
7	Project Number and Name	Sheet Identifier	Registry Number	HQ Estimated SNM	SNM Completed Survey Outline	Date Field Work Began	Date Field Work Completed	Estimated Date of Survey Submission	March Cumulative % Complete	April Cumulative % Complete	May Cumulative % Complete	June Cumulative % Complete	July Cumulative % Complete	August Cumulative % Complete	September Cumulative % Complete	October Cumulative % Complete	November Cumulative % Complete	December Cumulative % Complete
8																		
9																		
10																		
11	*OPR-xxxx*																	
12	*Location, State*																	
13																		
14																		
15																		
16																		

Figure G.1: Survey Progress Estimate

Appendix H Bottom Classification

Type	Term	Grain Diameter (mm)
Sand	Fine	0.1-0.3
	Medium	0.3-0.5
	Coarse	0.5-1.0
Stones		50-250
Boulder		≥ 250

Figure H.1: Sediment Classification by Size

Encoding for Bottom Samples

Bottom characteristics are limited in usefulness for charting purposes, but other users find the information helpful for a multitude of purposes, such as geologic, fisheries or habitat studies. Only the main constituents of the bottom sample you collect will be applied to the chart. Other constituents, as well as color, and many of your qualifying terms, will be omitted for charting purposes, but archived and made available for other users.

Use the S-57 object SBDARE (Seabed Area) for classification of bottom characteristics. NATSUR (Nature of Surface) is a required attribute for all NOAA bottom samples collected. For NOAA purposes in describing bottom samples the attribute NATQUA (Nature of Surface – Qualifying Terms) may also be used in conjunction with NATSUR, but is not to be used alone. COLOUR may also be used to further describe the NATSUR term.

How to Encode Bottom Characteristics Multiple NATSUR terms may be designated, for example, sand, gravel and shells. For more detailed descriptions the attribute NATQUA may also be used as a descriptive term. For instance, the sand may be NATQUA, coarse and the shells may be NATQUA, broken. *(NOTE: S-57 permits multiple NATQUAs to be applied to any individual NATSUR term. For example, mud may be both 'sticky' and 'soft'. However, for NOAA purposes do not apply multiple NATQUAs to a single NATSUR.)* COLOUR may also be applied to the NATSUR terms. *(NOTE: S-57 limits the use of COLOUR to just the first term, but for NOAA purposes we are applying COLOUR as needed for any or all of the terms.)* See the tables on the following pages for NATSUR, NATQUA and COLOUR options.

Follow these steps for encoding bottom samples.

(1) **NATSUR**: First determine the most appropriate general description of the seabed type using one or more of the choices for attribute NATSUR. List them in order of the most predominate first, comma delimited, using the S-57 ID number.

> Example: For sand, mud and shells where sand is the major constituent, followed by mud, then shells:

NATSUR = sand,mud,shells **(4,1,17)**

(2) **NATQUA**: Next, if clearly discernible, give more specific details for the NATSUR characteristics selected using the attribute NATQUA. NATQUA attributes should be listed in the same order as the NATSUR attributes to which they are associated, and should be comma delimited. For any NATSUR that has no NATQUA qualifier, its place in the list must be left empty and held by a comma.

> Example: Fine sand with mud and broken shells; mud is the only constituent with no qualifier:

NATSUR = sand,mud,shells **(4,1,17)**; NATQUA=fine,,broken **(1,-,4)**

Where the *last* NATSUR term has no qualifier, encode a trailing comma.

> Example: fine sand and mud, (mud has no qualifier):

NATSUR=sand,mud **(4,1),** NATQUA=fine, **(1,-)**

(3) **COLOUR**: Finally, if appropriate, encode COLOUR as above for NATQUA.

> Example: Fine white sand with black mud and broken shells

NATSUR = sand,mud,shells **(4,1,17)**; NATQUA=fine,,broken **(1,-,4)**; COLOUR=white,black **(1,2,)**

FigureH.2: Encoding for Bottom Samples

In ENC viewing software this is how the SBDARE and its attributes will appear for a sample encoded as 'fine white sand, black mud and broken shells'.

Selection

Acronym	Name
SBDARE	Seabed area

Attributes

Acronym	Name	
COLOUR	Colour	white,black,-
NATQUA	Nature of surface - qualifying terms	fine,-,broken
NATSUR	Nature of surface	sand,mud,shells

Many S-57 feature management software applications will automatically format the comma delimiters for NATSUR, NATQUA and COLOUR.

NATSUR (Nature of surface)

ID	Meaning	NATSUR Description
1	mud	Soft, wet earth.
2	clay	Particles of less than 0.002mm; stiff, sticky earth that becomes hard when baked.
3	silt	Particles of 0.002-0.0625mm; when dried on hand will rub off easily.
4	sand	Particles of 0.0625-2.0mm; tiny grains of crushed or worn rock.
5	stone	A general term for rock fragments ranging in size from pebbles and gravel to boulders or a large rock mass.
6	gravel	Particles of 2.0-4.0mm; small stones with coarse sand.
7	pebbles	Particles of 4.0-64.0mm; small stones made smooth and round by being rolled in water.
8	cobbles	Particles of 64.0-256.0mm; stones worn round and smooth by water and used for paving.
9	rock	Any formation of natural origin that constitutes an integral part of the lithosphere. The natural occurring material that forms firm, hard, and solid masses.
11	lava	The fluid or semi-fluid matter flowing from a volcano. The substance that results from the cooling of the molten rock.
14	coral	Hard calcareous skeletons of many tribes of marine polyps.
17	shells	Exoskeletons of various water dwelling animals.
18	boulder	A rounded rock with diameter of 256mm (25.6cm) or larger.

Figure H.3: Encoding for Bottom Samples

NATQUA (Nature of surface, qualifying terms)

ID	Meaning	NATQUA Description
1	fine	Falls within the smallest size continuum for a particular NATSUR term.
2	medium	Falls within the moderate size continuum for a particular NATSUR term.
3	coarse	Falls within the largest size continuum for a particular NATSUR term.
4	broken	Fractured or in pieces.
5	sticky	Having an adhesive or glue like property.
6	soft	Not hard or firm.
7	stiff	Not pliant; thick, resistant to flow.
8	volcanic	Composed of or containing material ejected from a volcano.
9	calcareous	Composed of or containing calcium or calcium carbonate.
10	hard	Firm; usually refers to an area of the sea floor not covered by unconsolidated sediment.

COLOUR

ID	Meaning
1	white
2	black
3	red
4	green
5	blue
6	yellow
7	grey
8	brown
9	amber
10	violet
11	Orange
12	Magenta
13	Pink

Figure H.4: Encoding for Bottom Samples

NATQUA / NATSUR	1 Fine	2 Medium	3 Coarse	4 Broken	5 Sticky	6 Soft	7 Stiff	8 Volcanic	9 Calcareous	10 Hard
1 Mud					x	x	x	x	x	x
2 Clay					x	x	x			x
3 Silt					x	x	x			x
4 Sand	x	x	x			x		x	x	x
5 Stone								x	x	
6 Gravel								x	x	
7 Pebbles								x	x	
8 Cobbles								x	x	
9 Rock								x	x	
11 Lava								x		
14 Coral				x						
17 Shells				x					x	
18 Boulder								x	x	

Figure H.5: NATQUA/NATSUR Allowable Attribute Combination

Appendix I: Survey Data Submission

NOAA FORM 61-29
(12-71)

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

LETTER TRANSMITTING DATA

REFERENCE NO.

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY (Check)

- ☐ ORDINARY MAIL
- ☐ AIR MAIL
- ☐ REGISTERED MAIL
- ☐ EXPRESS
- ☐ GBL (Give number)____________

TO:

DATE FORWARDED

NUMBER OF PACKAGES

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package contains [List drive(s) with description (e.g. Seagate 500 GB) and CD number or drive name]
Containing Hydrographic Survey Data Submission "[Type of data (i.e. Field/Raw and Processed Data]":

Checksum

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

[Add additional comments or notes here]

FROM: (Signature)

RECEIVED THE ABOVE
(Name, Division, Date)

Return receipted copy to:

USDOC NOAA NOS
[Insert field unit address here]

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

• U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

Figure I.1: Survey Data Submission for NOAA Units

NOAA FORM 61-29
(12-71)

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

LETTER TRANSMITTING DATA

REFERENCE NO.

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY (Check)

☐ ORDINARY MAIL ☐ AIR MAIL
☐ REGISTERED MAIL ☐ EXPRESS
☐ GBL (Give number)________________________

DATE FORWARDED

NUMBER OF PACKAGES

TO:

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package contains [List drive(s) with description (e.g. Seagate 500 GB) and CD number or drive name]
Containing Hydrographic Survey Data Submission "[Type of data (i.e. Field/Raw and Processed Data]":

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

[Add additional comments or notes here]

FROM: (Signature)

Return receipted copy to:

RECEIVED THE ABOVE
(Name, Division, Date)

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

• U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

Figure I.2: Survey Data Submission for Contractors

NOAA FORM 61-29
(12-71)

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

REFERENCE NO.

LETTER TRANSMITTING DATA

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY (Check)

- [ ] ORDINARY MAIL
- [ ] AIR MAIL
- [ ] REGISTERED MAIL
- [ ] EXPRESS
- [ ] GBL (Give number)________________________

DATE FORWARDED

NUMBER OF PACKAGES

TO:

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package contains [List drive(s) with description (e.g. Seagate 500 GB) and CD number or drive name]
Containing Hydrographic Survey Data Submission "[Type of data (i.e. Offsite Survey Backup)].

Survey: xxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

[Add additional comments or notes here]

FROM: (Signature)

RECEIVED THE ABOVE
(Name, Division, Date)

Return receipted copy to:

USDOC NOAA NOS
[insert field unit address here]

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

Figure I.3: NOAA Raw Offsite Survey Backup Submission

Appendix J: Data Directory Structure

NOAA Offsite Survey Backup Directory Structure

- **H#####**
  - **Raw_Public**
    - **Backscatter**
    - **Bathymetry**
      - **MBES**
      - **SBES**
    - **Features**
    - **Positioning**
    - **SSS**
    - **SVP**
      - **BOT_Files**
      - **CAT_Files**

Figure J.1: Offsite Survey Backup Directory Structure for NOAA Units

NOAA and Contractor Data Directory Structure

- **OPR-X###-XX-##**
  - **HXXXXX**
    - **Data**
      - **Preprocess**
        - **Backscatter**
        - **Bathymetry**
          - **MBES**
          - **SBES**
        - **Features**
        - **Positioning**
        - **SSS**
        - **SVP**
      - **Processed**
        - **Bathymetry_&_SSS**
        - **GNSS_Data**
          - **SBET**
        - **Multimedia**
        - **S-57 Files**
          - **Final_Feature_File**
          - **Side_Scan_Sonar_Contacts**
        - **SVP**
        - **Tide**
      - **Separates**
        - **I_Acquisition_&_Processing_Logs**
          - **Acquisition_Logs**
          - **Detached_Positions**
          - **Processing_Logs**
        - **II_Digital_Data**
          - **Checkpoint_Summary_&_Crossline_Comparisons**
          - **Sound_Speed_Data_Summary**
      - **Descriptive_Report**
        - **Report**
        - **Appendices**
          - **I_Tides_&_Water_Levels**
          - **II_Supplemental_Survey_Records_&_Correspondence**
      - **Public_Relations_&_Constituent_Products**
  - **Project_Reports**
    - **Data_Acquisition_&_Processing_Report**
      - **Report**
      - **Appendices**
    - **Horizontal_&_Vertical_Control_Report**
      - **Digital_A-Vertical_Control_Report**
      - **Digital_B-Horizontal_Control_Data**
        - **ATON_Data**
        - **Base_Station_Data**
    - **Project_Correspondence**

Figure J.2: Data Directory Structure for NOAA and Contractors

Appendix K: Marine Mammal Observation Log

Form 11US (POP)

Marine Mammal Sighting

NOAA/NMFS/AFSC/NMML
Platforms of Opportunity
7600 Sand Point Way NE
Seattle, WA 98115

Observer(s)	Vessel Name	Cruise Number	Permit Number

year ☐☐ month ☐☐ day ☐☐ local time (24 hr. clock) ☐☐:☐☐ +/- ☐ GMT ☐☐ latitude ☐☐°☐☐.☐'☐ N/S longitude ☐☐☐°☐☐.☐'☐ E/W

Sighting Conditions: ❑ excellent ❑ good ❑ fair ❑ poor

Beaufort ☐ +/- water temp. ☐☐☐.☐ °C

Species (*Please fill out a form for each species*) ____________

confidence ❑ sure ❑ likely ❑ unsure

Sighting Cue ____________

Closest Approach (in meters) ☐☐☐☐ m

Number Sighted: best estimate ☐☐☐☐ minimum no. ☐☐☐☐ maximum no. ☐☐☐☐

Narrative: Make identifications only on specific features seen. Mention them here. Include body features, markings and coloration, associated organisms, elaborate on behaviors, etc. The most valuable sightings contain a good amount of detailed information.

____

Sketches: When possible, make a sketch noting pigmentation, anatomical features, scarring, posture, anatomical anomalies, group positioning, etc. (*see silhouettes on other side*).

Photos/Video (optional)

❑ photographs (list filenames) ____________

❑ video (list filenames) ____________

❑ *Check here if there was more than one species of marine mammal present at this sighting*

BODY LENGTH ESTIMATE

- ❑ <3m (10')
- ❑ 3-8 m (10-25')
- ❑ 8-16 m (25-50')
- ❑ 1&-26 m (50-80')
- ❑ >26 m (>80')

Some common behaviors

(check all that apply)

SMALL CETACEANS

- ❑ Bow riding
- ❑ Leaping entirely out of water
- ❑ Porpoising (swimming fast, body out of the water)
- ❑ Rooster-tailing (usually a Dall's porpoise cue)
- ❑ Slow rolling

LARGE CETACEANS

- ❑ Blow visible from a distance
- ❑ Breaching
- ❑ Flipper slapping
- ❑ Group feeding
- ❑ Lob-tailing
- ❑ Spy-hopping
- ❑ Tail raised on dive
- ❑ Side wake riding
- ❑ Stem wake riding

PINNIPEDS

- ❑ Jug handle (flippers in air)
- ❑ Porpoising (swimming fast, at least partially out of the water)
- ❑ Rafting
- ❑ Spooked from haulout
- ❑ Vocalizing

Fishing Interactions

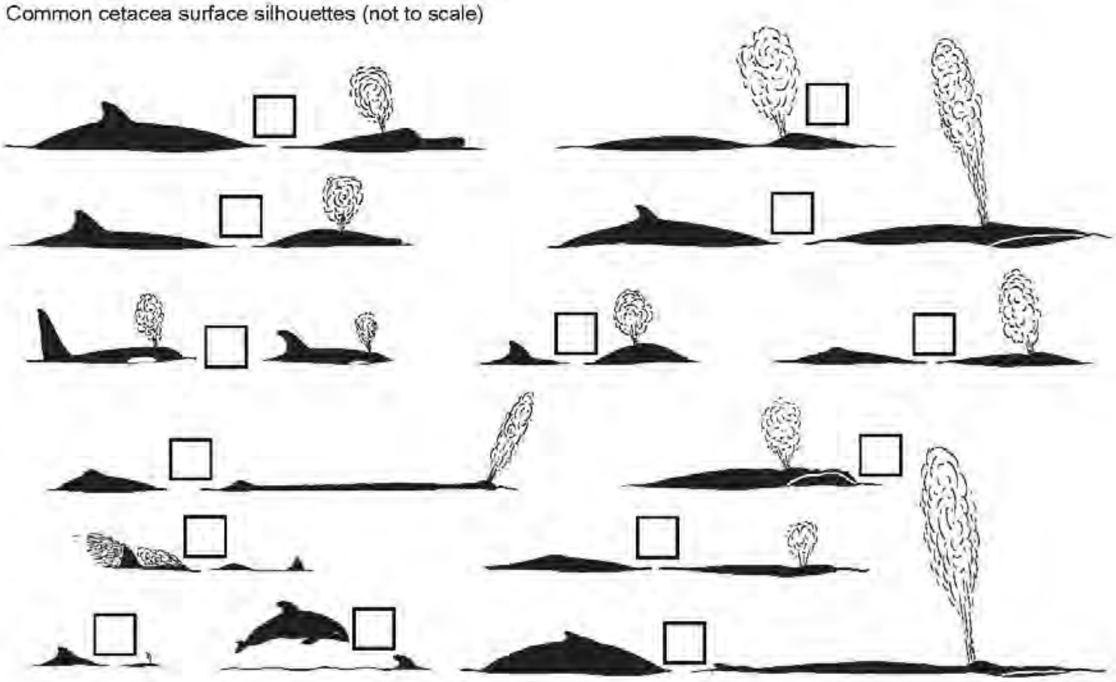
Please fill out the Marine Mammal Interaction and Specimen Form for all fishing interactions

- ❑ Contact with gear
- ❑ Contact with vessel
- ❑ Entangled in gear
- ❑ Feeding on discards
- ❑ Feeding from gear
- ❑ Following vessel while fishing
- ❑ Swimming near gear

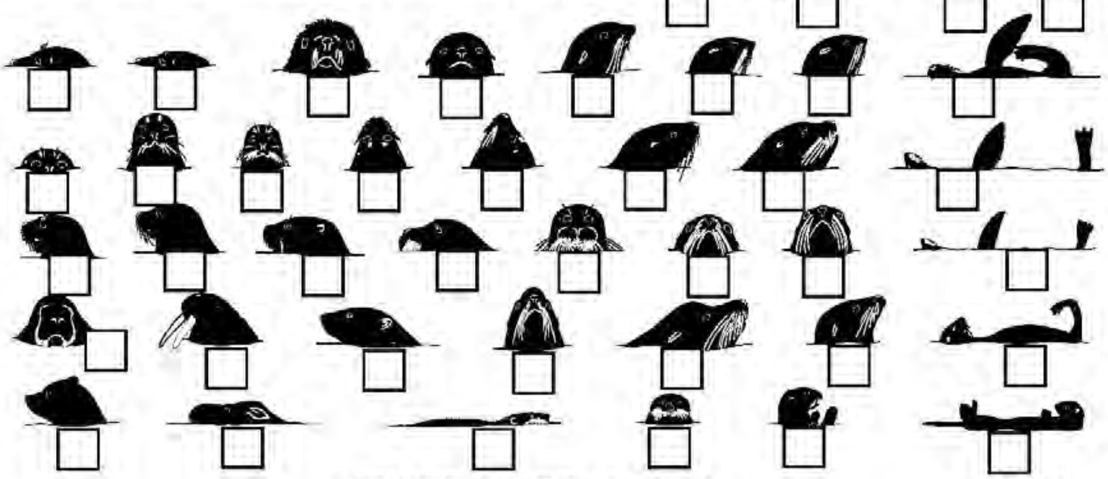
Form 11US : version 1 : 19 June 2013

These are silhouettes of most genera of marine mammals known to occur in and around North America. Subtilties exist between closely related genera. Care should be taken in identifying species. Assessing one's level of confidence with copious notes and observations is more valuable than a brief misidentification. **Please circle appropriate silhouette(s).**

Common cetacea surface silhouettes (not to scale)



Common other marine mammal surface silhouettes (not to scale)



BEAUFORT SCALE (Sea Condition)		***wind***	***wave height***	
0	glassy, calm	0 , 1 kts	calm	
1	light ripple	1 < 4 kts	light air	1/4'
2	small wavelets	4 < 7 kts	light breeze	1/2'
3	scattered whitecaps	7 < 11 kts	gentle breeze	2'
4	small waves, frequent whitecaps	11 < 17 kts	moderate breeze	4'
5	moderate waves, many whitecap	17 < 22 kts	fresh breeze	6'
6	all whitecaps, some spray	22 < 28 kts	strong breeze	10'
7	breaking waves, spindrift	28 < 34 kts	near gale	14'
8	medium high waves, foamy streaks	34 < 41 kts	gale	18'
9	high waves, dense foamy streaks	41 < 48 kts	strong gale	22'
10-12	not meaningful (time to go home)			